State of Palestine
Palestinian Water Authority

دولـــــة فلسطيـن
سلطة الميـاه الفلسطينيـة

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 6

FINAL Complementary Feasibility Study

Final

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Submitted by

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CAPEX	CAPital EXpenses
CMWU	Coastal Municipal Water Utility
CP	Cropping Pattern
EQA	Environment Quality Authority
FAO	Food and Agriculture Organization of the United Nations
MAR	Managed Aquifer Recharge
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGEST	North Gaza Emergency Sewage Treatment
NWC	National Water Company
OPEX	OPerational EXpenses
PIU	Project Implementation Unit
PWA	Palestinian Water Authority
ToR	Term of Reference
UAWC	Union of Agricultural Work Committees

WB	World Bank
WSRC	Water Sector Regulatory Council
WUA	Water User Association
WWTP	Waste Water Treatment Plant

RESULTS AND RECOMMENDATIONS

KEY RESULTS

- By improving the original design of the water reuse scheme, introducing modernized irrigation methods and a newly proposed cropping pattern, it is possible to save nearly 3.2 Million Cubic Meter of water per year (MCM/year) or 21.5% less water than what was required by the original 2010 design. Less water requirements also leads to reduced energy needs for the recovery of water from the aquifer. More precisely, the proposed changes will save 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation schedule that largely differs from the original by providing water to the entire irrigation project each day (instead of on a 6-day rotation with 12 lots irrigated 2 at a time once a week). Pumping water into the system on a constant rate drastically reduces the complexity of managing the irrigation scheduling and eliminates the risk of overdrawing water from the storage tanks and stalling the system.
- Palestinian law restricting the use of treated wastewater for irrigation does not apply to the NGEST reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that may be infiltrated into the aquifer: the quality must be either moderate ("C"), good ("B"), or high ("A"). Utilizing poor ("D") wastewater for aquifer recharge is prohibited.
- Three water tariffs options are suggested for covering the OPEX costs (including operating the WUA): farmers will be charged a flat rate of 0.9 or 1.2 or 1.461 ILS/m^3 for water delivered at the farm gate. The lowest rate is possible if all energy requirements are provided by the national grid; the highest fees are necessary to cover the costs in case 100% of electricity is produced by diesel generators. The median rate is possible if a 50/50 mix of energy production is achieved. Even if the operator of the system is charged the highest rate of 1.461 ILS/m^3, this would still be less than what farmers are paying, on average, today.

KEY ASSUMPTIONS

- The feasibility of the project is tested against the most conservative scenario of energy generation, with an assumption that 100% of electricity will be provided by diesel generators.
- The capital investment required for the construction of the irrigation network (and the O&M costs associated with a more complex and expensive network) is assumed to be much higher than previously estimated. The capital investments required for the construction of the irrigation network have seen a 75% increase from the original estimates made in 2010, when the network was designed. Some of this increase is justified by price changes in cost and material over the past 7 years but the largest increase is due to subsequent modifications of the original design which, this *Report* argues, could be streamlined for a better (and less expensive) design of the system.

KEY RECCOMENDATIONS

- The recommended Investment Scenario is for the capital investments (CAPEX) needed for the reuse and recovery scheme to be paid for by the government/donors and the operating costs (OPEX) to be paid for by the farmers. If the proposed cropping pattern and modern irrigation methods are implemented as suggested by this *Report*, this scenario is feasible and profitable for both phases of the project even if 100% of the energy required to operate the scheme is produced by diesel generators.
- The recommended Institutional Arrangement is for the operation of the irrigation system to be a combination of both governmental and non-governmental management. More specifically, the bulk water supplier (CMWU and then, when created, NWC) will own and operate the recovery and reuse infrastructure for the first 3 years. During that time, the WUA would receive intensive capacity building. After the first 3 years of the project, the WUA would assume operation and management of the recovery and reuse scheme, leasing the infrastructure from NWC. The WUA (the farmers) would pay for the OPEX from the start of the organization, as outlined in the Investment Scenario 3 above.
- Design drawings for the water reuse scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a precise cadastral and topographic survey have been provided.
- The design of the network should be revised to consider the reduced flows that come with the newly proposed Cropping Pattern. By revising the network design with updated cadastral and topographic data and streamlined flow requirements it is likely that the overall cost for constructing and maintaining the reuse system will be significantly reduced.
- Donors' engagement and government assistance to farmers is a critical component for the success of the project. Donors/Government must assist the WUA (and farmers) by providing intensive and continuous training and technical support. Such assistance program should last at least 3 years from the construction of the irrigation network. A provisional budget of $806,000 has been defined for training WUA.
- Managed Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural resource. Monitoring is an integral part of MAR management and should be robustly undertaken to determine the effectiveness of the recharge scheme, evaluate water quality and address clogging and other operational issues.

IMMEDIATE ACTIONS

After reviewing the project, this *Report* recommends the following **immediate actions**:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA;
- Contract UAWC to provide technical assistance to both the WUA staff and members;
- Hold the negotiations necessary to broker project agreements (*viz*., the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc);
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years;
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017;
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;
- Start the construction of Phase I of the reuse scheme by early 2018, and initiate the process for construction of Phase II by early 2019.

PROJECT BACKGROUND AND RATIONALE

PROJECT BACKGROUND

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

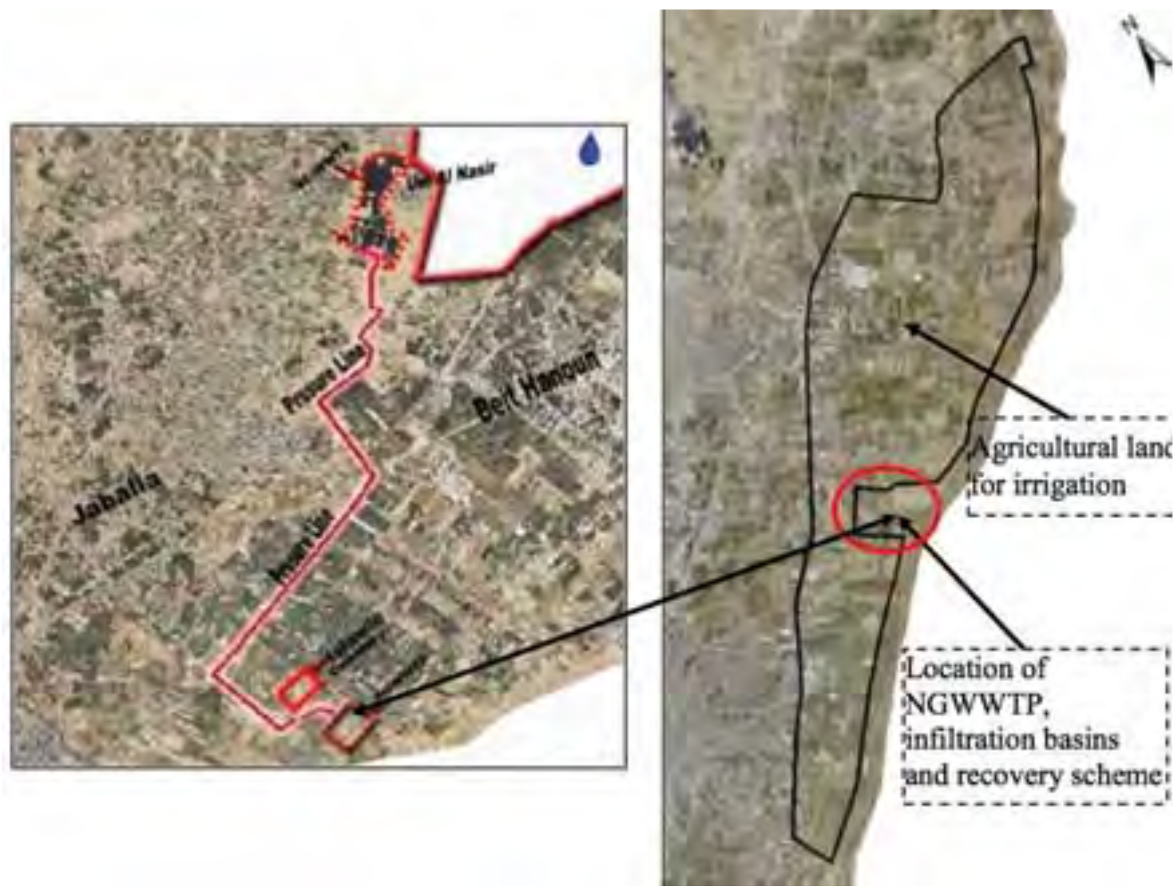


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

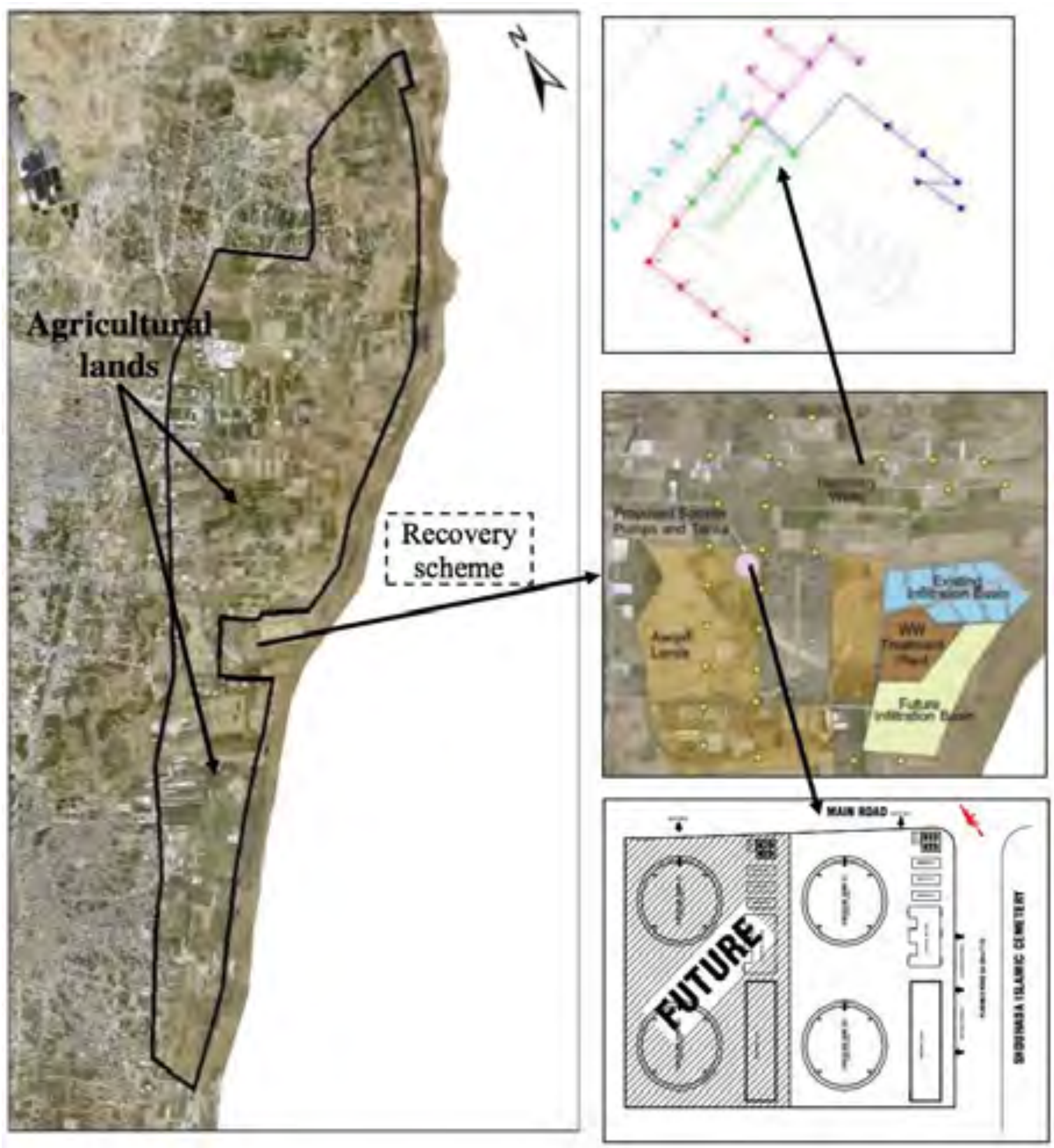


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, **supplementary phase** was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The treated sewage effluent will be disposed of into infiltration ponds, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 28 recovery wells, put into two storage reservoirs, and distributed throughout the network for irrigated agriculture.

THE PRESENT STUDY

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare this Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and making the project feasible. To carry out its task, this project has drawn upon data collection, field visits, and state-of-the-art computer modeling in order to best understand the irrigation project's hydraulics and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

COUNTRY AND SECTOR ISSUE AND POLICY

The activities of the NGEST project are in line with the policies and objectives of the National Water Policy (2012 – 2023), the Strategy for the Water and Wastewater Sector (2011-2013), the Draft Water Resources Management Strategy (1997), the National Water Policy (1995), Water Sector Strategy Planning Study (WSSPS, 2000), Water National Plan (NWP) 2000 and Coastal Aquifer Management Plan (CAMP) 1999-2004.

More specifically, this project puts into practice numerous water sector policy principles and statements, as set out in the National Water and Wastewater Strategy for Palestine, 2013, including:

Sustainable management of water resources:

- Water supply must be based on the sustainable development of all water resources (conventional and non-conventional, shared and endogenous).

- Develop additional quantities of water from non-conventional water resources without infringing upon Palestinian Water Rights.
- Recognize water users' associations (including farmers' associations) as formal entities entitled to negotiate and manage shared national water rights on behalf of their members.

Integrated water resources management:

- Agricultural, industrial, and other development and investments must be aligned to the water resource quantity available or to be developed.

Good Governance and Management:

- The responsibilities for water resources governance, being a regulatory function, and water services management, being an operational function, should be separated institutionally.
- Encourage the involvement of formal water users' associations to ensure optimal management of shared water resources (including wells, springs and treated wastewater) used for economic purposes (irrigation, industry, tourism).

Sustainable wastewater management:

- Treated wastewater effluent is considered a water resource and is added to the water balance.

Financial sustainability of water and wastewater utilities:

- Ensure that the abstraction, transmission and distribution of water, together with wastewater collection and treatment, is financially sustainable and that providers of these services can demonstrate their financial reliability as regards to the full recovery of operation, maintenance, capital investment and capital replacement costs.

Protecting the environment from pollution by wastewater:

- Treat all produced wastewater to a quality suitable for safe and productive reuse, in line with national standards, and support the distribution and productive reuse of treated wastewater.
- Priority shall be given to agricultural reuse of treated effluent. Blending of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.

PROJECT CHALLENGES

As described in the NGEST Assessment of Wastewater Treatment and Reuse Practices Report from 2011, there are several challenges and potential constraints to this project. A few of these challenges are outlined below.

Water Reuse Vision

An integrated vision for wastewater reuse issues in Palestine is still missing, which should include awareness-raising, targeted marketing, and a unified tariff. Greater effort should be devoted in producing good quality treated wastewater to be used for various purposes. Most of the treated wastewater (TWW) pilot projects have failed from the beginning, or only partially satisfied its objectives, mainly because:

- Some NGO's provide farmers of TWW with emergency subsidies, without a comprehensive system of follow up or sustainability.
- The absence of wastewater user associations to integrate and complete the role of donors and NGO's.
- The municipality was unable to operate the scheme because of lack of funds and lack of trained staff.
- The idea of reuse was not readily accepted by the farmers who had no incentive to use reclaimed wastewater.
- Some farmers could abstract fresh water from private wells at lower costs than the reclaimed wastewater.
- The effluent quality did not meet the standard required for reuse.

Political & Institutional Constraints

In Palestine, wastewater reuse projects face various political obstacles, in addition to financial, social, institutional, and technical ones. Although the reuse of reclaimed wastewater in Palestine is a priority confirmed in the Palestinian water policy and adopted in the strategies of the relevant institutions, the experience and promotion of water reuse is still in the early stages. The lack of coordination among stakeholders especially between governmental bodies and NGOs and the limited accessibility to data, information, and reports are hindering the scientific evaluation and the monitoring of implemented projects.

The installation of effective treatment systems to provide effluent that complies with water standards is a prerequisite for the success of this project. It is frequently the case that sewage treatment plants in Arab countries do not operate satisfactorily and, in most cases, treated wastewater discharges exceed the legal and/or hygienically acceptable maximum. This is usually

due to interrupted power supply, poor infrastructure and the lack of adequately trained staff with the technical skills to operate these plants, as well as the lack of an adequate budget for plant maintenance and operation.

Farmer Adherence

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

Training

A lack of technical knowledge and skills can cause failure in project implementation and, in the case of TWW MAR projects, can potentially increase environmental and public health risks. Training programs should be an integral part of the project, and it should include technical, environmental, health and socio-economic aspects. The educational input must provide farmers with an understanding of the details of techniques and their associated hazards and precautions. Capacity building in these areas are discussed in each of the relevant sections of this *Report*.

RATIONALE FOR DONOR INVOLVEMENT

Gaza faces a severe water crisis. Gaza relies almost completely on a coastal aquifer as the sole source of freshwater. However, 95% of the aquifer's water is not safe for drinking without treatment (PWA, 2014). Years of over-abstraction have taken a heavy toll on Gaza's present and future water resources. Annual abstraction of water from the aquifer has been well above the recharge rate by over 100 million cubic meters, almost twice the sustainable rate. Consequently, groundwater levels have declined, seawater from the Mediterranean has infiltrated and salinity levels have increased, making the water unsafe for drinking according to WHO standards (World Bank, 2009).

The over-abstraction and scarcity of drinking water have been exacerbated by crumbling sanitation infrastructure, while the Israeli blockade creates chronic shortages of electricity and fuel, which in turn aggravate contamination and the water crisis. The damage of contamination and over-abstraction is such that the aquifer may become unusable and, if unaddressed, the UN has stated the damage may be "irreversible" by 2020 (UNRWA, 2015a).

As early as 2009, the United Nations Environment Programme (UNEP) emphasized that prolonged over-abstraction and pollution jeopardized the sustainability of Gaza's aquifer unless it was rested (UNEP, 2009). The best suggested solution was to cease abstraction and install a monitoring system to continuously assess recovery. Once the aquifer recovers, sustainable abstraction may be resumed at carefully calculated levels. In the meantime, alternative solutions to the water crisis should be introduced, such as desalination, reduction of the loss of water in the distribution network, and wastewater treatment. Presently the application of wastewater treatment is limited because of the high cost and technological complexity of conventional systems.

In 2014, the Gaza Strip endured the third conflict of full-scale military operations in six years, coming on top of eight years of economic blockade. Reconstruction efforts have been extremely slow relative to the magnitude of devastation, and Gaza's local economy has not had a chance to recover. Socioeconomic conditions are at their lowest point since 1967 (UNCTD, 2015).

Large scale investment in water, electricity and sanitation infrastructure was needed even before the damage inflicted by the military operation in 2014. The operation resulted in severe damage to Gaza's water and sanitation infrastructure, including water wells and networks, tanks, desalination units, wastewater networks and pump stations. The preliminary static value of the damage is estimated by the Palestinian Water Authority at more than $34 million. However, long-term repair of the accumulated damage and decay of the water and sanitation infrastructure will require $620 million (UNCTD, 2015).

If the Gaza Strip is to overcome its uniquely disadvantaged situation, it will need help. Although the international community has failed to prevent these crises in Gaza from taking place, it can still play a role in its reconstruction and survival. Besides the rather stark moral imperative, as this *Report* has shown, the project has the potential to be sustainable and even profitable, arguably making the investment worth the risk on multiple levels.

LESSONS LEARNED FROM SIMILAR PROJECTS IN THE REGION

As stressed elsewhere in this *Report*, the NGEST project is not a treated wastewater for irrigation project. Rather, it is a treated wastewater for managed aquifer recharge project (TWW MAR). This section briefly looks at some of the experiences with MAR and TWW MAR in the region.

MAR in the Middle East and North Africa

Given the water scarcity in many Middle East North African (MENA) countries and the water saving capabilities of MAR, several countries have at least experimented with the technology. Although MAR is conducted in many countries in the region, monitoring is often lacking or

information is not published. As a result, the success of many of these schemes cannot be evaluated (Steinel, 2012). Below are brief descriptions of relevant projects.

Israel

Israel has been practicing wastewater treatment and reuse since the '50s, including through groundwater recharge (Soil Aquifer Treatment – SAT). The country has a 75% water reuse rate, which is much higher than most other countries [e.g. Spain 12%; Australia 9%] (Mekorot, 2013). Artificial groundwater recharge serves a number of purposes in Israel, such as increasing water reserves for periods of high demand (primarily for irrigation), reducing hydrological deficits, preventing saline intrusion from peripheral areas and ensuring efficient utilization of surplus water from Lake Kinneret (i.e. Lake Tiberias) (DWAF, 2007).

Comprehensive water quality monitoring is normally carried out throughout all stages of the recharge process. However, besides known problems related to clogging of recharge boreholes due to silt build-up and algae in the source water, health concerns have been raised lately, as endocrine disruptors, antibiotics and trace metals have been found in recycled water. In order to protect human health and groundwater quality, some experts are now calling for treatment to drinking water quality standards through desalination of treated sewage effluent by reverse osmosis (Tal, 2013).

The largest SAT facility in Israel is the Dan Region Wastewater Treatment Plant (Shafdan), where sewage water from the Tel Aviv region is treated. Wastewater treatment comprises four stages: pre-treatment, primary, secondary and tertiary treatment. Treatment methods include oxidation ponds, activated sludge and Mechanical Bio-Reactor (MBR). The Shafdan effluents are discharged into the soil for tertiary treatment and to recharge the aquifer. Water is then recovered and transported to the Negev for irrigation. The total effluent supplied for agricultural purposes is 216 million cubic meters per year (Mekorot, 2013).

Jordan

Jordanian law basically prohibits intentional recharge with reclaimed wastewater, as virtually all aquifers are also used for drinking water purposes. Yet as unintentional recharge of treated and untreated wastewater is taking place already through irrigational return flows and leaking sewage pipes, the standard is currently under review. The new standard is likely to loosen the restrictions to allow recharge of tertiary treated wastewater with near drinking water quality to all aquifers.

Jordan has one large recharge dam, Wala dam, where surface runoff is infiltrated via the side walls to recharge production wells downstream. Recently, sedimentation has decreased storage

volume and infiltration rates considerably as no sedimentation dams are installed upstream, necessitating the use of recharge wells.

Documentation on recharge volumes, water quality, clogging problems, and resulting increase in groundwater table is not available.

The expenses for MAR dam construction in Jordan are commonly covered by international donors, while the maintenance has to be summoned up by the governmental budget. Hence, the government sees it as cheaper to build a new dam rather than maintain existing ones, which is a significant flaw in the system. An important lesson learned from Jordan is that international donors should ensure that part of the budget is set aside for long-term maintenance during finance negotiations.

Iran

Iran practices aquifer recharge via a cascade of basins including settling basins or floodwater spreading systems (Hashemi et al., 2012). Removal of accumulated sediments is vital for maintaining infiltration rates in the infiltration basins (Mousavi and Rezai, 1999). In the flood spreading systems the accumulation of sediments is used as improvement to the soil for agriculture.

Oman

Oman has 15 recharge release dams that capture runoff from the mountains in the plain with high sediment loads (5 - 6 % of runoff volume) and infiltrate runoff downstream to prevent seawater intrusion and for irrigational reuse. Socio-political reasons and a lack of regulations are the main limiting factors and the recharge scheme does not generate economic benefits for irrigational reuse (Prathapar, 2012).

Saudi Arabia

Saudi Arabia has constructed a number of recharge dams, which are experiencing clogging problems. Sediment removal or release to downstream infiltration basins or the downstream wadi channel need to be undertaken (Al-Muttair et al., 1994). There are investigations to use treated wastewater in fully engineered artificial recharge and recovery systems in alluvial wadi aquifers (Missimer et al., 2012).

Tunisia

Tunisia recharges surface water for agricultural and domestic purposes after retention in small earth dams via basins and recharge wells. In upland areas, the reservoir area with collected sediments is often used for farming and further retained water is hence used for irrigation and

not for recharge. Profitability of the schemes is relevantly low (Ouessar et al., 2004). The release of captured flood water for downstream percolation in the wadi is also practiced (Ketata et al., 2011) and simulations showed much higher recharge rates especially when first flush release for silt removal was undertaken (Zammouri and Feki, 2005). In coastal regions seawater intrusions are controlled by recharge of reservoir water via wells (Bouri and Dhia, 2010). The infiltration of treated wastewater has also been investigated in coastal regions (Kallali et al., 2007).

Conclusion

MAR can only be successful if proper management plans and funding are in place and implemented. As seen in the region and around the world, clogging is a major issue, which can only be addressed with monitoring and proper maintenance. As seen in Jordan, international donors should be cautious in only funding the construction – and not also the maintenance – of MAR schemes. Lastly, water quality testing must evaluate not only regular parameters but also other emerging pollutants such as endocrine disruptors, antibiotics and trace metals, as shown in Israel’s experience.

PROJECT DETAILED DESCRIPTION

OVERALL DEVELOPMENT OBJECTIVE AND SPECIFIC OBJECTIVES

The overall project objective is to more sustainably utilize water resources in the Gaza Strip by seeking out alternative water sources for irrigation. Specifically, utilizing treated wastewater for managed aquifer recharge, which will then be recovered for irrigated agriculture throughout the Strip.

When completed the project will have:

- A WWTP capable of handling 35,600 m^3 of waste each day;
- Remediation of the Beit Lahia effluent lake;
- Nine infiltration basin
- 28 recovery wells and a network of 15 monitoring wells;
- 15,000 dunums of irrigated agricultural land.

More specific objectives related to the implementation of the Supplementary Phase of the project include:

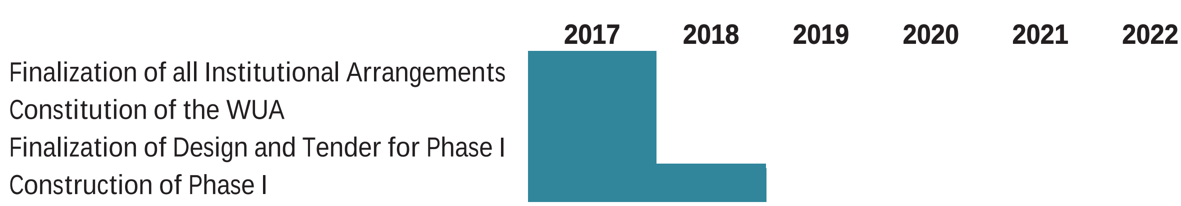
- Develop an irrigation project that assists local farmers to improve profitability and increase the value chain linked to agriculture;
- Test and promote MAR in Palestine;
- Improving groundwater health through introduction of higher quality water, and achieving more sustainable extraction practices;
- Promote the role of WUAs in managing and operating larger irrigation projects.

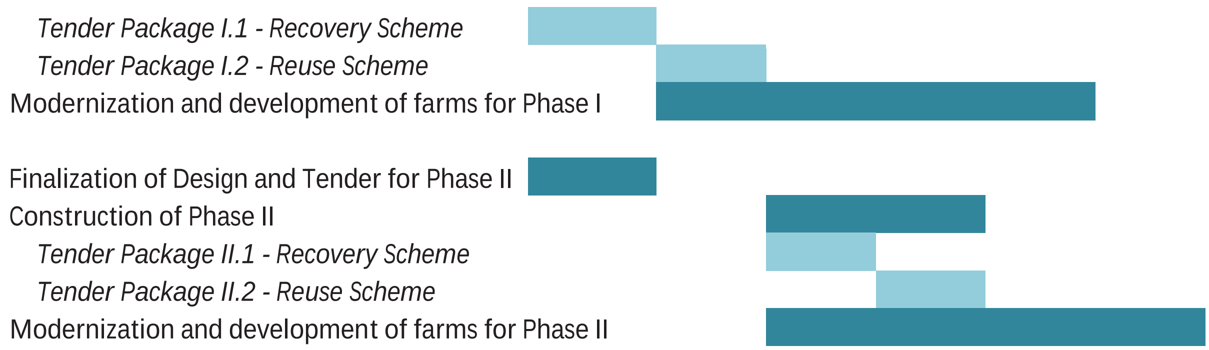
PROJECT COMPONENTS

LOGICAL FRAMEWORK

The logical framework and timetable for implementation is provided in the following Gantt chart. A detailed description of the various activities is provided in the following section.

Table 1: Project's Logical Framework





DETAILED ACTIVITIES

A gross agricultural area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit from the recovered water as well as the treated sewage sludge. This project component, known as the 'Supplementary Project', is divided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary component has been subdivided into three phases:

The **First Phase,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 14 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells – and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume from reaching agricultural and municipal wells located beyond the recovery wells.

The **Second Phase,** now scheduled for completion by the year 2020, would extend the recovery system by a second row of 14 supplementary wells (along with the previous 14 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated wastewater infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank,

booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **Third Phase**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

Phase I and Phase II shall be implemented via four separate tendering procedures: two related to Phase I and two related to Phase II. The following table provides a summary of the various tendering packages and proposed implementation schedule.

Phase	Package	Description	2017	2018	2019	2020
I	1	Supply and install 14 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	X			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		X		
II	1	Supply and install 14 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells			X	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)				X

Construction of the various component of the recovery and reuse schemes for both phases represent only one side of the overall project. Additional, critically needed, activities are defined as follows:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA. This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Contract UAWC to provide technical assistance to both the WUA staff and members. Also this activity should be implemented as soon as possible and ideally before tendering

procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017 so that training can be activated in conjunction to the development of the first phase of the reuse scheme. Training activities would then be intensified during the first year and carried on for a period of three years.

- Hold the negotiations necessary to broker project agreements (*viz*., the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc). This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017. Such activities must be implemented before tendering procedures for Phase I of the reuse scheme are initiated. Updating the design and tendering documents for both Phases of the project (for the reuse part only) will require the acquisition of more detailed topographic survey and a precise cadastral survey. Considering the small scale of these tasks, it is likely that the entire process of acquiring additional field data and updating the design and tendering document can be completed before the end of the year 2017.
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years. The necessary procedures for the creation of such fund and identification of suitable financial tools to support farmers should be started during the present year 2017 and best completed before the completion of the first stage of the reuse scheme in 2018.
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;

ADDITIONAL TECHNICAL ASSISTANCE PACKAGES

The following Technical Assistance Packages are proposed:

1. Update topographic and cadastral survey of the project area;
2. Update detailed design and tendering documentation for Phase I and Phase II
3. Assistance for finalization of MoUs and Agreements and creation of the WUA;

A short description of each Technical Assistance (TA) Packages is provided below.

UPDATE TOPOGRAPHIC AND CADASTRAL SURVEY OF THE PROJECT AREA

Objectives:	Update the existing topographic survey by expanding the survey area, collect additional survey points and provide a precise cadastral survey of the project area.
Level of Effort:	4 months/man to be divided between 1 senior topographer and supporting staff.
Deliverables:	Revised topographic map and cadastral map
Tentative Budget:	EUR 35,000
Proposed Timetable:	The proposed program shall be implemented between the months of October and November 2017.

UPDATE DETAILED DESIGN AND TENDERING DOCUMENTATION FOR PHASE I AND PHASE II

Objectives:	Prepare updated detail design and tendering document for both Phase I and Phase II of the project for the reuse scheme only.
Level of Effort:	4 months/man to be divided between 1 senior irrigation engineer, 1 junior irrigation engineer with the assistance of mechanical and electrical engineers
Deliverables:	Revised detailed design for both Phase I and Phase II in addition to General and Detail Specifications and Tendering Documents. The update design shall be provided only for the irrigation (reuse) scheme as the existing design for the recovery scheme does not need modificaitons.
Tentative Budget:	EUR 35,000
Proposed Timetable:	The proposed program shall be implemented between the months of November and December 2017, and can be implemented only after updated topography and cadastral survey has been completed.

GOVERNAMENT ASSISTANCE PROGRAMS

Objectives:	Assist parties in negotiating the necessary agreements for project implementation.
Level of Effort:	2 months/man of a senior legal advisor/mediator + local support staff

Deliverables: MoU[1] between CMWU and NWC (for CMWU to initially manage the system); a Contract between CMWU and the WUA (for CMWU to initially operate the system); a Water Supply Agreement between CMWU and the WUA (for bulk water supply); a Contract between the WUA and UAWC (for capacity building of the WUA); Lease agreement between whoever owns the system and whomever is going to operate it and collect fees (depending on the Scenario chosen).

Tentative Budget: EUR 25,000

Proposed Timetable: The proposed program shall be implemented between the months of October and November 2017.

[1] Because NWC and CMWU are both governmental entities, it is arguably more appropriate to have an MOU than a contract but this is open for discussion.

PROJECT APPRAISAL

BASELINE CONDITIONS

FIELD SURVEY

The foundation of this baseline assessment and a primary tool for collecting first-hand current data, the field survey aimed to **investigate the characteristics of the farming system** in the project area. A questionnaire was developed and tested in coordination with PWA. The questions were focused on the farm cropping system, market channels, selling prices, and incomes. Special emphasis was given to the water issue, by inquiring about the current use of water on crops, irrigation methods and the source and cost of water. Specific questions were dedicated to understanding the farmers' willingness to change/enlarge their cropping pattern and the role played by the farmers' associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017, by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 3.

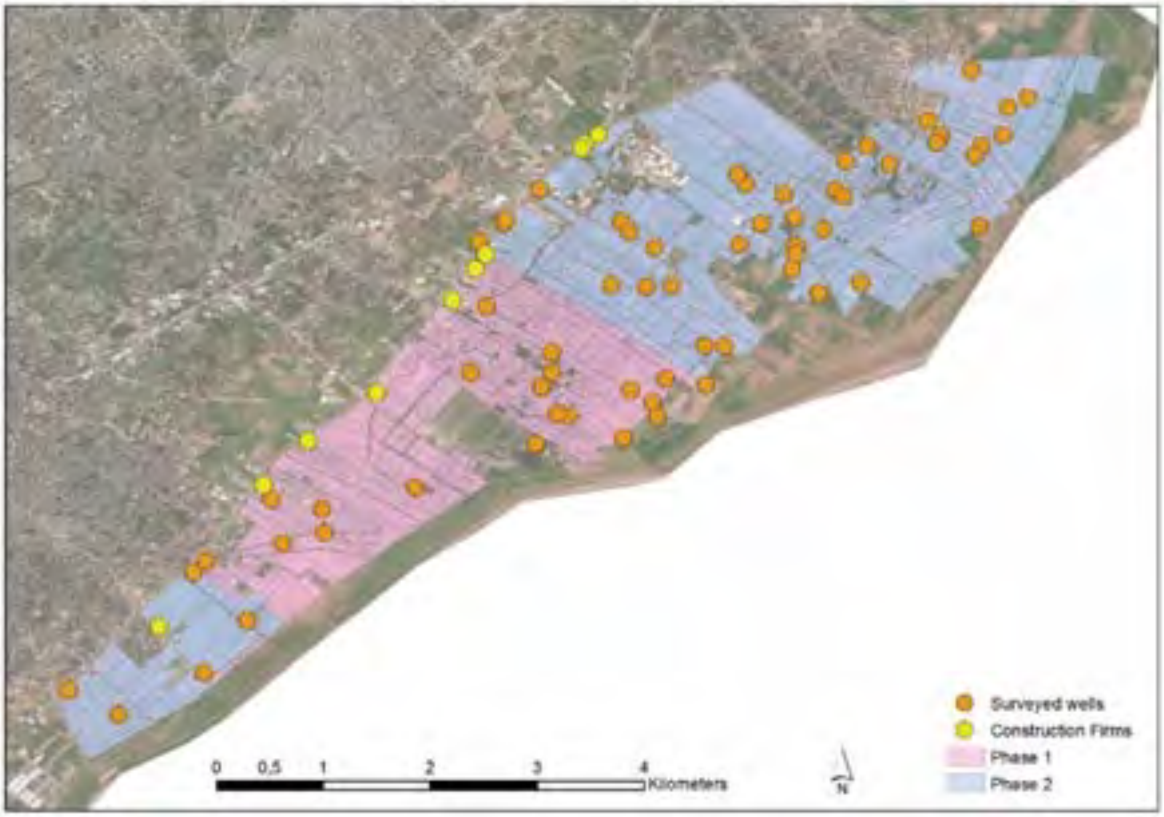


Figure 3: spatial location field survey

The survey resulted in the collection of **420 farm questionnaires**, **9 farm inputs questionnaires**, and **11 industry questionnaires**. The paragraphs below summarize the results obtained from the analysis of the questionnaires.

LAND TENURE AND CROPPING SYSTEM

FARM SIZE AND LAND TENURE

The Project area extends for 1,207 ha (12'068 du). As shown in Figure 4, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 du are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

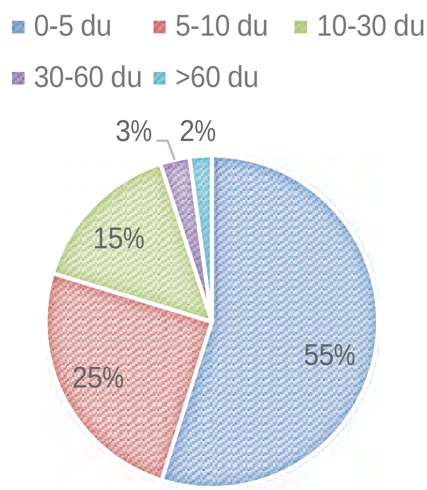


Figure 4. Distribution of farms by size.

CROPPING SYSTEM

The cropping pattern of the project area is shown in the following Figure 5.

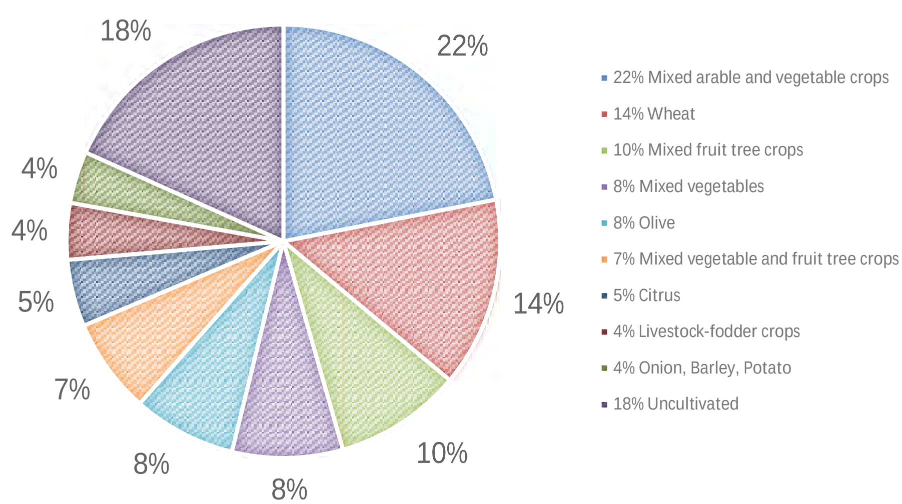


Figure 5: Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops. Almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 6). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 7).

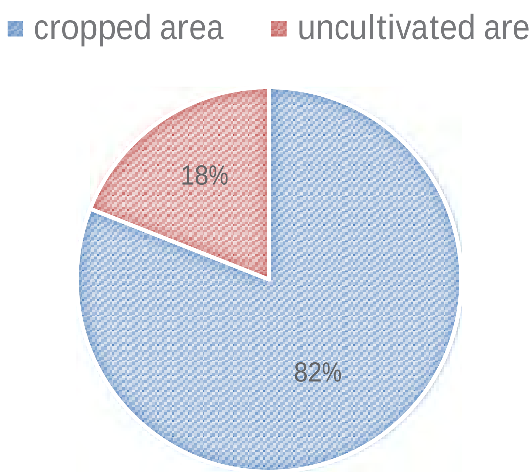


Figure 6. Cropped and Uncultivated Area

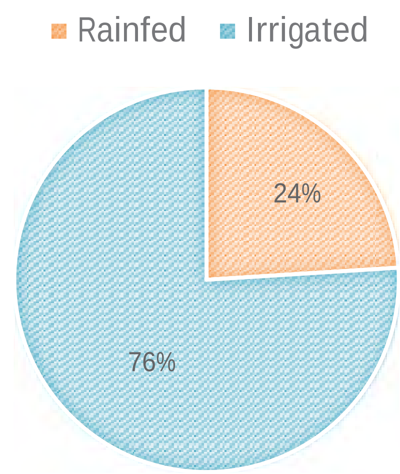


Figure 7: Irrigated and Rainfed Areas

CROP WATER REQUIREMENTS AND WATER CONSUMPTION IN AGRICULTURE

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well ("collective well") is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the "collective well" system owned by the remaining 8%.

Wells must be authorized by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also "non-legal" wells, estimated to be 3-4 times the number of the legal ones. The government does not close these wells but new unauthorized wells cannot be drilled.

The survey determined that water cost ranges[2] from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

[2] The value is the average among the ones provided by farmers during the field survey. During the filed survey, farmers provided the following rationale for their stated value for cost of water: a well's pump consumes 10 to 12 litters of diesel per hour to extract 40 to 60 m^3/hours at an average depth of 60 to 70 meters. The cost of diesel, on average, is between 6 and 7 ILS/litter. For that reason, the cost of water ranges from a minim of from 1 to a maximum of 2.1 ILS/m^3. On average, it is therefore approximately 1.5 ILS/m^3 or more.

Figure 8 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

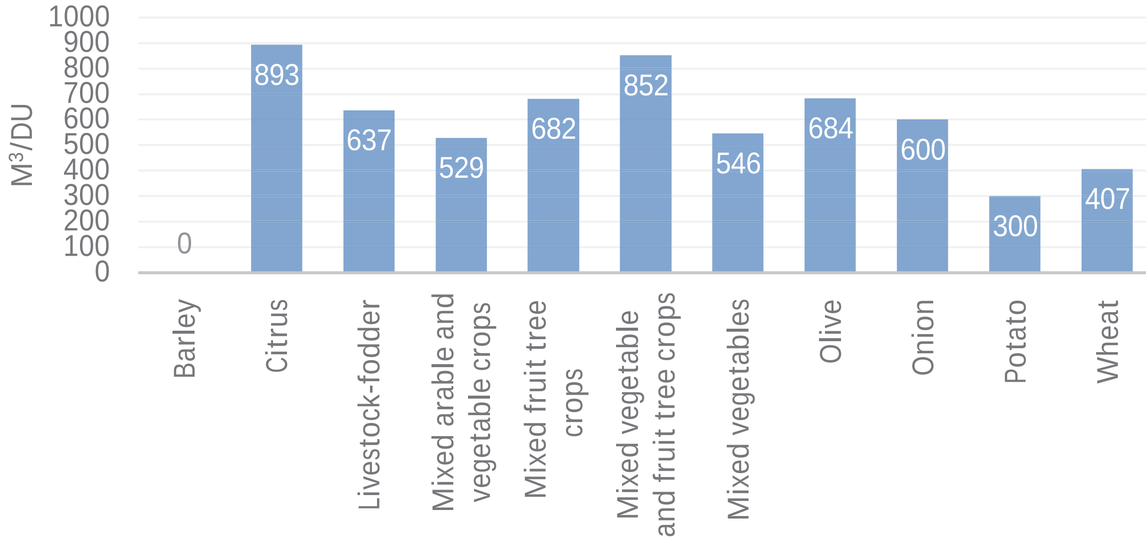


Figure 8. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m^3/du); Barley is rain fed.

The **total crop water requirements** for the agriculture currently developed across the whole 15,000 du is estimated to be **5.8 Mm^3/year** with an **average daily water requirement of 15,990 m^3/day**.

CAUSES OF THE PRESENT LAND ABANDONMENT

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is because of the frequent **land invasions by the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, as well as periodic herbicide sprays to keep the field clear, which kills the crops and makes farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out cropping operations (23%); and **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

WATER CONSUMPTION IN THE INDUSTRIES

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 3 their localization): generally, most of them are small factories (less than 10 employees), operating only a few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%) of them is using private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

VALUE CHAIN

Gaza Strip, with its high population density and reduced connections to a production system because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

Interviews with the producers showed that the vast majority of the agricultural products are sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

The market chain of horticultural and fruit products is as follows:

farmers → traders, wholesalers, middle men → retailers → consumers.

Next table summarizes revenues, costs and margins for the different crops expressed in the local currency.

Table 2. Summary of the single accounts cultivation statements of agricultural products

FARM/CROPS	REVENUES	COST	MARGIN	NET MARGIN PER KG	NET MARGIN + LH[3] PER KG
APPLE	1,000	2,495	-1,495	-2.99	-2.81

[3] LH: Labour Harvesting

BARLEY	655	1,630	-975	-2.02	-0.36
CITRUS	3,494	3,172	322	0.19	0.52
LEMON	1,400	2,048	-648	-0.65	-0.33
LIVESTOCK	1,582	2,310	-728	-	-
MELON	2,400	2,401	-1	0	0.17
MIXED ARABLE AND VEGETABLE CROPS	3,226	2,267	959	0.36	0.59
MIXED FRUIT TREE CROPS	2,487	2,472	15	0.02	0.34
MIXED VEGETABLES AND TREE CROPS	3,444	1,667	1,777	0.81	0.92
MIXED VEGETABLES	3,407	3,061	346	0.11	0.33
OLIVE	806	2,376	-1,570	-2.92	-2.05
ONION	675	1,837	-1,162	-2.58	-0.58
PEACH	1,000	1,055	-55	-0.11	0.07
POTATO	2,500	1,656	844	0.34	0.50
WHEAT	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

ASSESSMENT OF THE NGEST RECOVERY AND REUSE SCHEMES

PROJECT RECOVERY SCHEME

The recovery scheme comprises a system of 28 recovery wells and all related connection pipes as well as 15 monitoring wells. The following three sections provide a more detailed description of each component.

RECOVERY WELLS

There are 28 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 9. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

Figure 9: Location of the 27 Recovery Wells

The recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October, which is equal to 50,885 m^3/day. The total number of wells is 28 where each should have a capacity of pumping between 180 m^3/hr to 200 m^3/hr. 25 out of the 28 wells are assumed to be operational always with a capacity of 180 m^3/hr. The three additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure.

According to the numerical modelling results, the exact location of the 28 wells was selected to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 9 shows the locations of the recovery wells.

COLLECTION PIPES

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 10. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

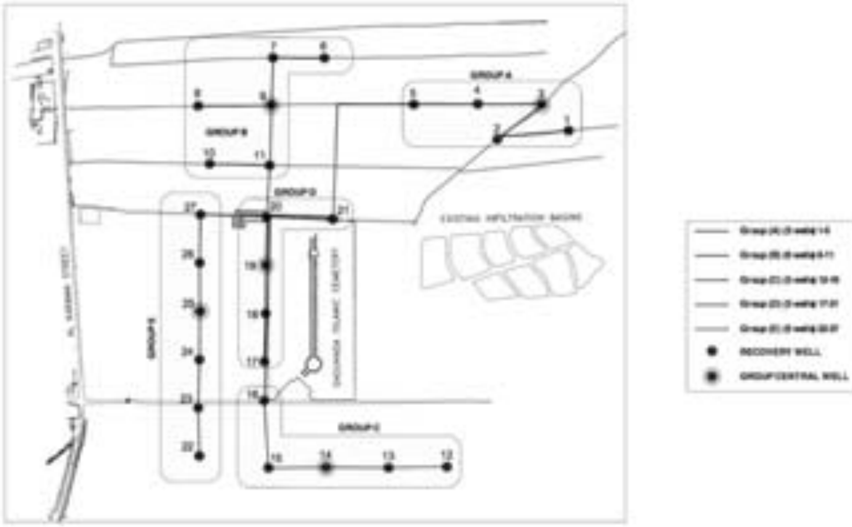


Figure 10: Wells grouping and Piping System

MONITORING WELLS

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore be taken and analyzed randomly at farm level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 43 wells will be implemented by using the 5 existing monitoring wells, the 28 newly built recovery wells and 10 new monitoring wells.

The location of the 43 wells is provided in the following Figure 11.

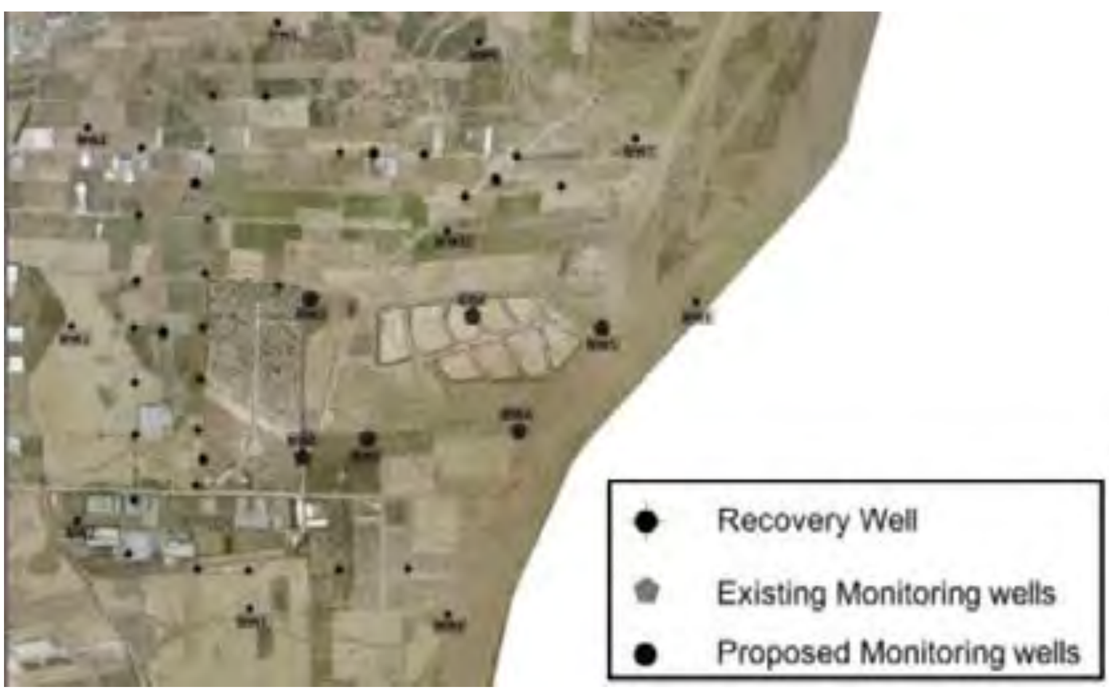


Figure 11: Location of the existing and newly proposed monitoring wells

PROJECT REUSE SCHEME

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 12. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 13.

In accordance with irrigation requirements, irrigation was to be carried out on a six-day rotational basis over six zones of almost equal size, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F, as shown in the following Figure 13. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 14.

Figure 12: Location of agricultural land

Figure 13: Proposed Irrigation Zones

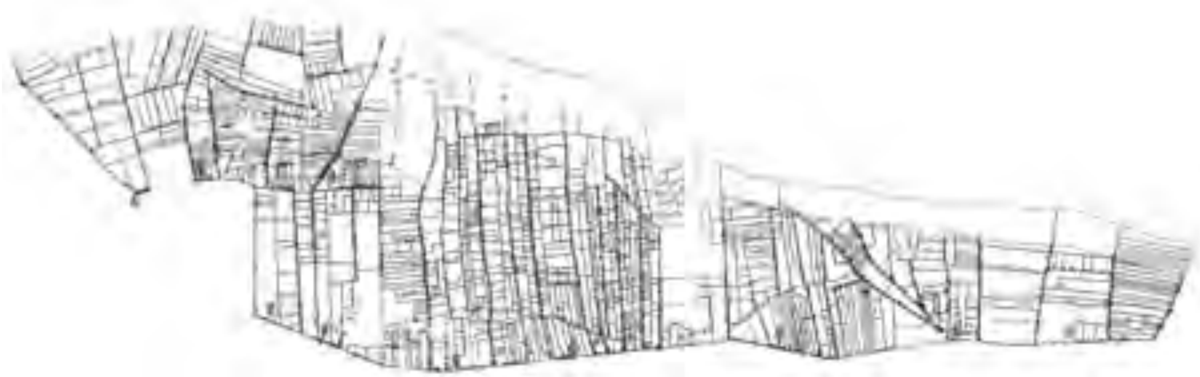


Figure 14: General Layout of the Originally Proposed Irrigation Network

REVIEW OF REUSE SCHEME: ADDITIONAL FINDINGS AND RECOMMENDATIONS

In addition to the key findings listed in the Executive Summary above, the following achievements were obtained while reviewing the original design of the Irrigation Project:

- A review of the original irrigation project layout resolved some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gate (the original design failed to do so for a sizable number of farms);
- A review of the original design for the recovery scheme confirmed its validity;
- A review of the original design for the reuse scheme confirmed the selection of materials, the general layout and the selection of the pumping system;
- The overall cost for the construction of the water reuse scheme has significantly increased (nearly 75% increase) from its original estimation. Although this might be justifiable in the context of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%. Further to that, it is possible that a further reduction in the overall cost for the construction of the irrigation scheme might be achieved with the adoption of a optimized layout. Particularly, several trunk lines had to be doubled up (sometimes even tripled up) to guarantee that the right water pressure is delivered thought the network. These changes are driving the cost of the construction up and could be optimized with the aid of a proper topographic survey and a further refinement of the original design.

PROJECT ECONOMIC AND FINANCIAL SUSTAINABILITY

The newly proposed development plan assumes that the entire project area (Phase I + Phase II) will be able to adopt the proposed cropping pattern within four years from the completion of the irrigation scheme. The adoption of the new cropping pattern involves not only planting new crops but also modernizing the farm and adapting it to the proposed irrigation method. The cost for the adoption of the cropping pattern and the modernization/development of the farms is expected to be 4.695 Million ILS (approximately 1.3 Million US$) per year for a period of four years assuming that Phase I and II are developed one after the other over a period of two years.

Farmers will require intense training to be able to implement the proposed plan. Additionally, maximizing the output of the irrigation project will require the farmers to cooperate via one Water User Associations (WUA), which has yet to be created. The macro-economic analysis assumes that the WUA should immediately invest approximately 3 Million ILS (approximately 0.8 Million US$) in trainings.

Finally, operating and maintaining the system (on-farm and off-farm, including the water recovery and reuse scheme) will cost anywhere between 7.2 Million ILS (approximately 1.98 Million US$) and 11.4 Million ILS (approximately 3.17 Million US$) per year depending on the cost of energy. The O&M costs include 0.36 Million ILS/year (100,000 US$) for the running costs of the WUA. Farmers will pay for the O&M of the system through their water bills.

In order to track the amount used, water consumed by each farm will be metered at the farm gate. Gross Irrigation water demand, excluding water needs for Industries (estimated to be 70,000 m^3/year) but including all system losses[4] and climate change[5], is estimated to be 11,110,000 m^3/year. The net irrigation water requirements (after all system losses are considered), is estimated to be 7,833,484 m^3. Farmers will be charged for the water delivered to their farms. The tariff farmers will have to pay to cover O&M costs will vary from a minimum of 0.9 ILS/m^3 to a

[4] System losses includes both on farm and off farm losses.

[5] The estimates for water demand assumes that, due the rising of temperatures over the next decades, water requirements for irrigation will increase.

maximum of 1.5 ILS/m^3 depending on the cost of electricity (if entirely provided by the national grid or entirely generated by the stand-by diesel generators installed at the site).

Then, after the new cropping pattern and modernized irrigation methods have been implemented, the irrigation project should generate a stream of revenue that, after the first three years, would provide a steady income of approximately 30 Million ILS/year (approximately 8.3 Million US$/year).

MICRO-ECONOMIC CONDITIONS

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

This section of the *Report* assesses what the net income for farmers would be with and without the project and assesses the availability in the farmers' budget to pay for water.

EVOLUTION OF THE CROPPING PATTERN

The analysis assumes that famers will be able to fully implement the proposed cropping pattern and irrigation methods over a period of four years after the construction of the irrigation network. These changes, changing the existing land use and planting trees and vegetables, are expected to increase land productivity.

The analysis of the value chain has shown that some crops such as fresh fruit (peaches, apricots, plums) are scarcely produced and often imported goods. Olive, as a crop to produce olive oil, is often sold at a low price and profitability might be improved by nearly 50% if olives, especially the better-preserved ones of the right variety, are processed into eatable olives. The new cropping pattern also includes almond as a profitable and long-lasting, easy to preserve, type of crop.

The newly proposed cropping pattern cannot produce the desired increase in production and profits unless farmers are extensively trained (see above for specific recommendations on capacity building for water user associations and farmers). Furthermore, It would be desirable for farmers to unite in associations or cooperatives to jointly handle the supply chain through the use, for example, of refrigeration storage facilities that allow the consumption of perishable products over a longer period of time.

Table 3: Evolution of the Cropping Pattern

LAND DEVELOPMENT OVER TIME [YEARS]

	BEFORE		AFTER		Y1	Y2	Y3	Y4
CROPS AND CROP GROUPS (**)	%	du	%	du	du	du	du	du
CITRUS	5	603	22	2,655	1,116	1,629	2,142	2,655
OLIVE	8	930	23	2,776	1,392	1,853	2,314	2,776
ALMOND	2	272	10	1,207	506	739	973	1,207
PEACHES	5	587	7	845	652	716	780	845
OTHER FRUIT TREE CROPS	5	544	3	362	499	453	408	362
GRAINS*	31	3.684	12	1,448	3,125	2,566	2,007	1,448
WINTER VEGS	13	1.603	4	483	1,323	1,043	763	483
WINTER VEGS (TOMATO IN GREENHOUSE)	1	121	3	362	181	241	302	362
SUMMER VEGS	8	1.009	6	724	938	867	795	724
ALFALFA (GREEN FODDER)	4	509	10	1,207	684	858	1,032	1,207
UNCULTIVATED	18	2.205	0	0	1,654	1,102	551	-
TOTAL	100	12.068	100	12,068	12,068	12,068	12,068	12,068

* GRAINS: WHEAT + BARLEY

** CROPS MARKED IN RED ARE THOSE THAT, IN FUTURE CONDITIONS, WILL OCCUPY LESS LAND IF COMPARED TO PRESENT CONDITIONS

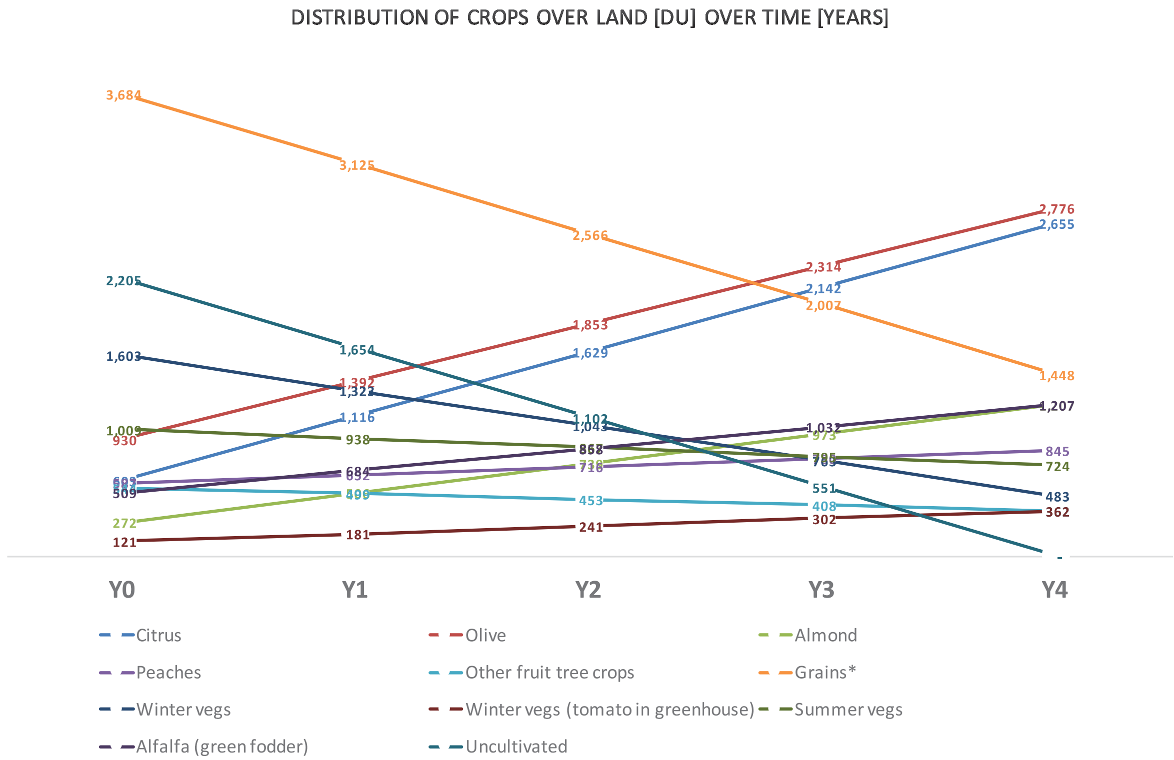


Figure 15: Evolution of the cropping pattern over land [du] over time [years]

FARM-LEVEL INVESTMENTS

Investments at the farm level would be largely spent on an increase in tree plantations and greenhouses placed in areas located away from the border with Israel.

The following table summarizes investments, expressed in Israeli New Shekel (ILS) per dunum (du) by type of crop and by type of material / activity required to produce such crop.

Table 4: Farm-level Investment [ILS] per dunum [du]

CROPS AND CROP GROUPS	*GREEN HOUSE*	*TREES*	*IRRIGATION GRID*	*LABOUR*	*MACHINERY*	*INPUTS*	*TOTAL*
CITRUS		400	380	400	0	200	1,380
OLIVE		800	380	400	0	200	1,780
ALMOND		1,200	380	400	0	200	2,180
PEACHES		1,000	380	400	0	200	1,980
OTHER FRUIT TREE CROPS							-
GRAINS							-
WINTER VEGS							-
WINTER VEGS (TOMATO IN GREENHOUSE)	37,500		492				37,992
SUMMER VEGS							-
ALFALFA (GREEN FODDER)			1,080	80	0	200	1,360

UNCULTIVATED	

Considering the evolution of the cropping pattern, total investments at farm level are provided in the following Table 5.

Table 5: Farm-level investments (ILS x 1,000) evolution during four years of full stage

CROPS AND CROP GROUPS	Y1	Y2	Y3	Y4
CITRUS	708	708	708	708
OLIVE	821	821	821	821
ALMOND	509	509	509	509
PEACH	128	128	128	128
OTHER FRUIT TREE CROPS				
GRAINS				
WINTER VEGS				
WINTER VEGS (TOMATO IN GREENHOUSE)	2,292	2,292	2,292	2,292
SUMMER VEGS				
ALFALFA (GREEN FODDER)	237	237	237	237
TOTAL ILS X 1,000	**4,695**	**4,695**	**4,695**	**4,695**

Based on the new cropping pattern, balance sheet statements have been re-calculated by considering:

- a new cultural organization;
- more modern and efficient farming practices due to training activities and better extensions services;
- better and more effective phytosanitary protection;
- a more rational distribution of the irrigation network of the farm;
- a sizable reduction in net irrigation water demand;
- a higher production, especially of the tree plants due to increased attention to thinning, correct ripening and fruit calibration;
- a water tariff based on the most conservative estimate of 1,461 ILS/m^3.

WATER TARIFF

The water tariff has been conservatively calculated including the effect of climate change, system losses, unexpected events due to pipe breaks, possible defects and/or breaks of the water metering system, possible reading errors of the water metering system and the assumption that 100% of the power requirements to run the recovery wells and the irrigation project will have to be generated by the stand-by generators and not by the national grid.

Ideally the water tariff should be able to cover all OPEX costs including those associated with running the Water User Association. Under these circumstances, farmers should be charged

based on the actual amount of water they consumed at a rate of 1.461 ILS/m^3 if energy is provided entirely by the diesel generators, 1.188 ILS/m^3 if energy is provided 50% by the national grid and 50% by the diesel generators and 0.916 ILS/m^3 if energy is provided 100% by the national grid. The details of such estimates are provided in the following tables.

Table 6: Water Tariff based on different energy generation scenarios

SCENARIO	ANNUAL COST FOR O&M AND WUAS [ILS/YEAR]	GROSS WATER REQUIREMENTS [M^3/YEAR]	NET IRRIGATION WATER REQUIREMENTS [M^3/YEAR]	TARIFF ILS/M^3
100% DIESEL	11,443,430	11,110,000	7,833,484	**1.461**
50% DIESEL	9,308,435			**1.188**
100% NATIONAL GRID	7,173,439			**0.916**

The details of the number presented above are given in the following Table 7.

Table 7: Gross and Net Irrigation Water Requirements at farm level and excluding industries

TYPE OF CROP	NET IRRIGATION WATER DEMAND	GROSS IRRIGATION WATER DEMAND
CROP	**m^3/year**	**m^3/year**
CITRUS	2,196,183	3,114,835
OLIVE	1,957,104	2.775,750
PEACHES	531,016	753,138
GRAINS	448,785	636,509
OTHER FRUIT	225,297	319,538
SUMMER VEGETABLES	470,724	667,626
WINTER VEGETABLES	141,871	201,216
WINTER TOMATO GREENHOUSES	51,337	72,811
ALMOND P	750,992	1,065,128
ALPHA-ALPHA P	1,060,174	1,503,639
TOTAL $M^{3/}$YEAR	**7,833,484**	**11,110,191**

BREAK-EVEN POINT FOR WATER TARIFF

In order to better qualify how the balance sheet of each individual crop changes by changing the water tariff, the break-even point between costs and revenues was estimated for each crop. The results, displayed in the following table, show that a large part of the crops has costs and revenues balance between a tariff of 0.90 ILS/m^3 and of 2.49 ILS/m^3.

Water price sensitivity is lower in summer and winter vegetables, while only vegetables grown in the greenhouse can withstand a high cost per cubic meter of water.

Table 8: Water tariff that involve zero net margin

CROPS	OLIVE	CITRUS	PEACHES	GRAIN	OTHER FRUIT CROP	SUMMER VEGETABLE	WINTER VEGETABLES	WINTER GREENHOUSES	ALMOND	ALPHA ALPHA
WATER TARIFF ILS/M^3	**1.00**	**1.63**	**2.49**	**-0.89**	**1.76**	**3.31**	**6.56**	**42.51**	**0.90**	**1.14**

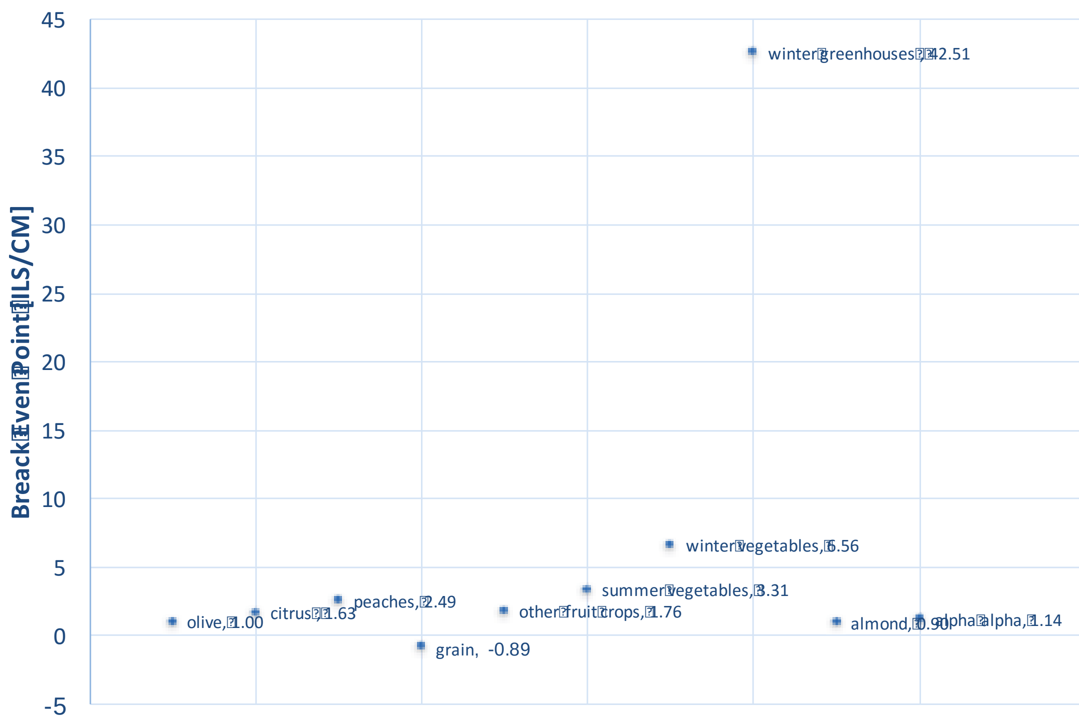


Figure 16: Water tariff that involve zero net margin

It is assumed that the following costs will be paid by the farmers: the Operation & Maintenance (O&M) costs of the recovery scheme, the reuse scheme and the irrigation network inside the farms, the costs for operating the Water User Associations (WUA). The farmers would be charged based on the actual water they consume. Water consumption is measured by a water meter installed at the manhole located at the farm gate.

BALANCE SHEET FOR THE CROPPING PATTERN

A summary and detailed analysis for both costs and revenues associated with each crop as suggested by the newly proposed cropping pattern is provided in the following series of tables.

Table 9 Summary of the Financial Costs [ILS x 1,000]

CROPS	Y1	Y2	Y3	Y4
CITRUS	2,493	3,639	4,784	5,930
OLIVE	2,253	2,999	3,746	4,493
PEACHES	995	1,094	1,192	1,291
GRAINS	3,584	2,943	2,302	1,661
OTHER FRUIT CROPS	857	779	701	622
SUMMER VEGETABLES	2,118	1,957	1,796	1,635
WINTER VEGETABLES	2,854	2,250	1,646	1,042
WINTER TOMATO GREENHOUSES	486	648	810	972
ALMOND	599	875	1,152	1,429
ALPHA-ALPHA	777	975	1,173	1,371
TOTAL FOR THE FINANCIAL COSTS [ILS X 1,000]	**17,016**	**18,159**	**19,302**	**20,445**

Table 10: Summary of the Financial Revenues [ILS x 1,000]

	Y1	Y2	Y3	Y4
CITRUS	3,456	5,044	6,632	8,220
OLIVE	2,672	3,558	4,444	5,329
PEACHES	1,792	1,969	2,146	2,323
GRAINS	2,109	1,732	1,355	978
OTHER FRUIT CROPS	1,253	1,139	1,024	910
SUMMER VEGETABLES	3,751	3,466	3,181	2,896
WINTER VEGETABLES	5,158	4,066	2,975	1,883
WINTER TOMATO GREENHOUSES	1,901	2,534	3,168	3,801
ALMOND	728	1,065	1,401	1,738
ALPHA-ALPHA	1,077	1,351	1,626	1,901
TOTAL FOR THE FINANCIAL REVENUES [ILS X 1,000]	**23,898**	**25,924**	**27,951**	**29,978**

The detailed balance sheet for each crop are provided in “Annex 5: Balance Sheet for Individual Crops”.

MACRO-ECONOMIC CONDITIONS

METHODOLOGY

Cost-benefit analysis (CBA) is a formal analysis technique used in public and private investment projects (Rakhra, 1991) as well as in programs and policies (Stoica, 2005) in order to make a comparative assessment of all the benefits and costs anticipated. It also represents an attempt to measure the costs endured and gains earned by a community or a private company after the project is implemented.

CBA proves its usefulness in feasibility studies (from an economic, environmental, social or technological perspective) by selecting the optimal option for investment projects (Hanley and Spash, 1993). The purpose of using CBA in a sector is to set up pragmatic administrative rules in order to *allocate resources efficiently*.

The use of cost-benefit analysis contributes to determining the financial sustainability as well as profitability of the NGEST water reuse scheme. It also:

a) highlights the economic and financial viability of the NGEST water reuse scheme for different scenarios;
b) enables the identification of possible errors in the design or implementation phase (incorrect information, unrealistic hypotheses, etc.); and
c) enables the correction needed to properly conduct the NGEST water reuse scheme.

GENERAL PROJECT ASSUMPTIONS

Within the CBA, costs are presented in terms of capital investments and operation and maintenance (O&M); the first being a one-time cost and the second being a recurring, yearly, cost.

The entire water recovery and re-use scheme requires capital investments to be implemented over time to provide water in two separate areas (Phase I for 500 ha and Phase II for 1,000 ha). The implementation of each phase has been subdivided into two separate tendering packages. The details are provided in the following Table 11 including the implementation schedule.

Table 11: Tendering Packages and proposed timeframe for the implementation of Phase I and Phase II

		DESCRIPTION	2017	2018	2019	2020
I	1	Supply and install 14 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$10,970,996.40			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		$7,519,531		

II	1	Supply and install 14 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$13,421,602.00	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)		$11,178,400.00

The O&M cost are provided in the following tables assuming three possible scenarios of cost for electricity. The first scenario assumes that energy will be provided 100% by the national grid, the second scenario assumes that 50% of the energy requirements are provided by the national grid and the other 50% by the standby diesel generators installed onsite. The third and most conservative scenario assumes that 100% of the energy requirements are provided by the standby diesel generators.

Table 12: Annual O&M costs (US$ and ILS) assuming all energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (ONLY NATIONAL GRID)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$1,074,060	$358,020	$716,040
FROM THE GRID (100%)	*$1,074,060*	*$358,020*	*$716,040*
FROM THE DIESEL GENERATORS (0%)	*$0*	*$0*	*$0*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	$1,886,002	$724,235	$1,161,767
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS	**$ 1,986,002**	**$824,235**	**$1,261,767**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 7,173,439**	ILS 2,977,000	ILS 4,558,000
WATER TARIFF (ILS/M^3)	0.918		

Table 13: Annual O&M costs (US$ and ILS) assuming 50% of the energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (50/50)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000

POWER CONSUMPTION	$1,665,144	$555,048	$1,110,096
FROM THE GRID (50%)	*$537,030*	*$179,010*	*$358,020*
FROM THE DIESEL GENERATORS (50%)	*$1,128,114*	*$376,038*	*$752,076*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$2,477,086**	**$921,263**	**$1,555,823**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	$2,577,086	**$ 1,021,263**	**$1,655,823**
TOTAL MANAGEMENT COSTS (ILS	**ILS 9,308,435**	3,689,000	5,981,000
WATER TARIFF (ILS/M^3)	**1.188**		

Table 14: Annual O&M costs (US$ and ILS) assuming 100% of the energy is provided by the standby diesel generators

OPERATION AND MAINTENANCE COST (ONLY GENERATOR)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$2,256,228	$752,076	$1,504,152
FROM THE GRID (0%)	*$0*	*$0*	*$0*
FROM THE DIESEL GENERATORS (100%)	*$2,256,228*	*$752,076*	*$1,504,152*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$3,068,170**	**$1,118,291**	**$1,949,879**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	**$3,168,170**	**$1,218,291**	**$2,049,879**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 11,443,430**	**ILS 4,400,000**	**ILS 7,404,000**
WATER TARIFF (ILS/M^3)	**1.461**		

Other costs that are included in this CBA are the water tariff, assumed to be 1.461 ILS/m^3, and the investments required at the farm level to support the introduction of the proposed cropping pattern.

Costs for supporting and training the Water User Association (WUA) are assumed to cost 3,000,000 ILS (equivalent to $806,000), divided in 2,000,000 ILS for the first year and 1,000,000 ILS for the second year.

FINANCIAL ANALYSIS

The financial analysis indicates whether the project will generate a positive net cash flow during the evaluation period (profitability) and whether the cumulative cash flow from the start of investment until the final prediction is negative (sustainability).

The analysis of the investment project's cash flow includes both the evaluation of the cash outflows (investment costs as well as and costs at farm level) and cash inflows (revenues at farm level, industries, grant and subsidies). As opposed to the economic analysis, in the financial analysis the cash flow does not include amortization, reserves and other accounting items.

From this perspective, the financial analysis was conducted with the following steps:

1. Estimating revenues and costs of the NGEST area farms and assessing the implications of these parameters on cash flow;
2. Defining the financing sources of investment and analyzing the financial profitability.
3. Determining the funding gap in achieving the investment project and identifying the best mechanisms to attract funding;
4. Checking whether the estimated cash flow could ensure the proper operation of the NGEST project. The investment project is financially sustainable if there is no risk of running out of cash during the operation.

For the financial analysis, the following costs and revenues were taken into account:

Cash Outflows (Costs)

- Capital cost – recovery wells, farm investment
- Costs related to the WUA operation and training
- Operation Costs at farm level including water tariff

Cash Inflows (Revenues)

- Revenues at farm level derived from the new cropping pattern
- Water tariff paid by Industry based on 2 ILS/m^3 per 70,000 m^3 /year
- Reduction of time spent in management of private wells
- Investments paid by Government/Donors
- Public Subsidies based on farm water tariff of 1.461 ILS/m^3 (worse case scenario).

The financial analysis carried out as part of the project's CBA uses market prices (which include VAT and indirect taxes) to check the balance of the investment and the sustainability of the project.

The cash flows accumulated in different years during the evaluation period (25 years) require a fair discount rate. The financial discount rate allows to account for the influence of time on the value of money and reflects the opportunity cost of the investor's capital.

In general, it is recommended to use a discount rate of 5%, but the model also used 2 more points (7%) and less (3%) to evaluate the sensitivity of the net present value.

SCENARIOS

Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

(1) Capital Investment for the Water Recovery Scheme;

(2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm's Gate;

(3) O&M Cost for the Water Recovery Scheme;

(4) O&M Costs for the Water Reuse (irrigation) Scheme;

(5) Capital Investments for Farm's Development.

The five scenarios are defined as follows

- **Scenario 1** - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under this scenario, farmers would pay back the full cost for the construction of both the recovery and the reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- **Scenario 2** - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built;
- **Scenario 3** - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government/donors and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the recovery and reuse schemes would be paid by the government or by a donor and every other cost would be paid by the farmer;
- **Scenario 4** - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that the Government/Donors would cover the cost for the construction of Phase I, but that the farmers will pay back the cost for the construction of Phase II. Farmers would also pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered

by the Government/Donors for the first 8 years (i.e. the time needed by the farmers to pay back the construction of Phase II). After that, the farmers will pay for the cost of O&M of the recovery and reuse schemes as well.

- **Scenario 5** - Capital and O&M Subsidies: considers costs (1) and (2) will be paid by the government/donors. Costs (3) and (4) would be subsidized by the Government only until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for the first 3 years (i.e. the time it takes for the farmers to be able to pay back for the improvement of their own farm). After that point, farmers will be responsible for paying O&M costs for the whole system.

A schematic representation of the five scenarios is provided in the following Table 15.

Table 15: Investment Scenarios

Scenario	Description	Cost Paid by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investments for Farm's Development	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Government and not charged to the Farmers		x	x	x	Paid by the Government and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Government until Farmers have paid back the Construction of Phase II	x	x	Paid by the Government and not charged to Farmers	x

5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5).	Paid by the Government and not charged to the Farmers	Subsidized by Donors/Government until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)	x	Paid by the Government and not charged to Farmers

FINANCIAL SUSTAINABILITY OF THE INVESTMENT PROJECT

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

In order to determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

FNPV represents the amount calculated when the estimated investments and operating costs of the project are deducted from the present value of the projected revenues. The investment project is profitable in the financial sense if FNPV has a positive value.

FIRR represents the discount rate for which FNPV is zero or which equals the present value of the financial cash flows projected for the reference period. If this indicator is less than the cost of the capital, the project is not profitable. When it is higher than the cost of capital, the project is acceptable because it will generate a positive FNPV.

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

The main results of the financial analysis are summarized in the following table.

Table 16: Main Results of the Financial Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]			BENEFIT COST RATIO (BCR)			INTERNAL RATE OF RETURN (FIRR)
	3%	5%	7%	3%	5%	7%	
1	-155,002	-140,864	-130,096	0.772	0.750	0.728	NF
2	-61,389	-56,792	-53,353	0.778	0.753	0.728	NF
3	**17,400**	**12,152**	**7,405**	**1.028**	**1.023**	**1.017**	**10.82%**
4	-52,493	-48,408	-46,166	0.922	0.913	0.902	NF
5	17,400	12,152	7,405	1.028	1.023	1.017	10.82%

ECONOMIC ANALYSIS

An economic analysis for major investment projects determines if the project contributes significantly to total economic welfare. It measures the project benefits depending on the following: the costs avoided due to project implementation; and the external benefits arising from the implementation, neither of which are included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. These externalities should be given a monetary equivalent.

In the economic CBA, some cost/benefits cannot be expressed in monetary units but only in qualitative terms. These costs/benefits are:

- Preservation and improvement of the quality of space for human life, as in the case of water pollution when human settlements located near water lose their basic quality.
- Prevention of flora and fauna destruction.
- Maintenance of natural system which will have a positive effect on people, like better mental condition and richer intellectual activities.

Benefits that cannot be expressed in monetary value are also called "intangible" benefits. Those benefits have been ignored in the cost-benefit analysis of the project. The reason is that these benefits cannot be assessed, and their detailed qualitative effects can be better described in an environmental impact assessment.

In the economic cost-benefit analysis the costs are expressed in accounting prices, and are measured in terms of 'resource' cost or 'opportunity' costs.

The economic analysis could be briefly described with the following steps:

- Conversion of market prices into accounting prices;
- Update the estimated costs and benefits;
- Calculation of economic performance indicators (Economic Net Present Value, Economic Rate of Return, benefit/cost ratio).

The corrections to be considered in the economic analysis are the following:

Fiscal Corrections. Fiscal Corrections are necessary because some transfers from one agent to another should be seen as pure transfers, without having an economic impact. For example, the subsidies provided by the government to those who want to invest in the NGEST Irrigation Project represent a pure transfer offering advantages to the beneficiaries, but not creating

economic value. The fiscal corrections are made for indirect taxes (VAT), subsidies and pure transfer payments (employer's obligation to pay social security contributions) which are generally included in the eligible costs and/or operating or maintenance costs. However, the prices should also include direct taxes. In addition, if certain indirect taxes/subsidies are aimed at correcting externalities, then they will be included in the analysis. In order to assess the project's economic impact, information on the tax system in the West Bank and Gaza, as calculated by World Bank, was used as presented in the following Table 17.

Table 17: Direct and indirect taxation in Gaza and West Bank

TAX OR MANDATORY CONTRIBUTION	PAYMENT (NUMBER)	NOTES ON PAYMENTS	TIME (HOURS)	STATUTORY TAX RATE	TAX BASE	TOTAL TAX RATE (% OF PROFIT)	NOTES ON TTR
CORPORATE INCOME TAX	2		18	15% - 20%	Taxable Profit	14.23	
CAPITAL GAIN TAX	1			15% - 20%	Capital Gains	0.76	
MUNICIPAL BUSINESS TAX	1			17%	Rental Value of Building	0.28	
EMPLOYEE PAID - PERSONAL INCOME TAX	12		96	5% - 20%	Taxable Salaries	0	withheld
IRRECOVERABLE VAT (ON FUEL)	0			15%	Fuel Consumption	0	
VALUE ADDED TAX (VAT)	12		48	16%	Value Added	0	not included
TOTALS	28		48			15.27	

Correction of labour cost from financial to economic. The correction of financial costs to economic costs of the price of labour has been made. The coefficient used to correct the financial value was 0.3 to consider taxation and social charges.

To carry out a neutral evaluation, positive and negative externalities of the project were not considered.

Based on the consideration presented above, the main results of the economic cost benefit analysis are presented in the following Table 18

Table 18: Main Results of the Economic Cost Benefit Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]	BENEFIT COST RATIO (BCR)

	3%	5%	7%	3%	5%	7%	INTERNAL RATE OF RETURN (EIRR)
1	-61,667	-61,628	-61,454	0.909	0.891	0.871	NF
2	-23,386	-24,446	-25,237	0.915	0.894	0.871	NF
3	**118,983**	**99,119**	**83,307**	**1.190**	**1.190**	**1.188**	**61.68%**
4	47,413	36,828	27,978	1.071	1.066	1.059	18.55%
5	118,983	99,119	83,307	1.190	1.190	1.188	61.68%

GENERAL ASPECTS

FINANCING MECHANISMS

The sources of funding provided by the various scenarios of the project are:

- government financial sources
- financial sources of international cooperation
- private financial sources

While government finance and international cooperation does not have direct impacts on the financial market system, it is necessary to provide support and guarantees to a private financing system. As we know the banking system requires, turning on a loan, guarantees and payment of the price of money (interest).

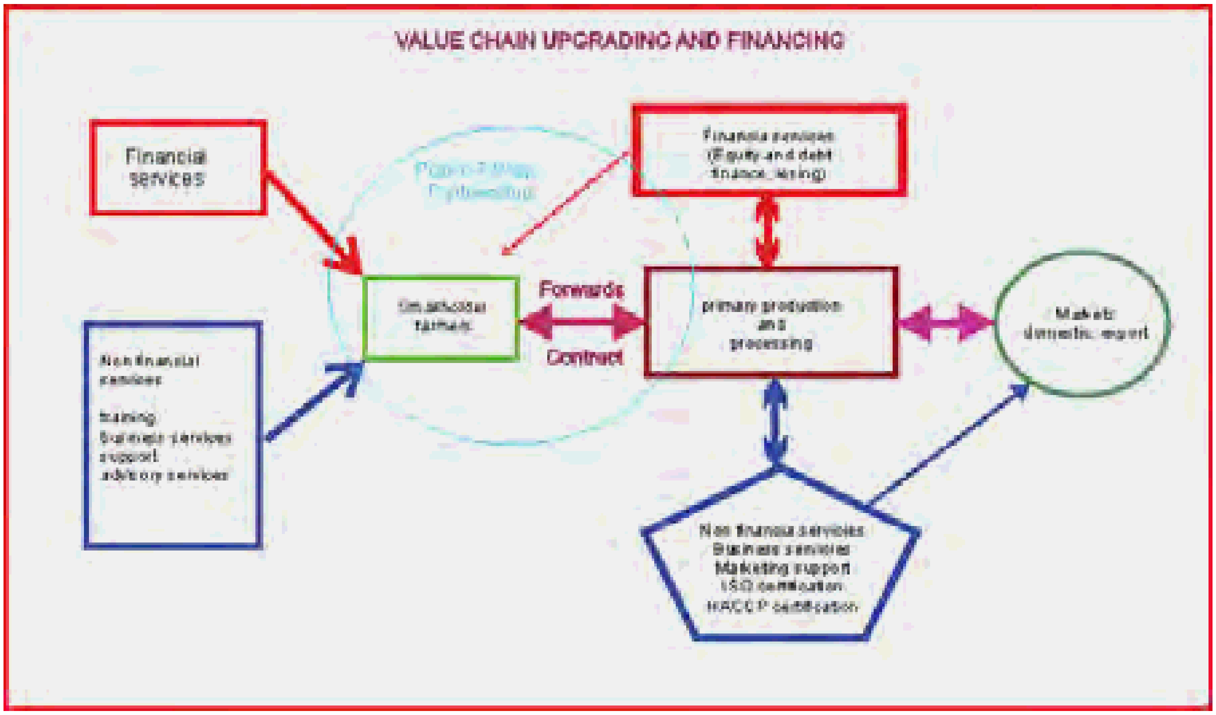
Farmers will need to have access to a banking system and most of them do not have enough income or capital to finance investment in farms or parts of the project, so it is necessary to provide them with support tools.

- First, the government must provide for a national guarantee fund supporting the banking system for when, due to personal problems or because of adverse meteorological conditions or distortions in market prices, the farmer is unable to repay the annual instalment of the loan.
- The second important thing is government or donor support for bank interest payments, given the high price of money locally. Farmers can repay the loan principal, but hardly the interest portion.

Farmers interested in the project are largely small companies (1 or 2 dunums) are heterogeneous and have different needs. It is important to identify the various sub-organizations of small owners and to evaluate their needs and constraints. In addition, small farmers do not only need credit

for agricultural activities, but also need credit for other family / needs, savings, payment systems and insurance.

Clearly knowledge of the needs of small farmers makes it possible to identify the real needs, in particular regarding the guarantees for the banking system. On systemic risk, agricultural insurance, catastrophic risk programs, price coverage through exchanges of goods or value chains, banks can provide some innovative solutions.



Agriculture value chain development is strongly influenced by:

<u>**Financial services**</u> Financial services identify the possibility of providing credit easily to small farmers who can expand their business by investing in more profitable crops, plant and machinery, improving the quality of agricultural production and starting up with other farmers on processing products in order to increase the value added on the farm.

On this point, it is important to develop warranty services, such as a **national guarantee fund** that supports the banking system in lending.

Another example of financial services for farms is the establishment of a **national rotation fund** for investment financing for small farmers.

Agricultural insurance must support farmers with regard to the risks of climate change that pose the greatest risk to agriculture and food security. It is clearly necessary to ensure farmers also for losses due to the contingent difficulties of the neighbouring Israel.

Financing needs are not high and are comprised between 1,000-2,000 ILS/du for new tree plantations, so they do not represent important figures to guarantee - only greenhouse construction requires more important investments around 35,000 ILS/du. Other investments relate to corporate mechanization as possible support for company work for medium-sized farms.

Non-financial services: Non-financial services are fundamental to farmers' training for new technologies, low-impact farming practices and organic farming. In addition, credit counselling services and advisory services for the processing and marketing of the products of their own farm are required.

Public-Private Partnerships (PPPs): Another element that could support the development of new financial management models is based on public-private collaboration.

Public-private partnerships (PPPs) enable the involvement of the private sector in the implementation and development of a programme. Various forms of PPPs can be implemented within the program are:

- Partnership with the private sector for better access of small producers to markets and enhancement of quality of production at grassroots level;
- Partnership with the public sector to enforce the necessary legal framework and to develop the indispensable infrastructure;
- Partnership with financial institutions inclusive of commercial banks, microfinance institutions and leasing companies to finance the needs of different stakeholders within value chains and service providers to the value chains;
- Partnership with insurance companies to develop specific products aiming at mitigating risks for stakeholders and financiers;
- Partnership with communities to strengthen their capacities to gradually own and operate productive assets and/or specifically created companies;
- Partnership with local SMEs and entrepreneurs to develop services to value chain stakeholders like processing, storage facilities, transport, maintenance and repair, inputs supply.

JOB IMPACTS

The project in its full version creates new employment, the estimate of the level of direct employment is about 150 new employees and the job security for current employees.

Table 19: Job Created

JOB CREATED	DAYS/YEAR
JOB DAYS CREATED AT FARM LEVEL	**23.741**

JOB DAYS CREATED WUAS				4.400
JOB DAYS CREATED O&M				4.840
TOTAL JOB DAYS CREATED				32.981
INCREMENTAL LABOUR	dd	32981	+	34%
	n.people	150		

The government may provide subsidies for young farmers who undertake to work on the farm in order to reduce youth unemployment.

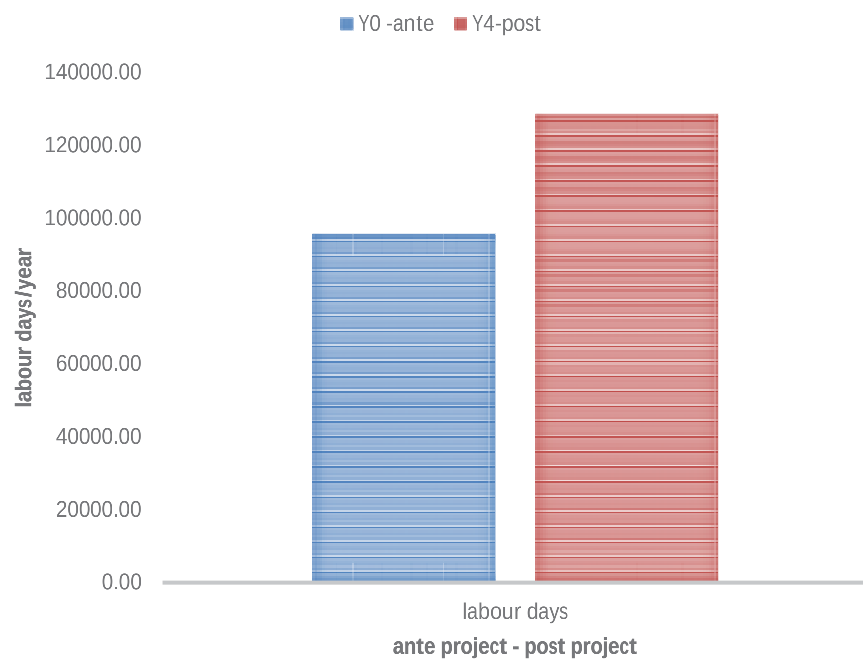


Figure 17: Job created per year before and after the project is implemented

PROJECT IMPLEMENTATION RECOMMENDATIONS

INSTITUTIONAL ARRANGEMENT

BACKGROUND

Traditional irrigation management in Palestine is community-based and informally organized around private wells in Gaza or springs in West Bank. Whereas in the Gaza Strip a small group of farmers share the operation and costs of a private irrigation well and organize the supply of water among themselves on a rotational basis, in the West bank, common irrigation schemes can supply up to a few hundred farmers and thousands of dunums, depending on the size of the spring. The organizational level is thus quite elaborate in West Bank, dealing with O&M, billing, and scheduling for hundreds of farmers in some cases. Still it is mainly informal, the number of WUAs in the Palestinian territories is very limited and the registered ones are very few. Governmental involvement in irrigation, therefore, has been very weak and limited to the licensing of agricultural wells.

INSTITUTIONAL OVERVIEW

Below is a summary of the responsibilities of the institutions that should be involved in the NGEST project, as outlined by the Water Law 2014 and the Draft Water User Association Regulation 2016.[6] It is important to note that the statements below are from the English translation of the laws. If there is a dispute as to the accuracy of a statement, the original Arabic version should be consulted.

As it pertains to this project, the PWA is responsible for (emphasis added):

- Setting a general policy for the planning and evaluation of water and wastewater projects in terms of their economic and social feasibility, setting design and quality control standards, technical specifications, and **monitoring their implementation**.
- Partake in the development of approved **standards of water quality** for various uses, in coordination and cooperation with the competent authorities, and ensure their implementation.

[6] Because the WUA Regulation is a draft, its provisions (outlined here) may be different in the final version.

- The **establishment of advanced monitoring systems** to monitor precipitation, surface flows, groundwater levels, utilization quantities, and water quality, as well as analysis of data to determine the safe and sustainable yield of Water Resources and improve water resources planning;
- Issue **licenses** for the drilling, exploration, extraction or collection of groundwater;
- Set the general policies for determining the water and wastewater **tariff**;
- Order the suspension of water extraction or water supply in cases of a water source or supply system pollution.

The Water Sector Regulatory Council is responsible for monitoring all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management. It has the responsibility and power to:

- Approve of **water prices**, costs of supply networks and other services required for the delivery of water and wastewater services, including setting a unified price for the provision of bulk water supply to Service Providers;
- Issue **licenses to Regional Water Utilities** and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of wastewater, and the levying of license fees;
- **Monitor operation processes** related to the production, transport, and distribution of water and operational processes of wastewater management;
- **Monitor water supply agreements**;
- Setting the basis for regulating the extent and percentage of **local authorities' participation** in the general assemblies of water utilities and ensuring implementation.

The National Water Company is responsible for the production and supply of bulk water at a national level. It is responsible for:

- The **supply and sale of bulk water** to water undertakings, local authorities, joint water councils and associations;
- The **extraction of water** from water resources, desalination of water, and **bulk water transmission** in accordance with a license issued by PWA for this purpose;
- The management, upgrade and development of any assets received from PWA;
- The provision of all the means necessary for the development of all activities and **infrastructure works related to the supply of bulk water**; and

- Propose a water supply tariff and submit to the WSRC for approval.

Service Providers include Regional Water Utilities and Water User Associations.

Regional Water Utilities provide water and wastewater services directly to the consumer, and are responsible for the provision of water and wastewater services within its specified administrative and geographical scope.

Water Users Associations are responsible for managing the service of supplying irrigation water at the local level. More specifically, it is responsible for:

- **Operation, maintenance and management of irrigation and drainage systems** in a fair, efficient and economical manner.
- **Produce or purchase water from its sources** at a certain rate and then redistribute it in a fair and timely manner to all farmers in the irrigation unit according to the criteria agreed with PWA;
- Determine the prices of water sold based on the tariff system in force;
- **Install, dismantle, repair and calibrate the means of measuring water** quantities used by water users.

To create a WUA, (at least) three people representing (at least) twenty farmers owning (at least) 100 dunums may submit an application to the Ministry of Agriculture. The application should contain basic information about the members, including the names and identity cards of the founding members, and the land owned or used by all members along with its agricultural pattern and water usage needs. The application should also include information about the Association, including its address, scope of work, and the water source to be used.

The Ministry of Agriculture will study the application and will then forward it to PWA, which in turn decides whether to grant a license to use the water source. If PWA approves the granting of a license, the Minister of Agriculture shall issue a decision to establish the Association. The application shall then be referred to the WSRC for approval to issue the license.

A WUA will be terminated if its approval to use a water source by PWA is cancelled.

The Ministry of Agriculture shall work with PWA and others in training WUAs on the following subjects:

- General training on participation in associations.

- Specialized training in the fields of financial, administrative and technical affairs necessary for the operation of the Association in accordance with the plans and programs established by PWA;
- Develop the operational plan, management and water distribution operations;
- Develop a maintenance plan for waterways, sockets and pumping mechanisms;
- Directly implement operation and maintenance plans; and
- Evaluation and follow-up.

During the transitionary period while the NWC, WUAs, and other new institutions are created, the relevant governmental authorities, official institutions, civil society organizations, and local authorities should continue to exercise their existing responsibilities and powers.

PUTTING IT ALL TOGETHER

Although it is clear which institutions should be involved in the various aspects of this project, what is not clear is where that authority exactly starts and stops. For example, it is stated that WUAs are responsible for "supplying irrigation water at the local level." But reasonable people may disagree with where that management should start in this project. Does it start at the recovery wells? At the booster station? Or somewhere else?

The main ambiguity, however, is regarding the responsibilities of NWC and the WUA. NWC is responsible for the extraction of water and bulk water transmission. Yet the WUA may "purchase ***or produce***" water, suggesting that the WUA may also be able to extract water itself without purchasing it from NWC. In the new Water Law, NWC is given the responsibility to sell to "associations", including WUAs. That statement alone, however, does not logically necessitate that associations *must* buy from NWC.

Moreover, the WUA is responsible for the irrigation system, which in the case of the NGEST project, coincides with the bulk water transmission system. In other words, the recovery wells extracting water and the pipes bringing the water to the farm gate can be characterized in one of two ways: 1) as bulk water supply (and therefore under the purview of NWC) or 2) as an irrigation system (and therefore under the purview of the WUA), or some combination thereof.

Below are three scenarios for O&M, which are meant to provide a starting point for discussions by Palestinian stakeholders on how best to run the project.

TERMS

Before introducing the scenarios, there should be some clarification of terms:

"**Recovery System**" includes the 28 recovery wells and 15 monitoring wells.

"**Reuse System**" includes all connecting pipes, two 4,000 m^3 water storage tanks, a booster station with 10 pumps, and an irrigation network of 126km of pipelines, which transports the water from the recovery wells to the farm gate and the water metering system.

"**On-Farm System**" is the infrastructure on each individual farm, including the tertiary pipe network to bring the water from the farm gate to the crops.

INSTITUTIONAL SCENARIOS

For the management of irrigation systems, world experience has generally followed three basic arrangements:

1) the government officials continue to manage the systems after completion;
2) the government turns the systems over to farmers to manage them; or
3) the government and farmers manage the systems jointly, meaning some parts of the physical system (generally the larger elements) are managed by governmental agencies while the smaller ones are the farmers' responsibility.

These scenarios are put into the NGEST context and discussed below.

It should be noted that during this transitional period, neither NWC nor the WUA exist. It is envisioned, therefore, that CMWU will handle the responsibilities of NWC until it is created and able to function. The WUA, which should be created as soon as practicable, will also be assisted by CMWU until it is ready.

Scenario 1 – Governmental Management

1. In this scenario, the Recovery and Reuse Systems would be owned and operated by the NWC.
2. This would mean:
    a. NWC will own and operate the Recovery System;
    b. NWC will own and operate the Reuse System;
    c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it is a simple, straightforward arrangement, whereby the governmental body that specializes in water distribution handles the supply.

The main detriments of this scenario are that it seems to contradict the spirit (if not the letter) of the law, which envisions a greater role for the WUA, and may perpetuate some of the problems with a centralized, governmental approach.

Countries have historically entrusted the management of their irrigation systems to government agencies, on the assumption that they will have the capacity and motivation to achieve high performance standards. The opposite has proven true, as documented reports and literature have shown the performance deficiencies of many government-managed irrigation systems has increased (see, *e.g.*, World Bank, 1997).

The deteriorated performance of irrigation systems under government agencies is generally the resultant of the following:

- the failure to operate and maintain systems adequately;
- the financial burden of subsidizing agencies to manage the system has become more onerous for many governments due to the low fee recovery rates from farmers;
- major difficulties in maintaining subsidies for irrigation systems that perform sub-optimally;
- difficulties in implementing water pricing and cost recovery as a traditional economic solution of "getting the prices right";
- local information constraints and inappropriate incentives for government employees.

Many of the issues delineated above have been problems in the Gaza Strip, and so significant consideration should be given to whether a governmental approach will achieve the goals of this project.

Scenario 2 – Water User Association Management

1. In this scenario, the Recovery and Reuse Systems are owned and operated by the WUA.
2. This would mean:
    a. WUA will own and operate the Recovery System;
    b. WUA will own and operate the Reuse System;
    c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it firmly places control and management into the hands of the WUA. As mentioned above, several benefits are expected to accrue from involving the WUA in owning and managing the network, including greater overall sustainability of the project.

The greatest detriment of this scenario is that NWC (CMWU) is much more knowledgeable and much better positioned to handle the system than the WUA. The WUA will need significant capacity building and technical assistance to step into this role, as discussed below.

For this approach, governments have followed two different methods to hand over irrigation systems to farmers. Some have favored the quick establishment of the WUA and a rapid transfer of responsibilities to it. Most countries, however, have favored a phased handing over, accompanied by training programs for the leaders of the WUA. The general belief is that a phased program has better chance of success and provides more opportunities to change course, if required.

Scenario 3: Joint Management

1. In this scenario, NWC would own (and for the first few years, also operate) the Recovery and Reuse Systems with the ultimate goal of transferring operation and management to the WUA.
2. This would mean:
   a) NWC would own the Recovery System, and operate it for the first three years of the project.
   b) NWC would own the Reuse System, and operate it for the first three years of the project.
   c) During the first three years, the WUA would receive intensive capacity building.
   d) After the first three years of the project, the WUA would assume operation and management of the Recovery and Reuse Systems.
   e) NWC would continue to own the Recovery and Reuse Systems but would lease them to the WUA.
3. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it blends the resources and knowledge of the NWC (CMWU) with the appropriate level of input and phased-in management by the users (WUA).

This scenario also dovetails nicely with the recommended **Investment Scenario 3**, where the capital investments necessary to build both Phase I and Phase II of the Recovery and Reuse schemes would be paid by the government (or by a donor), and the O&M of the Recovery and Reuse schemes and the capital expenditures and O&M of the On-Farm development would be paid by the farmers.

The main detriment of this scenario is that it is a more complex arrangement, necessitating various agreements and contracts between parties to delineate roles and responsibilities.

If this Scenario is chosen, the WUA could contract CMWU to manage the Recovery and Reuse Systems for a limited period of time, say 3 years. Also during that time, the WUA could contract the Union of Agricultural Work Committees (UAWC) to manage the training and extension services to the farmers to establish the executive capacity needed within the WUA.

Complete governmental or complete farmer management are both relatively rare in the world. The in-between option of joint management has become the norm, albeit with different variations. The Consultant recommends that PWA take advantage of world experience and select a joint management model.

WATER USER ASSOCIATIONS

WUAS IN GAZA

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – a "collective well". Namely, a farmer owns one well and other neighboring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The baseline survey of this Complementary Feasibility Study shows that 92% of the farmers depend on the "collective well" system, owned by the remaining 8%.

Usually, the farmers using a collective well do not sign any formal agreement, neither are they linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmers do not pay his share in due time, thus undermining the efficient operation of the well.

The few existing WUAs in Gaza are generally small and loosely organized. This low level of organization makes it difficult to initiate joint actions. They are also faced with harsh economic and financial circumstances, including limited access to the international market for agricultural products. Greater farmer cooperation under the umbrella of a WUA could yield significant gains.

COMMON TASKS OF WUAS

The main tasks and activities commonly found in WUAs include:

- Choose and specify the water source and take part in the planning, designing and implementation.
- Define the roles and responsibilities to manage, operate and maintain the water source and its structures.
- Solve conflicts among water users by achieving a fair water distribution among the users.
- By mutual control and increased sense of ownership and responsibility, reduce violations over water.
- Take part in the tasks and functions for the management of irrigation projects.
- Help to develop irrigation efficiency at a field and network level, also by facilitating the spread of modern irrigation techniques.

TRAINING NEEDS AND CAPACITY BUILDING

A capacity building program should be carried out to enable the WUA to achieve its mandate.

On-farm technical assistance and training on irrigation topics, in conjunction with best agricultural practice, will be handled by the Ministry of Agriculture and the non-profit organization Union of Agricultural Workers Committees (UAWC).

Table 20: WUA capacity building and training needs; estimated costs for 20 farmers

TOPIC	NO. PARTICIPANTS	DURATION (DAYS)	ESTIMATED COST (US$)
FACILITATION AND TRAINING SKILLS	10	30	$120,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN IRRIGATION TECHNOLOGIES, SUCH AS ON-FARM LOW PRESSURE SYSTEMS, LOCALIZED IRRIGATION, ETC. BASIC LEVEL.	20	15	$120,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN IRRIGATION TECHNOLOGIES, SUCH AS ON-FARM LOW PRESSURE SYSTEMS, LOCALIZED IRRIGATION, ETC. ADVANCED LEVEL.	20	10	$80,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN ON-FARM SURFACE IRRIGATION SYSTEMS.	20	5	$40,000.00

DESIGN, OPERATION AND MAINTENANCE OF ON-FARM DRAINAGE SYSTEMS.	20	7	$55,000.00
ON FARM DRAINAGE, DRAINAGE WATER REMOVAL AND CONVEYANCE OUT OF THE IRRIGATION AREAS TOWARDS THE DRAINAGE OUTFALLS	20	10	$80,000.00
SOIL SCIENCE, SALT LEACHING, LAND RECLAMATION	20	5	$40,000.00
COMPUTER MODELS APPLICATION IN I&D	5	5	$10,000.00
GIS AND REMOTE SENSING APPLICATION FOR IMPROVED WATER MANAGEMENT IN I&D	5	5	$10,000.00
I&D MANAGEMENT TRANSFER (INCLUDING PARTICIPATORY IRRIGATION MANAGEMENT/WUAS FORMATION PROCESS AND BACKSTOPPING)	5	15	$30,000.00
STUDY TOUR TO ABROAD (TO BE SELECTED)	5	7	$52,500.00
USE OF THE AGRO-METEO STATIONS NETWORK. INTERPRETATION OF WEATHER FORECASTING AND RECOMMENDATION FOR FARMERS	5	15	$112,500.00
IRRIGATION METHODS AND SCHEDULE FOR EFFECTIVE PEST AND DISEASE CONTROL	20	7	$56,000.00
		Total	**$806,000.00**

ECONOMIC SUSTAINABILITY OF WUAS AND COSTS

While they may be entitled to claim subsidies or state assistance, WUAs are usually largely self-financing, the bulk of their income being provided by their participants. For NGEST, it is presumed that farmers will cover the costs related to the WUA's management and basic activities (e.g. office rent, administration staff salaries etc.) from the beginning of the organization. Additionally, farmers are expected to pay the OPEX costs of the recovery and reuse scheme, and any on-farm development. The proposed water tariff options in this Report have been made with these expenditures in mind.

It should be noted that, because they are non-profit, WUA-specific legislation could confer powers on WUAs to take and impose compulsory measures. These can include: the right to impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; the right to make binding operational rules concerning, for example, the use and allocation of irrigation water; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts (FAO, 2007). None of these powers are currently in the Draft WUA Regulation. If they are not included in the final version, some aspect of these concerns must be addressed in whatever contractual agreement is brokered between the WUA and either CMWU or PWA.

Table 21 shows an estimated cost breakdown for the establishment and operation of a WUA (gathering approximately 20 farmers) for the NGEST Water Reuse Scheme.

Table 21: Estimated costs for the establishment and operation of one WUA, for 1 year

ITEM	UNIT	COST (USD)
4X4 CAR	1	25,000 USD
OFFICE AUTOMATION EQUIPMENT FOR ADMINISTRATIVE AFFAIRS	Forfeit	25,000 USD
SALARY FOR ADMINISTRATIVE STAFF	1	30,000 USD
RUNNING COSTS	Forfeit	20,000 USD
	Total	100,000 US$

COST SHARING MECHANISMS

Typically, WUA costs include some, or all, of the following:

- The cost of obtaining a permit to abstract and use water and/or to drain water or to dispose of wastewater together with any water use and wastewater disposal charges payable pursuant to such permit;
- Charges in respect of water supplied to the WUA on a contractual basis by a state agency or some other bulk water supplier;
- The WUA's own costs of operating and maintaining the infrastructure under its authority, which may include staff salaries, office expenses (including the costs of rent, utilities and

communication), operation costs including the costs of electricity if pumps are used, system maintenance including routine and annual maintenance, the maintenance of an emergency reserve fund, small replacement fund, transport expenses, purchase of equipment, social charges and taxes; and

- Investment costs for the construction, rehabilitation or reconstruction of infrastructure.

As mentioned above, a key feature of WUAs across the world is that they are usually self-funding, at least as far as operating costs are concerned. The typical sources of WUAs finance include fees and charges for services provided by WUAs to its participants as well as loans, grants and subsidies, income from assets or capital owned by WUAs, and fines from participants who have breached its operating rules.

The way in which the level of fees is determined can be left up to WUAs or specified in the relevant legislation. The amounts payable by individual WUA participants can be based on, for example, the volume of water supplied (if the main WUA service is water provision), flat rate charged per hectare of land (in case of a range of different and not easily measurable services provided by WUA), or value of possessed agricultural land. For the NGEST project, a proposal is made to charge the farmers based on the water delivered to their farms at a rate that ranges between 0.9 and 1.5 ILS/m^3. This fee would cover the expenses of the O&M of the Recovery and Reuse Systems and running the WUA organization.

If farmers are not able to pay the fee until after the irrigation season is over and they have harvested their crops, a range of solutions can be applied, such as: participants can pay deposits, the WUAs can borrow money by way of a loan or bank overdraft or issuing bonds, or receiving governmental or other grants.

Ideally, a WUA fund would be established to provide support for the creation and early administration of the WUA (an initial capital of, say, US$ 1 million). Otherwise the WUA may fail due to low membership fees from the farmers in the NGEST project area, most of whom own small plots of land.

RECOMMENDATIONS

- **Immediately pass enabling legislation for the creation of WUAs**

The Draft WUA Regulation from 2016 should be finalized, promulgated and implemented as quickly as possible. The draft Regulation sets out the basic parameters within which the design of each individual WUA can be crafted. Several important legal rights, however, have not been addressed.

One of those legal rights is the long-term right to abstract water from a natural source or, depending on which Scenario is chosen, a long term contractual right with a bulk water supplier

(e.g. NWC). As written, the Draft WUA Regulation states that PWA may cancel a WUA's right to use a water source; it does not say what process or justification would be required for PWA to do so. Moreover, if PWA cancels a WUA's right to use a source, the Regulation states that the WUA will be terminated by the Ministry of Agriculture. This prospect may have a chilling effect in WUA members' willingness to contribute to the long-term investment needs of the system. Although PWA's cancellation may be appealed, if the Association and its work may be terminated at the whim of a ministry, that creates an impression of a less secure institution overall.

Additionally, as mentioned above, WUAs will very often need to have express legal rights to do things like impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts. Without this authority, the work of the WUA may be significantly hampered.

- **International Norms**

To mitigate health and environmental risks, common international norms and standards for the quality of irrigation water should be followed.

STAFFING REQUIREMENTS OF THE PIU

The Project Implementation Unit (PIU) should have a multi-disciplinary technical team. Table 22 illustrates the proposed PIU composition.

The PIU shall assist field activities, and act as coordination unit for related on-farm initiatives. The PIU shall be directly linked with the future WUA that will be established to manage irrigation water distribution.

Table 22: PIU Staff Composition

NO.	AREA OF EXPERTISE	INSTITUTION	QUALIFICATION
1	On farm irrigation technology and water distribution	CMWU	Eng.
2	Land reclamation	CMWU	Eng.
3	Information Technology	CMWU	Eng.

4	Plant Production and Soil Fertility	MoAg	MSc
5	Plant Protection	MoAg	MSc
6	Agro-meteorology	MoAg	MSc
7	Rural Extension	MoAg	MSc
8	Administration		

Expert on On-farm irrigation technology and water distribution

Duties / Responsibilities:

- Review the irrigation requirements and water balance analysis performed and recommend further detailed studies as needed;
- Assist relevant team members in the preparation of work programs and schedules;
- Develop a quality assurance program for civil works for the irrigation component, and train staff on the in implementation of the quality control program;
- Operates power equipment and hand tools to install, maintain and repair irrigation systems and related components including irrigation lines, sprinkler heads, control panels, valves, pumps, etc.;
- Checks system for proper operation and timing. May participate in the design or modification of new or existing systems. Performs seasonal maintenance such as system charging and draining;
- Maintains inventory of related parts and supplies. May lead workers on irrigation projects and work on other grounds related assignments as needed.

Expert on Land reclamation

Duties / Responsibilities:

- Advise farmers about appropriate land management and conservation practices, adapted to the project environment;
- Advise other experts about environmental management and conservation;
- Design specific plans to reclaim non-cultivated areas in the project zone;
- Apply knowledge or research findings to address environmental problems;
- Train personnel in technical or scientific procedures;

- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Information Technology

Duties / Responsibilities:

- Design, program, and maintain IAS website using HTML5/JavaScript/CSS. Interface with SQL databases as required;
- Maintain Microsoft SharePoint site layout and permissions. Develop custom SharePoint lists and libraries;
- Contribute to Social Media system including creating original content, assisting users in content generation, and account management;
- Interact with and provide services to the other members of the staff in a highly dynamic and occasionally time-critical environment.
- Perform other duties as required.

Expert on Plant Production and Soil Fertility

Duties / Responsibilities:

- Support farmers in designing sustainable and productive cropping patterns;
- Help in crop budgeting & planning;
- Take soil samples, prepare and submit them for testing;
- Review soil test results and provide advice to farmers;
- Inspect crops in accordance with guidance;
- Record crop outcomes as requested;
- Manage required field services such as fertility, soil amendments, crop
- production, and more;
- Maintain crop and financial data in accordance with requirements;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Plant Protection

Duties / Responsibilities:

- Identify plant protection problems in the project area and provide technical support for the promotion of safe and sustainable plant protection activities, based on IPM solutions;

- Design and conduct periodic reviews and appraisals of the situation of plant pest and pesticide problems in the project area and advise farmers on necessary actions to implement pest and pesticide management programmes;
- Provide advice to IAS in training technical personnel through targeted training programmes, workshops and seminars related to plant protection and maintain close relations with international and national research institutions for the transfer of research findings;
- Perform other related duties as required;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Agro-meteorology

Duties / Responsibilities:

- Mainstreaming agro-met advisory services into the agricultural extension system;
- Developing and engaging in the delivery of a training plan to improve skills within the extension system for interpretation and analysis of climate information to inform agronomic advice;
- Developing and engaging in education programs for farmers regarding benefits of agro-met advisory services.
- Supporting integration of agro-met within extension packages.
- Reviewing proposed approaches for dissemination and communication of climate information and feedback.

Expert on Rural Extension

Duties / Responsibilities:

- Encourage farmers to adopt best practice techniques by providing exposure to new knowledge, information, skills, inputs and processes;
- Assess individual farms and making technical recommendations for improved production and sustainability;
- Collaborate with farmers in developing processing and post-harvest schemes;
- Suggest research priorities to research committees;
- Organise and manage field days, speak at grower groups, write fact sheets and publications, present courses;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Administration

Duties / Responsibilities:

- Support team leader in ensuring effective and efficient financial management system;
- Maintain efficient and effective financial system;
- Support in periodic financial planning, including Annual Plan and Budget (APB);
- Supervise general administration of IAS;
- Perform other duties as required.

INSTITUTIONAL CAPACITY ASSESSMENT

There are a number of particular skills that need to be developed for the successful implementation of the NGEST project, including management of MAR and sludge as well as the design, operation and maintenance of modern irrigation technologies. Communication and cooperative approaches should also be fostered through trainings on developing the WUA or community awareness to bolster support for the project.

In order to adequately assess the specific capacity development needs for each aspect of the project, this *Report* has interwoven capacity building throughout each section: Managed Aquifer Recharge; Farmer Assistance; WUAs; and Operation and Maintenance of the Irrigation System. Therefore, although there are recommendations below for Institutional Capacity Building, overall capacity development should be viewed through the context of the entire *Report*.

RECOMMENDATIONS

A capacity development system for the Water Sector in Palestine already exists and a substantial amount of resources are being invested to enhance capacities in this sector (PWA, 2016). Compared to some other countries, where capacity development efforts have to be developed from scratch, Palestine boasts a substantial foundation of sufficiently developed institutions and a high number of human resources investments. Palestinian Universities, polytechnics, industrial secondary schools and vocational training schools produce a constant inflow of trained professionals for the water sector, and international donors have expended considerable sums for training of water sector stakeholders.

However, there needs to be better coordination of capacity development initiatives with policies and strategies so that there is a more efficient utilization of resources and the training better meets the needs of the sector. In particular, PWA, NWC, CMWU and the WUA need targeted capacity building to implement the water law, to make effective and efficient use of increased investments, and to maintain the existing and new infrastructure.

In addition, work needs to be done to create an environment in which skill and knowledge acquisition can take place, including, for example, fostering a professional atmosphere in which technical growth is rewarded and there are incentives for participation, allocating a sufficient budget for on-going development, and ensuring monitoring and follow-up of capacity development efforts.

Below is a truncated list of institutional capacity building recommendations. As mentioned above, for a more detailed analysis of capacity development needs, see the other relevant sections of this *Report*.

Capacity Development Coordination. There is a need for sector-wide monitoring and evaluation of capacity development interventions. The current lack of the monitoring and evaluation is directly correlated with the need for coordination, but also lends itself to the mismanagement of limited resources, decline in performance and loss of value for money spent. It is expected that the newly created Capacity Development Directorate of PWA will lead this coordination as well as execute the recommendations contained in PWA's Water Sector Capacity Development Policy and Strategy of 2016.

Focus on Practical Skills. There should be increased focus on the development of practical knowledge and competencies to address existing and emerging water sector challenges, for example negotiation with the Joint Water Committee, and how to build, manage, repair and renew a modern irrigation system.

Encourage On-going Capacity Development. Water professionals need to refresh and expand their knowledge base in a number of training days each year to be able to excel in their work. Organizational Capacity Development Action plans, covering a 3-5 year period, should be prepared by the relevant units and persons within the respective organizations. These plans should be approved by the organization itself, endorsed at national level, and updates should be made annually.

Help Prepare CMWU. Because CMWU will likely handle the operation and management of the NGEST Recovery and Reuse schemes until the creation of the NWC and WUA, the capacity of CMWU should be expanded to provide this service. Additionally, there may be the need to modify the current mandate of the CMWU to reflect this change.

Sludge Management. Training is needed that tackles sludge collection, treatment, or dumping and sludge management. Sludge represents a completely new sector, which should be organized and well regulated in order to benefit from it.

MAR Training. A simplistic view that treating water to near drinking standards before recharge will protect the aquifer and recovered water is incorrect. For example chlorination, to remove

pathogens that would be removed in the aquifer anyway can result in water recovered from some aquifers containing excessive chloroform. In some locations, drinking water injected into potable aquifers has resulted in excessive arsenic concentrations on recovery due to reactions between injected water and pyrite containing arsenic. Source water that has been desalinated to a high purity dissolves more minerals within the aquifer than water that has been less treated (Dillon, 2009).

Therefore, PWA (and any other ministry that will be responsible for the MAR scheme) needs to understand how this aquifer will interact with the recharged water. More specifically, it should have hydrogeological and geotechnical knowledge, as well as knowledge on water storage and treatment design, water quality management, hydrology and modelling, monitoring and reporting. It needs to understand pathogen inactivation and biodegradation. The response of an aquifer to any water quality hazard depends on specific conditions within the aquifer, including temperature, presence of oxygen, nitrate, organic carbon and other nutrients and minerals, and prior exposure to the hazard, so the Authority should receive adequate training on these subjects.

Additionally, PWA (and any other ministry that will regulate the MAR scheme) should acquire basic stratigraphic and hydrogeological information for each well drilled. This information should be stored in departmental data bases, which would ideally be publically accessible on the web.

Create a MAR Unit. The human resources at PWA are limited as the number of staff is already not sufficient to perform all needed tasks (e.g. data evaluation, quality control) let alone to fulfil new tasks related to MAR. Therefore, it is recommended to create a MAR unit to handle strategic planning and the oversight of MAR activities.

FARMER CAPACITY BUILDING

PRESENT FARMERS' ORGANIZATIONS

The Union of Agricultural Work Committees (UAWC) is the main organization[7] active in the project area, already working with a few farmers. UAWC is a non-profit organization founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union aims to help Palestinian farmers to market their produce and provides

[7] Other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions.

Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors, in the West Bank and Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in different Palestinian rural areas. UAWC receives funding from numerous western governments and aid organizations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organizations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like MoAg. Relationships are also established with international development agencies, like FAO.

The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, such as land reclamation; building greenhouses; products quality enhancement and new crops introduction. Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistical and financial support for exporting goods such as strawberries and medical herbs, which usually ensure a good revenue.

IMPROVING FARMERS TECHNICAL SKILLS

The farmers interviewed during the baseline survey stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.

According to the outcomes of the baseline survey and the agronomic characteristics of the new proposed irrigated cropping system, the following training and technical assistance needs have been identified for the farmers:

Training on appropriate use of irrigation. So far, the irrigation practice has been left in the domain of individual farmers without any technical assistance. Underground water is being managed without considering the actual water requirements of crops, after computing the water balance of the area. Without an appropriate approach to irrigation, the amount of water supplied to crops is often under- or overestimated hence causing low yields and problems of uncontrollable pests and diseases on the cultivated crops. The envisaged training program has

the objective to make the farmers fully capable to design an irrigation plan suitable for their cropping pattern for various irrigation methods (e.g. surface, sprinkle or drip irrigation).

Training on integrated pest management (IPM). It has been observed that use of pesticides on crops is often high in north Gaza, although these products are quite expensive since imported from Israel. Pests outbreaks are common in the target area, probably because of irrigation misuse (see above). However, farmers lack specific knowledge on effective methods for preventing pests and diseases, which should allow them to drastically reduce the amount of sprayed pesticides, so saving money and making the farming environment healthier. The IPM method has been conceived in the '70. It is a pest control strategy that uses a variety of complementary strategies including: mechanical devices, physical devices, genetic, biological, cultural management, and chemical management. These methods are done in three stages: prevention, observation, and intervention. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. IPM practices have been so far successfully implemented on vegetables and fruit tree crops in the Middle East. These crop groups represent 65% of the new cropping pattern proposed for the project.

Training on Integrated Plant Nutrient Management (IPNM). This methodology has been devised by the Food and Agriculture Organization of the UN. It allows to match crop nutrient needs with sufficient accuracy to prevent surplus of fertilization. This in turn limits soil and water chemical pollution which usually is a consequence of the use of mineral fertilizers. The purpose is to maintain or enhance soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients, including biological nitrogen fixation. IPNM focuses first on the seasonal or annual cropping system (namely, the entire crop rotation applied by a farm), rather than on an individual crop; secondly, on the management of plant nutrients in the whole farming system; and, thirdly, on the concept of village or community areas rather than individual fields. The proper application of IPNM, among others, allows to minimize the use of mineral fertilizers which are particularly costly in Gaza, because imported from Israel.

Farming field schools (FFS) for effective training on IPM and IPNM. The Farmer Field School is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It was initially developed to help farmers tailor their IPM practices to diverse and dynamic ecological conditions, but subsequently the method has embraced also other relevant topics for improving farmers' technical skills. In regular sessions from planting till harvest, groups of neighboring farmers observe and discuss dynamics of the crop's ecosystem, under the guidance of a facilitator (usually an agricultural extensionist, well trained on running a FFS). Simple experimentation helps farmers further improve their

understanding of functional relationships within the agro-ecosystem (e.g. pests-natural enemy population dynamics and crop damage-yield relationships). In this cyclical learning process, farmers develop the expertise that enables them to make their own crop management decisions. Special group activities encourage learning from peers, and strengthen communicative skills and group building. Farmer Field Schools for vegetable crops have been successfully implemented by FAO in Egypt, Jordan, Syria, Iraq and in Palestine (West Bank).

BUILDING FARMERS' CAPACITY ALONG THE VALUE CHAIN

Supporting farmers in establishing organizations. Collective action can create a more effective market chain that is more stable and can produce the products required at the time needed and of the quality wanted. As a group, producers can provide a more stable and higher quality supply of raw material, which also improves the economic efficiency of the value chain. The higher bargaining power and improved access to markets for group members are made possible by creating a link with other actors along the chain (retailers, traders and processors). However, a farmer organisation cannot be simply created by a top-down approach from the government (for example, by providing strong subsidies to farmers if they join an organisation; or providing inputs for free). Many worldwide experiences clearly show that farmers organisations (under the shape of cooperatives, associations, etc.) fail when members are not fully convinced that collective action is really an opportunity for them to grow and improve their lives. Farmer organisations also fail when their members do not firmly aim at economic independence, but rather rely on external aid. The survey carried out in the project area highlighted that farmers work on individual basis. Even when they share collectively the same private well, everybody keeps on working on his own. It is also noted that only one organisation is existing in the project area, joining a small number of farmers.

To cope with this reluctance toward cooperation, farmers should be invited - through a tailored training programme - to progressively share their activities. For instance, an initial stage of farmer collective action may be started just by purchasing the farming inputs together, which will allow a discount from the seller. Then, farmer collective action can further evolve in growing crops together, according to a cropping plan that has been specifically designed to meet the market needs in a certain period of the year. When collective crop production is finally carried out relationships with the merchants (wholesalers, traders at any level of the supply chain) can be strengthened and options of contract farming may become feasible. Furthermore, associated farmers may start processing the raw materials and their marketing action will become more targeted and complex. By following this progressive process, the farmers' organisation purchasing power and its share of added value along the supply chain will increase.

Training on post-harvest operations and food processing and establishing suitable physical structures. This training programme requires high investments and well established farmer's organisations, which will handle the operations and run the post-harvest and processing structures. The survey carried out by the consultant highlighted that in northern Gaza the existing food industries do not buy raw food materials from the local farmers but they rather import it from Israel, probably because the industry cannot find the required amounts according to its needs. While this specific demand from the industry could be properly satisfied by an organised group of farmers (see above), on the other hand organised and well trained farmers could start simple post-harvest processing activities, such as sorting and packing fresh fruit and vegetables; preparing plant preserves, purée, jams, etc. Another option would be processing dairy products, considering the good milk production from cows, sheep and goats which are being reared in the project area.

All the above-mentioned activities will improve products quality and introduce new products into the local market which will increase the farmers' earnings.

However most of the farmers seem they cannot afford the cost of the initial investment (e.g. purchasing a refrigerator unit, packaging materials, other equipment for processing), nor bank loans seem available in north Gaza. Therefore, external aid should be foreseen together with sound training sessions.

MANAGED AQUIFER RECHARGE

Managed aquifer recharge (MAR), also known as enhanced recharge, water banking and sustainable underground storage, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can be used to store water from various sources, such as stormwater, reclaimed water, mains water, desalinated seawater, rainwater or even groundwater from other aquifers. With appropriate pre-treatment before recharge and sometimes post-treatment on recovery of the water, it may be used for drinking water supplies, industrial water, irrigation, toilet flushing, and sustaining ecosystems. The figure below shows the basic MAR process for an unconfined aquifer.

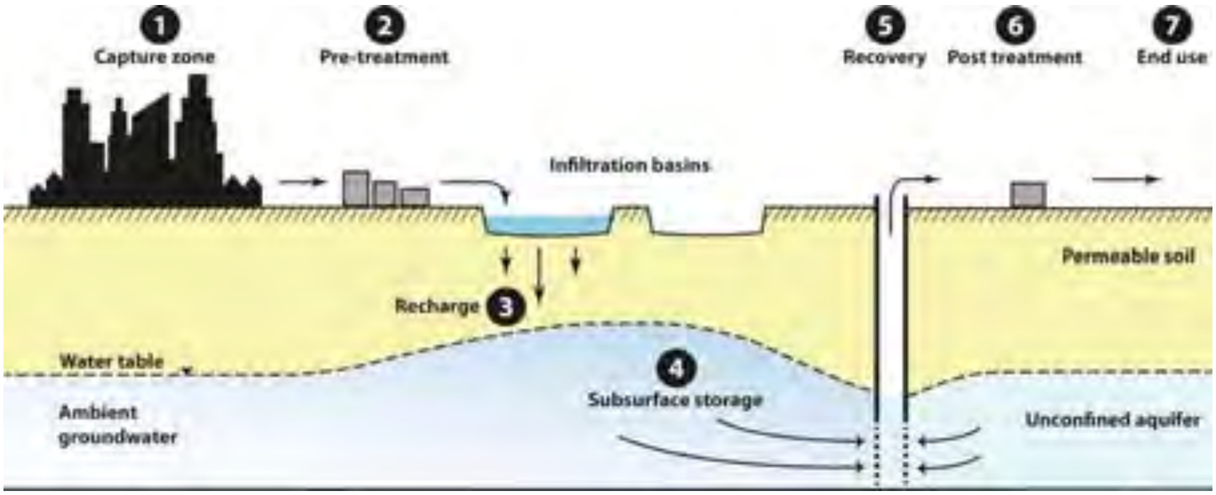


Figure 18: Schematization of Managed Aquifer Recharge System (Source: Dillon, 2009)

Several past documents describe the NGEST Project as if it is a treated-wastewater-for-irrigation project. It is not. Rather, it is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation. The difference is significant and has considerable implications for the feasibility and sustainability of the project. Outlined below are some of the central considerations and concerns for managing this segment of the project.

REGULATORY ISSUES

The main objectives of MAR regulations should be the protection of groundwater from pollution and the assurance of public health. Topics covered in a regulatory framework often include technical issues, water quality requirements to protect groundwater and human health, regulations on the authorization to recharge and to recover water, and institutional arrangements (NRC, 2008).

The quality of the water extracted from the aquifer should meet the most stringent standards related to the intended water use. The quality of the water of a recharged aquifer is a function of multiple factors, including:

- the quality of the recharge water;
- the recharge method used;
- the physical characteristics of the vadose zone and the aquifer layers;
- the water residence time;
- the amount of blending with other sources;
- the history of the recharge.

Setting requirements for indirect recharge is not an easy task. The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, thanks to retention and oxidation processes. These processes affect organic matter, nutrients, microorganisms, heavy

metals and trace organic pollutants. However, though much is known about these processes (Bouwer, 1996; Drewes & Jekel, 1996), forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is complex. Performances depend on a number of factors such as depth of the unsaturated zone, physical and mineralogical characteristics of the soil layers, heterogeneity, hydraulic load, infiltration schedule and infiltrated water quality (Dillon, 2009).

Therefore, particularly when transfer through the vadose zone is part of the treatment intended to bring the water up to the required water quality, pollutant removal tests should be performed, at the laboratory and onsite, to ensure the water achieves the desired quality. The example of the Dan Project in Israel shows that submitting secondary effluents to a Soil Aquifer Treatment system in a dune sand aquifer can result in the production of a nearly potable water (Sack, Icekson-Tal & Cikurel, 2001).

The complexity of reactive transport processes in the unsaturated zone highlights two of the main stumbling blocks that must be taken into consideration if treated wastewater is being considered for MAR: one specific challenge is to have numerical models that can include all of the hydro-biogeochemical processes involved in reactive transport, while a second, more operational, is the need to have a complete biogeochemical and hydrogeological characterisation specific to each MAR site. These should be taken into consideration in assessing the capacity building needs of PWA and other stakeholders involved in managing the NGEST project.

Several countries (the United States and Australia, for example) have developed guidelines for the use of treated wastewater for recharge (USEPA 2004, 2012; WHO 2006a, b). These guidelines focus mainly on the health and environmental risks that result from the presence of pathogenic microorganisms, suspended solids and dissolved organic carbon in this water. There are few recommendations concerning trace element contents in water (e.g. USEPA 2012), except as concerns five trace metals. These are: (i) arsenic; (ii) nickel, which is only weakly toxic but which accumulates in plants; (iii) cadmium, which is considered to be the metallic pollutant of greatest concern due to its rapid accumulation in plants and its proven toxicity even at low concentrations (acceptable daily intake (ADI) 0.057 mg/day/individual); (iv) mercury, which can be highly mobile; and (v) lead, the injection of which, even at low doses, can cause neurotoxic and hepatotoxic disturbances (Dillon et al. 2009a).

Although these guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse. Land use planning and environmental impact assessment legislation add to the complexity of the regulatory frameworks currently available for MAR schemes.

Under many countries prevailing water resources legislation (e.g. Israel, South Africa, Spain, USA, Australia), groundwater which has been recharged with TWW is subject to the extraction and management rules of native groundwater, and is regulated accordingly through abstraction licenses or concessions from the un-differentiated groundwater pool.

IMPLICATIONS FOR THE APPLICATION OF PALESTINIAN WASTEWATER REGULATIONS

The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater. As has been discussed in past NGEST documents, the Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced. There has been some expressed concern whether this regulation applies to the NGEST irrigation scheme, which would significantly restrict the types of crops farmers could grow in the project area and, as a result, have severe implications for the financial sustainability of the project.

But the concern of whether the regulation applies to the irrigation scheme stems from the misunderstanding of the nature of this project highlighted at the beginning of this section. The NGEST project does not entail using treated wastewater for irrigation *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. The recovered water, therefore, is no longer "treated wastewater," and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.

That being said, the regulation also covers the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A"). See the below Table 23 for the basic parameters for each category.

Table 23: Palestinian reuse standards (PS 742/2003)

CLASS	QUALITY	BOD MG/L	TSS MG/L	FEACAL COLIFORM MPN/100ML
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000

D	Low	60	90	1,000

The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.

The project, therefore, is in complete compliance with the Palestinian regulation, so long as the water quality parameters for aquifer recharge are met.

OPERATION AND MAINTENANCE

Clogging is the most limiting technical problem in artificial recharge and can only be managed with regular maintenance and pretreatment. Clogging can be caused by various mechanisms like physical clogging by suspended solids, chemical clogging due to precipitation or clay dispersion, mechanical clogging due to entrapped air or biological clogging due to microbial growth (Bouwer, 2002). Clogging leads to the decrease in porosity and hydraulic conductivity and is experienced at the bottom of infiltration basins as well as around injection wells. There are two basic principles for the management of clogging: (a) pretreatment of recharge water and (b) redevelopment (Brown et al., 2006).

Apart from maintenance related to clogging, regular inspections of the facility are needed to assess if any repair works or cleaning is needed. This could include the cleaning of any screens, change of batteries, lubrication or replacement for equipment prone to wear and tear, repair of damage done by natural forces or vandalism. If mechanical or electrical parts are involved their proper functioning needs to be tested.

RECOMMENDATIONS

REGULATING EXTRACTION

MAR is one of the measures that can be implemented to secure water supply, compensate for some effects of climate change and, more generally, handle the quantity and quality of groundwater bodies. It is not, however, a substitute for groundwater management based on decreasing abstraction and adapting withdrawal to resource availability.

There are a number of private wells in the Gaza Strip, only some of which are officially registered. Thousands of wells are estimated to have been drilled without authorization, which has contributed to more rapid deterioration of the aquifer. (UNEP, 2014) To protect the aquifer and

for the success of the NGEST project, both the authorized and unauthorized agricultural wells should cease operation.

In order to do that, PWA, which is the institution responsible for issuing and renewing licenses for agricultural wells, plans to include a new clause in the next annual renewal of licenses that specifies that the operation of an agricultural well should be stopped when reuse water is available. At the same time, the voluntary adhesion to the new irrigation scheme shall be pursued.

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

MAR TRAINING

There are various institutes within the Gaza Strip that currently provide training regarding water and wastewater management. These institutes should be encouraged to establish short courses for MAR operators and regulators. These could also help ensure risk management plans are designed and implemented effectively and management issues are understood and addressed.

More is said on the needs of MAR training in the section on Institutional Capacity Building.

AQUIFER PROTECTION

It is recommended to develop a holistic MAR strategy and to implement transparent and comprehensive regulations specifying maintenance, monitoring and reporting requirements. Regulations should also address water allocation, ownership issues and demand management.

GROUNDWATER MONITORING

OVERALL MONITORING STRATEGY

Before preparing a groundwater monitoring plan, the overall strategy of the groundwater monitoring program should be defined to guide the development of the plan. In this sense, "strategy" refers to the manner in which a hypothetical release from a regulated unit will be detected or measured. Examples of issues that should be addressed when developing a monitoring strategy include:

- The type of monitoring data needed;
- The locations (both horizontal and vertical) from which the samples are to be collected (i.e., definition of "target monitoring zones");
- The manner in which the samples will be obtained; and
- The ability of the monitoring features to rapidly detect a change in groundwater quality.

Development of a groundwater monitoring strategy is illustrated in Figure 19 and Figure 20. As shown in these figures, the potential sources of contamination and the aquifer of concern should be characterized before developing a groundwater monitoring strategy because selection of target monitoring zones cannot be made until the source and the aquifer have been evaluated, usually through a detailed hydrogeological evaluation of the site. When evaluating the ability of a monitoring system to rapidly detect a release from a potential source, the impact of preferential flow paths and vertical gradients should be carefully evaluated; a two-dimensional analysis of groundwater elevation may not reveal actual upgradient or down gradient locations of groundwater flow. The presence of vertical gradients may significantly effect the selection of monitoring locations.

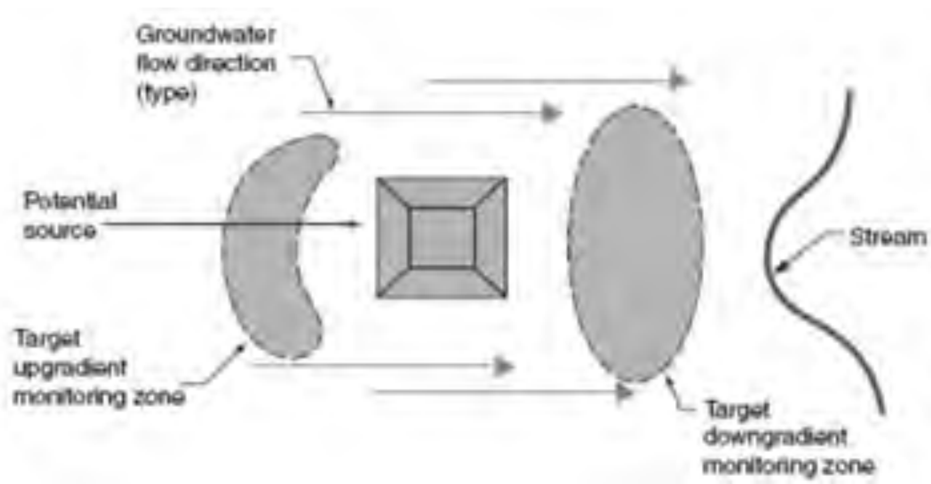


Figure 19: Plan view of typical unconfined aquifer groundwater monitoring system

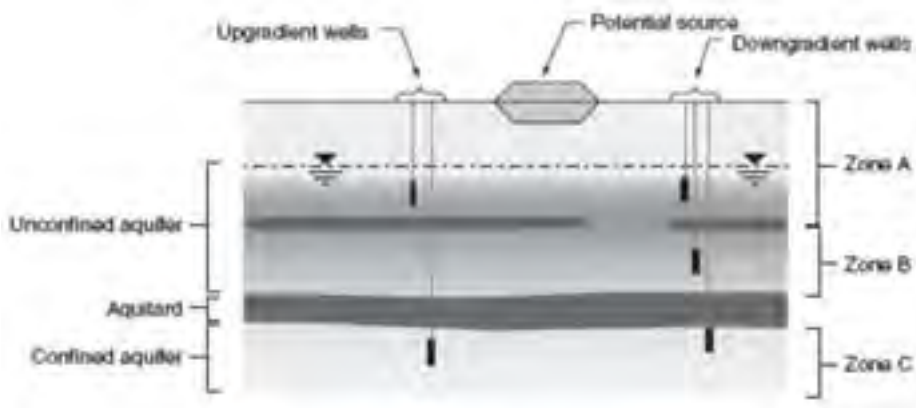


Figure 20: Vertical cross section of target monitoring zones.

MONITORING LOCATIONS AND PARAMETERS

Locating the appropriate monitoring point locations is essential in designing a monitoring network capable of providing data of adequate quality. Selected monitoring locations should provide the most reliable data needed to detect or assess a groundwater contaminant plume. To verify that the monitoring network can accomplish this goal, target monitoring zones must be selected based on the site hydrogeologic conditions and anticipated contaminant pathways. Figure 21 shows the recommended locations of the monitoring wells which was set up based on the location of the recovery wells.

The groundwater monitoring program in the NGEST Project is designed to evaluate the status of the groundwater quality after infiltration of partially treated and treated wastewater. The monitoring wells are distributed in two rows: around 400 to 500 m from the infiltration basin and the second row will be of 1100 to 1200 m from the basin. The first monitoring well row should be located before the first row of the recovery wells in the direction of the infiltration basin, and the second row of the monitoring wells should be located after the second row of the recovery wells to check the quality of groundwater outside the recovery wells areas. The monitoring network will also use the existing 5 monitoring wells constructed recently by PWA and used to monitor the infiltration basin. In addition, the recovery wells will be part of the monitoring network as shown in Figure 21.

Figure 21: Monitoring wells location

The main objective of monitoring is to check the groundwater quality after infiltration and check the operation of SAT process. The consultant made extensive reviews of similar projects such Gosh Dan Project where several parameters are monitored. Among these parameters, the consultant proposed in Table 24 some parameters which would reflect the status of groundwater after infiltration and could be analysed in Gaza Strip laboratories.

Table 24: Monitored Parameters and Frequency of Monitoring

WATER LEVEL	Monthly
PH	Four Times a year
TDS	Four Times a year
BOD	Four Times a year
COD	Four Times a year
DOC	Four Times a year
TC	Four Times a year
AMMONIA AS N	Four Times a year
NO_3	Four Times a year
NO_2	Four Times a year
T.N	Four Times a year
CL	Four Times a year
DETERGENT	Four Times a year
F.C	Four Times a year
PHOSPHORUS	Four Times a year
HEAVY METALS	Four Times a year
O_2	Four Times a year
NITROGEN AND OXYGEN ISOTOPES	Four Times a year

MG	Four Times a year

Samples will be collected from the monitoring wells to characterize the geochemistry of groundwater. The nitrogen and oxygen isotopes of groundwater nitrate will be used in conjunction with other geochemical data to place constraints on potential nitrate sources.

CONCLUSION

This *Complementary Feasibility Report* brings mostly good news. By reworking the original design, the project can save 21.5% of the water use while using 15% less energy, and can operate with a less complex irrigation schedule. It was determined that the project is in full compliance with Palestinian law, and should be financially sustainable by farmers. The review resulted in a new cropping pattern and design network, and offered a range of scenarios for the water tariff and O&M of the Recovery and Reuse Systems.

This *Report* also confirmed the validity of the original design for the recovery scheme and of the original design for the reuse scheme, confirming the selection of materials, the general layout and the selection of the pumping system. The newly proposed system fixes design inconsistencies of the original so that a minimum water pressure of 2.5 bars is provided to every farm gate.

The good news, however, is contingent. The water and energy savings, simplified irrigation schedule, and farmer profitability are contingent on improving the original design of the reuse scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern. The project's compliance with Palestinian law is contingent on a minimum level quality of water coming from the WWTP and being disposed of in the infiltration basins. And the project's feasibility overall is contingent on carrying out robust capacity building for ministerial and farmer stakeholders, and of adequately monitoring the Managed Aquifer Recharge component of the project.

Ultimately, therefore, the feasibility and success of the project hinge on whether all the essential stakeholders cooperate to fulfill their role.

ANNEXES

ANNEX 1: DRAFT MOU

A Memorandum of understanding (MOU) is a document describing a bilateral or multilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action. It is often used to establish a clear understanding of how common activities will practically function and each party's role and compensation. The contents of an MOU must (a) identify the contracting parties (b) spell out the subject matter of the agreement and its objectives (c) summarize the essential terms of the agreement, and (d) must be signed by the contracting parties.

Similar to a contract, a memorandum of understanding is an agreement between two or more parties. Unlike a contract, however, an MOU need not contain legally enforceable promises. While the parties to a contract must intend to create a legally binding agreement, the parties to an MOU may intend otherwise. For example, an MOU may recite that the parties “agree to promote and support the joint use of facilities.” This type of provision establishes an important public statement of cooperation, but it does not constitute a legally enforceable obligation. Alternatively, an MOU may outline the terms of an agreement but state that each party’s responsibilities are only enforceable “in the event that the parties’ decide to enter a joint use agreement.” Additionally, a non-legally binding MOU may be useful to serve as an agreement between two or more departments within a single public entity where a contract may not be legally appropriate.

Although there can be legal distinctions between contracts and MOUs, there may be no legal or practical difference if they are written with similar language. The key is whether the parties intend to be legally bound by the terms of the agreement. If so, they have likely created a legally enforceable contract regardless of whether they call it a contract or an MOU. Therefore, parties should address the legal status of their agreement early in the negotiation process.

Successful MOUs require a lot of thought, effort, and cooperation to reach agreement on a range of issues. In addition to the subjects listed above, an MOU can also cover issues such as: (a) who bears responsibility for the costs of maintenance and repairs, (b) insurance and liability, (c) staffing and communications, and (d) conflict resolution. Below is a sample MOU which lays out the basic provisions of an agreement. To agree on any specifics, however, it is highly advised that the parties meet to discuss the terms of the MOU, ideally with a mediator, facilitator or other neutral third party.

Sample

MEMORANDUM OF UNDERSTANDING

BETWEEN [AGENCY]

AND [AGENCY]

1. **Parties.** This Memorandum of Understanding (hereinafter referred to as "MOU") is made and entered into by and between the [agency name], whose address is ______ , and the [agency name], whose address is ______ .

2. **Purpose.** The purpose of this MOU is to establish the terms and conditions under which the NGEST Project partners will coordinate and function.

3. **Duration of MOU.** This MOU shall become effective upon the last signature by the authorized officials from the (list partners) and will remain in effect until modified or terminated by any one of the partners by mutual consent. In the absence of mutual agreement by the authorized officials from (list partners), this MOU shall end on (end date of partnership).

4. **Responsibilities of [agencies]**. [Delineate all obligations of the first party listed above. Include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, beneficial use of equipment belonging to other agencies while acting pursuant to this MOU.]

5. **Responsibilities of [other agencies].** [Delineate all obligations of the other agencies listed above. Identify the agency covered by this MOU, and include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, benefits and use of equipment belonging to an agency while acting pursuant to this MOU.]

6. **General Provisions**
   A. Each Party pledges in good faith to go forward with this MOU and to further the goals and purposes of this MOU, subject to the terms and

conditions of this MOU. The Parties shall attempt to resolve disputes through good faith discussions.

B. Either Party may unilaterally withdraw at any time from this MOU by transmitting a signed writing to that effect to the other Party. This MOU and the public/private partnership created thereby shall be considered terminated sixty (60) days from the date the non-withdrawing Party actually receives the notice of withdrawal from the withdrawing Party.
C. By mutual agreement, which may be either formal or informal, the Parties may modify the list of intended activities set forth in Paragraph 4.0 above and/or determine the practical manner by which the goals, purposes and activities of this MOU will be accomplished. However, any modification to any other written part of this MOU must be made in writing and signed by both Parties or their designees. Applicable Law. The construction, interpretation and enforcement of this MOU shall be governed by the laws of the State of Palestine. The courts of the State of Palestine shall have jurisdiction over any action arising out of this MOU and over the parties.
D. Entirety of Agreement. This MOU, consisting of [insert number], pages, represents the entire and integrated agreement between the parties and supersedes all prior negotiations, representations and agreements, whether written or oral.
E. Severability. Should any portion of this MOU be judicially determined to be illegal or unenforceable, the remainder of the MOU shall continue in full force and effect, and either party may renegotiate the terms affected by the severance.
F. Third Party Beneficiary Rights. The parties do not intend to create in any other individual or entity the status of a third party beneficiary, and this MOU shall not be construed so as to create such status. The rights, duties and obligations contained in this MOU shall operate only between the parties to this MOU, and shall inure solely to the benefit of the parties to this MOU. The provisions of this MOU are intended only to assist the parties in determining and performing their obligations under this MOU.

The parties to this MOU intend and expressly agree that only parties signatory to this MOU shall have any legal or equitable right to seek to enforce this MOU, to seek any remedy arising out of a party's performance or failure to perform any term or condition of this MOU, or to bring an action for the breach of this MOU.

Partner name

Partner representative

Position

Address

Telephone

E-mail

Partner name

Partner representative

Position

Address

Telephone

E-mail

Date:

(Partner signature)

(Partner name, organization, position)

Date:

(Partner signature)

(Partner name, organization, position)

ANNEX 2: WATER SUPPLY CONTRACT COMPONENTS

Either CMWU or NWC will need to sign a bulk water supply agreement with the WUA. Given the complexity and legal sensitivity of such an agreement, an actual contract is not included here. Instead, below is a list of thirteen areas that should be covered in any future water supply contract. This list is not exhaustive (it doesn't include boilerplate contract components, for example) but it does cover the items most needed for a comprehensive agreement.

1. Price and non-price terms

A bulk supply agreement should include both price and non-price terms so that the parties know what services are being provided at what price.

The price terms could include:

- a standing charge and volumetric rate for each water supply;
- charges for any volumes of water the WUA takes that are above the maximum amount allowed in the agreement;
- a minimum charge that the WUA pays whether it takes any water or not;
- a capital contribution to the connection cost;
- charges for the provision of information; and
- rules about the periodic adjustment of charges.

The non-price terms could include the ownership and responsibility for the assets used in the supply (discussed below), how charges are to be paid and how the parties are to operate the bulk supply.

2. Ownership of and responsibility for the assets

The agreement should be clear about who owns and who is responsible for operating the assets that are used to provide the bulk supply (which will depend on which Scenario is chosen). One way of doing this would be to include a detailed operational plan, which, as well as defining ownership and operating responsibilities, could include details such as maximum flow rate. This information will help in resolving any operational problems and will have a bearing on the price terms of the contract.

3. Measuring the water supplied

A bulk supply agreement should specify how the water supplied is to be objectively quantified. In this case, a meter will likely be used, which will need to measure the water supplied to the

degree of accuracy specified in the agreement. To ensure the accuracy of meter readings, meters should be tested (ideally, the type of test should also be specified in the agreement). Even with testing, there can be occasions when a meter is found to be faulty. To prevent a possible impasse between the parties the bulk supply agreement could specify the mechanism for determining the volume of water supplied in this case.

4. **Quality of the water supplied**

The agreement usually states the quality of the water to be provided and how it is to be assessed. This could be done by specifying the water quality parameters the non-potable water should meet. It is the WUA receiving the bulk supply that is responsible for the quality of water supplied to its customers (the farmers) but NWC (CMWU) must inform the WUA of any events that might lead to harmful water being supplied.

5. **Adjusting prices**

Price terms can be set in different ways. For example, some bulk supply agreements include volumetric charges for the supply of water. Other bulk supply agreements include contributions to the capital costs of building the bulk supply assets or the ongoing costs of operating the bulk supply.

As well as setting out the price terms, the bulk supply agreement might also explain how those price terms are to be adjusted to allow for inflation. Typically, bulk supply agreements include provisions for annual adjustments to the price terms to allow for inflation, although the parties could agree different frequencies of adjustment. The adjustments could be by set amounts, percentages or linked to measures of specific costs or general inflation. If the parties agree that no adjustment is to be made to the price, they could set this out for clarity.

6. **Interruptible or firm supply**

The bulk supply agreement should include details of any allowed interruptions. It would need to explain the number and duration of interruptions that NWC could make and under what conditions interruptions could happen. There might be a link between when NWC can make interruptions and interruptions for planned maintenance, emergencies and water shortages.

7. **Interruptions of supply to carry out planned maintenance**

Planned maintenance can disrupt the flow of water from NWC to the WUA. The WUA will want to know when maintenance will happen so that it can make alternative arrangements to supply the farmers.

The bulk supply agreement could put a requirement on NWC to minimize the frequency and length of any disruption to the bulk supply as a result of planned maintenance work. The agreement would need to define what is meant by 'planned maintenance'.

The agreement might set out the process by which NWC would consult the WUA over the timing of planned maintenance. It could specify how far in advance NWC should notify the WUA of the planned maintenance. The agreement might also allow a reasonable period for the WUA to express its views and could require NWC to consider them before making a final decision on the timing and duration of the maintenance.

8. Co-operation in emergency situations

Emergency situations could arise during the period of a bulk supply agreement that affect the quality of the water supplied, the volumes of the water supplied or some other aspect of the bulk supply agreement. It would be helpful if the agreement defined what is meant by an 'emergency' and explained how the parties would deal with one.

Obligations on parties to cooperate in an emergency could include:

- cooperating to prevent an emergency from occurring;
- notifying the other party of the existence and cause, if known, of the
- emergency;
- ensuring, as far as is reasonably practicable, that any emergency has the minimum possible effect on the supply of water;
- agreeing reductions in supply where this is reasonable to prevent or mitigate the effects of an emergency;
- ensuring that priority is given to vulnerable customers if a supply of water is restricted because of an emergency, and co-operate in agreeing categories of vulnerable customers;
- using all reasonable endeavors to restore the supply;
- investigating the cause of an emergency that has occurred; and
- sharing any lessons learned to prevent a recurrence of the emergency.

9. Co-operation at times of water shortage

The agreement could specify what is to happen during a time of water shortage. It might also place an obligation on both parties to cooperate in such situations.

The terms relating to water shortages could include:

- a definition of the circumstances under which NWC may limit the water it supplies under the agreement;
- an obligation for NWC to notify the WUA if it intends to impose a temporary ban on the use of water by some or all of its customers; and
- provisions relating to the actions the WUA should take to reduce water taken from the bulk supply in the event of a water shortage.

10. Liability for planned and unplanned interruptions

To give the WUA comfort that it would be adequately compensated for losses arising due to unplanned non-emergency interruptions, the agreement might include categories of costs such as:

- costs incurred in securing alternative sources of supply. The parties may wish to include a non-exhaustive list of potential alternative sources that would need to be deployed – for example, tankered water supplies; and
- GSS (guaranteed standards scheme) payments to customers.

To provide greater certainty, the agreement might allow for liquidated damages, that is, an estimate in advance of the losses the WUA might incur if the supply was not made available. To limit NWC's risk exposure, the liabilities in the agreement might be capped.

11. Duration

It might take many years for the revenues from the bulk supply to cover the cost of the dedicated bulk supply assets. A bulk supply agreement might therefore need to be long enough to allow for the parties to recover the costs of the assets. On the other hand, a long duration agreement can create problems if circumstances change and the agreement is no longer beneficial for one or both parties.

12. Dispute resolution

Disputes might arise from time to time with regard to the bulk supply agreement. It would be sensible for the agreement to include a provision to resolve disputes. It is best if this is comprised of an internal escalation process that must be followed before a matter may be referred to arbitration, the courts or some other form of formal adjudication.

Some energy contracts specify a time limit after which a party cannot raise a dispute about the other party's previous performance of the contract. For example, the contract might specify that parties must raise a dispute about an incorrect payment within a year of the payment being made.

13. Termination

The agreement should set out how it can be terminated by either or both parties. Ways in which a bulk supply agreement could be terminated include:

- on a date specified in the agreement;
- on either party giving a specified period of notice;
- by mutual agreement;
- if the WUA is terminated;
- if there is a material breach of the contract that is not remedied. A material breach could include repeated failure to pay on time or a one-off failure to pay on time which was not corrected within a specified period, or a persistent failure to supply.

ANNEX 3: SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT

INTRODUCTION

The summary below was prepared as part of the deliverable "Supplementary Environmental and Social Impact Assessment (SESIA)", which involved the preparation of an independent ESIA of the North Gaza Emergency Sewage Treatment Project (NGESTP), Effluent Recovery & Reuse System and Remediation Works.

The specific objectives related of this SESIA were as follow:

- Highlight the legislation under which the project will be implemented. Besides the Palestinian Laws and Regulations, the study also highlighted the Regional Laws and Regulations, especially from Jordan, Israel and Egypt, associated with wastewater reuse and sludge management and reuse. In addition, the International Standard and Guidelines, including World Bank (WB) procedures and FAO and WHO Guidelines were highlighted.
- Provide baseline environment and socio economic conditions of the project components.
- Identify of the possible positive and negative social impacts, permanent or temporary, of the project components. In addition, the analysis and mitigation measures will be developed to reduce the negative impacts resulted from the project component.
- Identify of any potential temporary or permanent land acquisition requirements associated with civil works. In addition, develop the outline of the vulnerable groups that might be affected by the project and identify the appropriate mitigation measures
- Develop an Environmental and Social Management Plan (ESMP) and monitoring plan to manage, mitigate and monitor any possible negative impacts. Moreover, a capacity assessment of the implementing party to implement the ESMP and recommendations for any capacity-building needs

In addition, as assessment was made for sludge management for the sludge resulting from the North Gaza Wastewater Treatment Plant (NGWWTP) and intended to be used in agriculture as part in the effluent recovery and reuse scheme or in emergency cases to be dumped to landfill.

The study was undertaken throughout July - October 2012. The team developed a cross-sectional study that used a multi-data source approach including site visits, primary data, secondary data, surveys and site measurements.

ENVIRONMENTAL BASELINE CONDITION OF THE PROJECT COMPONENTS

a. General Characteristics of the Project areas

Beit Lahia Wastewater Treatment Plant (BLWWTP) and Effluent Lake

- BLWWTP was constructed in 1976. It is located some 1.5 km east of the town center of the Beit Lahia, northern part of Gaza Strip.
- BLWWTP was built in sand dunes overlying a clay layer of variable thickness with un-continuous impermeable clay layer. It was constructed in stages and modification and rehabilitation activities were performed in order to increase capacity of the plant.

  • During the past few years the situation escalated. With the increase of wastewater network connection, the volume of wastewater inflow had far exceeded the plant's treatment capacity that have led to deterioration of the effluent quality and have led to clogging effects in the neighboring sand dune areas. The ongoing decrease of the infiltration capacity of the flooded areas and the increasing wastewater volumes have resulted in the formation of enduring ponds and finally a lake.
- Over the years the effluent lake had a volume of about 2 million m3 of foul wastewater, which covers around 300 dunums and continued to rise and was threatening to flood the whole sewage collection system and the neighboring communities.
- Starting in 2007 (NGESTP was starting to be implemented), almost 90% of the effluent lake had been dried due to weathering and limited discharge to the lake. Currently the wet area occupies around 10% of the total lake.

Agriculture Land Proposed for irrigation/Sludge use

- The area in the vicinity of NGWWTP is assigned designated to benefit from the recovery water and the treated sewage sludge in the agricultural activities.
- The proposed area is divided into two zones according to its location from NGWWTP. Zone A (northern part of NGWWTP) with about 10,100 dunums whereas, Zone B (southern part of NGWWTP) with about 5,000 dunums. Most of the area is considered as under rain-fed conditions.
- Citrus, Olives, fruits and vegetables are among the crops grown in the proposed agriculture land for reuse scheme.

b. Physical and Biological Environment of the project areas

- The project sites have a typical semi-arid Mediterranean climate with long hot and dry summer (from 25^{o}C in summer and 13oC in winter with maximum daily temperature can reach 29-30^{o}C and the minimum temperature is around 9^{o}C). The proximity of the Mediterranean Sea has a moderating effect on temperatures and promotes high humidity throughout the year. The prevailing wind direction is South West with an average speed of 4.2 m/s (winter) and from North West (summer).

- The average annual evaporation rate is around 1,900 mm/y (5.2 mm/day). The maximum evaporation rate increases during the summer and may reach over 6 mm/day between June and August.
- Ambient air and noise quality at the project sites are consider normal with a slightly high on BLWWTP due to more rapid population surrounding the area.
- The dominate soil type in the irrigation area can be considered as heavy soil with a deep soil profile, which means will not limit root penetration for deep rooted crops. The irrigation scheme assessment was done with taking into account the climate change through the mentioned 10 years by increase the air temperature of 1.5oC.
- The soil at different locations of the effluent lake has a normal pH range and Organic Matter content with negative and low Fecal Coliform. In addition, the Electrical Conductivity at the wet part indicates the higher number due to remaining heavy metal from the stabilized sludge that is present in the top layers of the effluent lake.
- No major fault type formations have been observed in Gaza Strip area.
- Mainly aquatic birds and the reptiles (rats, snake, crows, barn owl and other wild species) are present at the BLWWTP and the Effluent Lake. The effluent lake provides breeding, nesting, roosting and feeding habitats for different birds' species. Typical effluent lake landscape consists of sand dunes covered with Acacia shrubs.
- In the proposed agriculture land for effluent recovery reuse, many Olive, Plum, Almond, Citrus or Orchards have been encountered at agriculture land allocated for irrigation of recovered water and sludge reuse. Many wildlife species; particularly birds were found to inhabit these agro-ecosystems.

c. Water (groundwater quality) of the project components

- The water quality in this study focused on chloride and nitrate concentrations (the most important contamination indicators in the groundwater in the Northern Gaza aquifer).
- The highest chloride sources are expected in the areas affected by seawater intrusion and the deeper groundwater layer (generally exceed 250 mg/l). The seawater intrusion zone covers the western part with 2 to 3 km inland the aquifer. Most of the municipal wells were concentrated in this zone and due the high pumping rate of these wells resulted in accelerating the seawater intrusion.
- NO3 concentration exceeds the WHO drinking water guidelines in most of the Northern Gaza aquifer. In 2003 at the infiltration site (adjacent to NGWWTP), the maximum nitrate concentration in the groundwater was about 30 mg/l due to the operation of the infiltration basin using partially treated wastewater.

- Cl concentration in the wells close to the infiltration basin ranges between 350 to 650 mg/l (till the middle of 2012). The trend of the chloride concentration recorded is steady since 2011 in some wells. In addition, Nitrate concentration for the same period ranges between 20 to 120mg/l.
- From the analysis it found that the groundwater is free of Salmonella, Nematodes and Amoeba & Gardia. However, the total Bacteria ranges between 30 to 395 cfu/ml and the total coliform ranges between 6 to 50 cfu/100 ml in some wells.
- The heavy metals concentrations in all analyzed wells were less than the Palestinian standard values for irrigation. However, there were some wells that have concentrations of Boron and Mercury higher than the standard values.
- The groundwater quality under the effluent lake and the BLWWTP sites is improving after drying the lake.
- According to the groundwater modeling result, the recovered water is not expected to have bacteria, including fecal coliform due to the infiltration process (treated by the soil). In fact, the water quality, especially after the NGWWTP will have better quality than the wastewater reuse. However, to ensure the public health concern related to wastewater and sludge reuse, the monitoring plan is determined in the monitoring plan (including the mitigation measures for epidemiology).
- There is no archeological or historical site as well as the protectorate areas nearby the project component sites. The only site consider important and respected (psychologically important) by the community is the El Shuhada Cemetery, which is nearby the location of storage tanks and booster pumps (water distribution network).

POSITIVE ENVIRONMENTAL AND SOCIAL IMPACTS

The positive environmental and social impacts of the project are:

1. The recovered effluent from the groundwater will be an important source of irrigation water, as water resources in the Gaza Strip are scarce; especially during summer time, as a source of water will be continuously available.
2. The groundwater quality is suitable for Unrestricted Use. The only restriction is for the Total-N, which is higher than 15 mg/l. This could be considered as an advantage for agricultural use. However, it is advisable to restrict the use the recovered water for uncooked vegetables at least for the first year of implementation.
3. The recovery scheme will limit the horizontal dispersion and the vertical building up of the water table, which without recovery will have a negative impact on current land use.
4. Effluent reuse of the recovered water will solve the problem of the disposal of wastewater, as it will be treated and injected for agricultural use.

5. The groundwater quality after drying the lake is improving.
6. Sludge has a high content of organic matter that can help conserving soil organic matter, and sludge stimulates biological activity in the soil.
7. The sludge reuse brings possibility for farmers to supply their lands with organic fertilizer at low costs and reliably available. It is expected that the sludge will cost as low as the transport cost of around 1 ILS/50 kg (compare with 50 ILS/50 kg for Israeli imported fertilizer). Another level of competition reported was with the Palestinian organic fertilizers (each dunum needs about 8 cubic meter from this fertilizer. That cost around 850 ILS per ton which is relatively expensive). Thus, the produced sludge will be a competitive product if it cost less than 300 ILS/T.
8. The sludge reuse is environmentally the best solution compared to disposal inland fills or incineration plants and appealing solution for sustainable sludge management.
9. Sludge is one of the outputs of the project, and will increase the income for those who work in sludge trading,
10. Sludge reuse will work for reduction of chemical fertilizers.
11. Reduction of health risks associated with exposure of villagers or inhabitant surrounding the effluent lake and BLWWTP to environmental risks and nuisance released from the BLWWTP, such as effluent lake flooding and the risk of water borne disease, will be seen. In addition, the project will protect the livelihood status of people who suffered due to the flooding of BLWWTP,
12. The provision of recovered water will reduce the cost of water needed for irrigation in the area. The utilization of the recovered water of high quality and of less price might work for the benefit of the farmers (increase their profits)
13. The new lands gained due to the decommissioning of BLWWTP will be used in agriculture activities or as a recreational or residential place.
14. Potential increase of the price of lands and dwellings due to the implementation of the project,
15. Provision of jobs due to the implementation of the project components, both during construction and operation phase.
16. After decommissioning of BLWWRP, it will considerably reduce odor, mosquitoes and flies.
17. As soon as the NGWWTP is completed and starts its operation (2013) the infiltration of a high-quality effluent in the infiltration ponds will begin to compensate the negative effects on groundwater.
18. The construction of the site and the carrier line will improve the road network connecting the existing and the emergency area.

NEGATIVE ENVIRONMENTAL IMPACT ANALYSIS AND THEIR MITIGATION

a) During Construction Phase

i. Air Quality and Noise Pollution (low impact and temporary)

It is concluded that the air quality impacts associated with dust generation will be of "low" significance. However, whenever the dust emission becomes higher than normal and create disturbance to the workers and project activities, it is recommended to spray the location with water to reduce the impact.

ii. Gaseous Emissions (low impact and temporary)

Air emission impacts associated with the proposed project will be of "low" significance. However, to reduce and minimize the impact, it is recommended to check the vehicles regularly for the exhaust gas and minimize the vehicles and heavy equipment movement at the same time.

iii. Noise (low impact and temporary)

The noise generation is not expected to represent a significant issue to local residents (due to distance from the residential area, only during the day time and on a short period). The most affected people from noise impacts are the construction workers. The mitigation measures recommended in the ESMP and Monitoring Plan for control of noise and air emissions, especially to the workers are based on compliance with the Palestinian Outdoor Noise Standards.

iv. Vibration (low to medium impact and temporary for the water distribution networks and low impact and temporary for other project components)

The closest sensitive structure to the site of the booster pumps (due to psychological perspective of the respected site according to the people in Gaza) is El Shuhada Cemetery (around 10 m away). Consequently, medium vibration impacts could be anticipated to occur. The mitigation measures proposed during the construction of water distribution network component (storage tank and booster pump), near the El Shuhada Cemetery area are as follows:

- The base camp (workers site camp) and place for storage of equipment have to be on the future land dedicated for future expansion (pumps and the storage tanks).
- The construction of the storage tank and the booster pumps room including the generators and the electrical rooms have to be separated and not overlapped.
- The ready mix concrete is preferred to be used instead of onsite concrete mix. Beside the reduction of the dust transmitted to the agricultural land due to mixing onsite and

reduction of the hazardous wastes and other solid wastes on site, the vibrational load will be also reduced significantly (use of concrete pumps will be advantageous).

- In addition, due to the sensitivity of the groundwater, the vibration around the wells construction site should be minimized in order to avoid groundwater contamination due to potential spills.

v. Construction Waste and Handling of Hazardous Waste (low to medium impacts)

Based on the expected waste generation associated with the proposed NGESTP project activities, the impact will be of "low to medium" significance. The following mitigation measures are proposed:

- Onsite domestic sewage collection and disposal (adequate sanitation facilities) shall be provided by the contractor for construction workers' needs.
- Site waste management plan should be developed by the contractor prior to commencement of construction works.
- The burning of any type of wastes should be avoided.
- The reused clay or excavated sand should be stockpiled and stored away from
- Nearby sanitary landfill should be notified to receive the unusable non-hazardous construction wastes or damaged construction materials.

vi. Soil Contamination during Decommissioning of BLWWTP (medium impacts)

Soil may be exposed to contamination due to the movement of construction vehicles and equipment. The contamination will occur due to oil and fuel spills from the engines of machines, and also due to polluted wheels (importing pollutants from outside of the site). It is concluded, based on the above, impacts associated with soil contamination will be of "medium" significance. Mitigation measures proposed during the decommissioning of the treatment plant are as follows:

- The decanting activities should be done with a care and the pipe should be have sufficient length to prevent the spillage to the ground
- Preventive maintenance for any vehicle or equipment that has an engine that leaks oil or fuel.
- Preparing a special fuelling and oil change station on site to contain any possible fuel or engine oil spill. Otherwise fuelling and oil change should be conduct in the private oil stations out of site (concrete paved station on site).
- If any machine is broken on site, a containment system should be used to prevent the spill of oil or fuel on the soil.

- The vehicles moving in and out of site should be checked at the inlet gates of BLWWTP to assure that they are not importing pollutants through the wheels.
- The paved path / concrete paved parking or loading and uploading sites can be made to ensure that the vehicle will not transport the pollutant from the site.

vii. Remediation Works at the Effluent Lake

The best options for financially and technically feasible options (excluded the land investment cost) are the Phytoremediation, clay placement and three layers clay placement. The most sensitive criteria for the remediation selection is the land investment. As the land is being rented and the longer term of the remediation activities will affect the initial cost, in addition, the three layers of clay cap is not necessary as the contamination does not need deep soil replacement, the clay cap placement is the most suitable option, financially and technically.

Heavy machinery and vehicles might be used are excavators and heavy trucks. Impacts associated with remediation works will be of "medium" significance. Mitigation measures proposed during the remediation works of the effluent lake are as follows:

- Standard protection to the workers during the overall remediation activities
- Special tools for handling the dangerous wildlife found
- On site sanitation should be established for the workers
- Avoid the disturbance of the existing plants and wildlife as much as possible during the site preparation
- Handle with care found wildlife (catchment dangerous wildlife). It is recommended to seek the assistance from Ministry of Health and Ministry of Agriculture for the best practice for handling the catch dangerous wildlife
- Minimize the soil contamination by site management plan (place for temporary storage, handling, transportation and disposal)
- Replanting the affected plant that has to be displaced. If the replanting is not feasible, planting 2 new trees to compensate 1 removed tree has to be done by the contractor
- Notification to the designated landfill should be done prior to the soil disposal.

viii. Changes in Hydrology and Groundwater Quantity and Quality (low impact)

During the construction of the recovery scheme, remediation of effluent lake and decommissioning of BLWWTP there will be no impact on groundwater. It is expected the depth of the excavation will not significantly impact the groundwater but the wells construction. It is recommended to hire the highly qualified contractor for wells establishment. Therefore, the

impact negligible for decommissioning and remediation activities and low impact on the water distribution networks (only for wells construction).

The mitigation measures to avoid the hydrology of groundwater quantity and quality are similar to the general wells construction. To reduce the impact on wells construction, highly qualified contractor has to be contracted, isolate the access and the site area to avoid outside disturbance that can make the land fallen down to the wells.

ix. Health and Safety (low to medium impacts)

During the construction phase, as the proposed project are at a large distance from the nearest population or residential area and on the agriculture land, the health of the population is not expected to be significant and considered minimal.

Negative impacts will mainly concern the works for construction of new facilities, which are mainly within water distribution networks. It will have few limited negative impacts such as temporary discomfort and localized pollution to the communities caused by worksites (noise, exhaust fumes, dust and vibration, risk of accidents due to increased traffic in the project impact area, the presence of workers, very limited disruption of wildlife and vegetation, poor management of handled products: fuels and lubricants as well as worksite waste, etc.).

However, although the impact is considered low and temporary for the communities, the mitigation measures are developed to minimize the impact. In addition, due to the health and safety of the workers, which accidents might occur on site in various construction project activities, mitigation measures are as well developed to mitigate the risk of health and injuries to the workers. Mitigation measures developed to minimize the risk related to health and safety, both for community and workers are:

- Raising awareness campaigns to workers and community members to promote safety, and health and safety monitor should be appointed. The monitor can be chosen from among community members who accepted to work in the project.
- Workers should wear standard protection especially due to the dangerous wildlife on BLWWTP and effluent lake sites.
- Workers should be trained to cover the completed parts and keep their work areas safe. In case of causing an accidents, the workers should be penalized either by deduction of salaries or dismissal.
- Existing utilities (especially at BLWWTP and water distribution network), if exist, would be located and staked before construction begins, including and at intersections of other pipes and crossings. This would confirm the location and depth to ensure new construction does not impact the existing utilities.

5. The identification of the existing infrastructure (other pipelines, cables, etc) has to be identified prior to the construction phase.

- Heavy equipment would not normally be operating over the existing utilities during construction of the new line. If heavy equipment or trucks must cross the existing utilities, thus additional soil cover is needed to protect the existing pipe.
- Onsite inspectors would be present during construction to verify that the construction contractor is following engineering specifications and meeting regulatory requirements.
- Workers should take the following steps to protect themselves from falls during high construction:
  - Use 100% fall protection when working on higher construction site
  - Participate in all training programs offered by the employer (contractor).
    c) Follow safe work practices identified by worker training programs.
  - Inspect equipment daily and report any damage or deficiencies

As a mitigation measure, safety measures should be put into consideration and addressed with the workers. The contractor and the PMU are mainly responsible for any safety procedures to be applied

x. Archaeological Disturbance (low impact)

Surveys in the area of the BLWWTP and Effluent Lake concluded that there is no archaeological sites were identified. The confirmation letter was sent to the Archaeological Authority for assurance and clarification of the assessment and the replied letter indicating that the project components (including the irrigation lands) have non-existence of the archaeological site.

Although the sites do not have any archaeological importance, the Jordanian Antiquities Law still applicable and can be applied if there is any archaeological and valuable objects is found.

xi. Ecological Disturbance (medium impacts)

Wetland ecosystem and vertebrates living at the area surrounding the BLWWTP and the effluent lake might be affected during the decommissioning of the treatment plant and the remediation works of the effluent lake.

Although the biodiversity, especially fauna identified within the vicinity of the project sites (effluent lake and BLWWTP), are commonly found, it is not belong to endanger wildlife and in fact it could cause a vertebrate pest outbreak or other health impact, the mitigation measures have to be developed to avoid the ecological disturbance and provide safe and adequate

relocation for found wildlife and re-plantation for the fauna. Based on the ecological disturbance impact, the project at BLWWTP and effluent lake will have significant medium impacts.

However, due to the decommissioning activity and the remediation of the effluent lake, after the finalization of the works activities, the site will provide a permanent positive impact. The biodiversity disturbance of the site due to the remediation works and decommissioning activities, either by relocation, temporary shelter or re-plantation to another site or still within the project site area, will be compensated with the long term positive impact. In addition, as the fauna and flora found in the project site is a local and not belong to the endanger species, they will easily adapted and continue their life cycle.

Mitigation measures to reduce and minimize the impact of the existing wildlife and plantation within the BLWWTP and effluent lake are as follow:

- Standard procedure for health and safety of the workers at the site, especially the equipment that protect them from the wildlife.
- Equipment to handle the vertebrates should be prepared (this includes cages, snake sticks, net, etc.) in case of the found vertebrate during the activities.
- Assistance from the staff of Ministry of Health and Ministry of Agriculture is needed to advice the contractor for temporary relocation of the found wildlife.
- Re-plantation of the trees, if needed, should be done by the contractor, if it is needed. The re-plantation can be done within the area of the effluent lake.
- Avoid the disturbance of the nesting, breeding site. The found nesting or breeding found has to be handled with care and replace it to the safe site.

Regarding the water distribution network site, there is an opportunity that the networks will be laid in agricultural land and impose on the existing crops and local animals around the site. Mitigation measures shall be developed to limit and to reduce the impacts. Based on the ecological assessment, the project will have low to medium impacts.

Mitigation measures develop to avoid the crop and animal disturbances in the vicinity are as follow:

- Temporary construction fences have to be installed prior to the construction of the water networks and other components for recovery water distribution to avoid the fallen of the local animal and to localize the site from the local animals.
- In case the destruction of the crops or plants at the farms near the construction of the recovery water distribution network, compensation has to be settled.
- If it is needed, the replanting or trees relocation (temporary or permanently) has to be done. If the relocation or replanting of the existing trees is not feasible, the

compensation of planting 2 trees (for removal of one tree) has to be done in the other area. It is advisable to plant locally trees.

xii. Land Use and Accessibility (medium impacts)

During the decommissioning and remediation activities, the impact on land use and accessibility is considered "low". Regarding the land use and accessibility of the water distribution networks for the recovery reuse scheme, the main impact on roads traffic will be during possible lying of water distribution networks along or across main roads. In addition to the limited access road for the community during construction, this access difficulty will have more impacts on elderly people, handicapped and children, who may accidentally fall in open trenches or make tedious long cycles before they reach their targeted locations.

Mitigation measures proposed are as follow:

- Selection of suitable location for temporary storage of construction materials, equipment, tools and machinery prior to starting construction, especially on the site that is close to El Shuhada Cemetery.
- The employed machinery drivers should receive training on safe utilization of their machines to minimize accidents risks.
- Clear signs indicating the project site and temporary fences shall be installed prior to the preparation of the site, especially the water distribution networks area.
- Avoid the side of the road for all the temporary storage materials and the place for standby equipment.
- All the activities have to be during the daytime and have to be scheduled to avoid conjunction with the school and working peak hours (morning and afternoon).
- The traffic department should be informed and involved to manage the traffic during the congested time. In addition, the preferred route and an alternative road have to be recommended by the traffic department.
- If the digging (open trenches) is not completed within a day period, the clear sign (by light or fluorescence lights) has to be considered to determine and identify the site during the night.
- When the land use and accessibility is disturbed and the safety of the communities passing by the project location is triggered (especially to the children, handicapped or the elderly who might use the access road), the temporary access road has to be considered with the traffic department assistance.
- Temporary resettlement that might occur during the preparation and the construction phase has to be defined and accordingly has to be compensated.

b) During Operation Phase

i. Air Emissions and Noise Pollution (low to medium impacts)

The impact of such air emissions are considered minor, because the diesel generators are only expected to operate temporarily during power cut-offs. The compliance of generator emissions with Palestinian Standard for Ambient Air will be sufficient to safeguard against unacceptable air emissions impacts to the neighboring areas.

A relatively higher impact will be on the Pumping Station staff, which may be exposed to intermittent pumping noise. The standard protection of the workers, including earmuffs, has to be practiced all the time, especially at the Pumping Station area.

ii. Odor

The operation of the water distribution network system is not expected to have significant impacts on odor. However, due to the remaining pond #7 that will be used as the emergency pond, the operation of anaerobic ponds will have significant impact associated with generation of odor (mainly H2S) and vectors that mostly generated from raw sewage storage. The mitigation measures proposed for Pond #7 is as follows:

- Minimum standard is set to consider as an emergency (monitoring plan is presented at ESMP section). Maximum permissible level of the overflow or raw wastewater discharge in the pond is 2 m height.
- Maintaining high performance of biological treatment of wastewater. In addition, to be as far as possible from odor recipients and keeping buffer zones between odorous units and neighbors.
- The aerator from the aeration tank can be installed on the pond to maintain reasonable dissolved oxygen in the water to avoid anaerobic conditions.

iii. Vibration

Concerning the vibration at the effluent lake and the decommissioning site (including remaining pond #7 and the PS adjacent to pond #7), the impacts is considered negligible. The main impact (medium impact) expected during the operation of the water distribution network is on the site of booster pump (special attention has to be made to reduce the vibration impact at the pumping station and the generator to minimize the impact due to the close distance with the El Shuhada Cemetery). The mitigation measures to minimize the vibration impacts of the machines are:

- Tree plantation, heavy leaf trees to absorb the vibration and noise generated, is recommended to be planted at the Cemetery area along the proposed main road at the other side of the pumping station.
- Maintenance of the machines and equipment has to be maximized (less than the standard period required).

iv. Water Resource Contamination

The impacts on groundwater is one of the most important issues associated with the reuse project, as part of the project has been designed to prevent impacts on the groundwater from infiltrating partially treated sewage. To identify the impact of the groundwater, the verification of the available water quality monitoring (four rounds from PWA) has been analyzed and the groundwater modeling with different scenarios has been run (with and without recovery schemes and different scenarios of recovery wells implemented (12 wells and 25 wells) and during the different year of implementations; 12 wells implemented on the year 2013 and 2015). Based on the modeling results, the groundwater monitoring plan has been developed.

The groundwater monitoring programme is the key mitigation measures to indicate the water resource contamination. The groundwater monitoring programme will be explained in detailed on the following section, ESMP.

v. Impacts on Local Agriculture, Public Health and Water Resources

Based on the design project report three scenarios that considered the expected water quality recommended are as follows:

- Scenario I: It is more advisable to cultivate orchards on the available area to the west of the project along Al Karama Road. Based on crops water requirements, the available reclaimed water is just enough to irrigate 5,375 dunums divided into citrus, olives, fruit trees, alfalfa and grains (water quality does not have impact on the crops selection)
- Scenario II: Wastewater will be treated more effectively and consequently the effluent will be of better quality in general. The quantity of effluent diverted to the infiltration basin will increase to approximately 23,100 m3 daily. This reclaimed water will be used to irrigate additional land to 7,525 dunums in total.
- Scenario III: This Scenario assumes that the planned WWTP in East Jabalia will work with its full capacity by year 2025. The quality of reclaimed water (39,160m3/day) is expected for unrestricted use. The quantity of reclaimed water will be enough to irrigate about 12,577 dunums. In this scenario vegetable crops will be introduced with an area of 1,258 dunums.

vi. Decommissioning of BLWWTP on Groundwater Quality (positive impacts)

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

vii. Recovery Water Quantity and Quality (medium impacts)

Based on the groundwater modeling and analyses, the recovery water quantity and quality is expected to be acceptable for agricultural irrigation for unrestricted crops, but unacceptable to be used for drinking water. Besides continuous groundwater monitoring, public awareness is needed to ensure that the community is not using the recovery water as a drinking water.

Although the NGWWTP is located nearby the Israeli border, the flood risk is not expected to cross the fence to Israeli border due to the topographical nature of the project site. In addition, as the groundwater modeling result from different scenarios, the plume will not be significantly crossed the Israeli border as the infiltration basins are located more than 300 m downstream of the border and with the recovery wells implementation, the wells will accelerate the flow in the downstream direction away from the Israeli border.

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

viii. Land Use of Effluent Lake Remediate and Decommission of Beit Lahia Wastewater Treatment Plant (medium impacts)

In one year period, the remediation activities will be finalized. Afterward, the remediated effluent lake can be used for agriculture purposes or residential, depending on the Urban Planning of the area and El Awqaf future plan.

After the completion of the remediation works, depending on the urban planning of the area and the future plan of Ministry El Awqaf, the land use of the effluent lake will be mitigated. Based on the soil assessment prior to the completion of the remediation works, there are two options of land use which can be applied:

- To be used as an agriculture land. Although the area will not need additional filling or leveling, but due to the huge amount of the soil excavated at the nearby landfill site (Johr Eldeek) that will be implemented during 2018, if needed, the excavated soil can be transported to the effluent lake site as far as the soil is considered good. The soil quality has to be determined (soil analysis done at the landfill site, by the landfill management), before transporting it to another area.

The agreement between Ministry of Awqaf and the Land Authority or the Ministry of Economic in addition to the agreement of the Landfill management shall be reached prior to transferring the soil to the effluent lake. According to the capacity analysis during the EA of NGESTP, a maximum of 1.5 million m3 of soil can be transferred to fill the effluent lake

- To be used for residential purposes. Additional soil for leveling and soil conditioning, if needed, at the effluent lake site when the urban planning of the area is dedicated for residential area. The soil analysis will not be crucial as the option 1 and the agreement shall be reached only between Ministry El Awqaf and the Ministry of Economic and Land Authority in addition to the agreement of the landfill management for transporting the soil to the remediated effluent lake.

Due to the remaining pond # 7, the mitigation measures are developed to minimize the impacts due to the operation of pond # 7. The impact on the land use and accessibility of the decommissioning land and remaining pond #7 is of "medium" significance. Mitigation measures developed to reduce the impacts are as follows:

- Fences surrounding pond # 7 have to be constructed to reduce the accessibility of the community to the pond area. During the Public consultation, Beit Lahia Mayor announced that there is a budget allocated to build the permanent fence around the pond #7. The agreement between PWA and Beit Lahia Municipality can be reached on the construction procedures.
- There should be 10-15 m distance between the pond area and the fences to be constructed on the surrounding pond.
- The trees shall be planted nearby the fences, in order to reduce the odor or nuisance and separate the pond site from the surrounding neighboring area and future land use of the other decommissioning ponds. Planted trees will also bring positive impact on the visual impact.
- The site is only connected to one main gate and the access road to the neighboring site in addition the pond site should be connected with the pumping station at the vicinity for ease access

ix. Public Health related to Using Recovery Water for Irrigation (medium impacts)

Health protection measures which can be applied to the agricultural use are:

- Crop restriction
- Human exposure control and promotion of hygiene

Adopting crop restriction as a means of health protection in reuse schemes will require a strong institutional framework and the capacity to monitor and control compliance with regulations and to enforce them. Farmers must be advised why such crop restriction is necessary and be assisted in developing a balanced mix of crops so that production of surplus of a specific crop is avoided.

Control measures aimed at protecting agricultural field workers and crop handlers include:

- The provision (and insistence on the wearing) of protective clothing, the maintenance of high levels of hygiene and immunization against (or chemotherapeutic control) selected infections.
- Risks to consumers can be reduced through cooking the agricultural products before consumption and by high standards of food hygiene, which should be emphasized in the health education associated with irrigation schemes.
- Local residents should be kept fully informed on the use of recovery water in agriculture so that they, and their children, can avoid these areas.
- Special care must always be taken to ensure that agricultural workers or the public do not use irrigation water for drinking or domestic purposes by accident or for lack of an alternative.

All measures should be coordinated with the awareness campaign of using treated wastewater and pilot projects of using treated wastewater for irrigation. According to the clarification from the PWA team responsible for the effluent reuse study and pilot projects in Gaza, currently there are ongoing projects related to the awareness and the pilot projects, i.e. awareness workshops carried out for farmers, operators and managers of recovered wastewater (and more awareness will be carried out during the operationalization of the pilot projects).

Recovered water reuse, as it is demonstrated on the groundwater modeling concluded that there is no indication of bacteria or viruses, including the Fecal Coliform. The combination use of recovered water and the sludge for the same area proposed will not have significant impact to the soil, as only the nitrate is considered higher than standard (in this regard, it is not recommended to be used as a drinking but is considered an advantage for the agriculture).

Concerning the epidemiology due to the reuse of the recovered water and sludge for irrigation and soil at the irrigated land, based on the expected water quality, there will be no bacteria, viruses and other related pathogens that lead to the waterborne diseases, i.e. cholera, hookworm, diarrheal diseases or other helminthic infections is expected. However, the monitoring of the epidemiological diseases shall be done by the Ministry of Health through the health centers, especially the health centers within the area of the irrigated land using the recovered water and sludge. Once there is indication of patient with symptom of the diseases mentioned above, the Ministry of Health shall report the case to PWA to investigate the water quality of the water

distribution network and sludge quality. The investigation should conclude the source of the infections or diseases.

When the source is due to the recovered water or sludge reuse, the emergency procedure shall be prepared by the PWA in coordination with CMWU to stop the distribution for further investigation. When the infections or diseases resulted from other source, the standard procedure of the Ministry of Health concerning the outbreak or endemic should be followed.

x. Contamination from Reuse and Disposal of Sludge (medium impacts)

When the sewage sludge fails to meet Rule 503 Class-A on sludge use requirements, it will pose hazardous health and environmental impacts if applied to the lands for agriculture use. The potential contamination will affect soil, air, groundwater and crops. If for some reason the sludge fails to meet Class-A requirements, it will be disposed in a landfill. The most probable impact is high concentration of pathogens (over 1000 cells/100 ml). High concentrations of heavy metals (higher than those in Class- A standards) are not expected as verified by the sludge analysis results.

Concerning the reuse of the recovered water and the reuse of the sludge at the same area proposed, according to the groundwater analysis and current measurement, the recovered water does not contain any possible health risk as well as heavy metal that could have a significant effect on crops. In addition, based on the sludge analysis and the treatment technology at NGWWTP and low content of heavy metal found, the sludge is already stabilized and predicted to meet the Class A rules for sludge reuse.

However, the importance parameter to be ensured for recovered water is the pH and for the sludge is the stability of the sludge. Using the combination of the recovered water and the sludge are not expected to have high significant negative impacts on crop and soil. In addition, with the sludge reuse implementation schedule, sludge monitoring plan and the groundwater monitoring plan implemented during the operation phase, the impact associated is considered low. The importance of the monitoring plan for sludge and recovered water are highly significant. Accordingly, with the possibility of lack of enforcement, the trained qualified personnel for management and monitoring plan has to be taken into consideration. The good management monitoring practice, documentations and reporting has to be well defined and prepared accordingly

Proposed mitigation measures for emergency situation when the sludge is not meeting the requirement of Rule 503 Class A include:

- Sludge not meeting these requirements should not be used for agricultural purposes and should be disposed to landfills.

- As a protection measure in this project, is limiting the sludge application for vegetables that are eaten uncooked despite the fact that Rule 503 Class A sludge allows sludge application for all types of vegetables.
- Adhering to the monitoring and testing requirements
- If the sludge does not meet the Class-A requirements especially with respect to pathogen concentration it should be mixed with lime (the same way that floating sludge is treated) and disposed to landfills.
- Training and guidance for farmers and sludge transporters regarding healthy handling and usage of sludge in agriculture.
- Some precautions to protect farmers are to wear suitable clothes, gloves and boots; washing before eating; and using a facemask if the sludge is dusty.
- Vehicles should be carefully selected for their local suitability and transport routes chosen so as to minimize inconvenience to the public. Special care must be taken to prevent vehicles carrying mud onto the highway.
- Enclosed trucks should be used for transporting treated sludge to prevent sludge spill and to avoid any odor release.
- Keeping good communication between customer, regulator, public and stakeholders including landowners and retailers.

NEGATIVE SOCIO ECONOMIC IMPACTS AND THEIR MITIGATIONS

- Decommission of the BLWWTP will reduce water that some of the farmers relied upon to water their plants. Indicating that their income might be affected that will be mitigated through: i) Provision of recovered water of a competitive price to minimize the potential impacts. ii) Due to the fact that the sewage untreated water should be banned, appropriate laws shall be developed to criminalize the use of untreated water
- Potential risk for the people in the adjacent areas due to having no fence around Pond #7 that might affect children. Mitigation measures will be through constructing fences.
- The use of lands might be limited due to the pond as having recreational activities; especially in case of not having a fence surrounding the pond #7. In addition, the construction of residential compounds in decommissioned area will be limited due to the existence of the pond. Again, the fence will be the most appropriate mitigation.
  - The construction of the carrier pipes will have negative impact due to noise and obstruction of traffic and use of agricultural land during the construction stages.

The project should reduce the disturbance to community using most appropriate environmental mitigation measures in addition to information sharing.

- Due to the unfavorable odor, mosquitoes and flies might affect the health of the adjacent communities. The flies should be combated using hygienic and environmentally friendly procedures.
- The sludge reuse for fertilizer might affect those who work in the chemical fertilizers sector in Gaza Strip, especially, those who import fertilizers. Integrating laborers in the new market could be an appropriate mitigation measure.
- Negative impact on the livelihood status of those who operate wells. Potential loss of income for those who own and operate the wells that will be closed due to project implementation. The laborers and the well owners might be affected severely. It could be mitigated by provision of appropriate compensation i.e. jobs or monetary.
- Put limitation to the plantation of certain crops in the beneficiaries who will use the recovered water. Orientation sessions should be presented to raise farmers awareness regarding the type of crops that should be planted using recovered water
- Expropriation for the areas of lands needed to construct the recovery well and lands needed for the project. The 27 well and the expansion of the treatment plant need about 18,175 m2 (please note, during the social investigation, the wells implementation considered was 27, as it was stated on the design report). Mitigation measures include protective procedures should be applied to limit the resettlements; avoiding small plots in order not to raise poverty and compensation should be paid in a full market price.

POTENTIALLY AFFECTED PARTIES

According to the ranking for the most affected groups who has no alternative livelihood approach were ranked and recognized as follow:

1. The Operators of wells (who are uneducated, untrained) might suffer due the termination of wells. They are maximum 10 people. The magnitude of their vulnerability shall be mitigated

2. The Owners of wells (who might be terminated) will be badly affected due to losing a valuable asset (the well), as well as, being in critical need for alternative source of water, which will cost a lot. In addition, some of them used to gain his income through selling water which will not be available (indicating that his income will be badly affected)
3. Those who Rent Lands from Awqaf for a few amount of money that includes the cost of water. They will be affected in sense of losing their lands and paying for water.
4. The Owners of small plots of lands who will be expropriated during the construction of the recovery wells. Some of them have small plot of lands that don't exceed one dunum. The wells will pass in the middle of such plots of lands and the remaining land will be too small for any use.
5. Other Project Affected Persons due to the implementation of the project during the construction activities

The mitigation of impacts described in detailed in the mitigation measures section. However the discussion of mitigation measures with the above mentioned affected groups based on the entitlement characteristics, any one that might be affected due to expropriation should be compensated. It is recommended to develop a Resettlement Action Plan in order to identify accurately the Project Affected Persons (PAPs), their entitlement, compensation valuation and mechanisms proposed for compensation.

Residual Impacts and Costs of Applying Mitigation Measure

This discussion will cover the whole potential impacts resulted due to land acquisition and expropriation during the preparation, construction and operation phase.

The estimated cost for applying the different activities related to the potential expropriation and land acquisition will be mainly based on:

- Cooperation with the municipalities and other organizations Negotiation with the Awqaf
- Negotiation with the affected people

Therefore, any budget estimations for such activities is based on non-solid rationale

Willingness to Pay, Cost Analysis and Tariff Survey

Surveys have been conducted for willingness to pay for the wastewater and sludge reuse, water distribution network and cost analysis including proposed tariffs for the effluent recovery. The result is a stand-alone report that is presented in Annex 8.

Regarding the increment cost of the reuse system, the draft vision toward the reuse system is under developed. The study includes tariff assessment; cost analysis for water reuse as well as the sludge reuse. However, the tariff survey and willingness to pay conducted under this study should be taken into consideration.

Resettlement Action Plan (RAP)

Based on findings and the consultant's recommendation in addition to the WB approval, the RAP should be prepared as a document due to the certainty of the OP 4.12 triggered.

Once the RAP ToR is cleared (by the donors), work towards the RAP is underway. In specific, the RAP should provide details on how the affected parties are identified, consulted on the project and the adverse impacts they will experience, the compensation, and the modes of grievance redress that is available to them. More specifically, detailed information on the operators of the wells (license or unlicensed), owners of wells, those who rent lands from the Awqaf should be developed, and owners of small plots of lands who will be affected /expropriated; permanently or temporary (due to the disturbances; i.e. land use and accessibility, traffic, etc) should be identified.

Project Alternative

Basically, the objectives of the Effluent Recovery and Reuse, in addition of decommissioning of BLLWTP and remediation works of Effluent Lake adjacent to BLWWTP is to improve the environmental, socio economic and public health conditions in Gaza Strip, especially at the project areas. Accordingly it is expected, by definition, that the environmental and social benefits will overweigh the impacts.

All the environmental and social negative impacts discussed are mainly site-specific and could be managed / minimized through implementing the proposed mitigation measures as described earlier. Comparing the benefits to the impacts in a strategic level, it could concluded that the "no project alternative" is not supported from the environmental and social perspective, given that the project impacts will be controlled as recommended in this ESIA.

In addition, the implementation shall be implemented and start to be operated before 2015, otherwise the recovery scheme will not be able to catch the pollution and they will affect the irrigation wells around the recovery wells.

Environmental and Social Management Plan (ESMP)

ESMP was developed to reduce or eliminate the negative impacts of the project component. The table of the ESMP both during construction and operation phase (environmental and social perspectives) are presented at the following tables (Table 1 – Table 3). The tables also include the monitoring plan, the institutional responsibility for inspection and monitoring including the budget proposed for management and monitoring proposed. The Institutional set up and the roles and responsibility for implementation and supervision during the construction and operation phase of the project components is presented on detailed on the main report of SESIA.

Grievances and Compensation

All grievances received verbally or in written shall be documented in a grievance register and handled by the PMU (PWA). It is of importance to react as quickly as possible to the grievance of the citizens. A best practice standard is to acknowledge all complaints within 10 days. Due to the different character of the complaints, some of them cannot be resolved immediately. In this case medium or long-term corrective actions are required, which need a formal procedure recommended to be implemented within 30 days:

1. The petitioner has to be informed of the proposed corrective measure.

2. In case if a corrective action is not required, the petitioner has also to be informed accordingly.

3. Implementation of the corrective measure and its follow up has to be communicated to the complainant and recorded in the grievance register

The comprehensive grievance mechanism including the institutional responsibility, monitoring, responses procedure and disclosure of the grievance is presented at the main report of the SESIA.

Cash flow, and their respective representations in the financial statements, represent the best explanatory force in providing the reader strong information related to the project performance to create a positive cash flow resulting from the current management processes and/or investment/financing processes. The analysis of cash flow also allows the analyst to verify the existence of proper financial balance between sources of raising investment and the use of the same.

A cash flow statement is a listing of the flows of cash into and out of the project: Revenues and subsidies/grant are the cash inflow, Investments and the costs are the cash outflows. The balance is net cash flow at a specific point in time.

Scenario 3 considers a situation where the construction costs relating to the work of recovery of the waters and of the wastewater reuse projects, provided both in Phase 1 and in 2 are paid in full by funds provided by Donors or the government. The other operating costs of the plant and the maintenance are, however, by paying a water tariff by farms benefiting from irrigation.

The basic aspects of financial and economic analysis, which Scenario 3 has been submitted, are summarized below.

A) Financial analysis

Farm-level investments for an estimated total of about 18.7 million ILS (orchard plants, plant irrigation adjustments etc.) have been graduated over a period of four years.

Staff training activities, much smaller in scope, were instead paid on the first year.

The civil works and the equipment of the recovery wells - tank and booster system, (30,83 million ILS) based on the executive design, were planned to be carried out between the first and the second year of the twenty-five years of the analysis. The 24th year will require procedures for the rebuilding of some of the equipment at the end of useful life, with an estimated cost of 10 mln ILS.

Investments for the implementation of the consortium irrigation network (99,33 million ILS) , to be carried out as a result of the progress of the previous work, are attributed to the second and third year, at the end of which can be considered the final construction stage.

So the project management phase begins. Even for the irrigation network, after twenty-five years, it will be necessary to partially reconstruct the less durable components of the plant.

In the gradual phase of the investment, the irrigation management phase begins with the project.

In the first 4 years, farmers will increase their costs due to the progressive introduction of orchards and greenhouses. From the 4th year, with the full production of orchards and greenhouses, costs and revenues are estimated constant for the remaining 21 years.

It should be considered that farm management costs include, of course, irrigation costs (in the net income statement the cost of irrigation on farms is calculated as the water tariff multiplied by cubic meters of irrigated water).

The water tariff includes the general costs of recover, distribution and control of the irrigation network.

With regard to the investments and the related management costs, the revenues of the project consist of:

- Farm revenues: are calculated on the basis of surveys and estimates carried out in the early months of the year even at project farms;
- Water tariff paid by Industry: 70,000 cubic meters of water per year, consumed by industrial activities in the area at a tariff of 2ILS / CM;
- From the time saving of the farmers, for the lack of irrigation water coming from private wells; These time savings have been prudently estimated, and the hours saved by farmers can be dedicated to the farm, or to other, paid jobs;
- Last but not least, payments by Government / Donors, after one year, come to cover the investments already made for the project under consideration.

The cash flow balance, obtained from the costs and revenues just described, leads to a highly positive result in financial terms. The result holds high values even during the simulations; These were carried out by applying incremental interest rates, at which two financial indicators (Financial Net Present Value and Benefit Cost Ratio), maintains full performance.

B) Economic Analysis

The components of economic analysis include investment and management costs, as highlighted in the previous chapter.

To these have been added:

- Correction of labour cost from financial to economic, consisting of the attribution of labour costs, linked to social costs, such as payroll & social security tax rate;
- VAT Investment Adjustment;
- VAT Revenues / Costs Adjustment.

From the sum of these amounts to the financial ones, an economic flow has been estimated, which, according to the present, shows a good robustness of the project. In fact, by performing

simulations with incremental interest rates, even economic analysis after the financial one keeps values steadily positive.

A cash flow statement is a listing of future flows of cash that occurred during the life of the project. A cash flow statement is not only concerned with the amount of the cash flows but also the timing of the flows. In this analysis, a forecast of expected flows and outflows for the next 25 years of project has been made.

ANNEX 5: BALANCE SHEET FOR INDIVIDUAL CROPS

Table 25: Balance sheet for Citrus

Citrus	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,800.00	1.72	*3,096.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	80.00	5.00	400.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.				
Plant Protection*	kg.	4.00	100.00	400.00	
irrigation	m3	827.20	1.50	1,240.80	
Harvesting Labour	dd	14.00	40.00	560.00	
Harvesting machinery	h				
Depreciation of the plant	1,380	duration yrs	35.00	39.43	
TOTAL				*2,990.23*	*105.77*
Labour & Enterprise					665.77

Table 26: Balance sheet for Olive

Olive	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
olive oil 50%		45.00	16.00		
tables olive %		300.00	4.00	*1,920.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	450.00	0.50	225.00	
Soil Disinfection	kg.				
Plant Protection	kg.	3.00	40.00	120.00	
irrigation	m3	705.10	1.50	1,057.65	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h	5.00	6.00	30.00	
Olive's milling	kg.	45.00	3.50	157.50	
Depreciation of the plant	1,780	duration yrs	40.00	44.50	
TOTAL				*2,274.65*	*-354.65*
Labour & Enterprise					-34.65

Table 27: Balance sheet for Peaches

Peaches	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,100.00	2.50	***2,750.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.				
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	628.60	1.50	942.90	
Harvesting Labour	dd	4.00	40.00	160.00	
Harvesting machinery	h				
Depreciation of the plant	1,980.00	duration yrs	35.00	56.57	
TOTAL				***2,129.47***	***620.53***
Labour & Enterprise					*780.53*

Table 28: Balance sheet for Grains

Grains	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		450.00	1.50	***675.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.33	60.00	79.80	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	100.00	0.50	50.00	
Irrigation pipes (/5 y)	ml	1400.00	0.70	196.00	
Plant Protection	kg.	4.00	15.00	60.00	
irrigation	m3	309.90	1.50	464.85	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h				
Seedings	kg.	20.00	2.25	45.00	
TOTAL				***1,415.65***	***-740.65***
Labour & Enterprise					*-420.65*

Table 29: Balance sheet for Other fruit crop

Other fruit crops p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		750.00	3.35	**2,512.50**	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.50	60.00	150.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	250.00	0.50	125.00	
Soil Disinfection	kg.				
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h	5.00	6.00	30.00	
Depreciation of the plant	1,800.00	duration yrs	20.00	90.00	
TOTAL				***2,348.45***	**164.05**
Labour & Enterprise					**484.05**

Table 30: Balance sheet for Summer vegetables

Summer vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		5,000.00	0.80	***4,000.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	500.00	0.50	250.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	15.00	25.00	375.00	
irrigation	m3	650.10	1.50	975.15	
Harvesting Labour	dd	15.00	40.00	600.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				***2,822.15***	***1,177.85***
Labour & Enterprise					***1,777.85***

Table 31: Balance sheet for winter vegetables

Winter vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		3,000.00	1.30	***3,900.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	50.00	5.00	250.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	12.00	25.00	300.00	
irrigation	kg.	293.90	1.50	440.85	
Harvesting Labour	dd	20.00	40.00	800.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				***2,412.85***	***1,487.15***
Labour & Enterprise					2,287.15

Table 32: Balance sheet for winter tomato greenhouses

winter tomato greenhouses p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		7,000.00	1.50	***10,500.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	25.00	25.00	625.00	
irrigation	m3	141.80	1.50	212.70	
Harvesting Labour	dd	30.00	40.00	1,200.00	
Harvesting machinery	h				
Seedings	kg.	0.02	8,000.00	120.00	
Depreciation of greenhouse	mq	750.00	50.00	1,875.00	** 20 year*
TOTAL				***4,682.70***	***5,817.30***
Labour & Enterprise					7,017.30

Table 33: Balance sheet for Almond

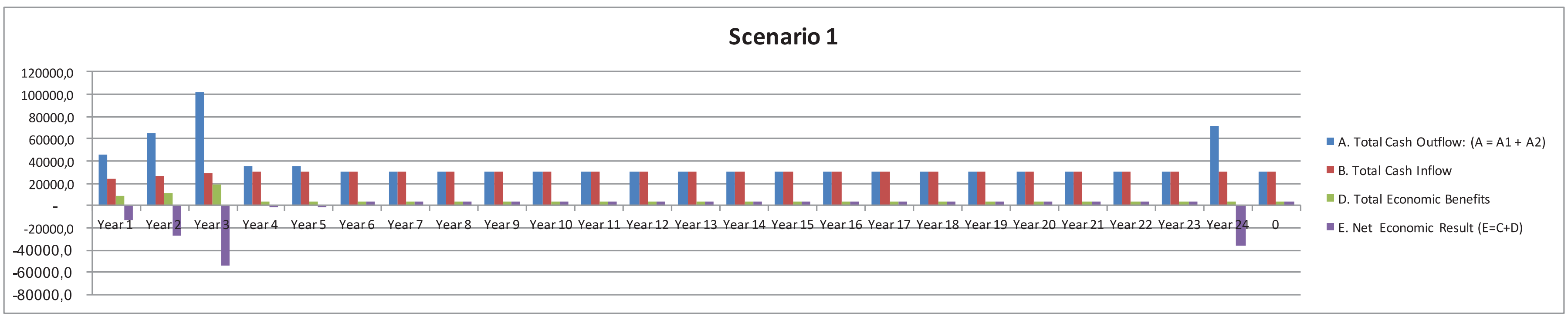
Almond	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		180.00	8.00	***1,440.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.				
Plant Protection	kg.	8.00	25.00	200.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting Labour	dd	3.00	40.00	120.00	
Harvesting machinery	h				
Depreciation of the plant	2,180.00	duration yrs	25.00	87.20	
TOTAL				***1,810.65***	***-370.65***
Labour & Enterprise					-250.65

Table 34: Balance sheet for Alpha-Alpha

alpha-alpha	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		4,500.00	0.35	***1,575.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	0.00	100.00		
Chemical Fertilizers	kg.	0.00	5.00		
Organic Fertilizers	kg.	0.00	0.50		
Soil Disinfection	kg.				
Plant Protection	kg.	0.00	25.00		
irrigation	m3	878.50	1.50	1,317.75	
Harvesting Labour	dd	6.00	40.00	240.00	
Harvesting machinery	h				
Depreciation of the plant	1,360.00	duration yrs	4.00	340.00	
TOTAL				***1,897.75***	***-322.75***
Labour & Enterprise					-82.75

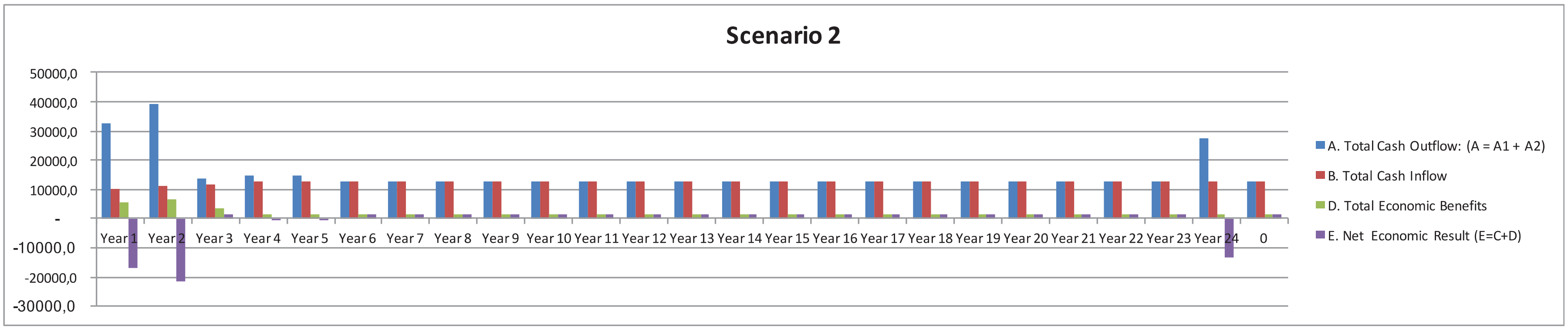
SCENARIO 1 – FULL COST/SOLUTION 1

Value in ILS*000		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Details							=>																			
A. Cost: Cash outflow: (NIS)																										
A1. Capital Cost																										
Investment cost at Farm level			4,695	4,695	4,695	4,695																				
Training activities		1,456	1,456																							
Recovery wells tank ans booster		22,997	7,838																						10,000	
Irrigation network			27,161	72,169																					30,000	
A2. Operating Cost (Recurrent Expenses)																										
Farmers pay off the investment					3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742
Cost at Farm level (including 1.50 ILS/CM)		21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total Investment	*147,162*																									
A. Total Cash Outflow: (A = A1 + A2)	944,282	46,266	64,771	102,295	35,675	35,675	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	70,980	30,980
B. Benefit: Cash inflow: (NIS)																										
Direct & indirect benefit																										
Revenue at Farm level		23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cr * 2.0 ILS/CM		140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells		657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors																										
Subsidies		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Total Cash Inflow	757,216	24,695	26,721	28,748	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-187,067	-21,572	-38,050	-73,547	-4,900	-4,900	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-40,205	-205
Financial Internal Rate of Return	#NUM!	FNPV@3%	-155,002	BCR@3%	0.772																					
Scenario 1 full stage investment		FNPV@5%	-140,864	BCR@5%	0.750																					
		FNPV@7%	-130,096	BCR@7%	0.728																					
D. Economic Valuation																										
Economic benefit																										
Correction of labour cost from financial to economic		2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement		3680	5600	11547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement		1729	1871	2012	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits		8,238	11,138	19,552	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)		-13,333	-26,912	-53,994	-996	-996	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	-36,300	3,700
Economic Internal Rate of Return	#NUM!	ENPV@3%	-61,667	BCR@3%	0.909																					
Scenario 1 full stage investment		ENPV@5%	-61,628	BCR@5%	0.891																					
		ENPV@7%	-61,454	BCR@7%	0.871																					



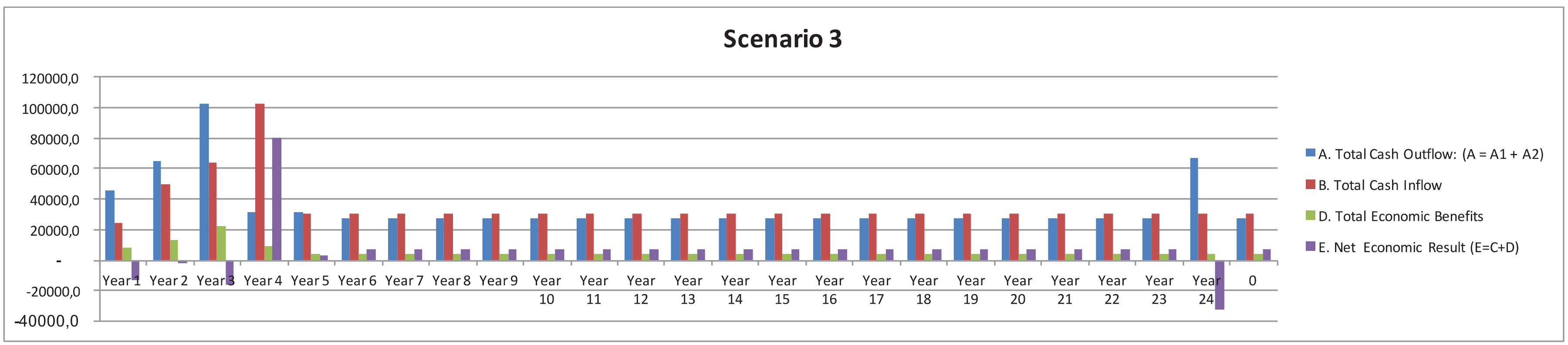
SCENARIO 2 – FULL COST/SOLUTION 2

Value in ILS*000										=>																		
Details				**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)																												
A1. Capital Cost																												
Investment cost at Farm level					1,925	1,925	1,925	1,925																				
Training activities				597	597																							
Recovery wells tank ans booster system				22,997																							5,000	
Irrigation network					27,161																						10,000	
A2. Operating Cost (Recurrent Expenses)																												
Farmers pay off the investment						1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492
Cost at Farm level (including water tariff	1.50	ILS/CM	)	8,944	9,685	10,426	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168
Total investment		*57,126*																										
A. Total Cash Outflow: (A = A1 + A2)		**383,109**		32,537	39,367	13,843	14,585	14,585	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	27,660	12,660
B. Benefit: Cash Inflow: (NIS)																												
Direct & Indirect benefit																												
Revenue at Farm level				9,798	10,629	11,460	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291
Water tariff paid by Industry 40,000 cm	*	2.0	ILS/CM	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Time saved for non management of private wells				269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269
Paid by Government/Donors																												
Subsidies				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Total Cash Inflow		**311,023**		10,147	10,978	11,809	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640
C. Cash Flow Results: (C=B-A)		**-72,085**		-22,390	-28,389	-2,034	-1,944	-1,944	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-15,019	-19
Financial Internal Rate of Return		**#NUM!**		FNPV@3%	-61,389	BCR@3%	**0.778**																					
Scenario 2 only Phase I investment				FNPV@5%	-56,792	BCR@5%	**0.753**																					
				FNPV@7%	-53,353	BCR@7%	**0.728**																					
D. Economic Valuation																												
Economic benefit																												
Correction of labour cost from financial to economic				1160	1504	2457	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718
VAT Investment Adjustement				3680	4346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				710	768	827	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885
D. Total Economic Benefits				5,550	6,618	3,284	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602
E. Net Economic Result (E=C+D)				-16,840	-21,771	1,250	-342	-342	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	-13,417	1,583
Economic Internal Rate of Return		**#NUM!**		ENPV@3%	**-23,386**	BCR@3%	**0.915**																					
Scenario 2 only Phase I investment				ENPV@5%	**-24,446**	BCR@5%	**0.894**																					
				ENPV@7%	**-25,237**	BCR@7%	**0.871**																					



SCENARIO 3: CAPITAL SUBSIDIES

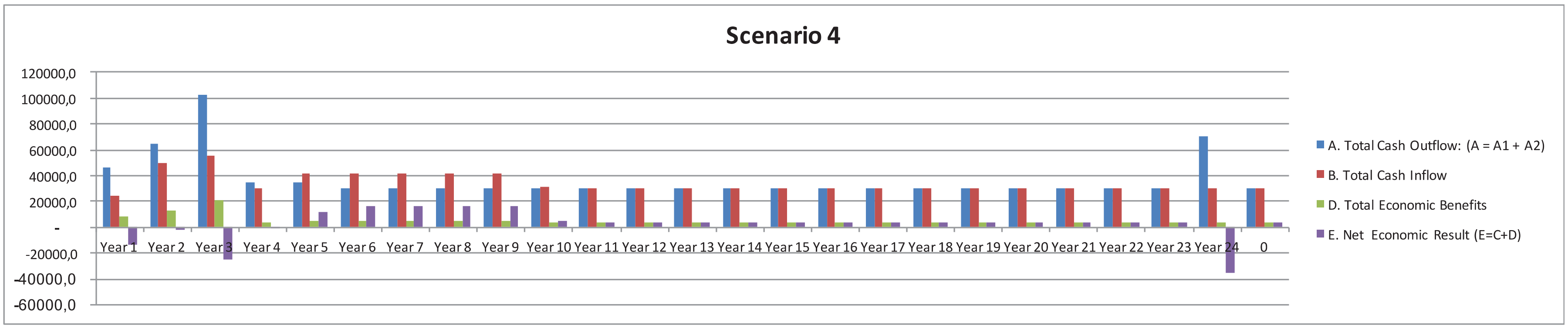
Value in ILS*000										=>																		
Details				**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)																												
A1. Capital Cost																												
Investment cost at Farm level					4,695	4,695	4,695	4,695																				
Training activities				1,456	1,456																							
Recovery wells - tank ans booster system				22,997	7,838																						10,000	
Irrigation network					27,161	72,169																					30,000	
A2. Operating Cost (Recurrent Expenses)																												
Cost at Farm level (including water tariff=	1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total Investment		*147,162*																										
A. Total Cash Outflow: (A = A1 + A2)		**861,958**		46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
B. Benefit: Cash inflow: (NIS)																												
Direct & indirect benefit																												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm	*	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors					22,997	34,999	72,169																					
Subsidies																												
B. Total Cash Inflow		**887,381**		24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)		**[illegible]0,663**		-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
Financial Internal Rate of Return		**10.82%**		FNPV@3%	**17,400**	BCR@3%	**1.028**																					
Scenario 3 - Capital cost payd by Donors				FNPV@5%	**12,152**	BCR@5%	**1.023**																					
				FNPV@7%	**7,405**	BCR@7%	**1.017**																					
D. Economic Valuation																												
Economic benefit																												
Correction of labour cost from financial to economic				2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				3680	5600	11547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits				8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)				-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442
Economic Internal Rate of Return		**61.68%**		ENPV@3%	**118,983**	BCR@3%	**1.190**																					
Scenario 3 - Capital cost payd by Donors				ENPV@5%	**[illegible]9,119**	BCR@5%	**1.190**																					
				ENPV@7%	**[illegible]3,307**	BCR@7%	**1.188**																					



SCENARIO 4 - CAPITAL AND O&M SUBSIDIES/SOLUTION 1

Value in ILS*000									=>						
Details			**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
A. Cost: Cash outflow: (ILS)															
A2. Operating Cost (Recurrent Expenses)															
Farmers pay off the investment						3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta	1.50	ILS/CM)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment	*147,162*														
A. Total Cash Outflow: (A = A1 + A2)	**931,258**		46,266	64,771	102,295	35,083	35,083	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388
B. Benefit: Cash inflow: (NIS)															
Direct & indirect benefit															
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors				22,997	27,161										
Subsidies				3,433	6,866	11,443	11,443	11,443	11,443	11,443	11,443	1,047			
B. Total Cash Inflow	**865,637**		24,695	49,718	55,909	30,775	42,218	42,218	42,218	42,218	42,218	31,822	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**-28,331**		-21,572	-15,053	-46,386	-4,308	7,135	11,831	11,831	11,831	11,831	1,434	387	387	387
Financial Internal Rate of Return	**#NUM!**		FNPV@3%	**-52,493**	BCR@3%	**0.922**	investm. Phase I		80,007						
Scenario 4 Capital cost phase 1 paid by government subsidies for 9 years to farmer payd capital cost pha			FNPV@5%	**-48,408**	BCR@5%	**0.913**	subsidies		80,007						
			FNPV@7%	**-46,166**	BCR@7%	**0.902**	9 year of subsidies								
D. Economic Valuation															
Economic benefit															
Correction of labour cost from financial to economic			2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement			3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement			1729	3480	3914	2154	2955	2955	2955	2955	2955	2228	2154	2154	2154
D. Total Economic Benefits			8,238	12,748	21,454	3,904	4,705	4,705	4,705	4,705	4,705	3,978	3,904	3,904	3,904
E. Net Economic Result (E=C+D)			-13,333	-2,305	-24,932	-404	11,841	16,536	16,536	16,536	16,536	5,412	4,292	4,292	4,292
Economic Internal Rate of Return	**18.55%**		ENPV@3%	**47,413**	BCR@3%	**1.071**									
Scenario 4 Capital cost phase 1 paid by government subsidies for 9 years to farmer payd capital cost pha			ENPV@5%	**36,828**	BCR@5%	**1.066**									
			ENPV@7%	**27,978**	BCR@7%	**1.059**									

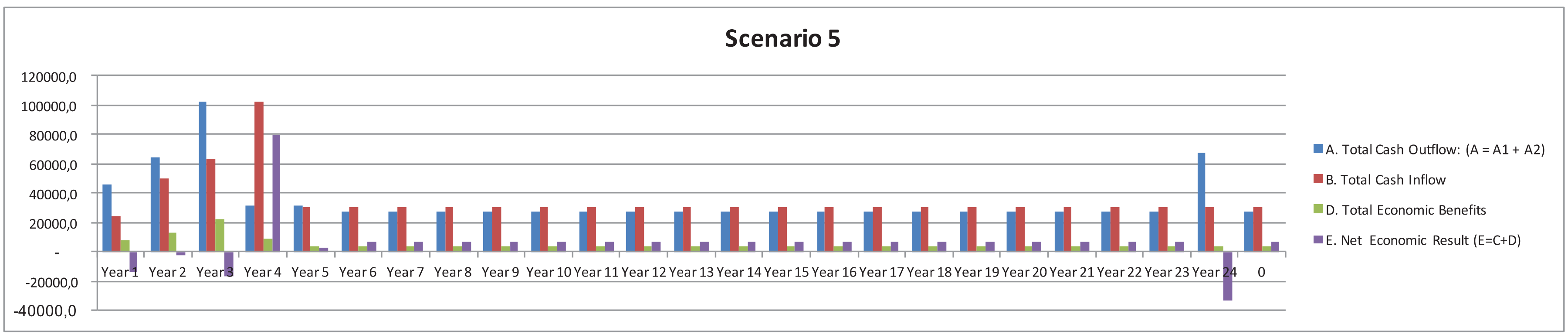
Details	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
Farmers pay off the investment	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	70,388	30,388
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm *	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Subsidies				0								
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	387	387	387	387	387	387	387	387	387	387	-39,613	387
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	-35,708	4,292



SCENARIO 5 - CAPITAL AND O&M SUBSIDIES/SOLUTION 2

Value in ILS*000																
										=>						
Details				**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
A. Cost: Cash outflow: (ILS)																
A1. Capital Cost																
Investment cost at Farm level					4,695	4,695	4,695	4,695								
Training activities				1,456	1,456											
Recovery wells tank ans booster system				22,997	7,838											
Irrigation network					27,161	72,169										
A2. Operating Cost (Recurrent Expenses)																
Cost at Farm level (including water tariff=	1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment	*147,162*															
A. Total Cash Outflow: (A = A1 + A2)	**861,958**			46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
B. Benefit: Cash inflow: (NIS)																
Direct & indirect benefit																
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm *	2.0	ILS/CM		140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors					22,997	34,999	72,169									
Subsidies					3,433	6,866	8,483					0	0	0	0	0
B. Total Cash Inflow	**887,381**			24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**40,663**			-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537
Financial Internal Rate of Return	**10.82%**			FNPV@3%	**17,400**	BCR@3%	**1.028**	investm. Fram level		8,782						
Scenario 5 Capital cost payd by government and and O&M payd by government until repa				FNPV@5%	**12,152**	BCR@5%	**1.023**		subsidies	8,782						
				FNPV@7%	**7,405**	BCR@7%	**1.017**	3 year of subsidies								
D. Economic Valuation																
Economic benefit																
Correction of labour cost from financial to economic				2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits				8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)				-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442
Economic Internal Rate of Return	**61.68%**			ENPV@3%	**118,983**	BCR@3%	**1.190**									
Scenario 5 Capital cost payd by government and and O&M payd by government until repa				ENPV@5%	**99,119**	BCR@5%	**1.190**									
				ENPV@7%	**83,307**	BCR@7%	**1.188**									

Details	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level												
Training activities												
Recovery wells tank ans booster system											10,000	
Irrigation network											30,000	
A2. Operating Cost (Recurrent Expenses)												
Cost at Farm level (including water tariff= 1.50 ILS/CM)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
B. Benefit: Cash inflow: (NIS)												
Direct & indirect benefit												
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors												
Subsidies	0	0	0	0	0	0	0	0	0	0		
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442



Contract 7173578

Feasibility Study Report

Power Generation (Solar PV) for North Gaza Emergency Sewage Treatment Plant

16 July 2015

Employer:

The World Bank
1818 H Street, N.W
Washington, DC 20433

Consultant:

GOPA-International Energy Consultants GmbH
Justus-von-Liebig-Str. 1, 61352 Bad Homburg, Germany
Phone: +49 (6172) 1791-800; Fax: +49 (6172) 944 95 20
eMail: info@gopa-intec.de; www.gopa-intec.de
Palestinian Hydrology Group (PHG) for Water and Environmental Resources Development
P.O.Box 565
Ramallah – West Bank - The Palestinian Authority

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Abbreviations Used

Acronym	Definition
AC	Alternating Current
ASTM	American Society for Testing and Materials
BLWWTP	Beit Lahia wastewater treatment plant
BOOT	Build Own Operate Transfer
CAD	Computer Aided Design
CAPEX	Capital Expenditures
CB	Circuit Breaker
CIS	Copper, Indium, Selenide cell
COP	Continuous Power
DC	Direct Current
DISCO	Distribution Company
DSL	Digital Subscriber Line
DUC	Dynamic Unit Cost
EIA	Environmental Impact Assessment
ESIA	Environmental and Social Impact Assessment
GEDCO	Gaza Electricity Distribution Corporation
GHI	Global Horizontal Irradiation
GPGC	Gaza Power Generating Company
GPP	Gaza Power Plant
GW	Giga Watt
HV	High Voltage
HVAC	Heating, Ventilating, and Air Conditioning
IAM	Incidence Angle Modifier
IB	Infiltration Basin
IEC	International Electro technical Commission
ILS	Israeli Shekel
ISO	International Organization for Standardization
kV	Kilo Volt
KW	Kilo Watt
LCOE	Levelized Costs of Electricity
LID	Light Induced Degradation
LV	Low voltage
MENR	Palestinian Ministry of Energy and Natural Resources
MPP	Maximum Power Point
MTF	Mean Time to Failure
MV	Medium Voltage, in this case also referred to as HV by PWA
MVA	Mega Volt Ampere
MW	Mega Watt
NE	North-East
NGEST	Northern Gaza Emergency Sewage Treatment
NW	North-West
OHL	Over-head line
OPEX	Operational expenditures
PEA	Palestinian Energy Authority
PEC	Palestine Electric Company
PENRA	Palestinian Energy and Natural Resource Authority
PF	Power Factor

Acronym	Definition
PHG	Palestinian Hydrology Group
PNA	Palestinian National Authority
PV	Photovoltaic
PWA	Palestinian Water Authority
RE	Renewable Energy
SCADA	Supervisory Control and Data Acquisition
SE	South East
TMY	Typical Meteorological Year
TPS	Terminal Pumping Station
USD	US Dollar
VA	Volt Ampere
VAT	Value Added tax
W	Watt
WB	World Bank
WWTP	Waste Water Treatment Plant

Executive Summary

Study Context and Objectives

The Palestinian Water Authority (PWA) is currently implementing the North Gaza Emergency Sewage Treatment (NGEST) project in North Gaza in order to improve the sanitation situation in the Northern Gaza Governorate as well as to alleviate the complex situation around the old Beit Lahia Wastewater Treatment Plant (BLWWTP) and the random lake which was formed due to capacity limits at BLWWTP. This includes the construction of a waste water treatment plant (WWTP) with an initial daily capacity of 35,600 m³ (expandable to 65,700 m³) and a recovery scheme (RS) of 29 recovery wells to refill the ground water aquifer with the treated water and retrieve the infiltrated water for agricultural purposes. The processing loads at the WWTP and the pumps at the RS have relatively high energy consumption. But the overall power supply situation in Gaza is constrained due to general political circumstances and options for extending existing supply via the distribution network are limited because of cost of fuel for the local power plant or due to difficulties in fuel availability as well as the limits to increase the supply from cross-border sources.

Consequently, PWA seeks together with the other responsible stakeholders; the Palestinian Energy and Natural resource Authority (PENRA) – and support from the World Bank (WB) – to assess and identify the most viable, long-term sustainable power supply option for the North Gaza Emergency Sewage Treatment (NGEST) facilities during its whole life-cycle. The target is to review the planned power supply, to propose improvements on it including the assessment of the installation of a photovoltaic system and finally to identify the most viable, long-term sustainable power supply option for the NGEST facility under the expectation that an external solution to the issues may be difficult to achieve in the mid-term. Within this study a thorough evaluation of the loads and consumption of the sewage treatment facility and effluent recovery scheme, review of the existing supply options, assessment of the share of each power supply option cover the demand including an optimisation of the utilisation of renewable generation sources from the existing biogas generators and an additional solar PV system, analysis of the economic implications and financing options and finally proposing a suitable project structure with a way forward to eventual implementation was conducted. The whole assessment is be complemented by a preliminary environmental impact analysis, and outline of the path for implementation as well as an appraisal of the effects on the local political economy.

The construction of the NGEST Waste Water Treatment Plant (WWTP) plant has been completed to about 95%. All buildings have been completed, and equipment is installed. During the site inspection good state and workmanship was observed allowing. The Recovery Scheme (RS) is then planned to be added at the later stages 1 and stage 2 of phase 1 and then finally expanded in phase 2. Currently, this Wakif land (common property) lies fallow but is rented out on seasonal basis for farmers for cultivation of seasonal crops.

Apart from the minor obstacles all designated areas are considered as suitable for the installation of PV systems. Some grading and levelling may be necessary and roof-top installations need to account for existing facilities. The closed-to finished construction of the treatment plant will result in rather long cabling distances. Despite these small issues no blockers were identified during the site visit and thus no red-flags were raised for a combined biogas and PV based on-site generation supported by the grid and the emergency gensets.

Results

Through a comprehensive analysis of the design loads and the energy consumption, the demand profile was drawn up for the different project phases and the two locations. The peak load of the WWTP and RS together in 2018 will be 9 MVA with daily energy consumption of 102 MWh (128 MVAh) resulting in an annual energy consumption of 37286 MWh (46608 MVAh), while in 2025 the peak load is 15 MVA with daily power consumption of 173 MWh (216 MVAh) resulting in an annual energy consumption of 63271 MWh (79089 MVAh).

The current power supply concept – as a result of the general concept and the Contractor's design – consists of the external supply from the GEDCo grid via a 22 kV overhead feeder line and on-site generation from emergency diesel generators with sufficient capacity to cover the load of the facility. Additionally, the local biogas as by-product of the sludge treatment cycle is used for electricity production. The portfolio of on-site generation shall be expanded by a PV system on designated areas within NGEST projects to allow truing the power supply more stainable through the increase of emission-free and independent renewable energy without low non-marginal costs.

The proposed 5.1 MWp design uses arrays composed of poly-crystalline modules. The fixed-mounted 25 degree is adapted in its azimuth angle to the geometry of the areas. This configuration offers the lowest specific costs per installed module power and consequently allows for a high annual production at lowest costs. A decentralized inverter with suitable sizes was chosen not only to avoid mismatching losses between differently aligned areas, but also because of its simplicity in maintenance. The system generates in average over the project lifetime 8,442 MWh annual totalling to 214,291 GWh during the 20 years assessment period. The investment costs (CAPEX) are estimated with 1,350 USD/kWp which amounts to a total value of 6,897,993 USD. The OPEX appraisal resulted in and estimated 9.44 USD/kWp totalling to 48,856 USD/annum.

Technically, the integration into the existing power supply is possible. A tight coupling of the PV monitoring system with the existing facility control infrastructures is necessary for this end. In order to estimate the impact on the operation and assess the combined annual costs, the energy balance of the facility for the scenarios with and without PV was produced.

By adding the PV system to NGEST, the annual supply from the grid in 2018 is reduced by 24% to 8250 MWh and the required annual energy from the emergency diesel is taken down by 27% to 14476 kWh allowing NGEST to reduce its diesel consumption by 30% leading to the saving of 1,293,615 litres of diesel fuel.

Accordingly, the PV share in 2018 reaches 8909 MWh representing (23.89%) of the total annual power generation, the diesel share is 14476 MWh (38.82%), the grid share is 8250 MWh (22.13%) and the biogas share is 5651 MWh (15.16%).

The preliminary Environmental and Social Impact Assessment (preliminary ESIA) used the Palestinian laws and World Bank guidelines as reference framework for the evaluation. During the investigation no identified permanent negative impacts on the local environment and community beyond smaller disturbances during the construction period were identified. The investigated areas are part of the overall NGEST terrain and already covered by a previous ESIA study. The surroundings were rather found to adversely affect the operation of the PV system by emission of dust which would reduce the system performance. Thus, a preliminary impact mitigation plan was elaborated. The outcome of the preliminary ESIA was reviewed by the ESIA expert of PWA and World Bank's safeguard team and no objections were raised.

An economic and financial analysis was conducted with the objective to identify the costs and benefits of the installation of a Solar PV plant as a power supply option for NGEST. The financial analysis in particular examines closely the investment's profitability and different financing scenarios.

NGEST's power supply without PV and the current supply options (biogas, diesel, and GEDCo grid connection) lead to an overall LCOE of 0.23 USD/kWh. NGEST with the PV option installed has an overall LCOE of 0.20 USD/kWh, making it 0.03 USD/kWh cheaper than the no PV option. Regarding the project lifetime of 20 years these 0.03 USD/kWh generate a saving in the present value of costs of 15,484,557 USD.

An overall investment sum of USD 9.7 million, including three funding scenarios (commercial funding, 50% grant and green funding), were calculated for NGEST. Depending on the type of financing, a total costs/debt was established to be in range from USD 6 million to USD 12.1 million. A recommendation for one specific scenario was not given as each donor/ investor prefers and sets different financing parameters.

The local political economy is expected mainly in a few ways: the need for local support during the construction and maintenance may – together with other PV systems currently in planning within the strip – such an undertaking will provide an opportunity to local companies to participate the project, enhance their experience and or even to participate over a longer period by providing support during maintenance. But more important support during to the relatively short construction period, the project can showcase to the local distributor GEDCo but also to local government offices and businesses how power supply to a facility with high energy demand can be rendered more sustainable and independent. Since this relives the constrained network with this effort on individual project basis can be regarded as beneficial. It may even – though the acquired experience – increase confidence in auto-consumer installations and raise the awareness to support a regulation for net-metering.

The primary stakeholders, PWA as responsible entity for NGEST and PENRA as institution responsible for the energy domain, were actively involved through milestones meetings (kick-off, outcome from assessment of power supply options and principle findings workshop) and very frequently and regular consultation via email or phone. During this process, confirmation on the interpretation of provided data was sought; findings were shared for discussion and support in further issues around the project provided. This had led to a very successful presentation of the principal and subsequent fruitful discussion on the path ahead under participation of the relevant Palestinian institutions and stakeholders from donors and administration.

Recommendations on PV System

Through a comprehensive analysis of the design loads and the energy consumption, the demand profile was drawn up for the different project phases and the two locations. The peak load of the WWTP and RS together in 2018 will be 9 MVA with daily energy consumption of 102 MWh (128 MVAh) resulting in an annual energy consumption of 37286 MWh (46608 MVAh), while in 2025 the peak load is 15 MVA with daily power consumption of 173 MWh (216 MVAh) resulting in an annual energy consumption of 63271 MWh (79089 MVAh).

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The proposed 5.1 MWp design uses arrays composed of poly-crystalline modules. The fixed-mounted 25 degree is adapted in its azimuth angle to the geometry of the areas. This configuration offers the lowest specific costs per installed module power and consequently allows for a high annual production at lowest costs. A decentralized inverter with suitable sizes was chosen not only to avoid mismatching losses between differently aligned areas, but also because of its simplicity in maintenance. The system generates in average over the project lifetime 8,442 MWh annual totalling to 214,291 GWh during the 20 years assessment period. The investment costs (CAPEX) are estimated with 1,350 USD/kWp which amounts to a total value of 6,897,993 USD. The OPEX appraisal resulted in and estimated 9.44 USD/kWp totalling to 48,856 USD/annum.

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An overall investment sum of USD 9.7 million, including three funding scenarios (commercial funding, 50% grant and green funding), were calculated for NGEST. Depending on the type of financing, a total costs/debt was established to be in range from USD 6 million to USD 12.1 million. A recommendation for one specific scenario was not given as each donor/ investor prefers and sets different financing parameters.

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Milestone	**Time**
PV: Decision & Financing	Q4/2015
PV: Elaboration of Specification & Tender Documents	Q4/2015
PV: Tendering	Q1-Q2/2016
PV: Construction	Q1-Q2/2017
PV: Commissioning	Q3/2017

1. Introduction

1.1 Brief Description of the NGEST Project

The Palestinian Water Authority (PWA) is currently implementing the North Gaza Emergency Sewage Treatment (NGEST) project in North Gaza in order to improve the sanitation situation in the Northern Gaza Governorate as well as to alleviate the complex situation around the old Beit Lahia Wastewater Treatment Plant (BLWWTP) and the random lake which was formed due to capacity limits at BLWWTP.

The NGEST project was designed of three main components:

a) **Part A**: The installations of the Terminal Pumping Station (TPS) located at BLWTP, the construction of a 7 km pressure pipe line to conduct the wastewater from BLWWTP to the NGEST WWTP site to eliminate the risk from the random lake and the building of nine infiltration basins (East to Al-Shuhada Cemetery).
b) **Part B**: The construction of a waste water treatment plant (WWTP) adjacent to the infiltration basins with an initial daily capacity of 35,600 m³ (expandable to 65,700 m³) to treat the influent coming from the TPS and to provide long-term, sustainable solution to the sanitation services in North Gaza.
c) **Part C**: A recovery scheme (RS) of 29 recovery wells to refill the ground water aquifer with the treated water and retrieve the infiltrated water for agricultural purposes by using it for irrigation of 1500 ha in the eastern part of the North Gaza Governorates. This measure shall help to achieve a positive impact by reducing the pressure on the limited coastal aquifer and by provision of good quality irrigation water for the local community.

The processing loads at the WWTP and the pumps at the RS have relatively high energy consumption. Thus, reliable and economically sound power supply is a key requirement for the operation of NGEST. But the overall power supply situation in Gaza is constrained due to general political circumstances and options for extending existing supply via the distribution network are limited because of cost of fuel for the local power plant or due to difficulties in fuel availability as well as the limits to increase the supply from cross-border sources. Consequently, PWA seeks together with the other responsible other stakeholder PENRA – and support from the World Bank (WB) – to assess and identify the most viable, long-term sustainable power supply option for the North Gaza Emergency Sewage Treatment (NGEST) facilities during its whole life-cycle.

The feasibility study on power supply to NGEST presented in this document forms a major contribution towards that end. This feasibility study assesses power supply of Part B and Part C, only, because the TPS and connected facilities grouped under Part A are already implemented and operating. In addition does the location these components –7 km away from the WWTP and RS – render the inclusion into the integrated power supply system impossible.

1.2 Project Timeline

Since any modification to the project requires a considerable amount of time planning, procurement and implementation, the different expansion stages of the NGEST project, mainly driven by the increased load, are grouped into two main phases. Phase 1 is targeting at a planning horizon until 2018 whereas Phase 2 is aiming towards the year 2025. Within the Phase 1, there are separate stages characterised by annual increase of volume of treated wastewater and effluent pumped at the recovery scheme. The uptake in volumes are then reflected by respective the power demand and energy consumption at the two locations. The corresponding energy profiles are assessed in the load and demand analysis of this report.

Part A is completed and in operation since 28th of April 2009. The construction of Part B is completed to about 95%. Due to an insolvency of the joint-venture leader of the treatment plant contractor, the project is currently stalled waiting for a conclusion of the construction and final commissioning. The start of regular operation is expected for the first quarter of 2016. The installation of Stage I of the recovery scheme is expected for end of 2016. Likewise, the implementation of Stage II is foreseen towards the end of 2017. In Phase 2 another expansion of the recovery scheme envisaged.

Consequently, this report separates the power supply situation into two main phases:

1) Phase 1 with the planning horizon 2018 (to be completed until end of year 2017) with
    a. the main treatment plant to be completed and commissioned by end of 2016
    b. the recovery scheme stage 1 and stage 2
2) Phase 2 with the planning horizon 2025 (to be completed between year 2019 and 2024) with
    a. An expansion of the treatment plant and an expansion of the infiltration basins
    b. An extension of the recovery scheme

The potential addition of the PV system – which feasibility is assessed in this report – is planned to be procured and installed within Phase 1 until mid-year 2017. The assumption behind this scheduling is that the planning, detailing of the concept, system specification and financing may easily take until the end of 2015. The procurement will require at least the first semester of 2016 and implementation with the steps executive design, construction and installation may take another year. Thus any power supply system with contribution from PV would actually be operational sometime in 2017. Although this would lead to the design horizon of 2018, full operation of PV already in 2017 is assumed in the study in order to assess the different conditions during the upscaling of NGEST's operations. Some areas designated for installation of PV modules are on the recovery fields and connected facilities. Consequently, the implementation of the recovery facilities is a precondition to the installation of the PV system at that location.

This particular timeline also explains the principle difference of the assessment of the power supply to other projects currently in planning by Palestinian authorities. At NGEST, planning of the whole systems including basic power supply had been conducted in the past years and the major part of components are already installed. The study presents a re-assessment of the designed and installed structures and proposes modifications aiming to reduce interference with the existing project to a minimum. In contract to this, other projects such as the Gaza Central Desalination Plant or the Gaza Central Wastewater Project are still on the planner's desk allowing integrating recent technical developments and advances in renewable energy technology right from the start.

1.3 General Conditions of Power Supply

The principal objective of any power supply concept for NGEST is defined by the need to safeguard the continuous and uninterrupted operation of the WWTP and the effluent recovery scheme.

The main motivation for analysing and reviewing the supply options is the observation that the distribution grid as main source can technically not provide steady and reliable supply and that the operation of the installed on-site emergency diesel generators on the other hand would lead to huge operational expenses as a result of the high fuel costs but also due to the uncertainty of the general fuel supply situation in Gaza. It is assumed that the current adverse conditions of the power supply system in Gaza will prevail at least for the mid-term. Thus, the observed intermittent and constrained supply of the local distribution network is the key driver behind any investigation into alternative solutions that bridge the supply gap arising from the load shedding. The unsecure situation compels planners and operators of critical infrastructure with high consumption such as water services to ensure constant operation by including additional sources of power supply into the systems. Diesel generators are normally used as primary on-site emergency solution because the gensets provide flexible and reliable energy to cover the loads. But this strength comes with a huge price tag and increased emissions as the purchase costs for the large fuel quantities required to run the facility when in off-grid mode do not only have a significant impact on the operational budget of the facility but do also upturn the overall environmental footprint of the project. This financial burden of fuel purchase costs triggers yet additional analysis aiming to utilise all possible options in order to ensure sustainable power supply. The biogas as by-product of the sewage process has already been considered as alternative fuel source in the design of the NGEST WWTP. Given the availability of spare land within the areas attributed to NGEST and good solar resource in Gaza, the addition of a photovoltaic system to the portfolio seems to be a logical step.

Consequently, the NGEST project stakeholders aspire to catch the two ends of this challenge through an optimisation of the existing set-up and the inclusion of a PV system:

- Higher independence from intermittent grid-based supply
- Fuel cost saving during times the grid is unavailable.

The consumption of NGEST is determined by the fixed load and variable process consumers. The operation of the water treatment plant and its flows are the leading driver for the fluctuations of the variable demand:

- When wastewater inflow is high, power demand from the different components will rise and vice versa.
- The production of biogas depends on this process flow and its cycles.

The general power network situation leads to two operational scenarios with corresponding consequences a power supply structure must be capable to support:

1) On-grid mode – during times the facility is mainly supplied from the GEDCo network
    a. All consumers can be supplied and normal operation is ensured
    b. The embedded captive on-site renewable energy generation (biogas, PV) would reduce the energy costs for supply by GEDCo in an auto-consumer or net-metering fashion.
2) Off-grid mode – during times the facility has to generate required power itself
    a. The limited supply in absence of the grid may in turn result in the necessity to manage and curtail some loads, e.g. the non-priority consumers such as some wells in the recovery scheme
    b. The embedded captive on-site generation (biogas, PV and diesel) would need to ensure the provision of the required power and heat. Renewable power from biogas and PV would serve as fuel-saver for the emergency diesel displacing costly fossil fuel as much as possible through operation as auto-producer.

The further technical analysis and economic evaluation will therefore need to

- verify if and how these envisaged operational set-ups can be sustained
- assess the consequences for the technical concept design and operation

- evaluate the associated costs and economic viability.

1.4 Objectives of the Feasibility Study

The setting described above leads to the general objective of the study. The target is to review the planned power supply, to propose improvements on it including the assessment of the installation of a photovoltaic system and finally to identify the most viable, long-term sustainable power supply option for the NGEST facility under the expectation that an external solution to the issues may be difficult to achieve in the mid-term.

Guiding questions of the study are therefore:

1. Which supply option secures the operation of the NGEST on a long-term basis in most sustainable way?
2. How would a more autonomous generation supported by PV with less emission need to be designed and implemented?
3. Which approach shall be adopted to finance the energy supply and potential PV plant of the NGEST and how should the project be commercially structured?

The study answers these questions through evaluation of the loads and consumption of the sewage treatment facility and effluent recovery scheme, review of the existing supply options, assessment of the share of each power supply option cover the demand including, the elaboration of a conceptual design of a PV system to be added to the portfolio of local generation sources, the optimisation of the utilisation of renewable generation sources biogas and solar PV, analysis of the economic implications and financing options and finally proposing a suitable project structure with a way forward to eventual implementation. Each of these assessment steps are regarded as decision gates where available options or variants are evaluated and recommendations based on the results of analysis are provided.

The whole assessment will be complemented by a preliminary environmental impact analysis, and outline of the path for implementation as well as an appraisal of the effects on the local political economy.

2. Site conditions

2.1 Localisation of the Site

The NGEST plant site and recovery fields are located South-East of Jibalya municipality and West of the Israeli border as shown on the satellite imagery on Figure 2-1. The main NGEST plant is situated closer to the border and South-East of the al-Shuhada cemetery. The effluent recovery and reuse scheme planned on the North-East side of the al-Shuhada cemetery. At both locations have electrical loads, emergency generators and certain areas which are designated for installation of PV systems,

The construction of phase 1 of the NGEST plant has been completed to about 95%. All buildings have been completed, and equipment is installed. During the site inspection PWA had given proof that there are no major obstacles which would block the commissioning of the facility although some issues would still have to be accomplished.

The recovery scheme is then planned to be added at the later stages 1 and stage 2 of phase 1 and then finally expanded in phase 2. Currently, this Wakif land (common property) lies fallow but is rented out on seasonal basis for farmers for cultivation of seasonal crops.

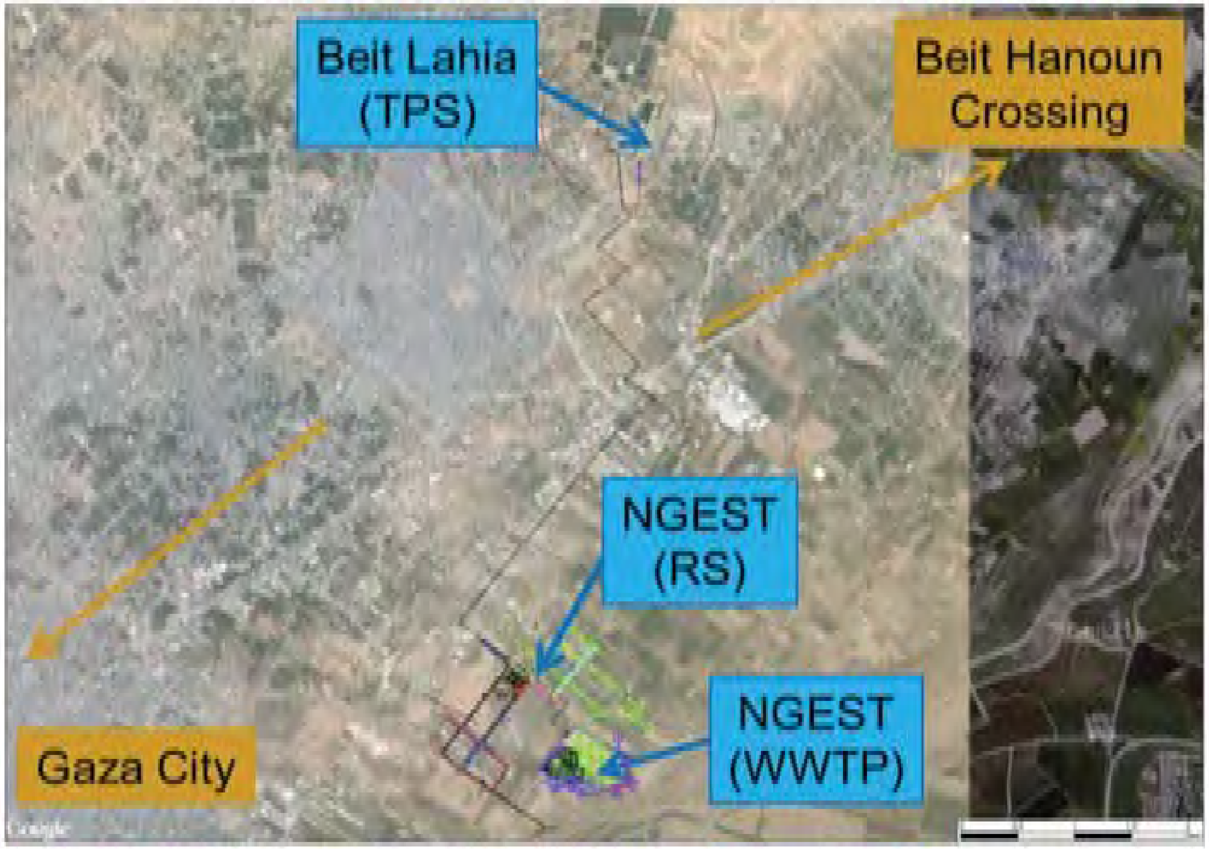


Figure 2-1: The site localisation including the pressure line from TPS, imagery by Google Earth and drawing by NGEST

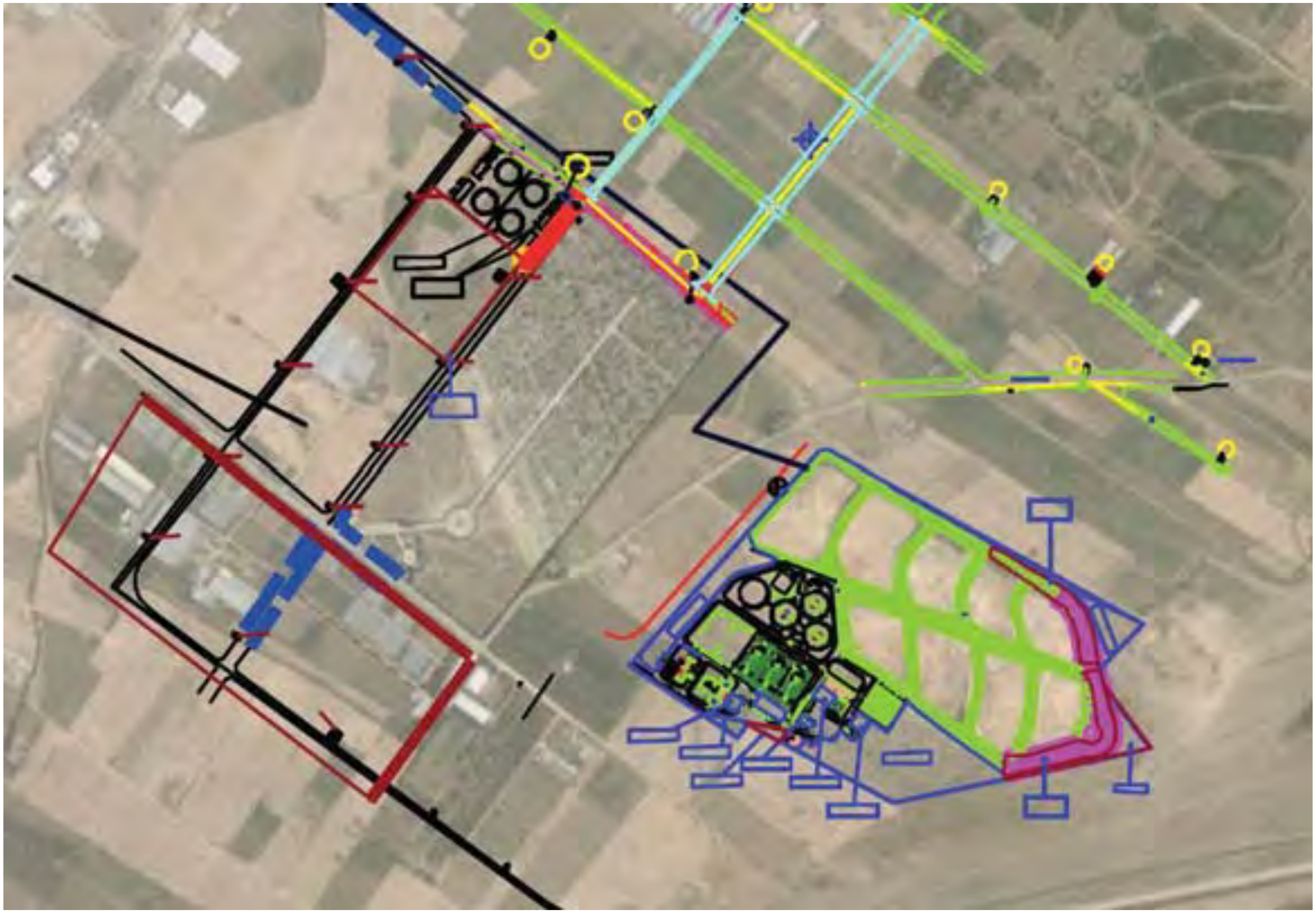


Figure 2-2: **Detail view of the area located South-East of Jibalya, imagery by Google Earth and superposed drawing by NGEST**

2.2 Overview of the Areas Designated for PV Systems

The areas of the NGEST project to be considered for the design and later installation of PV systems were indicated by PWA using site drawings of the facility. The drawing[1] identifies the areas within the current boundaries of the treatment plant and additional areas on the recovery scheme. An overview is provided in **Error! Reference source not found.**.

Table 2-1: Designated areas for PV systems

Area Code	Brief description and localisation	Type of PV installation	Size [m²]
A1	Southern edge	ground-mounted	20,280
A2	closed to road	ground-mounted	6,900
A3	NE corner	ground-mounted	4,000
A4	next to Digester & Thickener Building	ground-mounted	850
A4'	next to Digester & Thickener Building (small)	ground-mounted	512
A5	Workshop	roof-top	190
A6	Digester & Thickener Building	roof-top	400
A7	Preparation & Primary Clarifiers	roof-top	550
A8	Sludge Dewatering Building	roof-top	400
A9	SE corner	ground-mounted	3,180
A10	IB embankments	ground-mounted	5,600
A11	IB embankments	ground-mounted	4,550
Total WWTP areas			**47,412 m²** (47 ha)
A12	Waqf land for recovery scheme	ground-mounted	30,000
A13	Mechanical Room at recovery scheme	roof-top	391
A14	Electrical Building at recovery scheme	roof-top	217
Total Recovery Scheme			**30,608 m²** (31 ha)
Grand Total			**78,020 m²** (7.8 ha)

All areas have been visited and assessed during the site visit except the areas A3, A9, A10 and A11 where access was either not possible due to security reasons or difficulty of access to it during the short time on site. But all areas were visually screened from high-standing points.

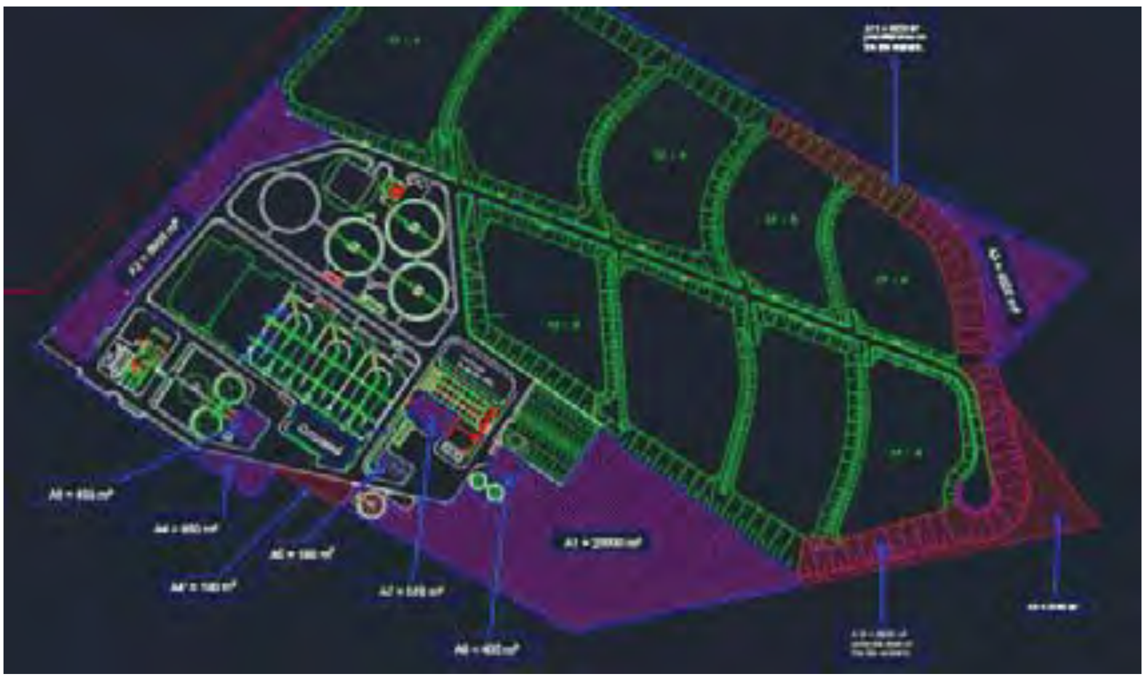
It is not expected that the terrain and characteristics differ from the other areas. Based on existing data on the areas, i.e. from the digital elevation model of the area, topographic survey and topographic maps, the slope and shape of the terrain can be confirmed.

[1] CAD-file “01 - Updated DWG - Final Grid Survey 23.2.2015_Coord Isr 1989 17.3.2015.dwg” submitted on 17.03.2015 by PWA

2.3 PV Areas within Treatment Plant Boundary

Within the treatment plant, suitable space is available on the roof-top of all major buildings with the exception of the power house (“Blower and Energy Building”). The areas around the facilities’ installations Open space for ground-mounted systems are available at the boundaries of the plant. The areas are shown in **Error! Reference source not found.**.

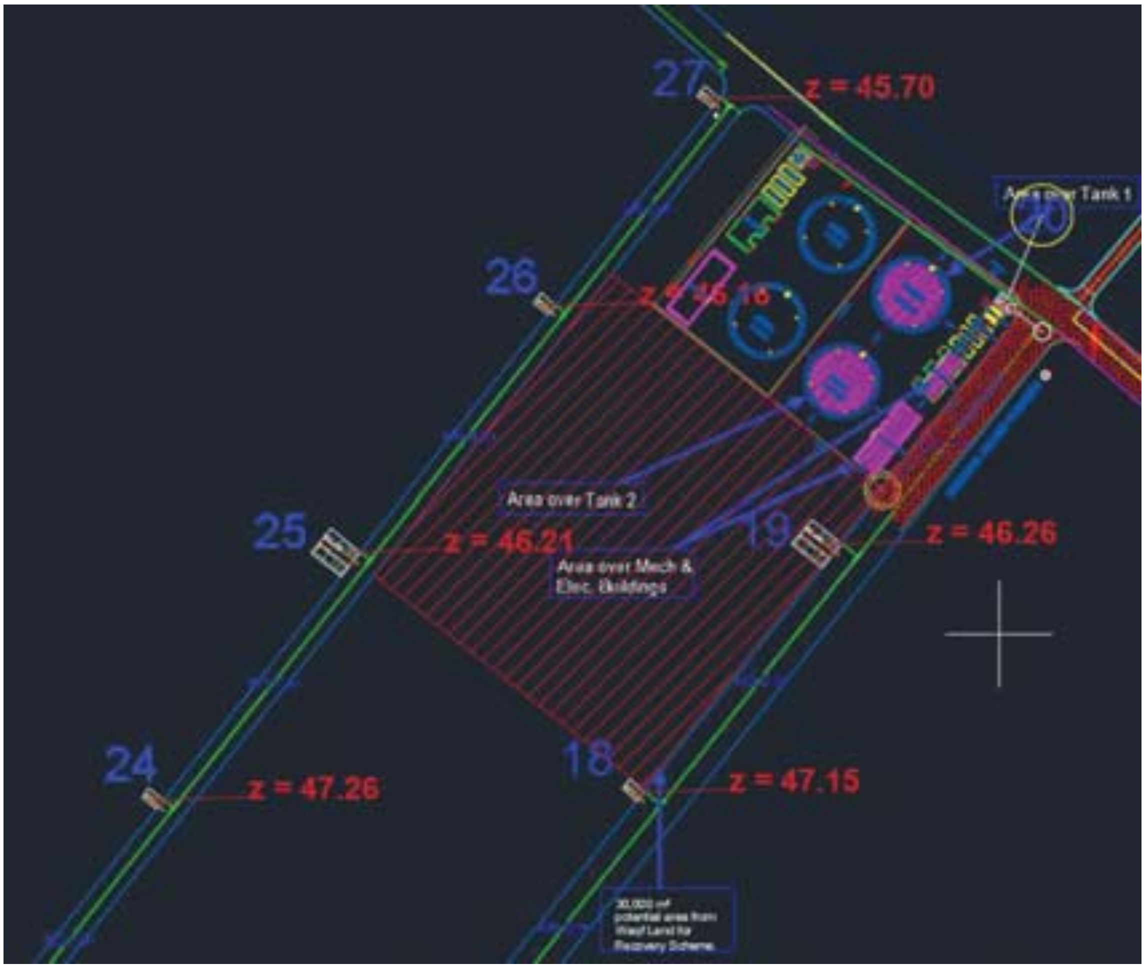
Figure 2-3: Designated areas within treatment plant boundary



2.4 PV Areas at Recovery Scheme

The second location with designated PV areas is the effluent recovery scheme behind the cemetery. It can be reached either via a untarred road from Jibaliya or by following the road along the plant's fence and then branching left at the Northern site corner. These areas are illustrated in Figure 2-4.

Figure 2-4: Designated areas at the recovery scheme



2.5 Summary and conclusion on suitability of the site

A more detailed documentation of the site including photos of the principal consumers of the treatment plant and the existing power supply infrastructure is provided in the ANNEX, section 12.1.

The key findings described in the previous sections, especially with regards to the potential PV system, are summarised in Table 2-2.

Table 2-2: Summary of key facts of the site and major findings

Parameter	Characteristic
Basic data	
Coordinates in Lat. (N) / Lon. (E)	31.5056 / 34.5102
Next Village/town	Jibaliya/Gaza City
Next seaport	Gaza City Port / Port of Ashdod
Next airport	Ben Gurion, Israel
General Characteristics	
Climate	semi-arid Mediterranean climate
Area type	Brownfield ground-mounted / roof-top on existing building
Terrain/area topography	Flat with slight slopes
Soil/ground condition	Backfilled material – suitable for ramming
Earthquake risk	medium (similar to the east Mediterranean region)
Natural hazards	No
Environmental Constraints (Lightning strikes, flash flood, dust, bush-fires, etc.)	Dust from landfill and collection lorries, particles from the charcoal production closed by, seasonal dust from agricultural activities
Approximate area	77740m² / 7.774 hectares (77.740 dunums)
Current use of site	Mainly unused, some plantations
Land ownership	Government (NGEST) and community Wakif land (recovery scheme)
Site Identification	NGEST treatment plant / NGEST effluent recovery scheme Individual areas are numbered as A1-A14
Infrastructure and Interfaces	
Road Access for Transport	Tarred road
Water	Currently groundwater
Grid Access	MV OHL 22 kV on-site Connection of PV AC output to power house or building specific LV panels

Parameter		Characteristic
Telecommunication Infrastructure		DSL line of NGEST SCADA, combined use for PV monitoring to be clarified
Supply Infrastructure		via Gaza City for mechanical/civil spare parts or other items via Israel
Restrictions and risks		
On-site objects		No objects on the brownfields All roofs have air-conditioning and water tanks
Surroundings (buildings, roads, external shadowing objects)		None, except for a few lighting poles.
Other external impacts		Proximity closed to the border with Israel
Summary	**positive (advantages)**	• Terrain is already secured and prepared • Good infrastructure • High radiation potential • No external shading objects
	negative (Risks)	• Scattered areas, many of them rather small • Roofs with facilities reducing the effective area and casting (limited) shadow • Electrical infrastructure (e.g. cable trenches, panels, boards) already installed without consideration of PV • Potential high dust emission from landfill, charcoal production and roads
Conclusion and Recommendation		• Construction of WWTP shows quality and good workmanship • Installation of PV systems is possible • Combination with biogas as on-site hybrid generation plant is possible • Grid support, or operation of emergency diesels, may still be necessary depending on the demand curve and the expansion sizes of the NGEST project • A tight planning between the PV system

Parameter	Characteristic
	planning and NGEST expansion to phase 2 necessary, especially for the effluent recovery scheme. • Recommended to use PV panels tested and certified resistant against ammonium corrosion (IEC 62716) against emissions from the treatment plan • Use a suitable terrain cover to reduce dust emission • Plantation of shrubs towards the border can prevent dust • Consider upgrading the road • Re-assess of some cable trenches could be used • Use the same design configuration at least for similar areas; for ground-mounted and for roof-top to facilitate O&M • Review the capability of the overhead feeder for future phases

2.6 Environment Conditions and Resources

2.6.1 General Climate Conditions

Gaza Strip enjoys a typical Mediterranean weather conditions with one wet and one dry season. The wet season extends from October through April and the dry season extends from May – September. The average rainfall varies from less than 200 mm in the south to nearly 500 mm in the north. Average rain intensity is 45 mm/hr, but often exceeded in storm events (60 mm/hr). The average is 25°C (min 11.6 - max 31) while average humidity is at 68%.

The ANNEX, section 12.2, contains a more comprehensive description of the environmental conditions and climate.

2.6.2 Reference irradiation and temperature (finalise)

The P50 and the P90 TMY provided with the Solar Atlas have been used for simulation of PV system and calculation of the energy production.

The TMY data set corresponding to the probability of exceedance of 50% (P50) for a representative site in Gaza was used as meteorological input data. The data for this site was generated as part of the Solar Atlas. The location has distance of about 4 km to the NGEST site as shown in Figure 2-5. On the basis of the previous research[2] the data generated for this representative location can be used for the design without significantly increasing the uncertainty.

[2] Zelenka A, Perez R, Seals R, Renne D (1999): Effective accuracy of the satellite-derived hourly irradiance, Theoretical and Applied Climatology, 62:199–207

Figure 2-5: Distance of NGEST site to Gaza data location from Solar Atlas

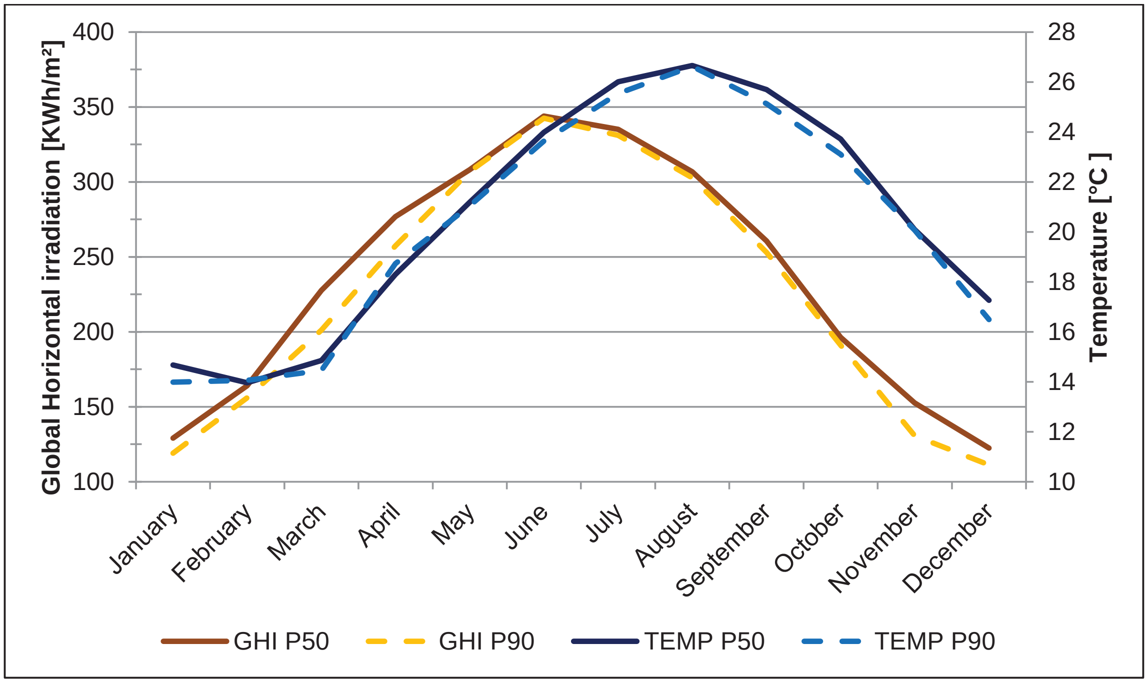
The monthly values of the imported data are shown in **Error! Reference source not found.**.

Table 2-3: TMY data for P50 and P90 case for Gaza City

Month	P50		P90	
	GHI P50	TEMP P50	GHI P90	TEMP P90
January	129	15	119	14
February	164	14	156	14
March	228	15	201	14
April	277	18	257	19
May	308	21	307	21
June	344	24	342	24
July	335	26	331	26
August	307	27	303	27
September	261	26	253	25
October	196	24	191	23
November	153	20	131	20
December	122	17	111	16
Annual	**2823**	**21**	**2703**	**20**

The annual course of radiation and temperature as most important meteorological parameters is shown in Figure 2-6.

Figure 2-6: Annual course of irradiation and temperature



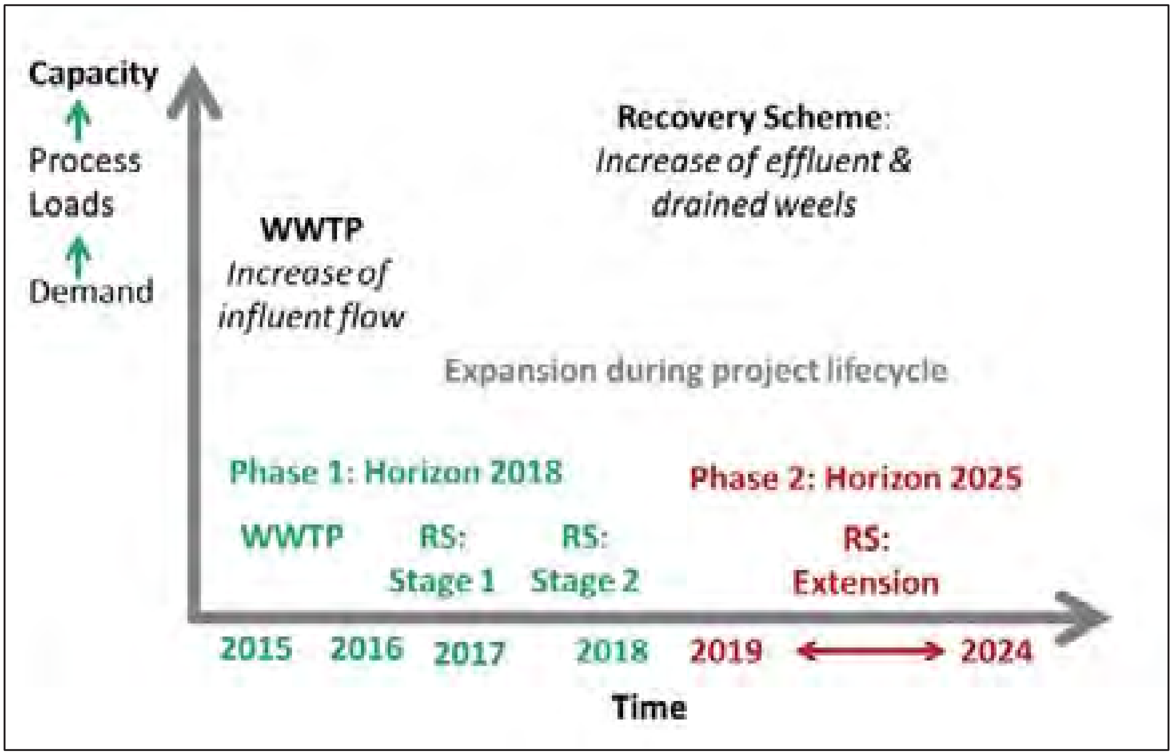
Global Horizontal irradiation [KWh/m²]
400
350
300
250
200
150
100
Temperature [°C]
28
26
24
22
20
18
16
14
12
10
January
February
March
April
May
June
July
August
September
October
November
December
GHI P50
GHI P90
TEMP P50
TEMP P90

3. Analysis of Loads and Consumption

3.1 Design Loads

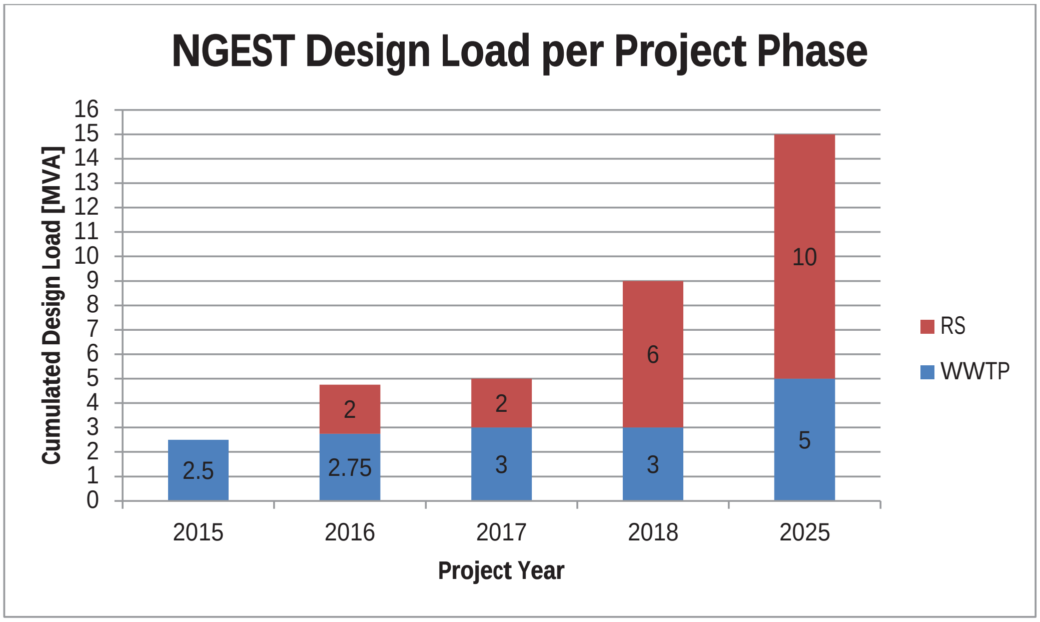
As outlined in the introduction, section 1.2, capabilities of wastewater processing and volume of effluent pumping will be scaled up during the project phases and extension stages. Likewise, energy consumption rises propositionally and requires an upgrade of the capacities. This development of energy demand, process loads and the resultant requirement on increased generation capacity during the project lifecycle is illustrated in **Error! Reference source not found.**.

Figure 3-1: Energy demand, process loads and power requirements over project lifecycle



During the planning and design of the WWTP and RS, the individual process components had been selected in accordance with the estimated inflow volume. Based on the power consumption and operation time of each device the total design load of each phase was determined. As shown in **Error! eference source not found.**, the total design loads will reach 9 MVA in Phase 1 (until 2018) and 15 MVA in Phase 2 (until 2025).

Figure 3-2: Installed and projected design loads during project lifecycle



The details of the demand profiles of the two locations at each phase are discussed in the following sections. This demand analysis forms the basis for the later energy balance described in section 7.2.

3.2 Waste Water Treatment Plant (WWTP)

The file "Consumers rev.01.10" received from PWA lists the demand details of the water treatment processes related consumers in the WWTP. For extracting the load profile of these consumers, some assumptions are taken into consideration:

- The profile of the inflow from the TPS is the single driver for the flow pattern at the WWTP.
- The given hours of operation are plotted in a daily profile considering the durations and load factors in the file. According to the discussion with PWA, the components which do not work continuously for 24 hours are estimated to form a peak load during the noon time, resulting the corresponding adjustment of the daily starting time of each consumer according to its daily operation hours, e.g. consumers with 8 hours of operation start at 08:00, consumers with 4 hours of operation start at 10:00 …etc.
- There is no seasonality of inflow taken into consideration and consequently the daily profile of the WWTP is assumed to have similar characteristics throughput the whole year.
- Assumed power factor of 0.8 applied to all design loads and power sources within NGEST[3]

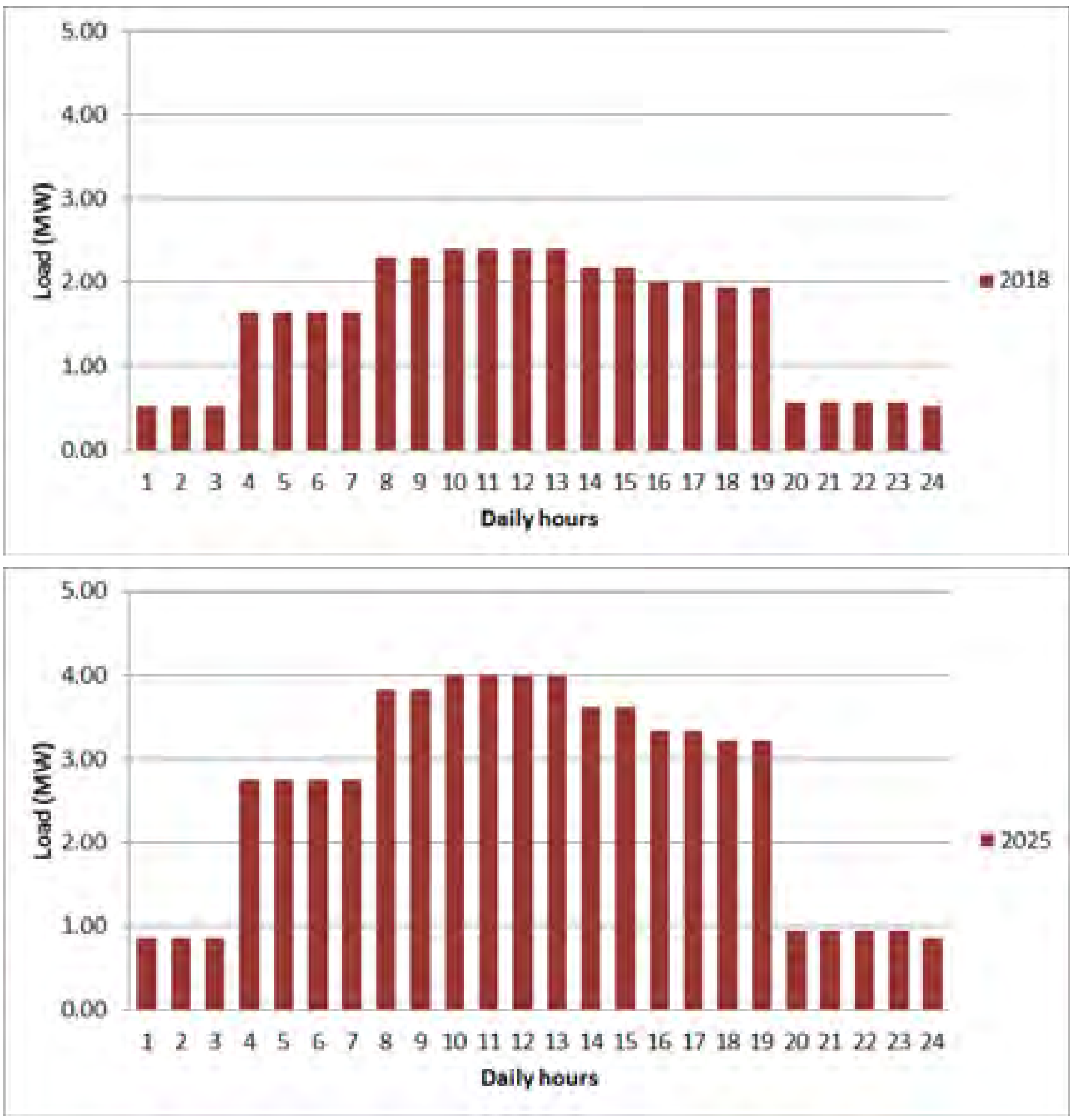
The demand of the WWTP per day for Phase 1 has a daily peak load of 1.3 MW and a daily energy consumption of 19.75 MWh. This process based demand was scaled from 1.3 MW to match the total

[3] Information and data on total design load [MVA] by PWA assumes the power factor 0.8 whereas the consumer data states demand of daily energy [kWh/d]

design load values provided by PWA in Table 12-16 for each year (see also Figure 3-1). The scaling difference makes up the fixed consumption for lighting and security system, HVAC, control and general purpose sockets.

The daily profiles of the years 2018 and 2025 are shown in **Error! Reference source not found.**. The esulting power consumption in 2018 is 37.31 MWh (46.63 MVAh), while the consumption in 2025 is 62.18 MWh (77.72 MVAh).

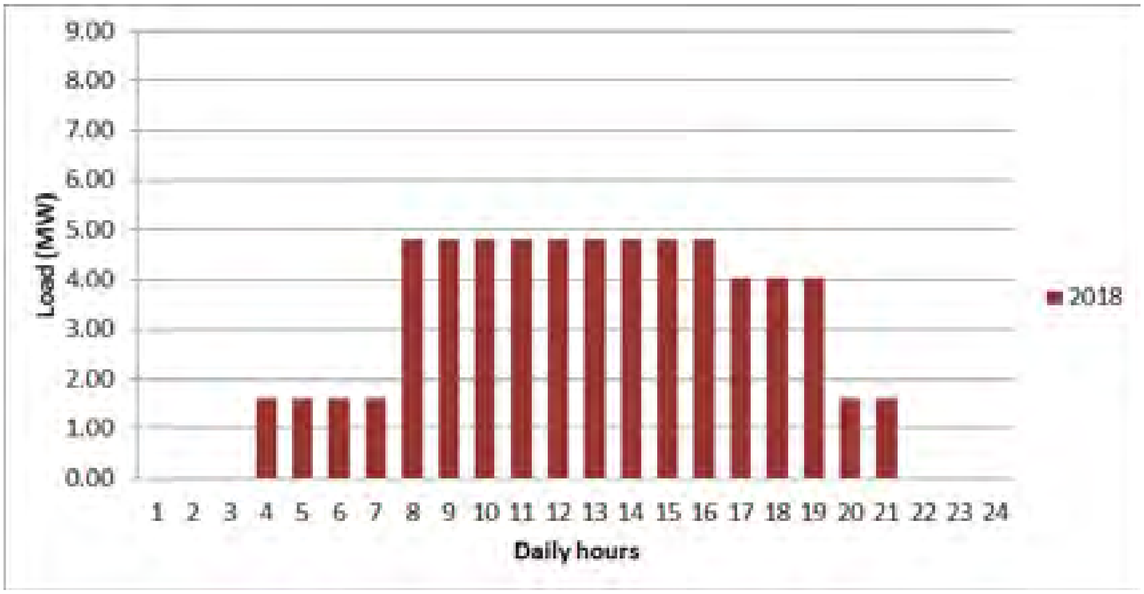
Figure 3-3: Daily load profile at WWTP for horizons 2018 and 2025

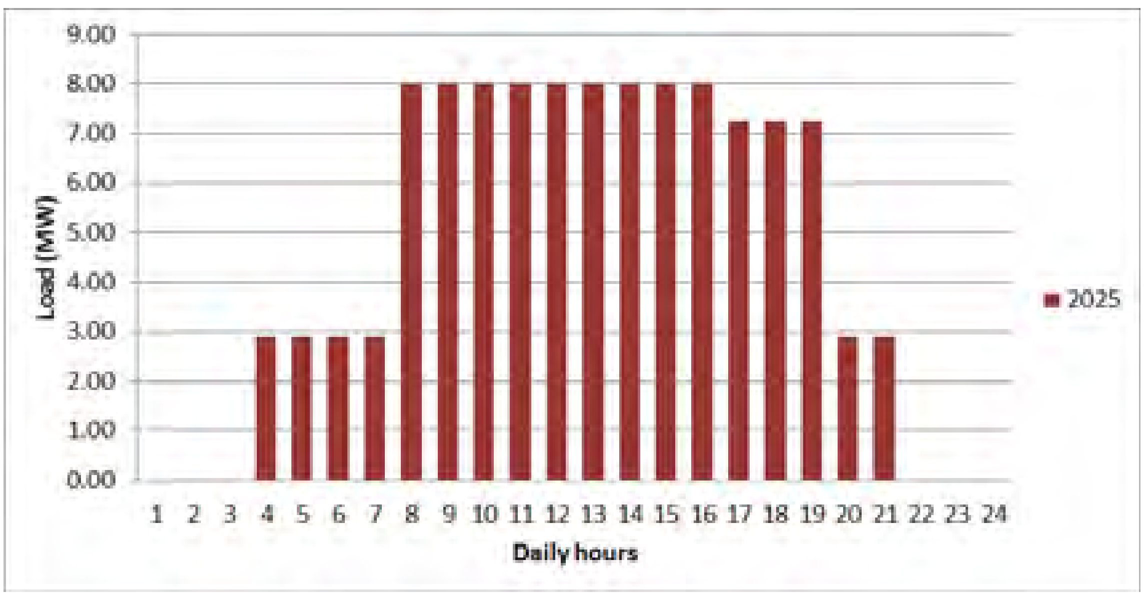


3.3 Recovery and Reuse Scheme

Based on the data received from PWA (Table 12-16), the designed load for the recovery and reuse scheme is 2 MVA for Stage 1, 4 MVA for Stage 2 and 4 MVA for the extension resulting in 10 MVA for the whole scheme. The demand at the RS is made of two functions, the strong booster pumps and the recovery wells. The consumption of the wells is calculated directly from the provided data (55 kW/unit working for 6 hours per day). The total consumption of the pumps has been scaled in such way that consumption tops up the demand of the wells and thus reaches the designed load frame mentioned before (10 MVA) while applying the different utilisation factors of the devices. The total of the daily load profiles of the wells and pumps in the recovery and reuse scheme in Stages 1 and 2 expected for 2018 is plotted in Figure 3-4. The total energy consumption per day is 64.85 MWh (81.06 MVAh). After the implementation of the Recovery Scheme extension in 2025, the resulting daily shown profile in Figure 3-4 totals to a daily energy consumption of is 111.17 MWh (138.96 MVAh).

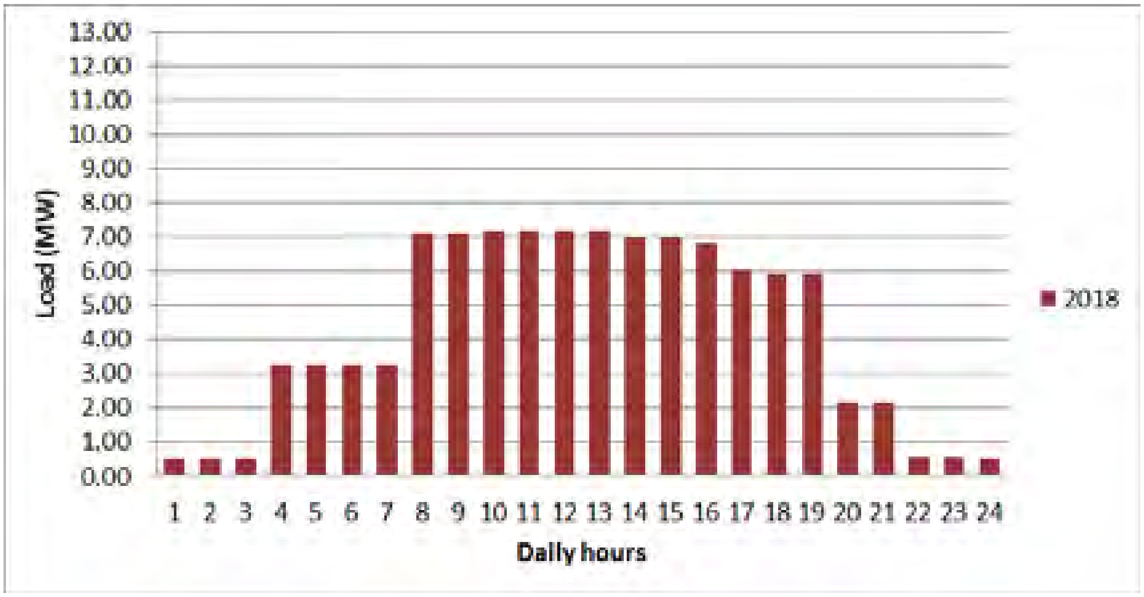
Figure 3-4: Daily load profile of recovery and reuse scheme for 2018 and 2025

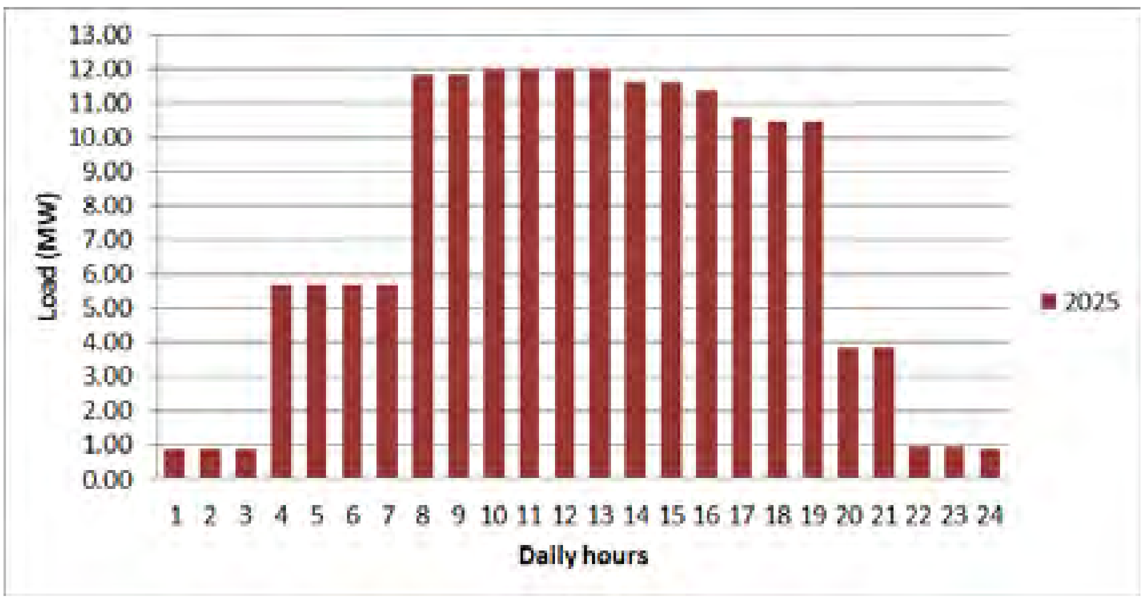




Adding the loads and consumption at two locations allow to concluded on the overall daily profile and demand. Figure 3-5 elaborates the total daily demand of NGEST in 2018 and 2025. As shown in the figure, the peak load reaches 9 MVA in 2018 and the power consumption is 102.15 MWh (127.69 MVAh), while in 2025, the peak load reaches 15 MVA and the power consumption is (181.52 MVAh).

Figure 3-5: Daily profile of the total demand of NGEST in 2018 and 2025





Since no seasonality is taken into consideration and a constant power factor of 0.8 is assumed the annual demand can be calculated as shown in Table 3-1. The total annual energy demand in 2018 is 37,286 MWh and in 2025 is 63,271 MWh.

3.4 Total demand

The project demand is summarised in table Table 3-1.

Table 3-1: Annual demand summary of NGEST in 2018 and 2025

NGEST Components	Annual Energy Consumption			
	2018		2025	
	MVAh	MWh	MVAh	MWh
WWTP	17022	13617	28369	22696
Recovery Scheme (Stages 1 & 2)	29586	23668	29586	23668
Recovery Scheme Extension	0	0	21134	16907
Total	**46607**	**37286**	**79088**	**63271**

4. Current Power Supply

4.1 Power Supply as per Current Concept and Design

The current power supply concept – as a result of the general concept and the Contractor's design – consists of the following components:

1) External supply from the GEDCo grid via a 22 kV overhead feeder line which is described and assessed in section 4.1.
2) On-site generation from emergency diesel generators described and reviewed for their capability to support further diversification of the generation portfolio in section 4.8.1.
3) On-site generation from biogas as by-product of the sludge treatment cycle described in section 4.8.2.

After having reviewed the existing design and related documents (design review report, engineer's approval notes, data sheets etc.) the design process for the above components can be described as follows:

- The design load was derived from the maximum consumption resulting from the total of the fixed consumption of the general operation and the variable demand arising from the treatment plant process components.
- The diesel generators were designed to cover the fixed and variable load under the assumption that not all components are operating at the same time and even consumption would follow different patterns throughout the day (e.g. no lighting during day time, less need for HVAC during night).
- The dimensions of the biogas engine and related components like gas holder and gas flare are derived from the estimated daily gas production resulting from the sludge processing.
- The grid supply was installed to meet the full design load at phase 1.

This means that the current design already incorporates and ensures

- Supply of a large part of the demand dependent of the availability of the grid supply
- Maximum possible utilisation of the existing biogas generation

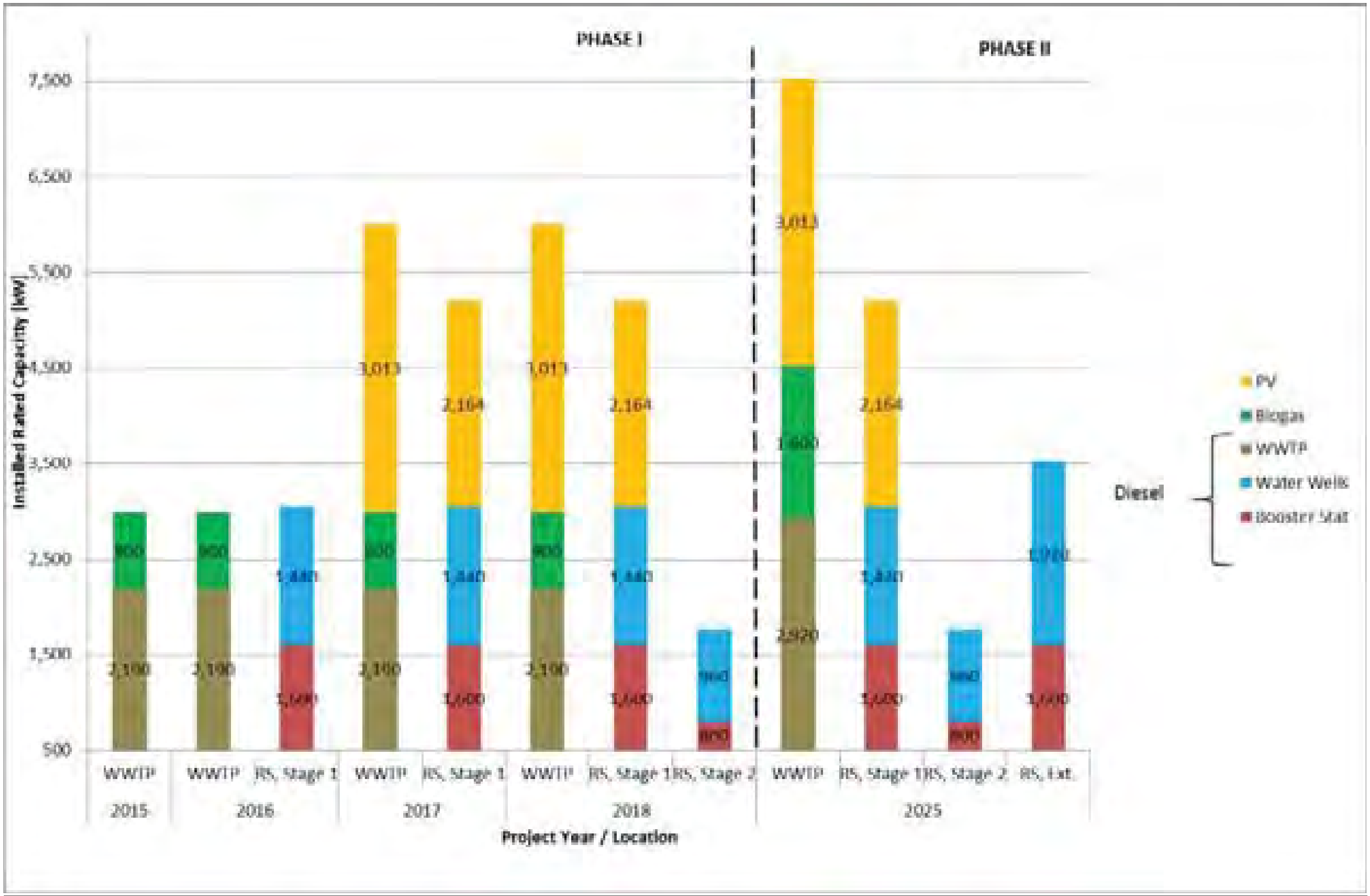
In the next section 5.1, the modification of this setup by adding a PV system as additional on-site generation option is briefly described.

The number of planned generation units and the individual power rating corresponding to each unit are listed in Table 4-1. The illustration of the resulting on-site generation capacities in Figure 4-1 provides a good overview of the power sources installed at NGEST.

Table 4-1 Overview on generation units and capacities corresponding to the project timeline

Phase / Horizon		Phase I / 2018								Phase II / 2025			
Installation year		2015	2016		2017		2018			2019			
Number of units / sub-systems (rating per unit / sub-system)		*WWTP*	*WWTP*	*Recovery Scheme*	*WWTP*	*Recovery Scheme*	*WWTP*	*Recovery Scheme*		*WWTP*	*Recovery Scheme*		
				Stage 1		*Stage 1*		*Stage 1*	*Stage 2*		*Stage 1*	*Stage 2*	*extension*
Diesel	WWTP [kW]	3 (730)	3 (730)		3 (730)		3 (730)			4 (730)			
	Booster Station [kW]			2 (800)		2 (800)		2 (800)	1 (800)		2 (800)	1 (800)	2 (800)
	Water wells [kW]			3 (480)		3 (480)		3 (480)	2 (480)		3 (480)	2 (480)	4 (480)
Biogas [kW]		1 (800)	1 (800)		1 (800)		1 (800)			2 (800)			
PV [kWp]					12 (3012.88)	3 (2164.24)	12 (3012.88)	3 (2164.24)		12 (3012.88)	3 (2164.24)		

Figure 4-1: Total installed generation capacity per project year and location



4.2 External Supply GEDCo Distribution Network

4.3 Brief Description of GEDCo

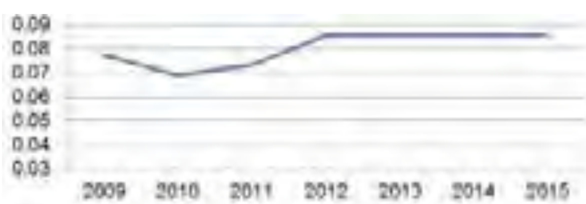
GEDCo is mandated to distribute electrical energy to all areas within the Gaza strip under the control of Palestinian Authority. Its responsibilities reach from billing, technical supervision and maintenance works, to improvement of the supplying system of the low voltage (0.4 kV) and the medium voltage network (22 kV). GEDCo is the sole provider of electricity services in Gaza.[4]

GEDCo is a private limited company owned to 50% by the Palestinian National Authority (PNA) and 50% by local municipalities and councils. The corporation was established in 1998 by ministerial decree and all duties of electrical energy distribution were transferred from the different municipalities in the Gaza Strip to GEDCo. Overall, the corporation delivers services through 5 branches in the Northern district, Middle area, Khanyounis, Rafah and Gaza city, distributing energy to 1.8 million Palestinians.

Its distribution system in the Gaza strip is configured to supply the load centres using power from the IEC supply sources and the GPP respectively including a portion of energy purchased from Egypt.[5] Due to its control over the only three external power supply options of Gaza, it also has a price monopoly.

Furthermore, even though the Palestinian Territories have a unified sales tariff, GEDCo sets its own tariffs. As shown in Figure 4-2, these tariffs did not fluctuate over the last 3 years:

Figure 4-2: Average sales price Gaza (excl. VAT/in USD)



GEDCo's mark-up price and margin are particularly low when compared to the tariffs in the region, mostly due to the daily electricity cuts of 6-12 hours. Moreover, political reasons also influence the low retail price policy.

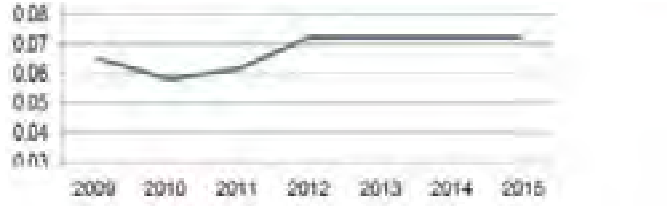
The tariff margin – the difference between the purchase and the sales price – in Gaza is currently at 16%[6]. This margin should allow the conclusion that the purchase prices over the last couple of years looked as in Figure 4-3.

[4] http://www.gedco.ps/en/index.php, accessed on 30 March 2015

[5] World Bank Report, West Bank and Gaza Energy Sector Review, (2007)

[6] World Bank Report, Assessment and Action Plan to improve payment for electricity services in the Palestinian Territories, (2014)

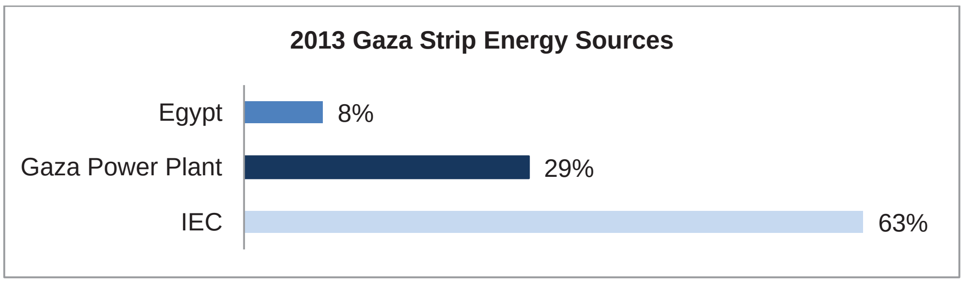
Figure 4-3: Average purchase price Gaza (excl. VAT/in USD) [7]



4.4 Power Purchase Sourcing

The Gaza strip has, as already mentioned under Chapter 4.3 three different energy sources. The different share of these types on the total supply is presented in Figure 4-4 for 2013

Figure 4-4: Share of energy purchase sources on total supply



There was unfortunately no information available on the sales tariff structures of GEDCo's three energy sources. GEDCo only clusters its customers in three categories but does not indicate the different source-purchase prices behind the overall tariffs as shown in Table 4-2.

[7] The data for the calculation of the average sales and purchase prices incl./excl. VAT were taken from the World Bank Report, Assessment and Action Plan to improve payment for electricity services in the Palestinian Territories, (2014) and is based on the assumption that GEDCos tariff margin is 16%

Table 4-2: GEDCo's customer categories and corresponding tariffs

Category	Users[8]	Range	Tariff (03/2015)[9] incl. VAT	Tariff (03/2015) excl. VAT
1	Residential	1-200 kW	0.11 USD/kWh	0.09 USD/kWh
2	Commercial	>201 - <1000 KW	0.13 USD/kWh	0.10 USD/kWh
3	Industrial users connected at low voltage level, industrial users connected at medium level, water pumps, agricultural areas, street lights and temporary services	>100 - <500 KW	0.15 USD/kWh	0.13 USD/kWh

Nonetheless, the following chapters 4.4.1, 4.4.2 and 4.4.3 will highlight the most important influencing factors of each source on NGEST's energy supply.

4.4.1 Domestic Production by Gaza Power Plant (GPP)

29 % of electrical energy used in the Gaza Strip come from the fuel operated Gaza Power Plant.[10] The plant suffers from inadequate fuel supply due to sanctions from Israel and high taxes imposed, reducing the overall electricity production of GPP by up to 50%. This results in a broad load shedding scheme including severe blackouts. The power station requires a minimum of 400,000 litres of industrial fuel per day to produce 65 MWh. The access to this fuel however is not secured.

GEDCo can thus not guarantee a complete and constant power supply through Gaza and is stating this in its power supply agreement with PWA for the supply to the NGEST, signed in September 2013[11]. Thus the Grid will not be able to be used as an only source for NGEST power supply.

4.4.2 Sourcing from Israel (IEC)

Next to the domestic production of power, GEDCo is supplying NGEST with electricity from Israel. Overall the Palestinian Territories are largely dependent on imported energy from adjacent countries. 88% of this energy comes from Israel through the Israeli Energy Corporation (IEC).

The relation with the IEC is however strained as non-payment for the imported energy is a large issue. 58% of IEC's total costs for the energy delivered were not paid for over the last couple of years, still trending upward and not exempting Gaza. In addition, GEDCo is the largest non-payer among the distribution companies in the territories, with an accumulated debt of 471 million USD, representing 42% of the overall debt. [12]

[8] World Bank Report, Assessment and Action Plan to improve payment for electricity services in the Palestinian Territories, (2014)
[9] Information on current tariff received from GEDCo Customer Service by phone
[10] World Bank Report, Assessment and Action Plan to improve payment for electricity services in the Palestinian Territories, (2014)
[11] Power Purchase Agreement GEDCo/PWA of 23 September 2013, supplied to Consultant by PWA officials
[12] World Bank Report, Assessment and Action Plan to improve payment for electricity services in the Palestinian Territories, (2014)

Even though the largest part of the power supply could come from Israel, the issue of non-payments and the unstable political situation does not allow this. Nonetheless, GEDCo is dependent on the Israeli supply and includes this source in the general purchase cost structure.

4.4.3 Sourcing from Egypt

8% of the electrical energy used in the Gaza Strip is delivered through imports from Egypt[13]. GEDCo purchased 124,521 MWh from the neighbouring country in 2012 at a cost of 7,318,119 USD (purchase price 0.05 USD/kWh).[14] Egypt, as a supply source of electrical energy, makes up a part of GEDCo's general purchase cost structure.

4.5 Economic Review

Based on the information gathered and presented above an economic review of GEDCo's tariff structure was conducted. The following inputs were considered for the economic review:

Global data:

Assessment period:	20 years
First year of assessment:	2015

GEDCo tariff to NGEST:[15]

0.15 USD/kWh incl. VAT
0.13 USD/kWh excl. VAT

Specific financial parameters:

Discount rate:	7%
VAT:	18%

The Levelized Cost of Electricity has been obtained using this formula:

$$LCOE = \frac{I_0 + \sum_{t=1}^{n} \frac{A_t}{(1+i)^t}}{\sum_{t=1}^{n} \frac{M_{t,el}}{(1+i)^t}}$$

LCOE	Levelized cost of electricity in Euro/kWh
I0	Investment expenditures in Euro
At	Annual total costs in Euro in year t
Mt,el	Produced quantity of electricity in the respective year in kWh
i	Real interest rate in %
n	Economic operational lifetime in years

[13] World Bank Report, Assessment and Action Plan to improve payment for electricity services in the Palestinian Territories, (2014)
[14] Estimate based on a kWh price of 0.45 EGP (exchange rate EGP/USD 0.1306)
[15] Tariff according to Sept. 2013 Agreement between GEDCo and PWA

t Year of lifetime (1, 2, ...n)

Variation of LCOE: +/- 5% to +/- 10%

NGEST is currently paying 0.15 USD/kWh (0.6 ILS/kWh incl. VAT) as agreed upon in the power supply agreement between GEDCo and PWA. The NGEST tariff is the equivalent to GEDCo's category 3 sales tariff for "industrial users connected at low voltage level, industrial users connected at medium level, water pumps, agricultural areas, street lights and temporary services".

The end user tariff from GEDCo has been analysed through a calculation of the economic Levelized costs of Electricity (LCOE) over an assessment period of 20 years, starting in the year 2015 under consideration of GEDCo's tariff excl. VAT of 0.13 USD/kWh offered to NGEST.[16]

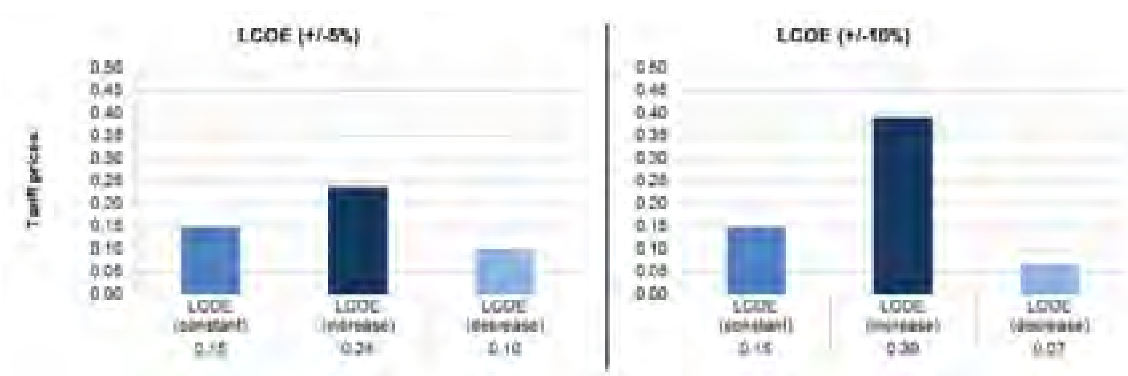
This approach shows what the LCOE would look like if GEDCo were to supply the full energy demand of NGEST. The equivalent evaluation corresponding to the different supply options assessed can be found under section 9.2**Error! Reference source not found.** of this report.

For the LCOE the following variants were considered:

- Constant
- Increase (5 and 10%)
- Decrease (5 and 10%)

The fluctuations were put into place in order to show different price variables and give a better insight into possible future developments, i. e. changes on the agreement between GEDCo and PWA for the power supply of NGEST. Of course the variations in price levels cannot conclusively be assessed over a period of 20 years but the levelization gives a comprehension of constant price, increased price and decreased price. The differences of the LCOE's are shown in Figure 4-5 below.

Figure 4-5: Levelized Costs of Electricity +/- 5 and 10% (prices indicated in USD/kWh excl. VAT)



The constant economic price of 0.15 USD/kWh (excl. VAT) can be predicted for the energy tariff from GEDCO if the price guarantee stays the same. In the variation "increase" it ranges between 0.24

[16] It should be noted that in absence of some relevant information, in particular the percentage of operation costs in relation to the costs of the energy purchased by GEDCo they were estimated at 20%

USD/kWh at 5% and 0.39 USD/kWh at 10%. In the variation "decrease" it ranges between 0.10 USD/kWh at 5% and 0.07 USD/kWh at 10%.

4.6 Technical Capacity of the OHL Connection Line

As described under site conditions, in section 2, the WWTP and RS are connected to the GEDCo network by one 22 kV OHL exclusively built for supply of the project. Based on information provided by PWA, the network connection is exactly designed to provide the design load of 13 MVA targeted for Phase 2. A brief check of the dimensioning of the conductor (3x150/25 mm² ACSR Conductor Type Rabbit) reveals that the line capacity would only be reached if very high ambient temperatures are observed or additional power is routed through this line. Once NGEST will be completely implemented, (Phase 2), there will be no room for feeding of excess energy, i. e. surplus PV power, from NGEST facilities back to the network during the periods of high energy demand at the site or during high temperatures. The solution proposed in section 12.4 fulfils to this constraint.

4.7 Technical Availability of the Grid

Even though the capacity of the connection line is sufficient, the actual capability of the network to supply the required power cannot be confirmed. As mentioned before the availability of electric power supply from GEDCo is not guaranteed at all times due to political reasons/conflicts and especially sanctions on fuel supply for GPP. The distribution company therefore responded to this constraint by implementing a rotational load shedding scheme. The GEDCo network is subject to cuts and connects as follows:

- 6 hrs ON and 12 hrs OFF or
- 8 hrs ON and 8 hrs OFF (depending on fuel available for the GPP)

All users are forced to either remain idle during the blackout times or compensate for the deficit of the grid by installing on-site generators. This pattern is used in the calculation of the energy balance in section 7.2 to assess the extent to which the demand could be covered by the regular network.

4.8 On-site Generation

4.8.1 Emergency Diesel Gensets

The three diesel gen-sets installed at WWTP are of the characteristic presented in Table 4-3.

Table 4-3: Diesel engine characteristics

Parameter	Value
Manufacturer	FG Wilson as container installation
Electrical output	380-415V, 50 Hz
Speed	1500 rpm
Engine make & model	Perkins 4006-23TAG2A
Alternator from	Leroy Somer, LL7024L
Rating by operational mode (*ratings at 0.8 power factor)	
Prime	730 kVA / 584 KW*
Standby	800 kVA / 640 kW*

For the diesel fuel quality the following standards shall be respected:

- ASTM D7467
- EN 590

When assessing the igniting quality the cetane index may serve as reference. In comparison to the biogas engines the diesel engines can be easier operated due to the quick response to an immediate charging or discharging.

4.8.2 Biogas-based Generation

4.8.2.1 Biogas Engine and Sewage Gas

A gas engine generator set with the key properties shown in Table 4-4, taken from the datasheet dated 16.04.2012, is currently installed. Another machine with the same characteristics is planned to be added in the next phase.

Table 4-4: Properties of the gas engine

Parameter	**Value(s)**
Engine:	MWM TCG 2016 V16 C
Speed	1500 rpm
Generator	Marelli MJB 400 LC4
Voltage / voltage range / cos φ	400 V+/ -5% / 1
Frequency	50Hz
Electrical power (COP) acc. ISO 8528-1	800 kW

The fuel for operation of the engine is the sewage gas produced by the water treatment process. In order to allow a smooth operation of the generator, the gas has to adhere to certain properties. The sewage gas shall be dry, when entering the storage tank. Furthermore the sulfur content has to be eliminated by a special process-technology. Otherwise the “inside atmosphere” of the gas engine will create sulphurous acid (H2S) and sulphuric acid (H2SO4) which will cause extensive corrosion problems and shorten the life-cycle.

An important characterising figure is the Methane index. The methane index describes the ignition quality of a fuel gas. A methane value of 100 is presented by methane CH4, a gas with a very high ignition quality resulting in smooth burning without any knocking. In this case it is not necessary to equip such an engine with knocking sensors. A methane number of 0 is presented by hydrogen, which shows a very poor combustion quality with precipitated uncontrolled ignitions.

In terms of ignition quality sewage gas is a very good and acceptable fuel gas. However the high CO_2 content makes the engine very slow in taking step charges. Thus, differing heating values have to be considered. It needs to be mentioned that reciprocating gas engines tend to load fluctuations which are difficult to be handled and eventually will cause vibrations.

4.8.2.2 Biogas Production

Reference to the approved comment notes received by PWA, the average gas production is 6,576 m^3/d, while the peak gas production is 7,307 m^3/d based on the scenario of 2018. In order to obtain the biogas production for the scenario of 2025, the above values are scaled based on the increased capacity of the WWTP in 2025 from 3 MVA to 5 MVA; resulting average gas production is 10,960 m^3/d while the peak gas production is estimated with 12,178 m^3/d.

4.8.2.3 Electricity Generation from Biogas

According to the provided biogas generator catalogue, the electrical output capacity of the generator is 800 kW, with operating hours of 20 hours/day, resulting in an energy generation of 16,000 kWh. The annual electricity production totals to 5,840 MWh/year. An additional biogas generator will be installed by 2018 to be ready for operation 2019 and onward, increasing the electrical output capacity to 1600 kW and annual electricity production to 11680 MWh/year. These are assuming that the required gas amount is available.

4.8.2.4 Potential for Increased Gas Storage

With an electrical efficiency of around 43%, the input energy is 37,420 kWh. The amount of fuel supply needed for satisfying the energy input can be calculated from the fuel specific energy content which is 6.5 kWh/m^3. Accordingly the amount of fuel required per day is 5,757 m^3/d.

The potential of the storage can now be calculated. In 2018 the average storage annual amount of biogas is 819 m^3/d, while in 2025, the average storage is -600 m^3/d, which leads to a lack of gas required to operate the generator at full load.

As a result the potential of gas storage is low; the stored amount is less than 15% of the used amount for fuel input. This amount is too small to justify the addition of an additional generator in Phase 1 or even enlarging the storage. In 2025, gas storage potential is of a negative value. Both values lead to the conclusion that the biogas generations had been sized well to fit the estimated gas production.

5. Photovoltaic System

5.1 Intended Modification by Adding a PV System

The existing configuration summarised above shall be modified by adding a PV system utilising suitable free areas of the project. The aim of the modification is to reduce the operation times and effective load of the emergency diesel generators in order to save fuel. In addition, the supply from the two renewable generation options shall be increased to avoid emissions.

Consequently, the proposal for modification of the existing design consists of:

1) Installation of a PV system on the available areas within and around the NGEST site, described and assessed in section 5.1;
2) Analysis of the potential for an increase of the biogas holder in order to store the produced gas during times of high PV production and balancing of the variable PV output in times of low generation (e.g. evening hours, during cloud cover), described in section 7.2 and;
3) Analysis and identification of adjustments in the energy management and control of the generation systems for optimisation of the interplay of components, especially during times when the project is in off-grid (island) mode as evaluated in section 7.2.5.

The above mentioned aspects will be presented in the following sections from a technical and economic point of view.

5.2 Approach for the PV Design

It is assumed that general knowledge of PV technologies and applications are familiar to the reader. Earlier studies described the general market potential in Palestine and strategies[17] for implementation. The solar resources and energy generation potential[18] have been analysed on country level and renewable energy generation including solar PV technologies were assessed for their contribution to energy supply in Palestine.[19] In addition, a draft for the renewable energy law had been formulated.[20] Especially the report on RE sources provides a good introduction to the technologies, general system set-ups and comparison of typical design variants. Thus, this section on PV design variants will directly present possible solutions responding to the requirements of the NGEST project.

The PV plant concept itself will be developed in a two-step approach:

1) Assessment of variants: definition, description and ranking of possible variants
2) Elaboration of concept design (Basic Design): a design as input to a functional specification on concept-level for the most favourable variant

The assessment of the variants is part of this very important report which is regarded as decision gate

[17] PENRA (2012): Palestine Solar Initiative, Project Report by PwC

[18] PEA (2014): Atlas of Solar Resources – State of Palestine by SolarGIS/GeoModel

[19] PENRA and World Bank (2011): Assessment of Renewable Energy Sources

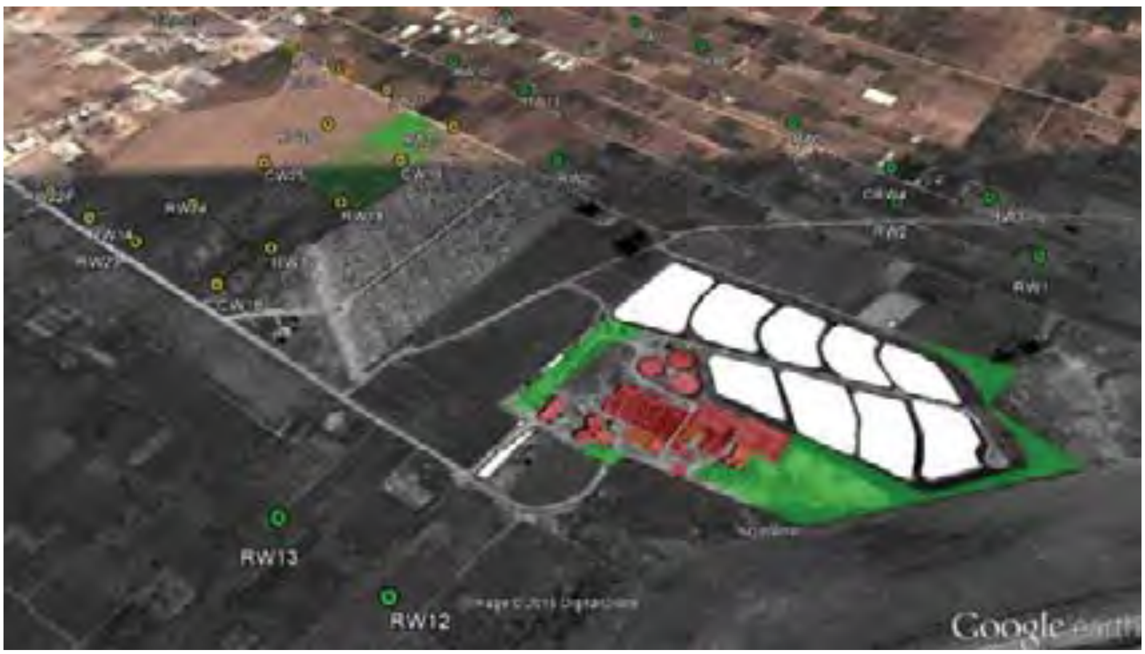
[20] World Bank (2015): General RE strategy law

for the selection of the preferred variant. The concept design of the PV plant and its integration with the rest of the system is then conducted in a second step, the Concept Design and Costing Report.

5.3 PV Contribution at Different Stages

Figure 5-1 shows the planned locations of the recovery and reuse scheme wells. The Google Earth screenshot was provided by PWA (02.04.2015, via email). It separates the wells into the 15 wells to be constructed in Stage 1, depicted with yellow markers, and the 14 wells, signalled by a green marker, proposed for Stage 2. The PV areas in the West to the cemetery are part of Stage 1and 2.

Figure 5-1: Recovery scheme wells for stage 1 (yellow) and for stage 2 (green)



5.4 Planning Target and Design Conditions

The general design target for the PV plant is to achieve maximum output though a cost-effective configuration and while making as much as possible use of the allocated areas.

The overall design conditions reflect the general target of the study:

- The overall utilisation of the local energy sources (biogas and PV) shall be maximised and together with the emergency diesel allow to operate the NGEST during load shedding – the times when the incoming 22 kV is down.
- The use of biogas and its potential storage shall be maximised to introduce a possibility to react on the intermittency of the PV output.

More specifically, the PV plant will be designed to adhere to the following technical design conditions:

- on grid PV plant tied-in and managed by the NGEST SCADA – meaning that the grid (i. e. voltage, frequency) will be built by another component and the PV system will synchronise thereon
- using available boundary areas for ground mounted generators and roofs of the major buildings as provided by PWA / NGEST and thus consisting of a PV plant with several sub-systems
- Proven technology shall be used for the system components
- The PV output shall be maximised by the choice of
    - appropriate technologies for key components
    - a suitable connection to the LV and HV distribution panels
    - optimum plant geometry: tilt angle, azimuth, etc.
- The plant configuration shall aim to optimise the plant power production in such way that the peak production during the day with the least production during the year is maximised.
- Since the aim of the PV system is to supply actual energy for supplying the demand of NGEST, its design shall be developed in a way that maintenance can be performed easily by trained and skilled local technicians and the requirement for specialised spare parts is reduced as much as possible.
- The integration with the electrical infrastructure of the NGEST project shall allow an uninterrupted operation of the treatment plant facilities itself and seamless co-operation of all components of the power supply system.

5.5 Possible Design Variants of the Potential PV System

5.5.1 Description of Possible PV System Configuration Options

The basis for the development of the PV variants is the CAD drawing[21] with the designed PV areas defined by PWA.

In a first step, the technologies for the main components were pre-selected.

- Crystalline silicon technology was regarded as preferred cell technology for the PV modules, based on the track-record and market share of such modules. The higher rated capacity of the c-Si modules when compared to other technologies such as thin film module would also lead to a higher yield per available area. Nevertheless, the potential higher output of c-Si based PV arrays shall be demonstrated by comparing simulation results of the c-Si variant with the highest production against the results of an alternative use of thin-film.
- De-central multi-string inverters are expected to be most appropriate choice for NGEST due to the simple handling and easier maintenance procedures of this small and light but yet well performing inverter type. The resulting topology of the PV arrays would allow for a high level of flexibility in the design and installation. Since the inverters are attached to the mounting structures or installed on the roof-top space need for DC cabling over long distances is reduced and the outgoing AC cables could be connected at any suitable location in the electrical infrastructure of NGEST project (e.g. the LV panels of buildings).

In consequence, the possible PV design variants are mainly determined by the adaptation of PV arrays and structures to the geometry of the designated areas and the available mounting structures in-

[21] 01 - Updated DWG - Final Grid Survey 23.2.2015_Coord Isr 1989 17.3.2015.dwg

cluding variations main configuration parameters thereof (i.e. tilt angle and azimuth).

The possible configuration options for the roof-top areas are:

1) Fixed structures with optimum orientation at azimuth 0° – i.e. modules facing true south – and using the optimum tilt angle
2) Fixed structures with geometry adjusted orientation where modules aligned to follow the geometry of the area (i.e. in parallel to the roof edges) and tilt angle is modified in such to maximise installation capacity, if appropriate
3) Fixed structures but with East-West orientation and a lower inclination angle

For the brownfield areas where ground-mounted structures will be used, more mounting options are available:

1) Fixed structures with optimum orientation at azimuth 0° – i.e. modules facing true south – and using the optimum tilt angle
2) Fixed structures with geometry adjusted orientation where modules aligned to follow the geometry of the area (i.e. in parallel to the main area borders) and tilt angle is modified in such to maximise installation capacity, if appropriate
3) Fixed structures but with East-West orientation and a lower inclination angle
4) A series of 1-axis tracker arrays
5) Two-axis trackers which can be installed on all available areas and additionally the banks between the infiltration basins.

5.5.2 Preliminary Qualitative Evaluation of PV System Configuration Options

After an initial qualitative evaluation of the above listed configuration options, the following set-ups and areas can be discarded:

- The roof spaces on the silos and towers are not considered further due to the circular geometry and small area.
- The East-West configuration, depicted in Figure 5-2, which became increasingly popular in recent years, mainly for roof-top systems, offers the advantage of installing high module capacities by saving considerable on row-to-row space and additional produces a smother daily generation profile – both effects which are generally favourable for NGEST as well. But the set-up was discarded because the reduced access space to the modules and string cabling would require profound experience in maintenance. Since the areas are not strictly oriented in East-West/North-South direction nor do they all have a rectangular shape, the effect of higher capacity would not be leveraged on all areas. Given that maintenance will probably be executed by trained technicians also responsible for other components at NGEST and thus not being full-time PV specialists, access to the components for fault detection and defect remedy should be easy and most areas should have similar configuration, this variant was eliminated from further analysis.
- One-axis trackers, similar to the two-axis trackers, allow for higher yields by tracking the sun position in one or two dimensions throughout the day. Although such installations would theoretically allow to increase the share of PV penetration in the power supply, such trackers show their benefit in larger multi-megawatt power plants where area is not the limiting factor and investors aim to optimise on return rather than on share on power supply. Apart from this general observation 1-axis trackers require a larger width of the area because the concept is based on one or many module tables connected to one or more central drive (motor) via a

gear or lever arms. The geometry and size of the areas make it hard to meet these requirements. 1-axis trackers are included in the further analysis for the sake of completeness and to support this preliminary evaluation with actual results.

- The situation with the 2-axis trackers is slightly different. Similar as for the 1-axis trackers a considerable space is required around each tracker structure to avoid that shadow from one tracker is casted on other trackers installed around. Thus the distance between structures is higher than for the fixed structures. Since 2-axis trackers use single-pillar foundations instead of the multiple pole foundations aligned in longitudinal rows used by 1-axis trackers, this mounting option allows for more flexibility and thus could potentially be installed at locations of the terrain where other mounting structures would not fit, i.e. the high slopes of the infiltration basin embankments or the dams between the basins.

Summarising, the three mounting types – East-West, 1-axis tracking and 2-axis tracking – are not regarded as suitable for the design conditions. The tracked variants are included in the further assessment of variants in order to a factual reason for this judgement.

Figure 5-2: East-West orientation on a roof-top, press photo by manufacturer Renusol

5.5.3 Definition of the PV System Variants

The complete PV system variants have been formed by a combination of the corresponding roof-top and ground-mounted configuration options. Based on the qualitative evaluation in section 5.5.2 and under consideration of the planning target as well as design conditions the following possible variants have been defined:

1) Variant 1 – fixed structures with orientation true south with c-Si modules
    a. **Roof-top area:** fixed structures with optimum orientation at azimuth 0° – i.e. modules facing true south – and using the optimum tilt angle
    b. **Ground mounted:** fixed structures with optimum orientation at azimuth 0° – i.e. modules facing true south – and using the optimum tilt angle
    c. Characteristic: maximised output per capacity installed
2) Variant 2 – fixed structures with geometric adaptation with c-Si modules
    a. **Roof-top area:** fixed structures with geometry adjusted orientation where modules aligned to follow the geometry of the area (i.e. in parallel to the roof edges) and tilt angle is modified in such to maximise installation capacity, if appropriate
    b. **Ground mounted:** fixed structures with geometry adjusted orientation where modules aligned to follow the geometry of the area (i.e. in parallel to the main area borders) and tilt angle is modified in such to maximise installation capacity, if appropriate
    c. **Characteristic:** maximised capacity per available area
3) Variant 3 – one-axis tracker with c-Si modules
    a. **Roof-top area:** fixed structures with optimum orientation at azimuth 0° – i.e. modules facing true south – and using the optimum tilt angle
    b. **Ground mounted:** 1-axis tracker arrays
    c. **Characteristic:** maximised capacity per available area
4) Variant 4 – 2-axis tracker with c-Si modules
    a. **Roof-top area:** fixed structures with optimum orientation at azimuth 0° – i.e. modules facing true south – and using the optimum tilt angle
    b. **Ground mounted:** 2-axis tracker array, including dams and embankments of infiltration basins
    c. **Characteristic:** optimised output
5) Variant 5 – fixed structures with geometric adaptation with CIS modules
    a. **Roof-top area:** fixed structures with geometry adjusted orientation where modules aligned to follow the geometry of the area (i.e. in parallel to the roof edges) and tilt angle is modified in such to maximise installation capacity, if appropriate
    b. **Ground mounted:** fixed structures with geometry adjusted orientation where modules aligned to follow the geometry of the area (i.e. in parallel to the main area borders) and tilt angle is modified in such to maximise installation capacity, if appropriate
    c. **Characteristic:** maximised performance per available area

Detailed parameters and corresponding values for these variants are presented in Table 5-1 supplemented by an explanation of the configuration angles in Table 5-1.

Further modifications of these variants may need to be looked at. For instance, if the analysis of the hybrid system balance reveals that an additional biogas holder could be installed the variants shown above may need to be modified by slightly reducing the installation capacity on area A1.

Key system data have been derived and performance results have been calculated for the defined variants in order to allow comparing and ranking the variants and finally proposing the preferred one. The methodology, assumptions and results of this step are presented in the next sections.

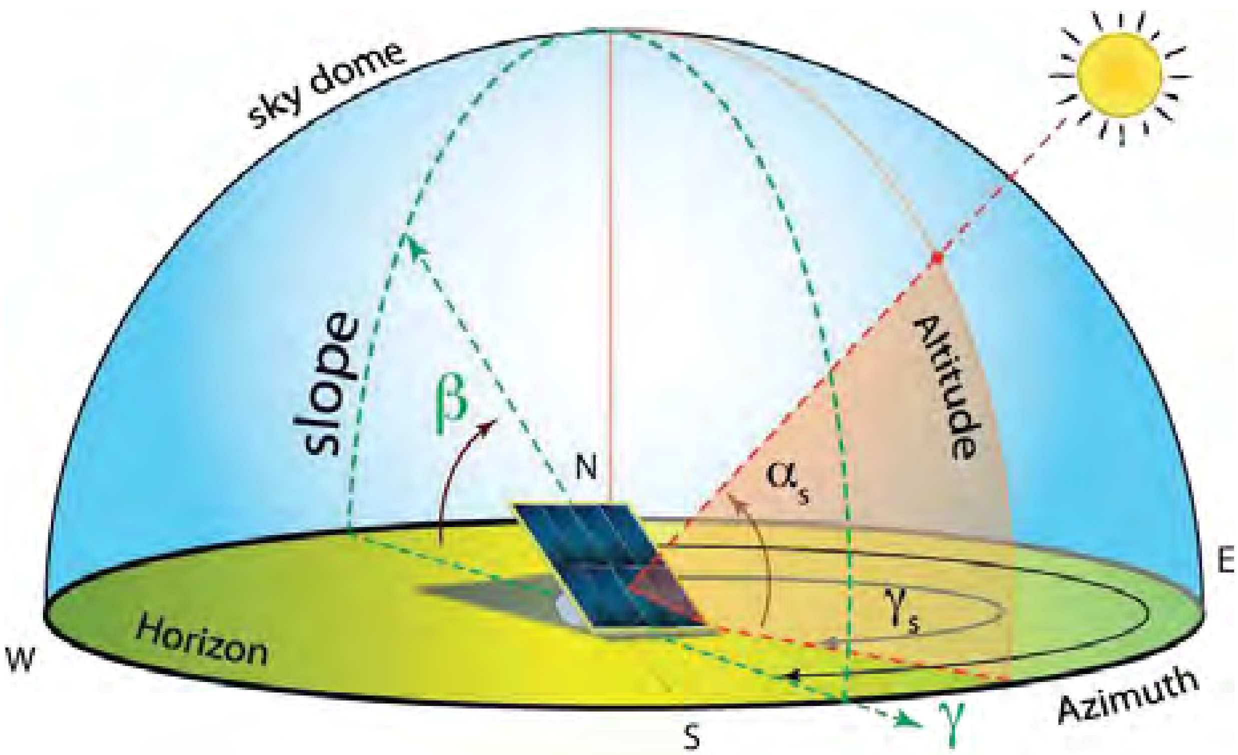
The details of the five variants and the methodology of comparison are explained in the ANNEX, section 12.3.1

Table 5-1: Key configuration parameters and values for the defined variants

Type of Instal-lation	Location	Area Code	Variant				
			1	2	3	4	5
			true south	follow the geometry	1-axis tracked	2-axis tracked	geometry
			c-Si	c-Si	c-Si	c-Si	CIS
ground-mounted	WWTP	A1	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 28.6$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 28.6$
ground-mounted		A2	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 42.3$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 42.3$
ground-mounted		A3	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 25.3$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 25.3$
ground-mounted		A4	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.6$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 34.6$
ground-mounted		A4'	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 28.6$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 28.6$
roof-top		A5	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$
roof-top		A6	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$
roof-top		A7	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$
roof-top		A8	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 34.4$
ground-mounted		A9	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 11.5$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 11.5$
ground-mounted		A10	$\beta = 25$ & $\gamma = 0$			$\beta = 0.0/80$ & $\gamma = -120/120$	
ground-mounted		A11	$\beta = 25$ & $\gamma = 0$			$\beta = 0.0/80$ & $\gamma = -120/120$	
ground-mounted	Recovery Scheme	A12	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 38.4$	$\beta = -45/45$ & $\gamma = -90/90$	$\beta = 0.0/80$ & $\gamma = -120/120$	$\beta = 25$ & $\gamma = 38.4$
roof-top		A13	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 39.2$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 39.2$
roof-top		A14	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 39.2$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 0$	$\beta = 25$ & $\gamma = 39.2$

β = module tilt angle γ = array azimuth (0 means towards equator / South, in this case)

Figure 5-3: Angle definition for description of PV collector configurations[22]



α = solar altitude angle

β = module tilt angle

γ = array azimuth (0 means towards equator / South, in this case)

[22] Graphics by Jeffrey Brownson (2014): of Solar Resource Assessment and Economics, Penn State's College of Earth and Mineral Sciences, https://www.e-education.psu.edu/eme810/node/576

5.5.4 Assessment and Ranking of Variants

Using the system parameters and results as input (see the details on the variants in the ANNEX, section 12.3.2), variants 1 to 5 are compared.

The key characteristics of the configuration are summarized again to illustrate the differences in the configuration:

1) Variant 1
    a. a polycrystalline 60 cell module with a 25 kVA 3 phase inverter.
    b. Modules orientated to true South (Azimuth 0).
2) Variant 2
    a. a polycrystalline 60 cell module with a 25 kVA 3 phase inverter.
    b. Modules orientated to maximize space utilization instead of maximum yield.
3) Variant 3
    a. a polycrystalline 60 cell module with a 25 kVA 3 phase inverter mounted on a single axis tracker (N-S axis) to achieve a higher output.
4) Variant 4:
    a. a polycrystalline 60 cell module with a 12 kVA 3 phase inverter mounted on a double axis tracker to achieve the highest possible output by following the sun path.
5) Variant 5:
    a. a CIS module with a 25 kVA 3 phase inverter mounted.
    b. Modules orientated to maximize space utilization instead of maximum yield.

A summary of the key results and qualitative rating is shown in Table 5-2.

Table 5-2: Summary of the key results for all variants

Criterion	Variant 1	Variant 2	Variant 3	Variant 4	Variant 5
Total Capacity (kWp)	4821	5177	2058	1868	4148
Installation	+	+	-	-	+
Maintenance	+	+	-	-	+
Specific Yield kWh/kWp/year	1668	1635	1744	1783	1726
Confidence in PV Technology	+	+	+	+	0
Energy Generation MWh/ Year	8021	8502	3665	3440	7146

When comparing the space utilization a huge difference between the fixed mounted systems and the tracker installations can be observed. The lower capacity of the tracker installation is a result of the requirement for higher distances between the individual trackers needed to avoid shadows from one moving module area to the other in the morning/evening. Although the 2-axis tracker of Variant 4 can compensate some of this capacity deficit by its flexibility in positioning – the device can also be installed between the basins where all other kinds of PV lack ground area are to be mounted – it cannot even catch up with the single axis tracker in terms of installed capacity.

The rooftops only contribute with 154 kWp (Variant 1) to maximum 172 kWp (Variant 2) to the installed capacity. Due to this relatively small amount it might make sense to exclude them completely and concentrate on the ground mounted system. This would facilitate the execution of the project in several ways: less variety of components, no need for working in heights, elimination of the existing but technically manageable risk of water leaking through the roof.

The installation of Variants 1, 2 and 5 is relatively easy as there are no moving parts and modules are in comfortable working height. Variant 3 and 4 have motors so that the modules can follow the sun. Installation of this structure is more sophisticated compared to fixed ones.

The maintenance of trackers requires more effort. Motors can fail and every moving part needs more frequent inspection and maintenance. As rule of thumb maintenance of trackers can be regarded as twice as cost intensive as maintenance of fixed PV arrays.

A criterion where tracker solutions are leading is the specific yield. Due to the sun tracking more energy can be produced with the same amount of modules. Nevertheless, it is recommended to start with employing fixed mounted systems in new upcoming PV markets. The lower specific investment and operational costs are an advantage. Likewise may the lack of understanding on how to install and maintain trackers can lead to malfunction of trackers which would then reduce the actual yield significantly.

When comparing the specific yield of the fixed solutions the improved performance of the CIS technology based thin film modules stands out clearly. Thin film modules in general are attributed to work better with diffuse irradiation and under high temperatures. In comparison with other thin film technologies CIS modules show higher efficiency but can still not compare with the head start of the polycrystalline modules technology in specific yield due to its higher efficiency. Total energy output by polycrystalline modules is still higher than of thin film modules because with this technology achieves more capacity on the same ground area.

Developed in the 1990s and in mass production since 10 years, CIS is a very promising but also still the youngest generation of PV module technologies and critical effects like "light-soaking" are rarely discovered but also hardly tested on field. An available field test only covers a few years.

The polycrystalline module used in the other variants is one of the oldest PV technologies, installed and approved in many GW of PV plants.

Finally, when comparing Variant 1 and Variant 2 it may be highlighted that by installing 7 % of extra power 6 % of more energy can be produced, which is a good compromise if maximizing energy production is the highest aim of this PV plant.

5.5.5 Selection of Preferred PV Design Variant

As a result of the assessment of configuration options and the comparison of the variants, Variant 2 is recommended to be selected as preferred variant for the Concept Design.

The advantages are summarized as follows:

- highest installable capacity for the available area;
- Highest annual production
- Moderate CAPEX
- Relatively trouble-free operation due to absence of moving parts and facilitated maintenance with a fixed structure that can be repaired by local staff and contractors
- Shows that in this case where absolute output is of more importance than financial return, fixed structures show clear advantages over trackers.

5.6 Conceptual Design for Preferred Variant

5.6.1 General Plant / Array Layout

The proposed 5.1 MWp design uses the concept of the selected Variant 2 and is mainly characterised by the following components:

- Arrays composed of poly-crystalline modules from a manufacturer currently ranging among the market leaders offering high efficiency at low cost;
- The fixed 25 degree racking structure is simple to install and carries lower maintenance cost compared to tracking systems. The azimuth of the PV arrays was adapted to the designated areas instead of aligning all modules straight to south. This allows maximizing installed capacity and by that also yielding per area, expressed in kwh/m². The resulting higher installation capacity (+7%) outweighs the losses (-1%) in comparison to an optimal alignment of the system towards South.
- A decentralized inverter with sizes in between 15 and 25 kVA was chosen not only to avoid mismatching losses between differently aligned areas, but also because of its simplicity in maintenance. These inverters can be exchanged by one single person, if necessary.

The 5.109 kWp PV plant can be separated in 2 different structure types. Free field - ground mounted systems which hold with 18.986 modules (4.936.36 kWp) the major part of the installed power and rooftops with 663 modules (172.38 kWp). The electrical schematics can be found in the Drawing 010. In the free field always 22 modules in series create a string and are mounted on one table (independent mounting structure). For the rooftop in general also 22 modules make up one string but this rule is more flexible and to reach highest utilization of roof-top space sometimes strings with fewer modules were allowed. Any case the strings were designed to never exceed limiting inverter parameters like, max and min MPP voltages, max system voltage or currents, considering local max and min temperatures.

Row spacing of 2.20 meters for free field and 1.10 meters for rooftop is necessary to avoid major shadowing from one row to the other. The above mentioned distances were defined to avoid row shading on the shortest day in the year (21st of December) for at least 4 hours, assuming a PV plant aligned to South. Besides shadowing the row spacing is important to ensure good work flow in installation and maintenance. Both values leave enough space for installers to move in between rows and if necessary even drive with vehicles.

The existing infrastructure for PV purpose at existing sewage treatment facility can be used as temporary storages during the time of the installation of the PV plant as in Drawing 001 and Drawing 002 are mainly already prepared and can be used.

There are three different types of connection of the separate PV areas to the electrical system of the NGEST facility:

1. The rooftops sub-systems are connected on LV directly to the connection point of the very building to the already existing electrical infrastructure. Consequently, the PV generation will reduce the building consumption to a lower residual demand (net balance).
2. The free field sub-systems are connected to the main switchgear of each location, i.e. the Blower and Energy Building of the WWTP and the Electrical Room at the RS.
   a. Using AC combiner boxes, the LV cables are guided to this panel.
   b. Due to the long distances between the areas A3 / A9 and the power house an extra transformer at A9 is included to elevate voltage allowing transferring the energy to the powerhouse at 22 KV where it will also be connected in medium voltage. Using the higher voltages, the otherwise enormous the cable losses can be avoided.

Since Gaza is located in a relatively humid area all types of structure, racking, module frames, connectors, etc. should be made out of aluminium or galvanized steel.

5.6.2 Electrical Design

5.6.2.1 DC Side

- Due to the decentralized inverter solution DC circuits are very simple. Depending on the inverter size between 3 and 5 strings lead to one inverter. A string holds between 14 and 20 modules. The standard cable is a 6 mm² copper solar cable. This is sufficient to keep energy losses on DC and AC cabling in STC conditions below the established limit of not more than 2%. In places with extremely long distances 2 x 6 mm² solar cable or 1 x 10 mm² can be used.
- The inverter serves, apart from its principle function of converter of DC power into AC power, as the control unit brain of the PV array. Most of the protection and monitoring tasks are executed by it. The design limits itself to three different inverter sizes, 15, 20 and 25 kVA, in order to keep complexity of the installation low.
- The inverter type used for all three sizes chosen in this conceptual design have an "All-pole sensitive residual-current monitoring unit" which substitutes the string fuse and a DC surge arrestor type II to protect against electrical surges and spikes. With this solution there is no need for external DC boxes between modules and inverter which simplifies installation and maintenance as well as reduces costs. A less sophisticated inverter would need a string box with a DC surge arrestor and 12 A to 15 A DC string fuses to secure the string against over and reverse currents that might occur during installation by switching positive and negative pole of one string in the system

5.6.2.2 AC Side

- AC cabling starts with 16 mm² cables at the inverter and goes to a local AC combiner box positioned in short distance to the inverter. These local combiner boxes gather cabling of up to 5 inverters and transfer the energy to the connection point. In case of the rooftop systems the energy distribution box of the proper building serves as the connection point. In case of the free field areas longer distances have to be passed which results in cabling diameters of 240 mm² copper with in some places even using two cabling systems in parallel.

- The long distance of 650 meter from area A3 and A9 to the point of connection creates a challenge in the transmission of energy. Long low-voltage cables must not only be avoided because of the high losses and thus reduced but also because of the voltage drop on the cables which can lead to a mal-function at the inverter, by not recognizing the low voltage as grid voltage. If no alternative solution was chosen, every combiner box would need at minimum 3 cable systems in parallel with 300 mm² copper each cable to keep losses below 1 %. For the 4 AC combiner boxes this configuration would result in ca. 30 km of single core 300 mm² copper cable, which needs an enormous cable trench. Although technically possible a more suitable solution was found in the implementation of a local transformer at area A9 which elevates the voltage to 22 kV and transfers the energy from A3 and A9 using a 35 mm² cable with only 0.03% of energy losses to the point of connection.
- The cable from the inverter to the local AC combiner box is relatively short. This setting allows using only a 50 A circuit breakers in the combiner box and thus permits to spare another breaker at the AC side of the inverter as well. Obviously, this configuration implies proper signalling on the equipment. All other cables are protected at the beginning and at the end with circuit breakers that have an over current protection as well as the possibility to be turned off and on under load. This is well depicted in Drawing 019 where the 250 A circuit breakers can be found in the AC boxes and the medium voltage box to protect the cable from over currents as well as for disconnecting the cable section from both sides in case of maintenance.
- To ensure grounding of the PV plant all rows are connected with each other by a Ø 10 mm galvanized round bar steel underground. Connections between the tables are made with a Ø 8 mm Aluminium grounding jumper over ground as shown in Drawing 011. To ground the PV module frame a special grounding clamp is used. The grounding system should also be connected to the already existing grounding system.
- Lightning protection as in Drawing 012 is foreseen to avoid strikes into the modules or DC cabling. Sufficient arrestors are distributed in the fields to cover all areas and with a height of 7 m these overtop even the highest rooftop by more than 3 m.

5.6.2.3 Connection to existing Electrical Infrastructure of the Facility

As shown in Drawing 017 and Drawing 018, the incoming AC cables from the free-field sub-systems connected to main switchgear are split among different bus bars and LV/MV transformers due to capacity limits of the individual bus bars and transformers. Starting with Drawing 019, the set of SLDs shows at first the single-line-diagram of the PV sub-system and then in the subsequent drawing a SLD detailing the connection of that very system part to the NGEST grid. Area 1 is connected to transformer EMT 11 of the Blower and Energy Building, Areas A2, A4 and A4' are connected to trans-former EMT 21. Areas A3 and A9 are combined using a MV line, as described in section 5.6.2.2, which is connected to the same bulbar as EMT 11 and EMT 21. Area 12 of the recovery scheme had to be split up because of its size and is connected to the 3 transformers: TRF-06, TRF-07 and TRF-08.

The rooftop areas A5, A6, A7 and A8 of the WWTP have relatively small PV power and are connected directly to the on the incoming bulbar of LV panel of the particular building before the main circuit breaker, as shown e.g. in Drawing 029 and Drawing 030. For the buildings at the RS hosting the rooftop areas A 13 and A 14 no details on the LV system are available but the same concept applies.

All inverters have anti-islanding protection and are delivered with the corresponding country code. The switch gears and all AC boxes are to be equipped with appropriate warning signals showing operating and maximum voltages and currents as well as necessary instructions for installation and maintenance teams.

To protect the PV plant from surges and spikes from the grid side AC surge arresters are implemented in all main combiner boxes.

5.6.3 Mechanical and Civil Works

Drawing 001 and Drawing 002 show maintenance paths and exits. Due to the already existing structures a lot of roads and access points can be utilized for the PV plant. Only for A12 and A1 a significant amount of extra roads was planned due to the large size of these PV areas. All the rooftops are easily accessible, for example by ladder or scaffolding and allow use of a standard forklift.

At all the free fields ramming posts, as in layout Drawing 015, are foreseen as foundation. At the rooftop the appropriate solution to fix the system to the roof would be to cast concrete blocks that serve as a foundation. The rooftop structure can be mounted on these blocks using concrete anchors. Before applying this solution the free mechanical load of the rooftop should be checked.

During construction works usually certain batches of delivered equipment like AC combiner boxes, modules or inverters accumulate. It is therefore recommended to guard the items in containers on the pre-defined storage areas ensure the well estate of these components. Some extra containers for the installation crew, tools and toilets help to keep the site in order during installation.

Layout Drawing 13 shows typical cuts of cable trenches. Solar cable is usually protected by conduits, thicker cable can, if authorized by the manufacturer, be buried directly in the ground. The drawing also shows the grounding conductor which is usually laid 10 cm below the power cables and the warning tapes which are necessary to warn against potential damage during future excavations.

As long as solar cables run parallel to the mounting structure ducts, plastic hooks or cable ties are the preferable solution to fix the solar cable. Once the cable leaves the structures, trenches with conduits are the more elegant solution to save space and leave the surface free for lawn mowing and other maintenance labour.

Even though water does not affect cables and the modules directly because of the IP 67 protected junction box, a surface drainage system is planned to avoid the accumulation of water, especially next to the racking structure where water could influence the statics (see Figure 12-2). Critical paths are expected to be next to the slopes near to the basins and next to sealed areas (roads).

Fences are only foreseen for the areas A12, A9 and A3, as they are outside of the main area which is already fenced. Access to area A12 will be provided via two gates (see Drawing 002).

5.6.4 SCADA and Monitoring System

5.6.4.1 Basics of PV performance monitoring

Monitoring is crucial to utility scale sites with high performance requirements. It alerts the operator to take action on underperforming areas of the solar facility. By comparing the output of different inverters installed at the same site underperforming parts can be identified. Monitoring can be configured in several with different solutions. The most comprehensive solution finest would be monitoring of each module, the most basic solution would be to only monitor the output of the whole plant. The chosen concept of monitoring each inverter is the compromise between the two extremes and leverages the advantages of the distributed set-up representing cost benefit wise the adequate solution. Since some strings are combined with DC combiner boxes, the acquired aggregated monitoring data represents at maximum units of 28.6 kWp. Since most inverters can provide data for each input connector and each MPPT, higher resolutions of data are even possible.

5.6.4.2 General Concept

Drawing 014 provided on overview on the topology of the proposed concept for the SCADA system. A main cluster controller can communicate with a max. number of 75 inverters and can be connected to the local communication network which can even be connected to the extranet. This enables to integrate the PV SCADA System into the already existing SCADA System. The whole system, PV plant and sewage treatment can be monitored and controlled from one, or more, control rooms (NGEST ADMIN. STATION BUILDING / remote O&M Contractor's control centre) and inverter power can be reduced or shut down, if necessary. Besides the data of the inverter the cluster box can also read out irradiation, wind and temperature sensors which will act as an independent source to evaluate the efficiency of the plant.

5.6.4.3 Failure Identification

The monitoring system comprises of functionality to detect obvious failures on its own. For example a non-working inverter would trigger an immediate alert. Issues with system output and underperformance can be identified by comparing output of different inverters with each other or with the irradiation sensor over a certain time interval. Smaller errors like "dirt on modules" or "loose connections" can be identified with this method. It is recommended to mount at least one array sensor for every area with a different azimuth and module tilt allowing a comparison between similar configures irradiation sensors and PV arrays.

6. O&M Requirements

6.1 O&M Strategy

In this section the optimized process of O&M is analysed and experts to be trained for data processing and O&M data based periodic evaluation. NGEST PV-plant is planned for a long lifecycle, this system requires maintenance. NGEST PV-plant as a system with high performance needs permanent monitoring, technical staff should be able to take action on underperforming parts of the plant according to alerts of the monitoring system. Moreover NGEST PV-plant faces high instability of grid supply in Gaza. This requires qualified staffs that are able to coordinate well with GEDCo and keep NGEST operational under the variable GEDCo supply system. Main elements of NGEST PV-plant O&M strategy are:

- Cost effective O&M deployed human resources (engineer, technician)
- Monitoring plan and data processing,
- Periodic and emergency maintenance,
- Safety instructions,
- Maintaining warrantee compliance,
- Budget needed for NGEST PV-plant successful O&M strategy.

6.2 Human Resources Needed for O&M Strategy

Analysing the technical NGEST staff it could be concluded that an electrical engineer should be added to the staff as a PV-plant specialist. Other technical assistance can be provided by the existing technicians within the team. A one day per week is a plan to use one technician for PV-plant maintenance. So, the technical staffs of NGEST PV-plant are consisted of:

- One electrical engineer with essential knowledge in solar engineering- the engineer is PV-plant's operations manager, he/she monitors the control room and meteorological station, follows up the periodic cleaning, determines maintenance requirements and actions for emergency cases, and evaluates the deviation levels of actual and planned energy generation, and reports to management level.
- One technician – for cost effective O&M strategy this technician is part of the general NGEST staff and provided with PV knowledge. The technician assists the engineer and maintains cleaning and maintenance.

Reporting to management level should include weather conditions, generation performance and analysis of lost energy (kwhrs).

A PV-plant engineer is also responsible of data documentation, follow up of the key performance ratios (PR), PV-plant availability, monitoring of energy losses particularly on DC side, and unscheduled outages. In addition to that the engineer should maintain database of external experts and O&M service providers working in the solar sector and possible involvement in specific cases. Database prepared by the engineer should include spare parts requirements and manufactures in a clear spreadsheet tables with listing of equipment and quantity.

For NGEST PV-plant a division of responsibilities (DOR) should be developed. It can be included as special sheets in the manual. DOR is needed to identify who is responsible for monitoring, reporting, scheduled maintenance and corrective maintenance. These sheets show the responsibilities of the engineer, technician, and management level, in addition to identifying cases when NGEST needs an external O&M provider.

6.3 Staff Training

In addition to basic solar knowledge, NGEST PV-plant technical staff (mainly the engineer) is essentially to be trained on:

1. Large scale solar plants;
2. Grid-connected systems; available systems for grid-connection, grid electrical indicators, synchronic electrical indicators between grid and PV-plant,
3. Use of monitoring system at the plant,
4. Dynamic management of NGEST electrical loads under variable GEDCo supply,
5. Preventive, breakdown and predictive maintenance, conditional wear monitoring,
6. PV systems performance measurements and thermo analysis of PV plant components.
7. Ensure knowledge in sizing of DC cables and the impact of under-sizing on plant performance during maintenance processes,
8. For the engineer reporting skills should be ensured.

6.4 O&M Manual

O & M Manual should be prepared which essentially includes:

1. Use of entire PV system and components description, this includes all guidelines for the operation of the PV-plant.
2. Use of entire monitoring system
3. NGEST PV-plant preventative maintenance schedule to be maintained on periodic basis, and dynamic depending on changing weather conditions or prominence of any new polluting source around NGEST.
4. Cases when NGEST needs external maintenance provider,
5. Procedures to be taken when unscheduled incidents occur,
6. Annexes containing electrical and mechanical drawings of PV-plant at NGEST.
7. Special sheets describing the technical specifications of provided solar modules, inverters with a space to add changes in case of repairing with components have other specifications.
8. PV-plant's safety regulations.

6.5 Monitoring Plan and Data Processing

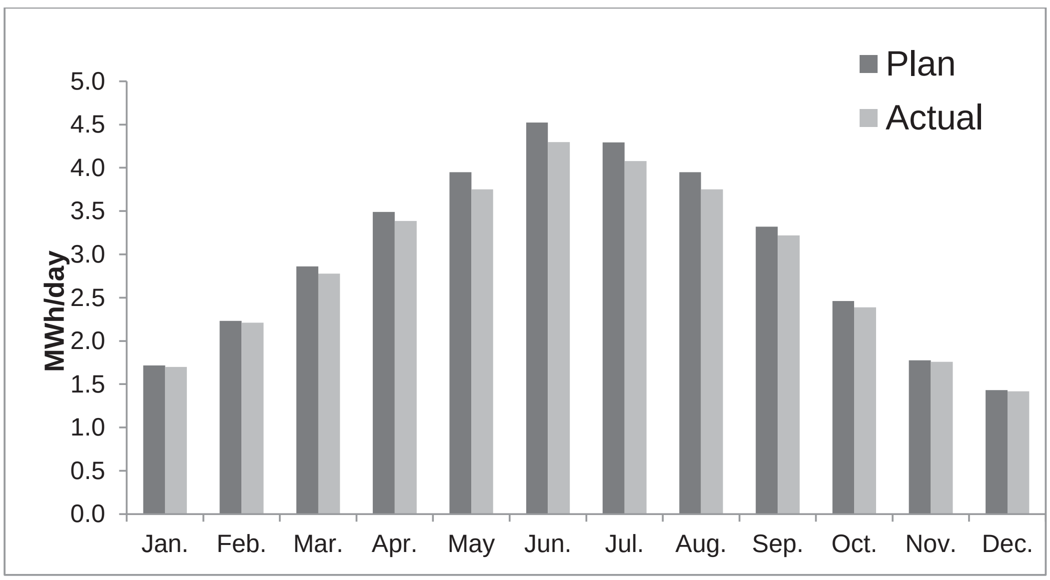
Monitoring plan consists of:

1. Reading and documenting the control appliances (voltmeters, ampere meters) installed for both DC generation side and AC consumption side.

2. Daily readings of energy meters; special attention should be given to kwh meters as a main performance indicator of the plant.
3. Monitoring the compliance of cleaning cycles as planned,
4. Alerts of the monitoring equipment and documenting maintenance actions made,
5. Data entry in a special software,
6. Monitoring of the locally installed meteorological station,
7. Documentation of new polluters around the plant, and measuring the level of added dust.
8. Monthly reports to NGEST manager; each report records all important indicators from mentioned above points. These indicators will be reflected on NGEST PV-plant revenue enhancement.

Monitoring plan should conserve the energy generation process of NGEST PV-plant in a range of 95-99% of planned among the 4 seasons as described below in figure 4.4.2.4.1. Deviation of PV-plant's generation out of mentioned levels indicates incompliance of the monitoring system. These levels consider differences of shadow caused of dust particles during different seasons, in addition to equipment obsolescence.

Figure 6-1: Exemplary comparison of actual vs. expected electricity production



6.6 General Safety Regulations

Operating instructions contained in the manual lists the most important instructions on how to operate the PV-plant safely. Operating the NGEST treatment plant includes other non-electrical and non-mechanical hazards in regard to liquids, pools, the use of chemicals in the work area, all these hazards are indicated in the manual and staff should refer to all safety instructions in NGEST.

All safety operating instructions generally in NGEST and particularly in PV-plant must be always at hand in NGEST work area. Staff must be aware that the relevant Palestinian rules and regulations for accident prevention shall be complied with, in addition to the eventual NGEST internal regulations.

NGEST management level must allow to work at NGEST only people,

- That are well acquainted with regulations concerning safety and accident prevention,
- That have the knowledge on how both NGEST and PV-plant function,
- That have read and understood the operating instructions.

Safety warnings like slogans must be marked in red and large enough to be seen, with danger symbols and placed in the sites and equipment containing dangers.
It's the responsibility of the management level to always ensure that these cautions mottos still exist in a place of danger. Any modification, addition of parts like NGEST phase II and phase III must be accompanied with addition and modification of danger cautions. These changes and additions must be done by an external safety consulting provider.

Consequences of non-compliance with safety regulations may lead to serious hazards as follows:

- Danger for staff or visitors by mechanical or electrical influence,
- Failure of prescribed methods of maintenance and repair,
- Failure of the whole process of energy generation at NGEST PV-plant.

6.7 Maintenance and Repair

6.7.1 Procedures

PV plants have a reputation as low maintenance power plants nevertheless some actions should be considered to ensure the highest possible output of the system.

All inspection work and maintenance is to be carried out according to the instructions

- Preventative maintenance: testing on equipment and systems based on a schedule or conditional wear monitoring.
- Breakdown maintenance: when maintenance is initiated on an as-needed basis with alerts from monitoring equipment.
- Predictive maintenance techniques: how to initiate a plan for lifecycle maintenance e.g. PV-plant cleaning cycles depending on Gaza specific weather conditions/ any other sources of modules pollution in the area and replacing of repair parts.

For all maintenance, repair and inspection work power supply of the PV-plant or its parts and power from the grid is to be turned off, and breakers of power supply are to be made secure against an unexpected restart. In addition to that, a warning plate against restarting should be placed.

6.7.2 Module Cleaning

The tilt angle of 25 degrees already secures a very good self-cleaning effect most of the dirt or snow will slip down the module and rain washes down the rest. For very dry seasons there should be the possibility to wash the modules using only water and soft brushes. To avoid power losses all cleaning or maintenance actions should be scheduled for the early morning hours or late afternoon when the system is producing on low scale.

Depending on the site conditions module cleaning can be done in certain periods, like every month, or can be established as first measure when significant power loss is recognized by the monitoring system.

6.7.3 Site Maintenance

Typical maintenance work that should be done on a quarterly basis is cutting vegetation and inspection. Bushes and high grass can cause shadowing and should be trimmed or cut completely in certain time intervals. Also inspections of modules, inverters and AC combiner boxes are recommended to prevent failures and keep the output of the PV plant constantly on a high level.

6.8 Protective Equipment

Before PV-plant is operated all protective equipment must be installed. Before maintenance operations related protective equipment must be checked. Manual switchgears must be kept in a closed non-operational position, access to which is to be granted only to authorized persons. Power supply connections, breakers are to be kept secure against unexpected restart and a warning label must be attached against restarting.

In addition to that, protective devices must be serviced regularly according to the manufacturer's instructions.

Work on electrical instrumentation and protective equipment must be carried out only by qualified engineer and technician/s. Staff is not allowed to continue with maintenance unless the functional state of protective equipment is ensured. The required personnel protective equipment like electrically isolated rubber gloves and tin hat when working with mechanical reconstructions are to be provided by NGEST. Protective work clothing should be available for the staff in NGEST. For this purpose a changing room should be available at the site and the street clothes to be kept separately from work clothes.

Main NGEST PV-plant protective equipment and system are;

- ✓ DC and AC circuit breakers,
- ✓ Manual switchgears,
- ✓ earth leakage and earthing system,
- ✓ Short circuit protection system,
- ✓ Lightning rod system,
- ✓ On-grid connected inverters and PV and grid frequency regulation,
- ✓ cut-offlines and separating breakers.

This protective equipment can only be removed under the direct supervision of PV-plant engineer and after they have been protected against switching on again.

In addition to all mentioned loose connections and scorched cables must be removed immediately.

The PV-plants control room must contain all safety measures as follows;

- ✓ firefighters,
- ✓ free of flammable materials,
- ✓ natural and artificial ventilation,
- ✓ under the eyes of NGEST safety guards,
- ✓ secured door/s against unintentional closing during inspection work and maintenance,
- ✓ emergency exit window to be ensured

6.9 Security

All PV areas will be fenced and integrated in the overall security concept with 24/7 presence of manned guards.

6.10 Disposal of Parts

PV-plant can contain dangerous parts during disposal like electrical dangers of charged batteries and condensers, chemical dangers of acids, scrap metals and other mechanical dangers. Any substances and materials used are to be handled with and disposed of appropriately in accordance with the existing rules. This concerns in particular all waste materials such as waste of electrical appliances, oil, acids and other chemical waste.

6.11 Spare Parts

The availability of spare is crucial for a swift remedy of defects and reliable operation. The spare parts requirements can be estimated based on the quantity of the components and the procurement strategy: In a commercial project at a very accessible project, minimum numbers of spare parts required to keep the major part system in operation are purchased. After replacement of equipment, the spare part store would be refilled with a brand new device purchased with the means set aside in the so-called maintenance reserve account (MRA). This, the project can benefit from the technical innovation and potential price decrease as well as avoid to have large unused spare parts at the end of the lifetime. Systems built and operated by public entities (bound to rather long procurement procedures) or located in a difficult location (remote access, import restrictions), more conservative numbers are used in order to prevent supply issues and procurement constraints to block repair and thus operation. This applies especially to the NGEST project where security approvals with only 6 month validity are required for importing goods to the site and a strict OPEX budget is established. The parts used by the free field and the roof-top systems differ slightly (e.g. different inverter sizes). But when quantifying the spare parts the PV sub-systems can be regarded as one unit because and therefore reductions on gross quantities applied. The assumption made hereto is that a module clamp can be applied equally on either type of the system.

Table 6-1 lists the assumptions considered in the CAPEX estimate for the PV system and compares in the comment the deviation to a typical investor-driven or commercial project.

Table 6-1: Spare part assumptions for PV system costing

Item	Percentage	Deviation from typical commercial projects
PV modules	7%	High
Inverter	9%	High
Mounting structure	2%	Medium
DC Cabling	5%	Medium
AC Cabling	~1%	Medium
Communication & Monitoring system	1%	Normal
Conduits	1%	Normal

7. PV Electricity Production and Energy Balance

7.1 Energy Generation from PV System

7.1.1 Site Information and Meteorological Data

The system location is configured based with the site coordinates mentioned in the site description under section 2.5. The data sets for the exemplary site in Gaza supplied together with the Solar Atlas of Palestine, as described in section 2.6.2, are used as meteorological input data sets for the P50 and the P90 scenario.

7.1.2 PV Plant Design Parameters

7.1.2.1 Components

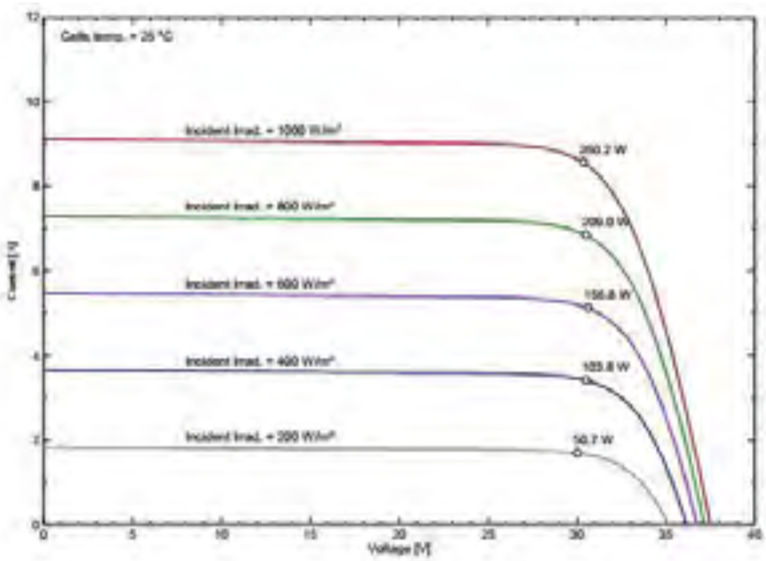
A standard module with poly crystalline silicon cells and a preferable low temperature coefficient has been used as example for the yield calculation. The key data is listed in Table 7-1.

Table 7-1: Characteristics of the PV module selected for the yield simulation

Characteristic	Value	Unit
Nominal Power	260	W
Vmpp (Voltage at Mpp)	30,4	V
Impp (Current at Mpp)	8,56	A
Voc (Open Circuit Voltage)	37,5	V
Icc (Short Circuit Current)	9,12	A
Module Efficiency	15,85	%
Operating Temperature	- 40 to + 85	°C
Max, System voltage	1000	V
Power Tolerance	+5	W
Cell Type	Poly-crystalline	
Cell size	6	Inch
Module dimension	1638x982x40	mm
Weight	18	kg
Connectors	MC4 comparable	
Temperature Coefficient (Pmax)	-0.43	%/°C
Temperature Coefficient (Voc)	-0,34	%/°C
Temperature Coefficient (Isc)	0.065	%/°C

Figure 7-1 shows the I-V curve of the module at different irradiance levels.

Figure 7-1: Characteristics of PV Module

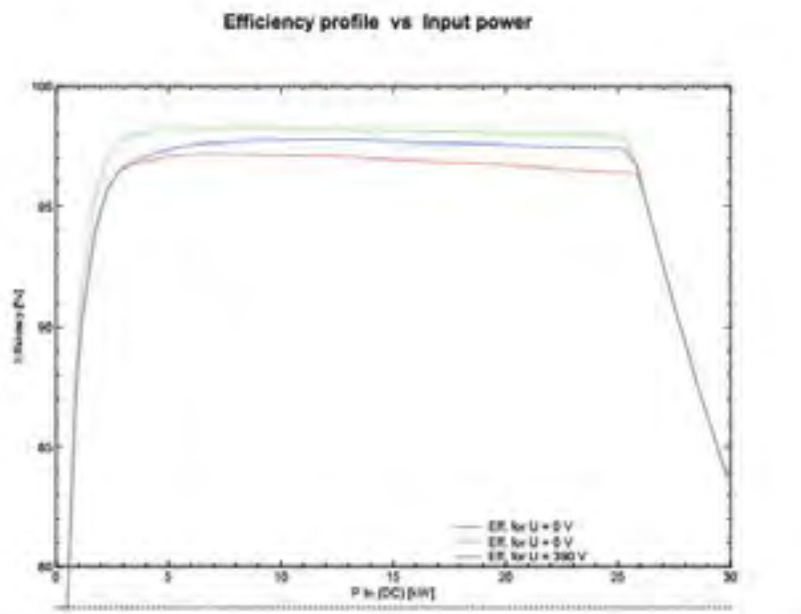


Likewise, an industry standard decentralised multi-string inverter solution has been chosen. The key data of the inverters is listed in Table 7-2 and the corresponding efficiency profile is displayed in Figure 7-2.

Table 7-2: Characteristics of the inverters selected for the yield simulation

Characteristic	Inverter 25 kVA	Inverter 20 kVA	Inverter 15 KVA	Unit
Max. DC power	25.550	20.440	15.340	W
Max. input voltage	1000	1000	1000	V
MPP voltage range	390 to 800	320 to 800	360 - 800V	V
Rated Ac Power	25.000	20.000	15.000	W
AC nominal voltage	3/N/PE; 230/400	3/N/PE; 230/400	3/N/PE; 230/400	V
AC voltage range	180 V - 280V	180 V - 280V	180 V - 280V	V
Frequency	50 or 60	50 or 60	50 or 60	Hz
Rated output current	36,2	29	24	A
THD	<3	<3	<3	%
Max efficiency / European efficiency	98,3 98,1	98,4 98,0	98,2 97,8	% %
DC Switch	Yes	Yes	Yes	
DC Surge Arrester (Type II)	Yes	Yes	Yes	
Dimensions	661 x 682 x 264	661 x 682 x 264	665 x 690 x 265	mm
Weight	61	61	59	kg
Operating temperature	-25 to 60	-25 to 60	-25 to 60	°C

Figure 7-2: Characteristics of Inverter



With the above components the array configuration shown in Table 7-3 was used in the simulation.

Table 7-3: Array configuration

Orientation type	Ground mounted	Roof-top	Unit
Plane tilt	25	25	°
Azimuth	-11,5 to 42,3	34 to 39.2	°
Mounting	Fixed	Fixed	
Modules / string	22	9 to 22	
PNom	4936,36	172,38	kWp
Effective module area	30.539,28	1966,45	m²
PV array	863 strings	37	
	22 modules in series	9 to 22 modules in series	
Total	18.986	663	Modules
Inverters	163 / 10	2/10	
Each	25 / 20	20/15	kWac
Total	4.275	190	kWac
PNom Ratio	1,15	0,91	

7.1.3 Losses and Uncertainties

The following losses have been considered in the simulation of the energy yield:

- **Losses due to the environment (irradiation, shading and soiling)**
    - Horizon
    - Near shading losses
    - IAM factor on global / reflection

    - Soiling losses
- **Losses due to modules characteristics**
    - LID (Light induced degradation)
    - Loss due to irradiance level
    - Loss due to temperature
    - Mismatching losses at MPP
    - Module Quality loss
- **System losses**
    - DC cabling losses at STC / Ohmic wiring losses
    - Inverter Loss during operation
    - Inverter Power Limitation
    - AC LV losses
    - Transformer Loss
- **Further losses**
    - internal consumption / parasitic loads
    - AC circuit
- **Operational losses**
    - Degradation, annual
    - Technical unavailability

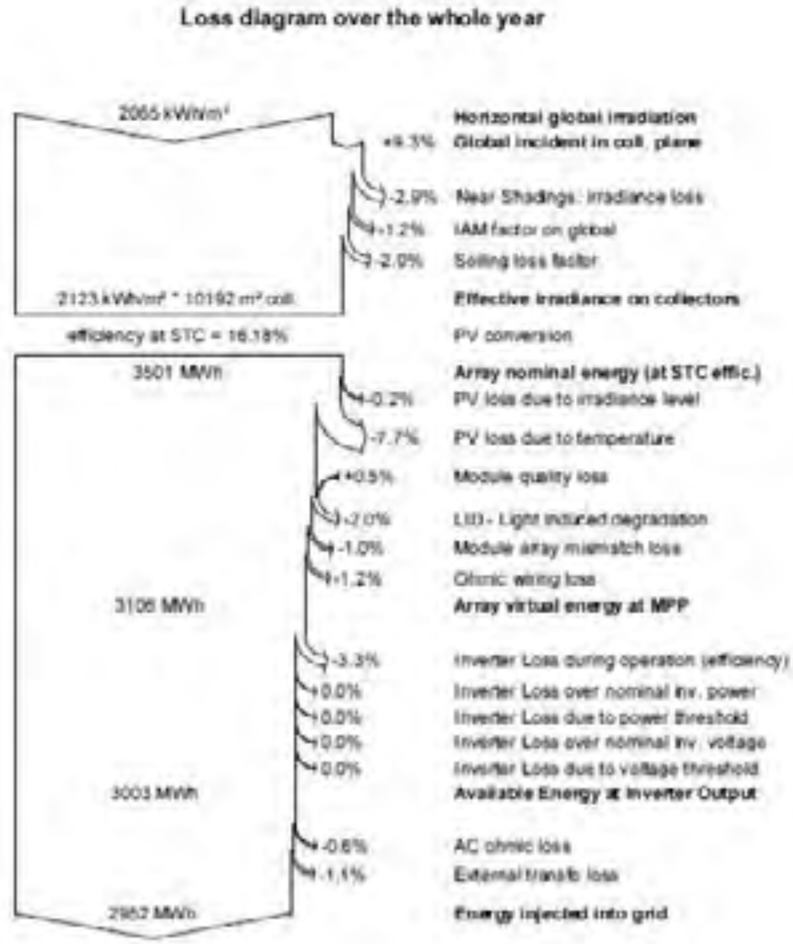
It is assumed that soiling may have a considerable impact as the location is dusty and prone to sand storms.

Technical unavailability includes downtime of the plant during normal production hours for repair or maintenance. It further includes times where the plant is ready to produce electricity, but the national grid is unable to accept the power.

Table 7-4: Fixed installation ground-mounted, losses and uncertainties

Parameter	uncertainty	source of uncertainty	description	impact (gain/loss), [%]
Meteorological Data	4.5%	generation of resource data		
(Global Horizontal Irradiation, Ambient	1.2%	interannual variability		
Global Tilted Irradiation	**0.0%**	**Conversion to inclined surface (PVSyst)**		**9.30**
Losses due to the environment (irradiation, shading and soiling)				
Horizon	0.0%		Losses due to far	0.00
Near shading losses	1.0%		Near shading loss	-2.90
IAM factor on global / reflection	0.5%			-1.20
Soiling losses	3.0%			-2.00
Array nominal energy (at STC effic.)				
Losses due to modules characteristics				
Loss due to irradiance level	1.0%		Deviation of actual	-0.20
Loss due to temperature	2.0%		Thermal behaviou	-7.70
Mismatching losses at MPP	1.0%		Losses due to "mi	-1.00
Module Quality loss	1.0%		Deviation of the av	-0.50
LID - Light induced degredation (1rst yr.)				-2.00
System losses				
DC cabling losses at STC / Ohmic wiring losse	0.5%			-0.80
Inverter Loss during operation	1.0%			-3.30
Inverter Power Limitation	1.0%			0.00
AC LV losses	0.5%			-0.60
Transformer Loss	0.5%		-1.1	-0.40
PVSYST result: block performance				
further losses				
internal consumption / parasitic loads	1.0%			-0.20
AC circuit	0.5%			-0.50
Performance at PoC / PCC				
operational losses				
Degradation	0.5%	annual, lifetime		-2
				-0.60
Technical unavailability	3.0%			-2.00
Specific Yield after 1 year of operation				
total uncertainty	***7.2%***			

Figure 7-3: Loss diagram over the whole year



7.1.4 Yield Prediction Methodology

The PVSyst software is a PV system modelling tool. It is based on many years of experience in PV simulations and performance assessment and is commonly used worldwide to design and evaluate the energy produced by PV grid-connected solar power plants.

The simulation software PVSyst (Version 6.31) was used to simulate the system behaviour and energy production of areas with similar orientation and configuration separately.

The following models have been used for the PVSyst:

Simulation Step	Model
Irradiation transposition	Perez-Ineichen model
Near shadings	• Unlimited sheds for areas without significant shadings • 3D Drawings for areas with shading objects
Reflection (IAM)	User defined profile supplied by module manufacturer: Incident Angle / IAM:

Inc. Angle	0	10	20	30	40	50	60	70	80	90
IAM	1	1	1	1	1	1	0,99	0,92	0,74	00

Power factor adjustment or curtailment limitations of the grid on evacuation were not considered.

The production of the total PV plant was calculated by summing up the hourly results of the separately simulated areas.

From the output on the PVSyst model, further plant losses were deduced:
- Ohmic losses in the MV circuit between the outlet of the inverter-transformer stations at the individual blocks and the revenue meter
- Parasitic loads and internal consumption

The resulting value corresponds to the expected output at commissioning.

During continuous operation, further losses occur. These are mainly due to:
- technical unavailability
- degradation of modules and system components

These operational losses during the lifetime of the project are considered in the project of the production over the lifetime of the project.

7.1.5 Long-Term Expected Energy Production

For prediction of electricity production of the PV power plant for a period of 20 years degradation (ageing) of nominal power (conversion efficiency) of PV modules has to be assumed. Since not only the modules are subject to ageing, the overall performance of the power plant depends also on cabling and performance of inverters during the lifetime respectively. Another possible source of uncertainty is non-uniform degradation of individual modules which results in higher mismatch losses.

Table 7-5 shows the weighted long-term expected energy production as annual net energy output in GWh per year. The calculation of P90 assumes the 19-years inter-annual variability of GHI and all combined uncertainties as described above. In other terms it refers to the multi-year probability.

Table 7-5: Long-term expected Energy Production, Annual Net Energy Output [GWh/a]

Variant 2	Fixed Structures			
PoE-Level	P50		P90	
Aggregation Method	Specific Yield [kWh/kWp]	Annual Net Energy Output [MWh/a]	Specific Yield [kWh/kWp]	Annual Net Energy Output [GWh/a]
Average	1,653	8,442	1,502	8,292
Sum [GWh]		214,291		174,812

Specific yield values in kWh per kWp for P50 and P90 are further detailed in the Annex. The PV production including degradation and further technical losses are used in the next section to build the energy balance for each project year as input to the economic and financial cash-flow calculations.

The project has good potential of solar energy utilisation with stable electricity production during the year, only slightly influenced by seasonal weather changes (stable electricity production during the whole year).

7.2 Energy balance of the energy supply system (comments)

7.2.1 Annual demand and supply balance

Chapter 3 discussed the energy demand of each component of NGEST; the annual demand summary is calculated as shown in Table 3-1. The total annual energy demand in 2018 is 37,286 MWh and in 2025 is 63,271 MWh.

In the coming sections, energy balance is calculated between the calculated energy demand of the Waste Water Treatment Plant (WWTP) and the Recovery Scheme (Stages 1 & 2) versus the external power supply and components installed on-site.

Based on the technical analysis of the on-site power generation discussed in Chapter 5, the energy balance of the WWTP in 2018 and 2025 is calculated showing the amount of shortages that will be covered by the grid and diesel sets.

The drawing up of the energy balance follows the overall objectives defined for the power supply system (independent, cost effective and sustainable) which defines the internal merit order of the supply options for satisfying the demand leading to the following ranking:

1. Cost effective sources increasing autonomy (biogas, PV)
2. Cost effective sources with insecurity in supply (external network)
3. Sources allowing higher level of autonomy safeguarding operation (diesel)

The aim for sustainable supply including the consideration of reduced emissions (PV) or at least emission-neutral (biogas) are not given direct preference but this aspect is considered indirectly in criterion (1).

The balance presented in the following sections analyses first how much of the demand could be covered with the renewable sources and then seeks cover the residual demand first the external supply from the network and finally fills the remaining gap caused by the load shedding with the costlier diesel generation.

Based on the technical availability of the grid discussed in Section 4.7, it will be assumed that the two grid scenarios are likely to happen half a year for each one. This means as follows:

- 6 hrs ON and 12 hrs OFF (for 4380 hours/year)
- 8 hrs ON and 8 hrs OFF (for the other 4380 hours/year),

where the diesel generators will work in the Off-Grid hours, this scenario will be called the average grid contribution.

The scenarios PV yield estimate discussed in Section 7.1 are also put into consideration. The PV yield scenarios are combined with grid scenarios. So the P50 scenario for the hybrid power supply will include the average contribution grid scenario described above, while the P90 scenario will include the worst case grid contribution.

7.2.2 Waste Water Treatment Plant (WWTP)

7.2.2.1 Typical Daily Profiles

The demand evaluated in section 3.2 is the basis for the energy balance of the WWTP

The average daily energy balance is plotted as shown in Figure 7-4 and Figure 7-5 in 2018 and 2025 respectively.

Figure 7-4: Average daily profile and balance of the WWTP in 2018

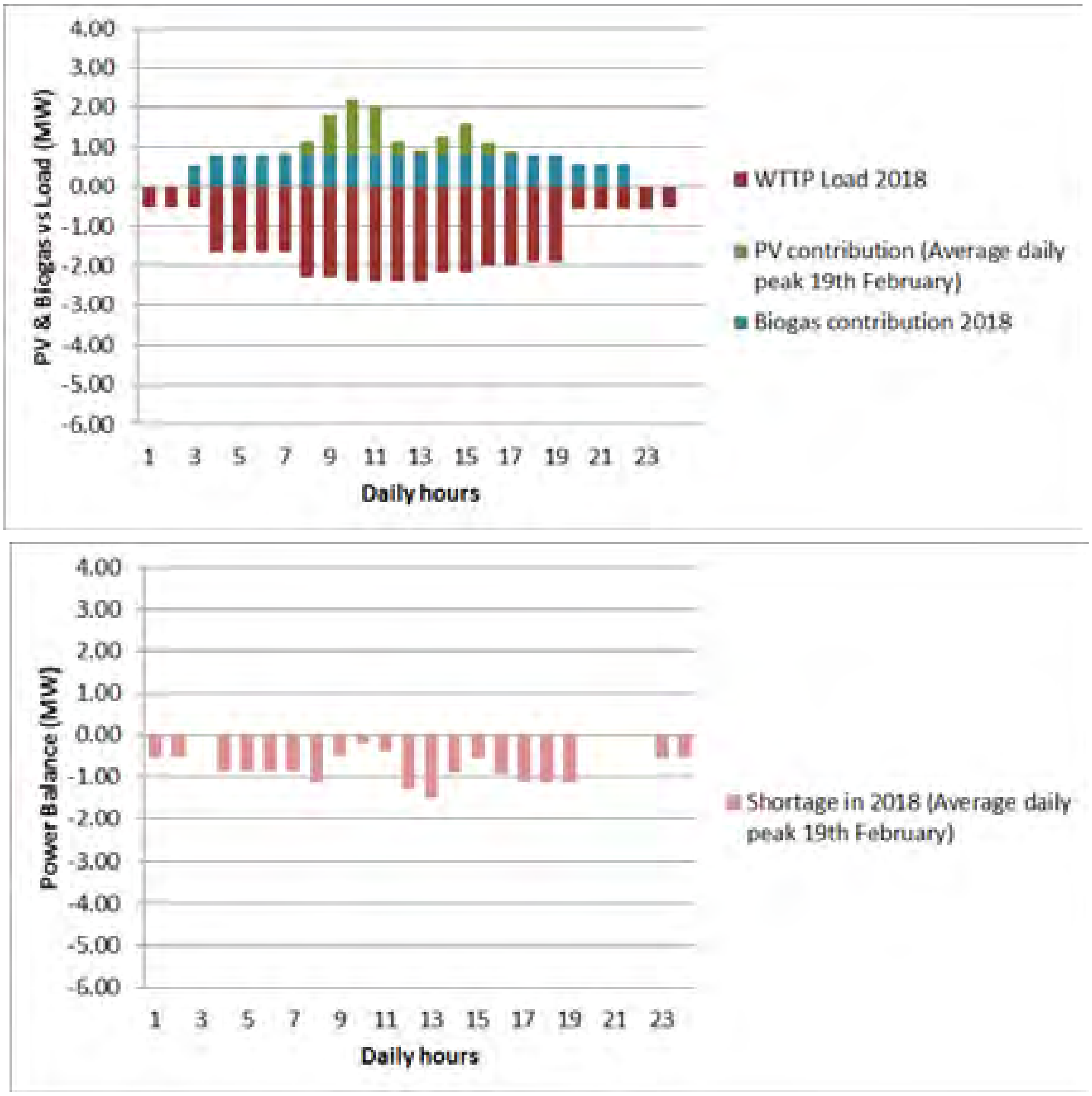
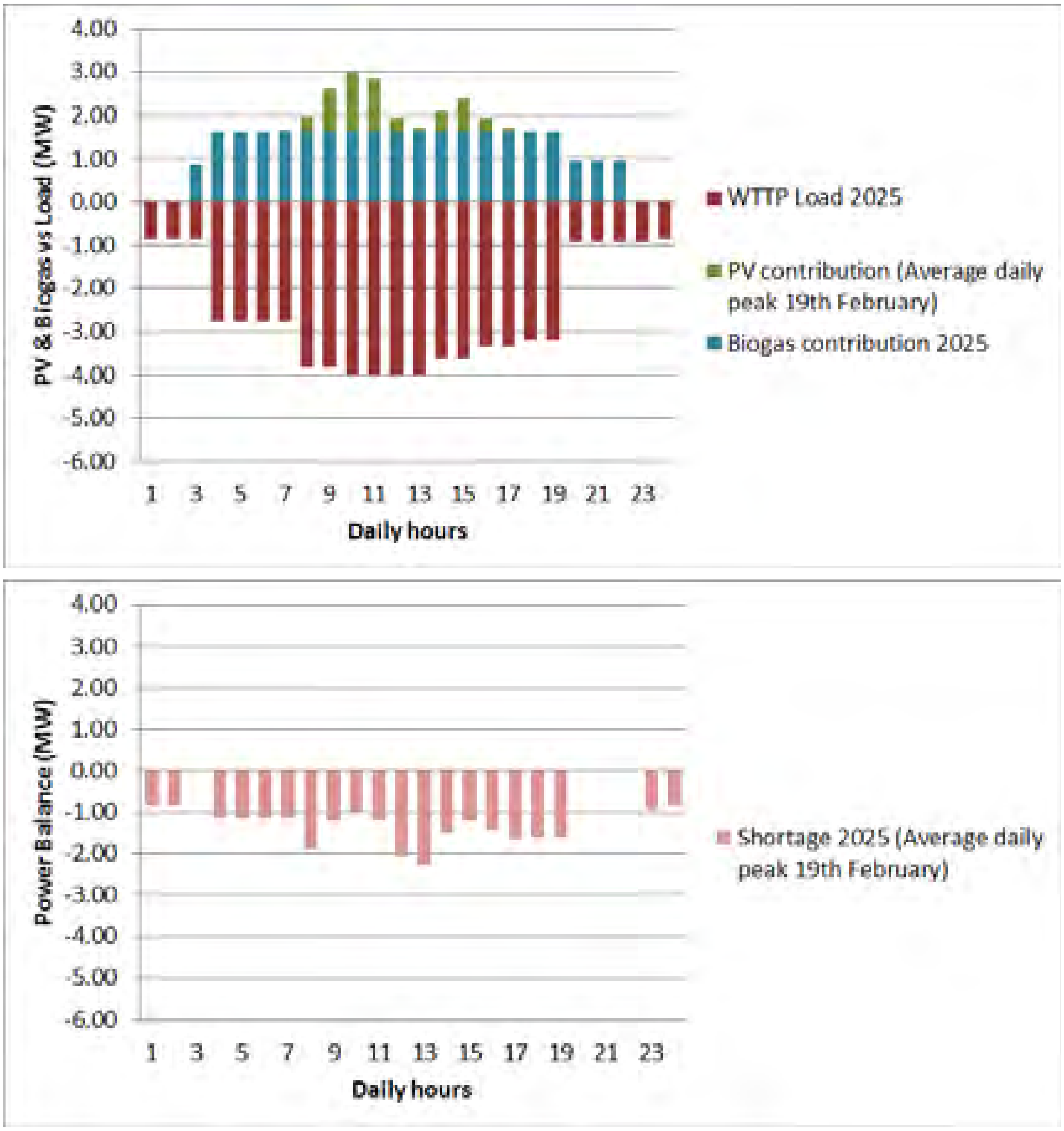


Figure 7-5: Daily profile and balance of the WWTP in 2025



As concluded from the figures, the electrical power production from the installed capacities of the PV and biogas generators is not sufficient to cover the design demand. Hence, the supply gap needs to be filled by the grid and the diesel generators are necessary.

Under normal conditions the WWTP will be supplied via the public network of GEDCO via the two transformers of each 1600 kVA. The WWTP has load sharing governors and auto synchronizing system which controls the three Diesel and the Gas Generators.

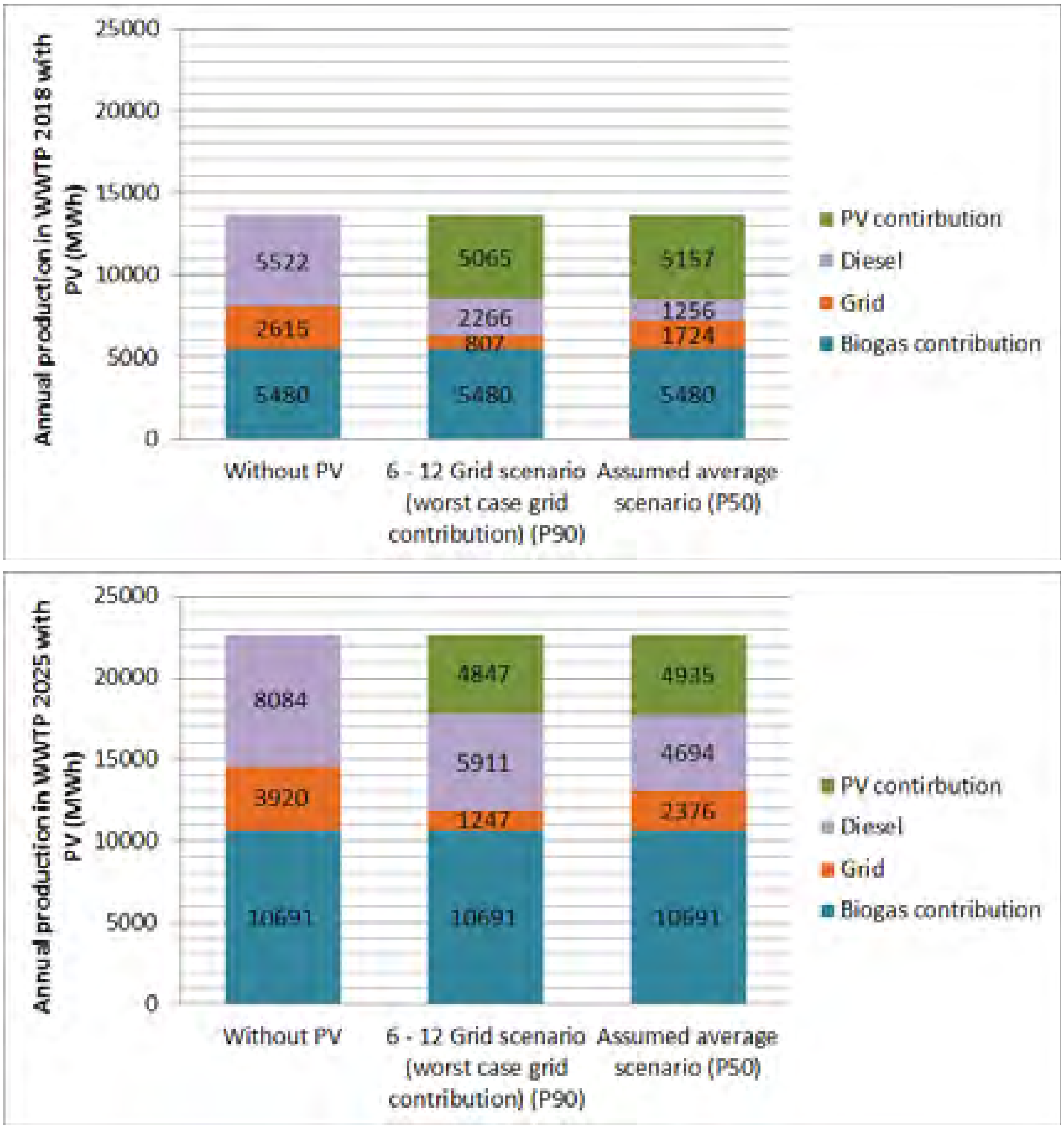
In 2018 and 2025, the installed PV contributes by the same values, while the biogas contribution is doubled in 2025 and the share of grid and diesel generated power is increased to satisfy the higher shortages which occur in 2025 than that in 2018.

The resultant annual energy balance for 2018 and 2025 is elaborated in Figure 7-6 showing the P50, P90 scenarios in addition to the current design without PV ("Without PV" case). Table 7-6 shows the percentages of the contributions in P50 scenario (the typical case).

Table 7-6: Annual energy mix of the WWTP (P50)

Years	2018		2025	
Total (Demand)	MWh	%	MWh	%
	13617	100%	22696	100%
PV	5157	37.87%	4935	21.74%
Diesel	1256	09.22%	4694	20.68%
Grid	1724	12.66%	2376	10.47%
Biogas	5480	40.24%	10691	47.11%

Figure 7-6: Annual energy mix at the WWTP in 2018 and 2025

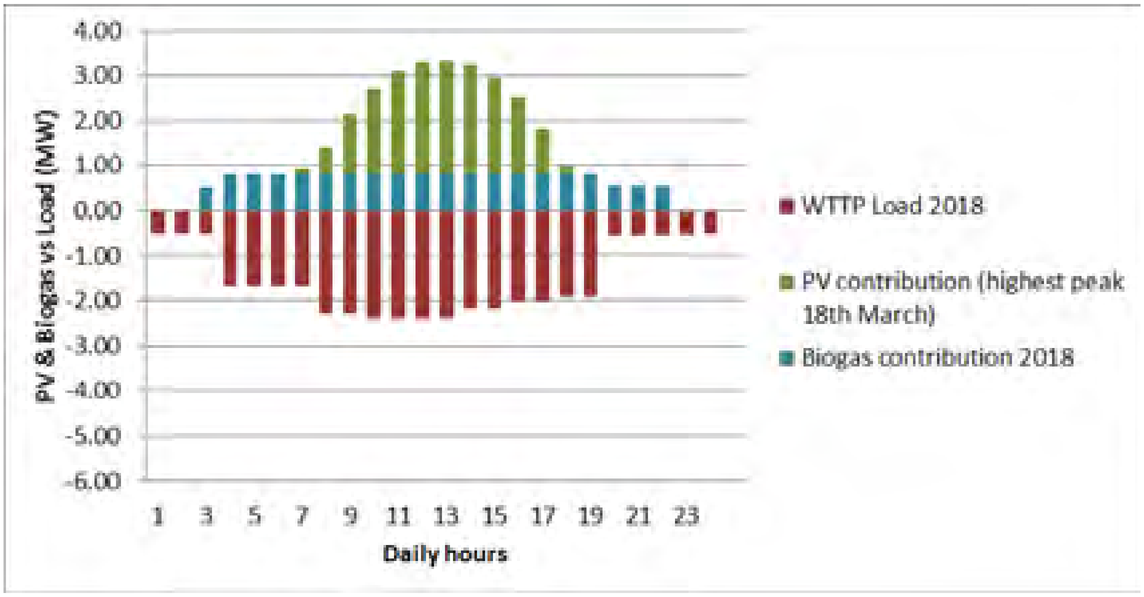


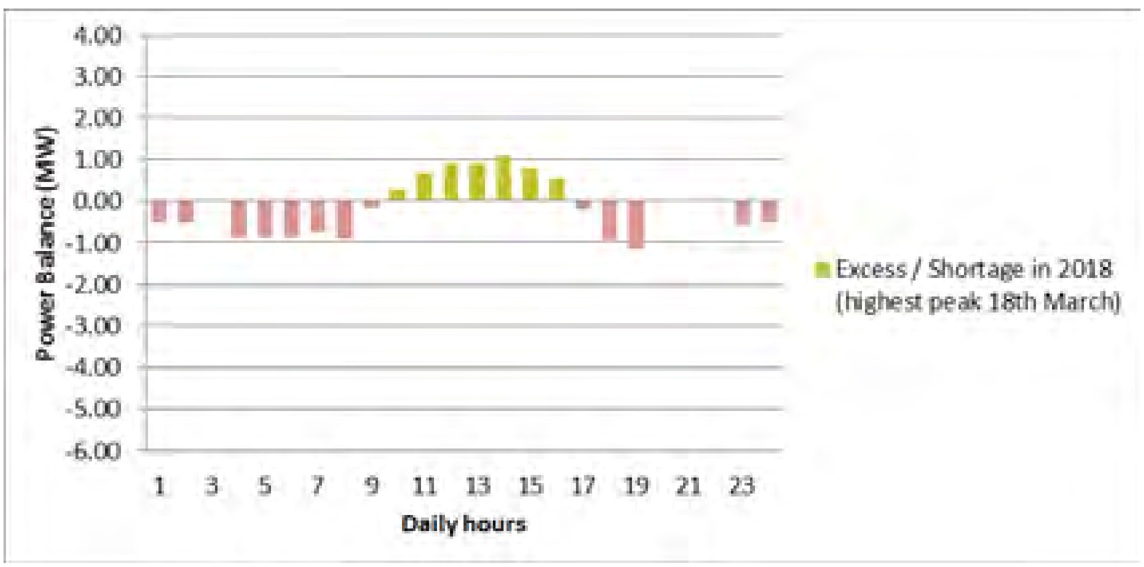
7.2.2.2 Selected Daily Profiles

On certain days excess power generation from the biogas and PV occurs at the WWTP. Since the main target of the local energy supply is the coverage of NGEST's demand and not to export electricity to grid the operation and interplay of components would need to be optimised for these situations. The absence of regulations allowing net-metering in Palestine make it even more necessary to find a solution which does not interfere with the constraint GEDCo network.

According to the provided meteorological data, the PV power generation reaches for a typical meteorological year its peak of 2.5 MW on the 18th of March as shown in Figure 7-7.

Figure 7-7: Daily profile and energy balance at the WWTP on 18th of March





In the off-grid situation the diesel generators are used to build and stabilise the grid (voltage/frequency control). Thus, at least one diesel generator from the genset will work at 30% of its rated full load capacity which is equals to 0.220 kW MW of the 730 kW. If the WWTP is run isolated from grid (and the RS), this results in offsetting the biogas generator in these working hours. The corresponding excess from the diesel generator per year will be equal to 472 MWh.

Two solutions were suggested to optimize the use of this excess:

1) Battery Storage
2) Connecting the Waste Water Treatment Plant to the recovery scheme

The first alternative is not recommended since the consumption from newly added loads increases in the following years. This reduces the potential of the storage in the future by project lifetime which would render the investment into storage banks less feasible approach. In addition, the amount of 10% of excess is not a promising amount for storage given that yet another component would increase complexity and this maintenance effort.

The combination of the two project locations as second alternative has a higher potential to be implemented. The rationale for this assumption will be further explained after the discussion of the loads and contributions of power sources at the recovery scheme the coming sections., the excess power generation reaches during the peak generation hours 5.25 MWh. The annual excess during the peak hours in 2018 is 938 MWh. Accordingly, the total expected unused excess of power generation in 2018 is 1410 MWh which represents 10.35% of the total annual energy demand of the WWTP. In 2025, this excess will decrease to 48 MWh due to the increase of the load of the WWTP; this value can be neglected with respect to the total load (22696 MWh).

The combination of the two project locations as second alternative has a higher potential to be implemented. The rationale for this assumption will be further explained after the discussion of the loads and contributions of power sources at the recovery scheme the coming sections.

7.2.3 Recovery Scheme (Stage 1&2)

7.2.3.1 Typical Daily Profiles

The recovery scheme energy balance was calculated as a total of both Stages 1&2 and extension. The same assumptions of the grid availability were also considered here. In the recovery scheme, there is no biogas generator; hence the energy balance is calculated between the loads and the installed PV system as shown in Figure 7-8.

The section 3.3 contains the analysis of the consumption which is the guiding condition for the energy balance.

Figure 7-8: Daily profile and balance of the recovery scheme in 2018

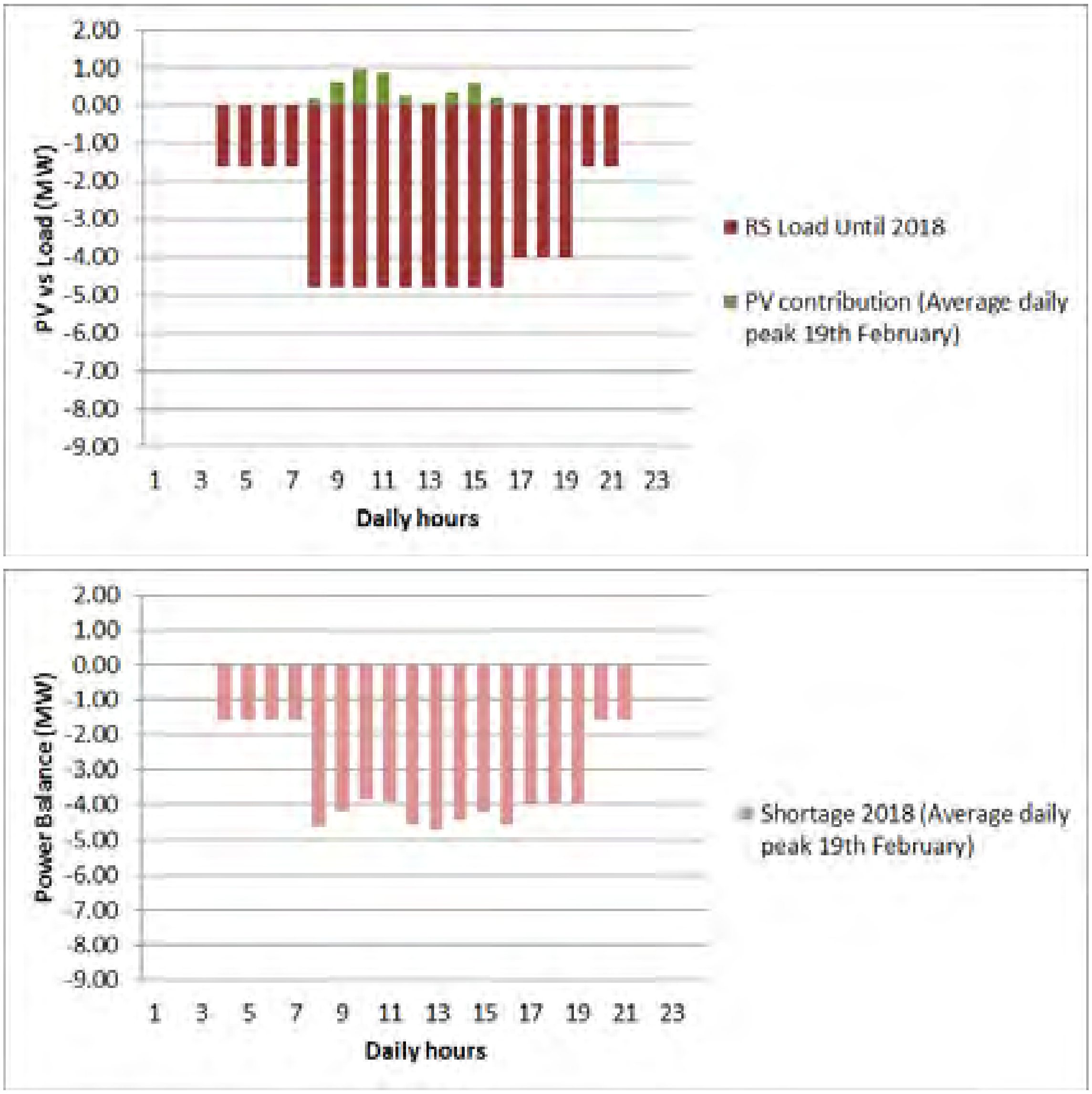
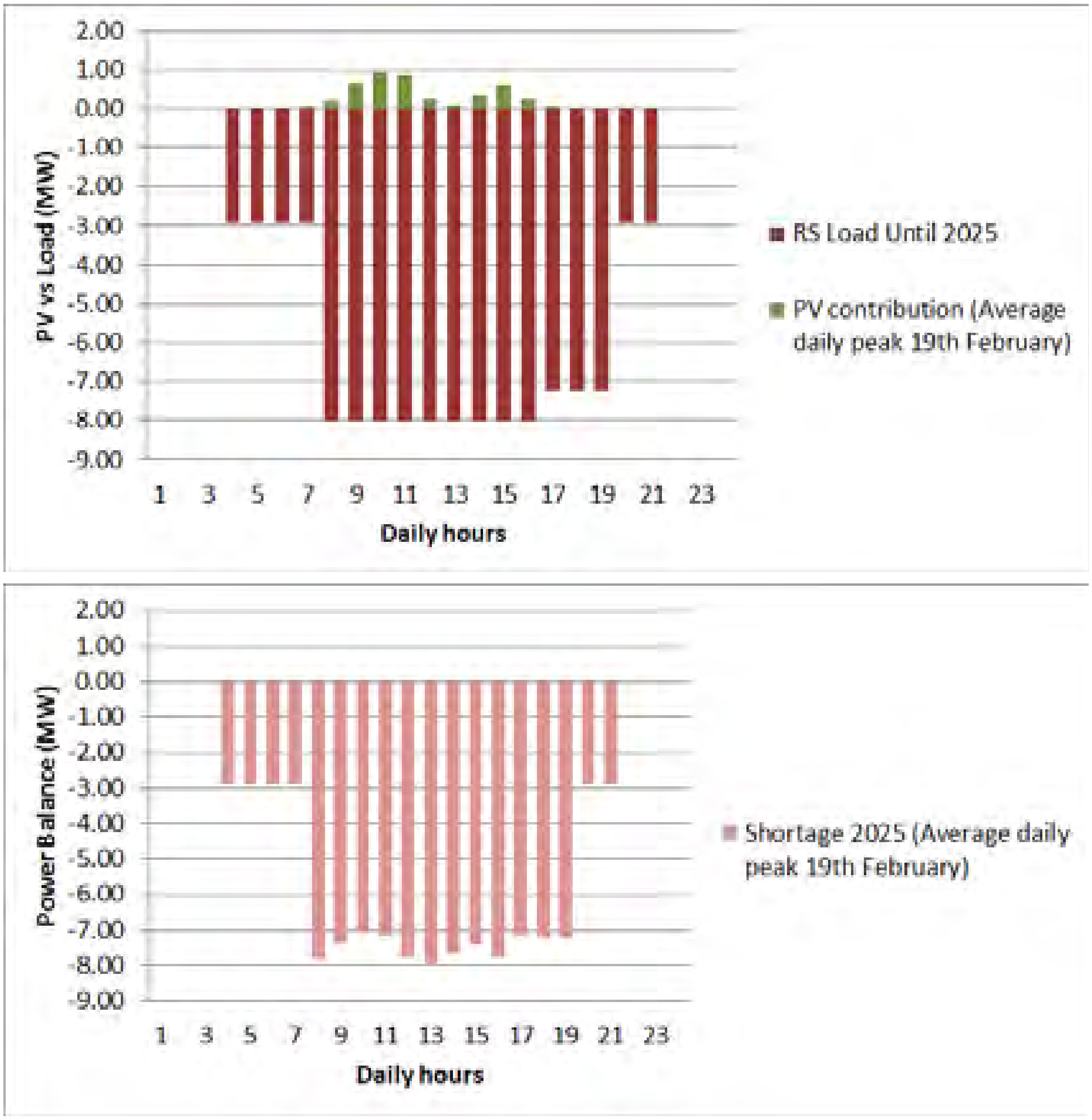


Figure 7-9: Daily energy balance profile of the recovery scheme in 2025

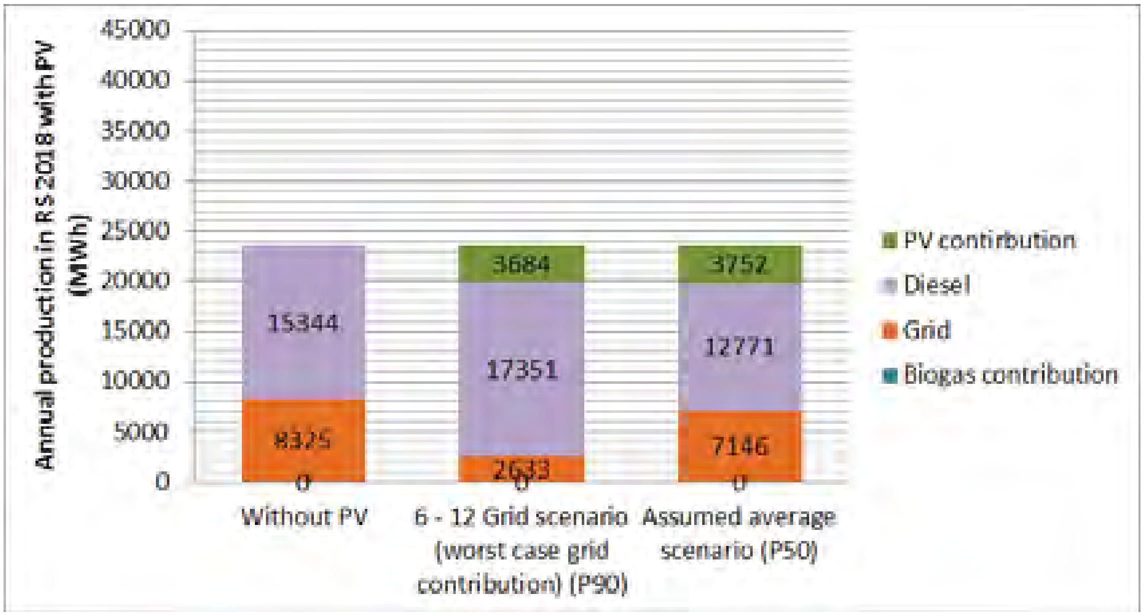


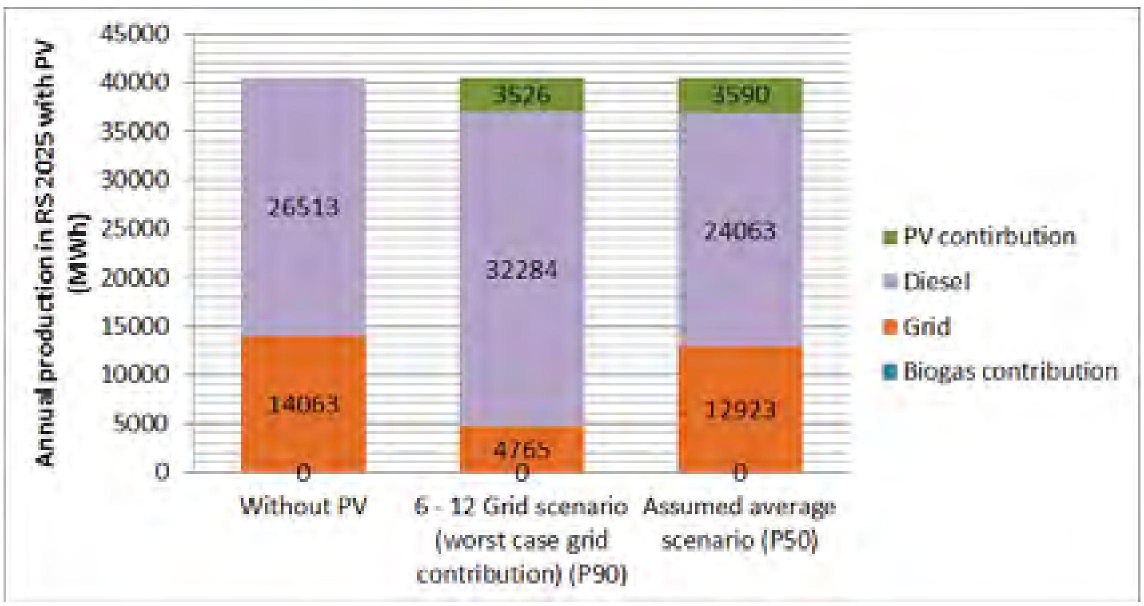
With the same assumptions of grid availability, P50 and P90 scenarios mentioned in the last section, the resultant annual energy mix is elaborated in Figure 7-10.Table 7-7 shows the percentages of the contributions in P50 scenario (the nominal case).

Table 7-7: Annual energy mix in the recovery scheme

Years	2018		2025	
Total	**MWh**	**%**	**MWh**	**%**
	23668	**100%**	**40575**	**100%**
PV Share	3756	15.87%	3590	8.85%
Diesel Share	12771	53.96%	24063	59.30%
Grid Share	7146	30.19%	12923	31.85%
Biogas Share	0.00	0.00%	0.00	0.00%

Figure 7-10: Annual energy mix at the recovery scheme in 2018 and 2025

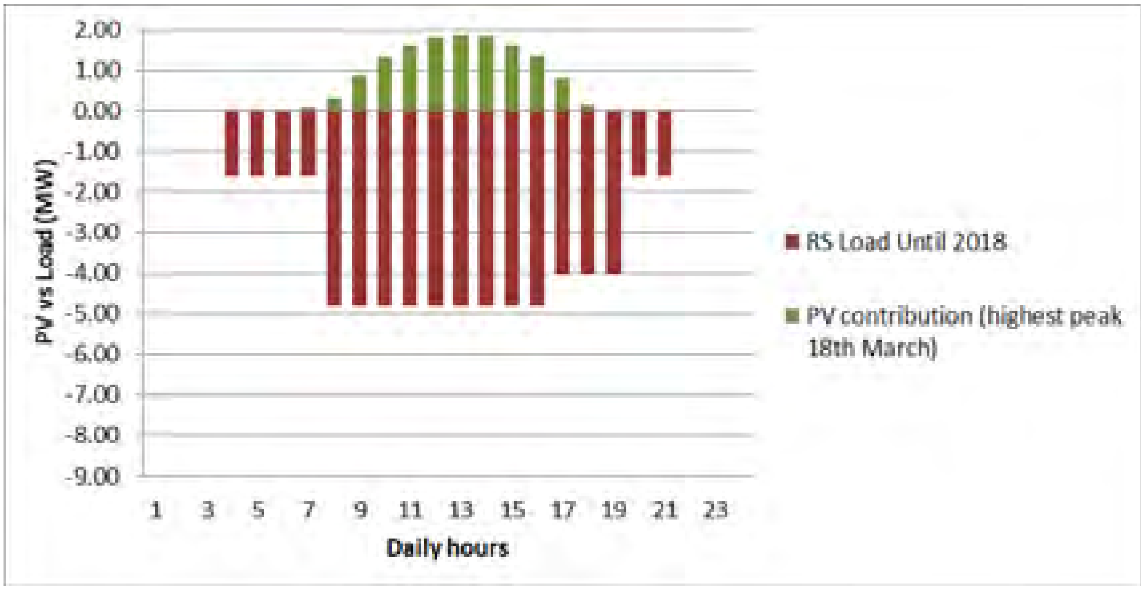


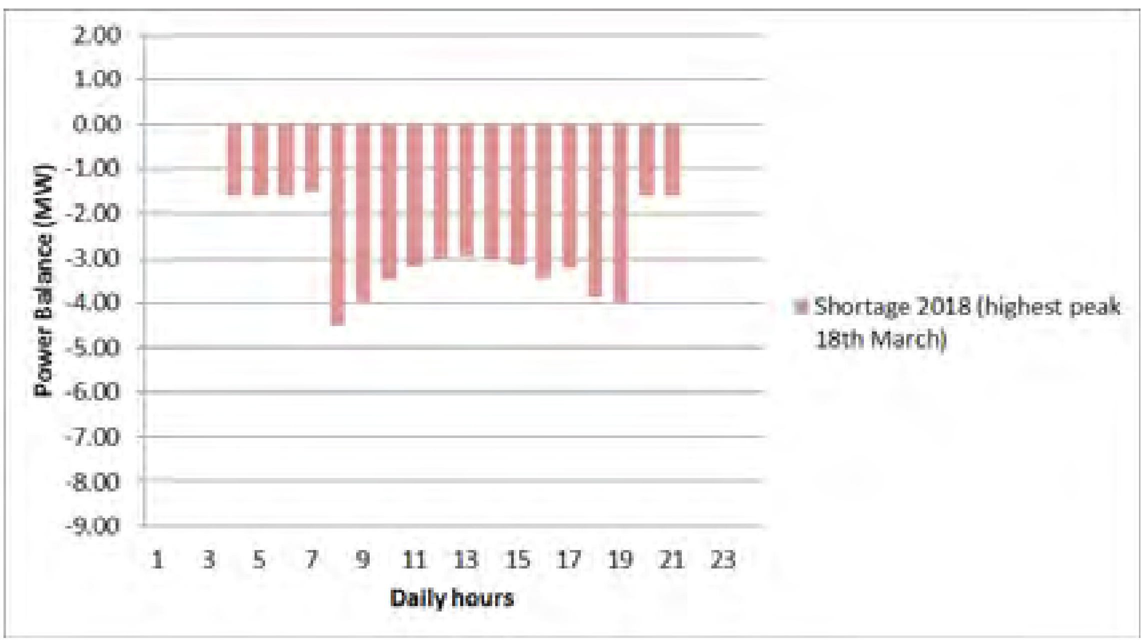


7.2.3.2 Selected daily profiles

On the 18th of March, the PV power generation reaches its peak of 1.8 MW in the recovery scheme field as shown in Figure 7-11.

Figure 7-11: Daily profile and energy balance at the RS on 18th of March





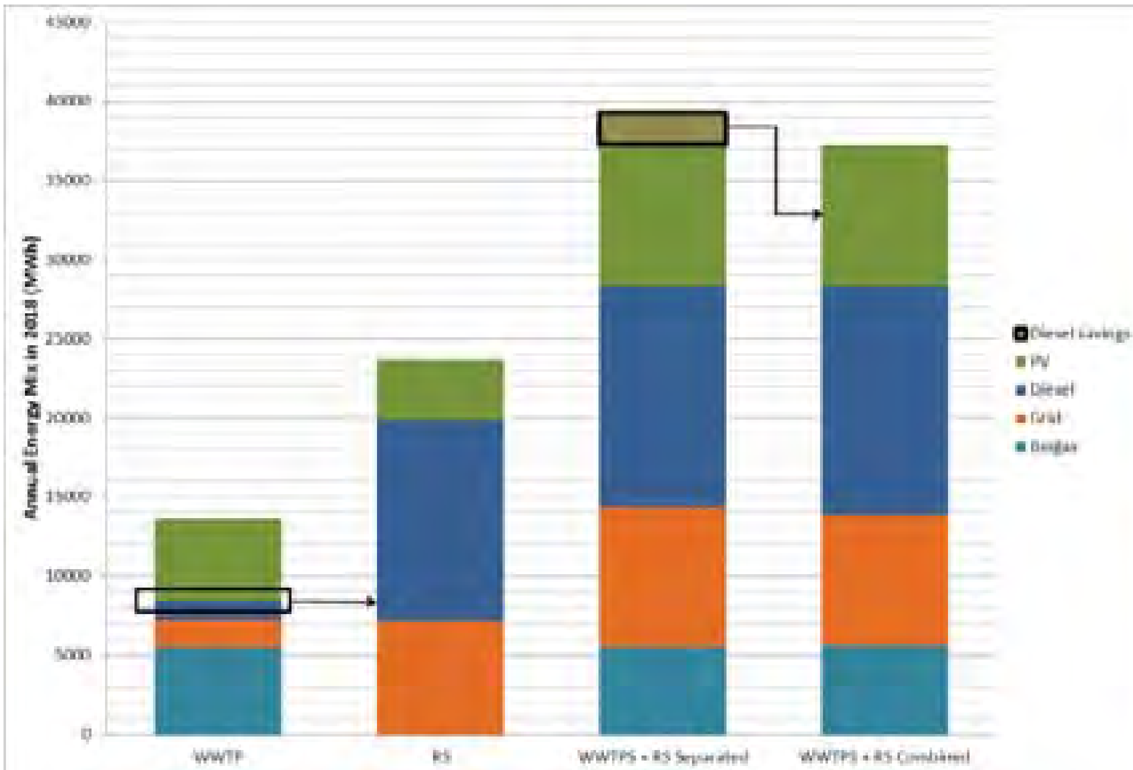
The shortage prevailing over the whole day, also called residual load, shown on Figure 7 11 explains that the peak generation of the PV system does not result in excess as in the previous case in the WWTP. The daily shortage in the RS in the peak day reaches 51 MWh, much higher than the daily excess in the WWTP. The annual residual demand of 19817 MWh would need to be covered by the external network and the diesel genset.

The configuration described above shows the potential for optimisation of the use of the excess of power generation in the WWTP by using to reduce the residual load at the RS further. Accordingly, combining both systems together will be discussed in the coming section.

7.2.4 WWTP and RS Combined

Connecting the fields of the WWTP and the RS together aims at optimizing the unused excess of the generated power in the WWTP in 2018, and therefore allows reducing the residual load at the RS. This is illustrated in Figure 7-12. If the two locations are separated (displayed with the first and second bar), the portion of the required at the WWTP diesel generation and consequently the sum of the annual balance of both locations (depicted by bar number three) is higher than for a scenario where both locations are combined as shown by the fourth bar. The difference between bar three and four represents the energy savings from diesel generation which could potentially be realised in a combined scenario.

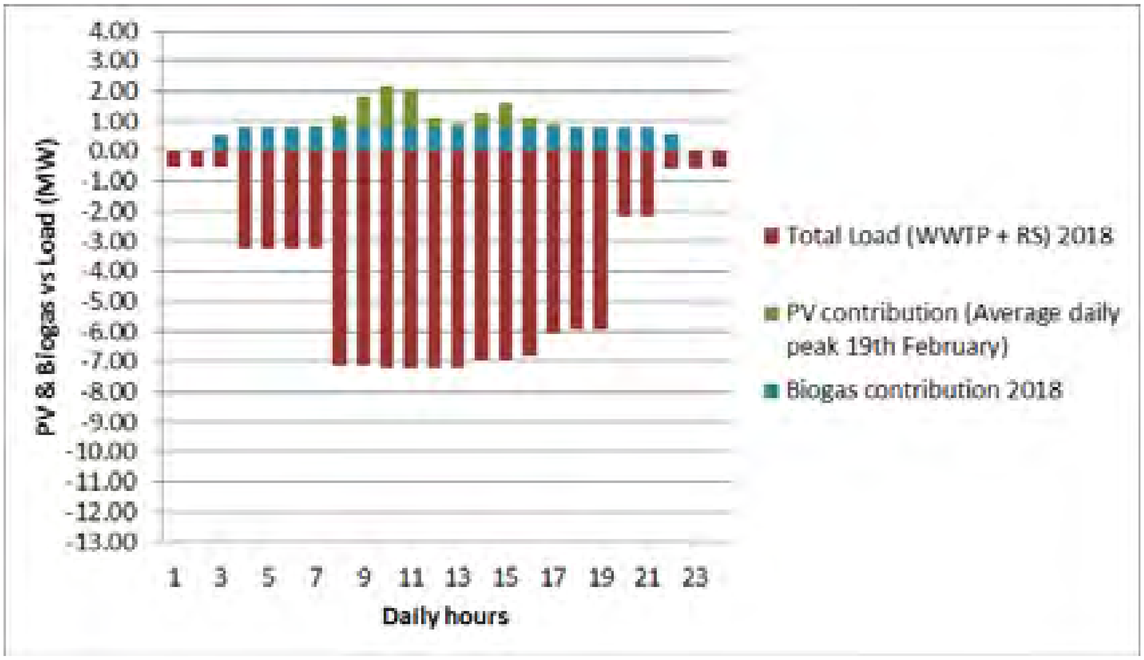
Figure 7-12: Excess RE generation in separated and combined scenario for 2018



The basis for the energy balance is the combined demand of the WWTP and RS together Section 3.3.

The average daily energy balance is plotted as shown in Figure 7-13 and Figure 7-14 in 2018 and 2025 respectively.

Figure 7-13: Daily profile and balance in 2018



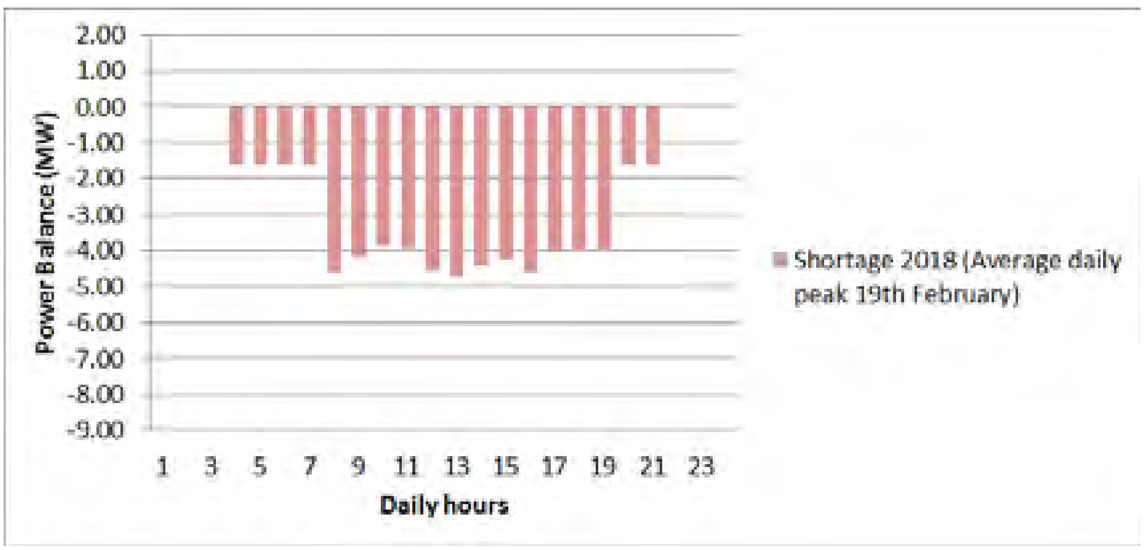
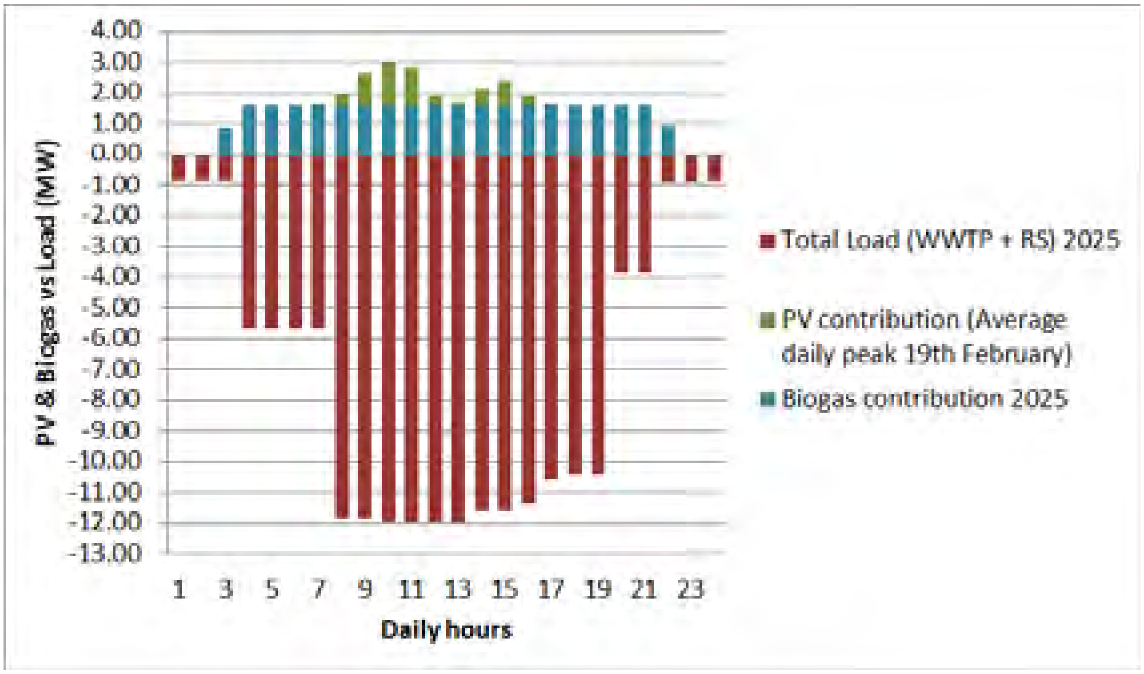
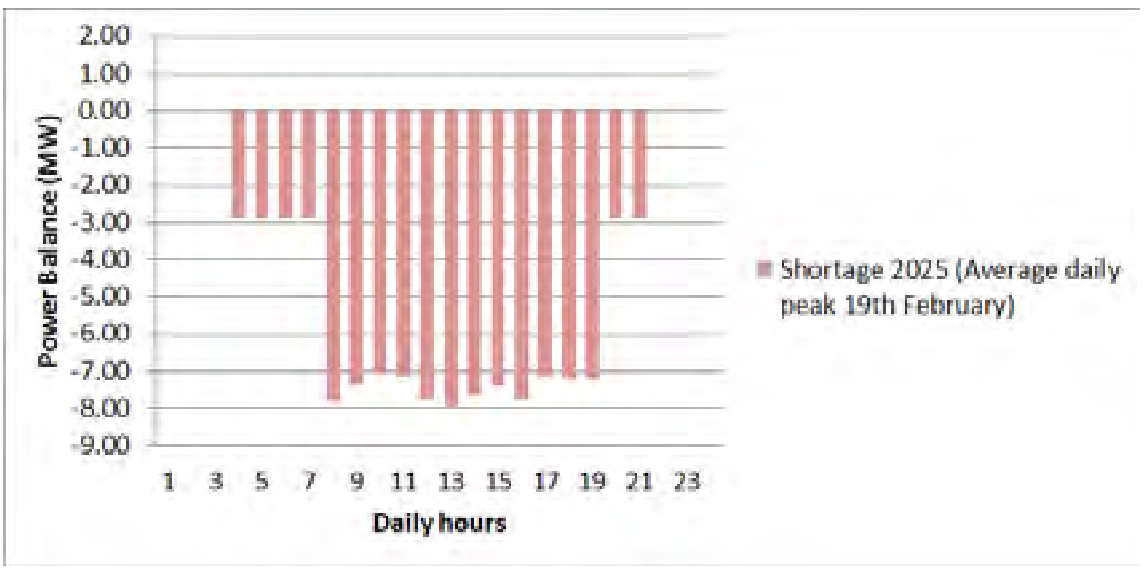


Figure 7-14: Daily profile and balance in 2025





As expected from the integration of the WWTP and RS, the installed capacities of the PV and biogas generators are not sufficient to cover the total project design demand. Hence, the additional supply from the grid and the diesel generators are necessary.

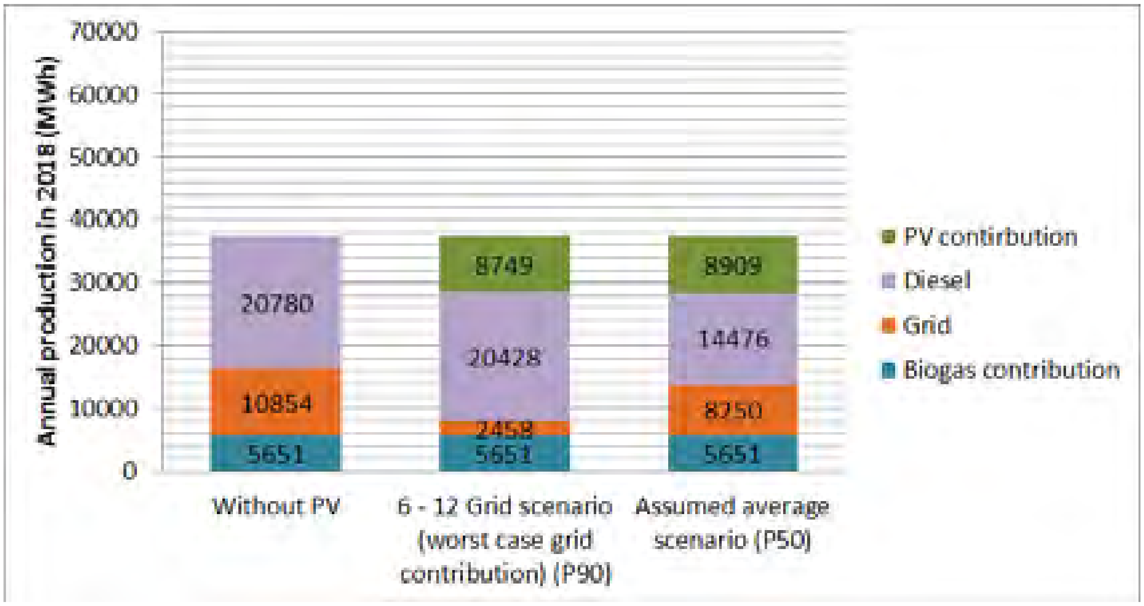
The scenarios PV yield estimate discussed in Section 7.1 and the grid scenarios discussed in Section 7.2 will be put here into consideration. So the P50 scenario will include the average contribution grid scenario described above, while the P90 scenario will include the worst case grid contribution.

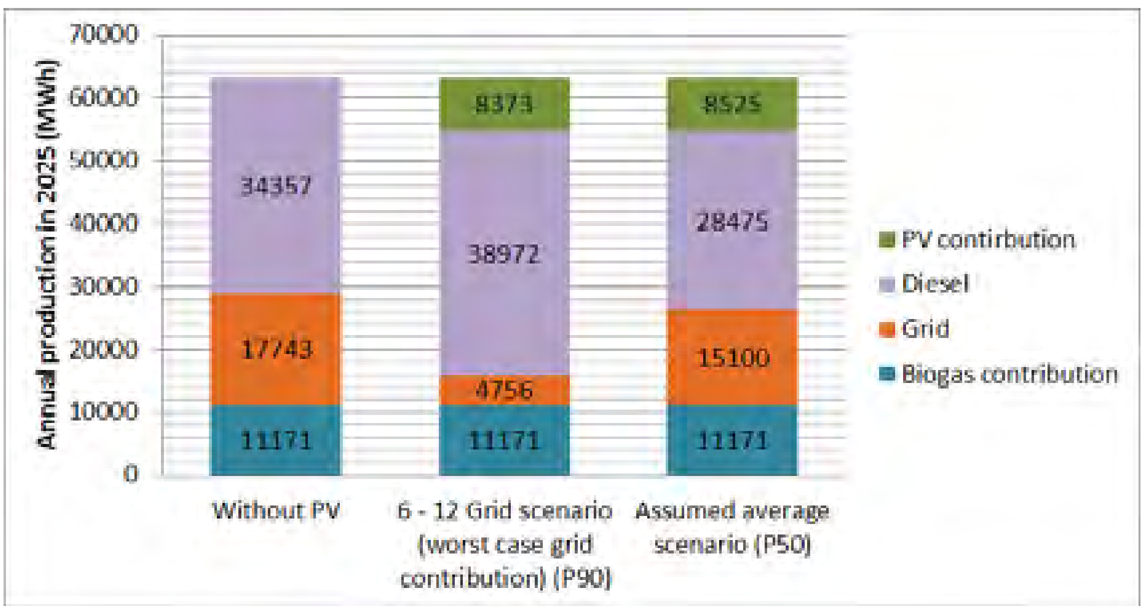
The resultant annual energy balance for 2018 and 2025 is elaborated in Figure 7-15 showing the P50, P90 scenarios in addition to the “No PV” case. Table 7-8shows the percentages of the contributions in P50 scenario (the nominal case).

Table 7-8: Annual energy mix (P50)

Years	2018		2025	
Total	MW.hr	%	MW.hr	%
	37286	100%	63271	100%
PV Share	8909	23.89%	8525	13.47%
Diesel Share	14476	38.82%	28475	45.00%
Grid Share	8250	22.13%	15100	23.87%
Biogas Share	5651	15.16%	11171	17.66%

Figure 7-15: Annual energy mix at 2018 and 2025





In this configuration, the total amount of the excess unused generated power at the WWTP is all utilized to contribute to the total demand of both WWTP and RS and no PV power curtailed or biogas flared. Through this measure, the total annual shortage decreases by 171 MWh in 2018, while in 2025, the total annual shortage decreases by 48 MWh.

7.2.5 Concept for Improved Local Supply

A hybrid power supply from different power sources requires a well elaborated instrumentation and control concept to secure the operation of the varying loads. The conditions under which this can be realised with the designed components are described in the ANNEX, section 12.4. Based thereon a the optimisation of the use of the renewable energy generation at NGEST is proposed in the following:

The analysis of the energy balance of the two project locations in section 7.2.4 shows that the combined operation of WWTP and the RS brings advantages to the power supply and thus to the operation. This applies especially in the off-grid periods with high production from the biogas and PV components occurring during mid-day when NGEST's operations have their daily peak.

Therefore, it is proposed to implement a Point of Common Coupling (PoCC) in the 22 KV OHL to the GEDCo network ahead of the RS switch gear.

For illustration of the power system, Figure 7-16 shows a generalised schematic diagram of the power system with current design well as after installation of the PV system as proposed in the conceptual design.

To establish the PoCC it is proposed to install an additional circuit breaker in the connection line with signal cables connected to the switchgears at WWTP and RS, and ideally an energy meter.

In the off-grid case, this measure has the following effect:

- The facilities can be completely islanded from the network during load shedding.
- This avoids any negative impact from and to the network including back-feeding.
- The higher loads are installed at the RS. Thus, at no time excess of power is expected at that location. Consequently, the generator gensets at the RS would be running constantly during load shedding.
- In the control sequence, these generators would be defined as the master devises which start first after grid goes off. The master devices would also build the grid whereon the other components would synchronise on.
- With this setting, the diesel at the WWTP could then potentially be shut down.
- The signal cable would allow sending a stop signal to the commercial energy meters located at the low-voltage side (0.4 kV) of each transformer.
    - This is an important commercial aspect because if meters are not halted NGEST would have to pay for any excess power which is transferred from the WWTP to RS.
    - Another option could be to allow the meter at WWTP to reverse and the meter at RS to continue spinning forward. But due to the constant operation of the diesel at the RS (load high and the requirement on the diesel as grid builder) a power flow from RS to WWTP would occur during the very short synchronisation phase.
    - Thus, the metering and billing of energy produced local within the NGEST facilities can only be avoided if meters are stopped during island operation.
- The arrangement shows that NGEST is actually supplied on LV and GEDCo bears the costs of the transformer losses. In case energy is transferred among the two locations, transfer losses occur at either side, e.g. when stepping up at WWTP and then again when stepping down at the RS. These losses are regarded as minor – also because a connection of both locations on LV level is not viable.

In case the grid is operating during the period the excess at WWTP occurs, the two facilities would not be disconnected at the PoCC. A commercial solution has to be identified that allows NGEST to export the excess from the WWTP to the RS without being double-charged. Possible solutions are:

- Stopping the energy meter at the WWTP, or
- Allowing the meter to reverse (bi-directional meter) and then subtract the recorded amount from the readings at the RS

This metering issue would be best solved by allowing NGEST to employ net metering. As shown in the energy balance analysis, net metering in the case of NGEST, with its high net demand, would have a no effect the commercials of GEDCo, i.e. it would not require implementing a credit system to account for annual import from and export to the network as it was the case for a network-wide net-metering regulation for end-consumers.

With this proposed concept, complexity of the commercial part increases slightly. The different cases, supplied by grid and isolated, can be managed and verified by a proper documentation and verification of metering values in a frequency higher than monthly values. The SCADA system and monitoring devices will be of additional help providing an indirect control function, e.g. by logging time the grid is not available or providing the power output of the PV system and biogas engine.

Ideally and under a well-defined load shedding regime, the system could be prepared for non-interrupted transition from grid to off-grid, e.g. the master diesel already synchronises to the grid a short time ahead of the rolling blackout. Also, all the consumers need to be protected from the few seconds of interruption in case of sudden break or be able to withstand such short interruption.

The independent operation and metering of both locations would lead to a certain amount of excess, especially until processing volume at WWTP is increased in 2025. This is shown in the evaluation of the energy balance shows (compare section 7.2.2 and section 7.2.4). Through installation of battery banks or an expansion of the biogas storage, this excess could be utilised locally at the WWTP. But costs for these measures are expected to be higher than the benefit:

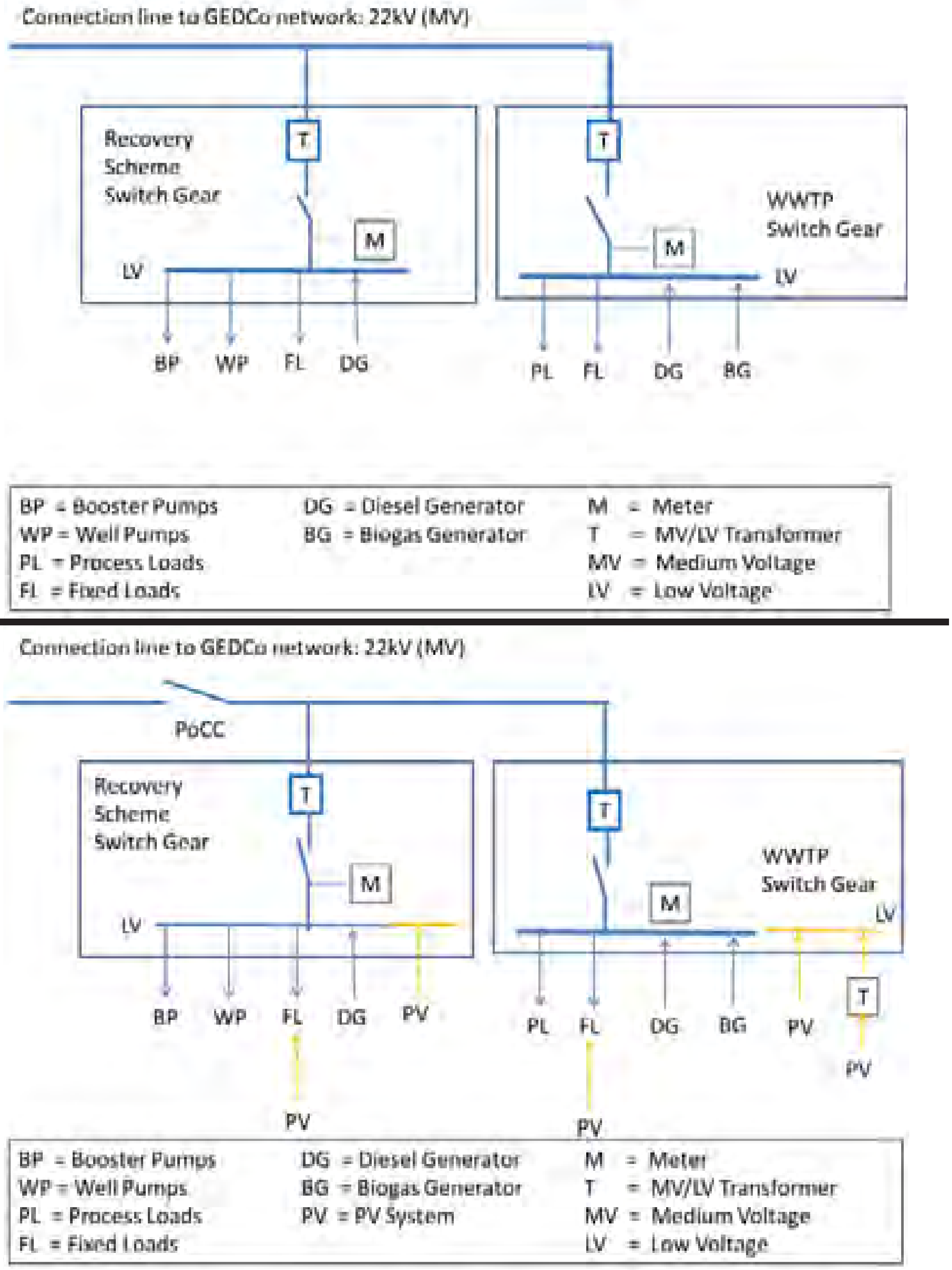
1. The high excess is only observed during Phase 1, meaning that the payoff and utilisation of the measures would be less after 2015;
2. Batteries would increase the total CAPEX of the power supply and add more complexity;
3. Increase of the biogas holder would require a modification of the already installed biogas facilities, incur additional costs and reduce the installation area for PV A1. This option is may be adopted if the net-metering for the combined scenario is not accepted by GEDCo.

As conclusion it can be stated that the described concept, would comparison with other measures (i.e. additional connection line between the two locations or independent management of the two locations) lead to the lowest modification of existing structure and technical design. Additionally, carries a relatively low impact on GEDCo's network and come with minor commercial implications.

In this context, it shall be noted that it was not possible to obtain the Grid Code for the GEDCo network from the utility nor was it provided by the stakeholders. Tight consultation and coordination with the utility on the next step is recorded as condition for the success of the project. The final solution can only be identified and agreed upon together with GEDCo.

On the technical level, it is suggested to initiate a discussion with SIEMENS as the NGEST SCADA supplier regarding integration of the control of the PV system into the overall facility administration.

Figure 7-16: Generalised schematic of current design (above) and with of PV (below)



8. Preliminary Environmental and Social Impact Assessment

8.1 Objective of the Preliminary ESIA

The main objective of this preliminary environmental and social impact assessment (ESIA) is to assess both the negative and positive social and environmental consequences related to the construction and operation of photovoltaic systems at the NGEST site. Moreover, it shall outline an implementation and monitoring plan for mitigating the negative consequences and define the institutional responsibilities for the implementation of the plan.

More specifically the ESIA will address the following main issues:

1. Environmental and social impact of the project.
2. Potential Land acquisition needed for temporary construction work or for permanent use by the project.
3. Preparing an implementation plan for mitigating the negative impact (if needed)
4. Assess the capacity of the implementing institution and recommending any capacity building needs (if needed).

8.2 Legal Basis and Reference Guidelines for the Assessment

8.2.1 Palestinian Legislations, Regulations

The relevant laws and policies that govern conducting environmental assessments in Palestine can be summarized as follows:

- Palestinian Environmental Law # 7 issued 1999.
- The Palestinian Legislative Council approved the first Palestinian Environmental Law, which was signed by Chairman Arafat on 28 December 1999.
- The Palestinian Environmental Strategy (PES) which was published in October 1999 by MEnA. It covers the political and social context, the legal and institutional framework, the environmental driving forces, the environmental themes and the strategy elements
- MEnA (EQA) has issued an Environmental Assessment Policy which provides implementation procedures. The Environmental Assessment Policy, will assist in meeting, *inter alia,* the following goals:

  - to conserve the social, historical and cultural values of the Palestinian people and their communities;
  - to ensure an adequate quality of life, health, safety and welfare for the Palestinian people;
  - to preserve natural processes;
  - to maintain the sustainable use and the long-term ability of natural resources to support human, plant and animal life;
  - to conserve bio-diversity and landscapes;
  - to avoid irreversible environmental damage from development activities; and
  - to ensure that the basic needs of the people affected or likely to be affected by a development

activity are not jeopardized.

Within the terms of the draft policy, MEnA (EQA) is responsible for the implementation and for the approval and assessment of environmental considerations in relation to proposed developments. It is expected that the EQA will liaise with relevant institutions, such as the PWA, in relation to the proposed developments.

The form of the policy is similar to that of the World Bank (see details below) and it specifies the requirement for comprehensive EIAs (necessary for projects likely to have significant impacts) and an Initial Environmental Evaluation (IEE) for projects where significant impacts are uncertain, or where compliance with environmental regulations must be ensured. Completion of an IEE may necessitate the conduct of a comprehensive EIA.

The Palestinian Water Law # 14, 2014, and the Palestinian Energy Authority Establishment Law #12 enacted in 1995 form part of the wider legal framework. The latter law sets the main responsibilities of the Palestinian Energy Authority and defines the various energy sources including from renewable sources that the authority can utilize for the generation of electricity.

8.2.2 WB Reference Criteria Catalogues

The key reference in this context is The World Bank's Operational Policy/Bank Procedures/Good Practices (OP/BP/GP 4.01) and associated documents.

The purpose of undertaking an EIA is to improve decision-making and to ensure that a project options under consideration are environmentally sound and sustainable. The EIA should identify ways of improving the environmental compliance of projects by preventing, minimizing, mitigating or compensating for adverse impacts. Accordingly WB OP 4.01 identifies that project-specific EIAs should normally cover the following aspects:

- existing baseline environmental conditions;
- potential environmental impacts;
- systematic environmental comparison of alternative investments;
- systematic environmental comparison of alternative sites;
- systematic environmental comparison of alternative technologies and designs;
- preventive, mitigation or management plan;
- environmental management and training; and
- environmental monitoring.

The level of EIA performed should be based on the expected environmental impacts, as determined by the type, location, sensitivity, and scale of the proposed project, as well as the nature and magnitude of its likely potential impacts. Projects are grouped into categories characterising the potential impacts in accordance with the OP.4.01:

- Category A (those that are likely causing significant impact) projects should be subjected to full environmental analysis through the planning and implementation phases.

- Category C: A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impacts. Beyond screening, no further EA action is required for a Category C project

- Category FI: A proposed project is classified as Category FI if it involves investment of Bank funds through a financial intermediary, in subprojects that may result in adverse environmental impacts

According to the World Bank operational policies (OP 4.01), the current project can be classified as category C project where it has minimal or no adverse environmental impact. Therefore, preliminary environmental assessment or environmental screening will be carried out for the project component (PV solar panels) that will be installed in the NGEST location.

8.3 Review of the ESIA Issued for the NGEST Project

8.3.1 Scope

A detailed ESIA has been prepared for the NGEST project (Waste Water Treatment Plant and Effluent Recovery Scheme) since it was classified as Category A project, according to World Bank operational policy, because involves wastewater production, treatment and reuse as well as recharge to the groundwater which might entail some environmental and social impact. The risks involved related to the possible groundwater pollution, agricultural land contamination, land acquisition for the construction of the project (infiltration ponds and the treatment plant it, etc). Accordingly, the scope of the ESIA includes the determination of any expected environmental and social impacts and preparation of an environmental management plan for managing, mitigating and monitoring risks and negative impacts.

Moreover, the ESIA took into account the temporary and permanent land requirement for the project and checked the type of land acquisition foreseen and prepared safeguard instruments in compliance with World Bank OP 4.12 related to involuntary resettlements.

The preparation of the ESIA has taken into consideration the requirements of the EIA policy of the Palestinian Environmental quality authority as well.

However, the ESIA does not address the impact of the surrounding environment on the PV plant.

8.3.2 Areas Covered

The ESIA for NGEST project covers the entire project location and the surrounding areas including the areas currently proposed for the PV solar panels.

The ESIA also covers the recovery field areas in the analysis and potential impact. The analysis included potential public health impact and monitoring, groundwater quality and pollution as well as capacity building needs to manage recovery scheme.

8.3.3 Power Generation from Different Energy Sources

8.3.3.1 Diesel

The ESIA addresses the power generation issue under the section on "energy demand and response plan of energy shortage from the grid". The project has three standby 800 KVA diesel generators and two 500 KVA ones that will be used for wastewater treatment and recovery and reuse (phase 1) in case of electricity shortage or failure from the grid. In addition three 500 KVA standby generators will be considered for phase 2.

8.3.3.2 Biogas including gas holder with flare

The generation of biogas is considered part of the energy sources envisaged to cover the demand of the plant energy demand within the ESIA. It is assumed that up to 0.8 MVA (40%) of the energy demand is secured from the biogas generation from the two sludge digesters.

8.3.3.3 GEDCo supply

The line route of GEDCO supply is not covered by the ESIA.

8.3.3.4 Power supply and diesel generators at recovery areas

The power supply for recovery and reuse during phase 1 is assumed to be covered from the grid as well as from the biogas generated in the plant. The two standby diesel generators of 500 kVA each are also considered in case of electricity shortage or failure from the grid.

8.3.4 Gap analysis

The ESIA of the NGEST project has addressed most of the environmental aspects related to the wastewater treatment plant, the infiltration basins and the recovery and reuse schemes. It developed detailed environmental implementation and management plan to tackle potential environmental impacts during construction and operation phases.

However, the ESIA did not anticipate the PV energy generation and therefore did not address the impact of the PV on the environment nor did address the impact of the surrounding environmental conditions as well human interventions on the PV plant proposed for the NGEST project. Accordingly, the main areas that will be covered under this preliminary environmental assessment can be summarized as follows:

1. The environmental and social impact of the PV panels on the NGEST project area and in the proposed Waqif land in the future stage. More specifically, the analysis will address the impact of land use change, land acquisition for the new PV panels, the impact on flora and fauna, the impact on air and water, impact on local community.
2. The impact of natural conditions and human activities on the PV panels. Specifically, the solid waste collection vehicle movement around the site using dirt roads, the charcoal factory, the temperature and humidity and other climate conditions and their implications on local environment.
3. Impact of political conditions and wars on the PV
4. Develop an environment management plan to propose mitigation measures of negative impacts and possible costs associated with mitigation.

8.4 Preliminary Social and Environmental Impact of PV on Project Area

8.4.1 Terrain under investigation

The scope of the current preliminary ESIA is limited to the location of the PV system that will be installed within the fenced boundary of the NGEST project in addition to the proposed future expansion to the Waqf land located to the west of the cemetery. Therefore, the space where the assessment will focus on is very limited. The major part of it is already fenced for the waste water treatment plant (WWTP) and covered by the main ESIA report that was developed for the NGEST project.

The use of space within the boundaries of the plant will vary according to the type of PV variant that will be finally selected. However, the space needed for four of the proposed design variants is nearly the same. Only the variant 4 with the two axis tracker differs slightly because it utilizes more space but places the structures less in less dense pattern on the designated areas as shown in in Drawing 001 and Drawing 002.

Total area that will be covered by the PV systems ranges between 35,000 m² to 73,000 m² in the case of the two axis tracker PV system on the NGEST project area. In addition to this a free field system will cover around 30,000 m² of the Waqf land.

8.4.2 Potential Impact

Figure 8-1: Example of area within the WWTP

Due to the fact that the PV panels will mostly be installed within the WWTP terrain no additional potential negative impact on the local environment is expected. The area is already closed and reserved for utilized for the plant. The flora in the site is limited to species of local seasonal wild plants which are commonly available in Gaza with no any record for endangered species in the site. The vegetation has regained the areas after covering up upon end of the main construction activities.

Figure 8-2: Example of area within WWTP on East side

Moreover, no fauna is expected in the site except some birds and possibly insects and lizards, again there is no record for any endangered species in the area. The impact of the PV installation might cause some disturbance during the construction stage to these creatures but it will be limited and for a short period of time.

The PV panels are free of hazardous material (liquid, solid or gas) and therefore are not expected to create any risk for the surrounding areas in terms of spillage or emission. The same would apply to the workers' health during installation and operation.

The impact of the PV on land use will also be limited. The areas inside the NGEST plant are already artificial surfaces covered with roads and paved areas. Only limited areas of the WWTP terrain are currently open space. The impact on the aesthetic view is therefore very limited with no major change in the land use shape and no major excavation or change of morphology in the area. Similarly, the PV installation will have no pollution threat to the air and local water resources in the area.

The expected social negative impact is also very minimal since there is no close community adjacent to the plant, where the nearest community is Jabalia at distance of around 5 km. Moreover, the land is not used for any production purpose. However, it is likely that some positive impact can potentially be anticipated during the construction stage and later on during the operation stage especially when electricity generation from the PV panels starting and the surplus is fed into the grid. Such surplus will benefit the local communities and they will enjoy more frequent electricity or longer supply hours. This in turn will enable the community to enjoy more electric supply hours and likely improve the livelihood. This effect can only be finally confirmed once a final and reliable energy balance is generated as part of the feasibility study. Moreover, another positive impact during the construction stage could probably arise from job creation for the technicians and local workers who will be involved in the installation of PV system. Although this impact is for limited period but under the given hard economic situation of Gaza and high unemployment rate it creates a positive impact. Since PV is a new technology in Gaza, workers would gain also from the knowledge transfer during the activities.

The investigated land is owned by the state and therefore, no acquisition procedure is required and no impact on individuals land ownership that would require a dedicated safeguard process.

The impact on safety of workers and operators during installation and operation will be low to moderate. Only precautions are needed since work will be carried out mostly inside the plant and next to open filtration ponds and roofs of buildings. Clear work procedures during the installation have to be taken into account by local contractors to avoid any potential work incident.

8.4.3 PV System Impact Mitigation Measures

It is clear that no major mitigation measures are needed since the negative impact is low on various social and environmental constituents of the project area. The only measure needed to ensure safety of workers during installation and operation and to have clear working procedures and take safety measures to avoid falling in the ponds or from the roofs of buildings. In addition, it is recommended to limit the working time during construction to the day time only and to consider using light machines to minimize noise and vibration so that no disturbance to local fauna is secured.

8.4.4 Impact of Natural Conditions and Human Activities on the PV Systems

The potential impact of the local environment on the PV panels arises mainly from two sources:

8.4.4.1 Impact of solid waste vehicle movement on dirt roads

Figure 8-3: Lorry carrying municipal waste to the landfill

It was observed that the NGEST plant is surrounded by two dirt roads that are used by solid waste collection vehicles to transfer solid waste to the land fill used by Jabalia to the east of the plant as shown in

. The dust created by vehicle movement will likely lower the efficiency of electricity generation from the PV panels and will require frequent cleaning (eg. by using water).

8.4.4.2 Impact of the charcoal production site

Figure 8-4: Local charcoal production site

The existence of charcoal factory at nearly 300 m distance to the west of the plant has potential impact on the efficiency of the PV plants. Smoke resulting from the charcoal production might cover the PV panels and reduce the exposure to sunlight. This in turn will reduce the potential electricity production.

8.4.4.3 Mitigation options for the external impacts on PV system

The dust created by vehicle movement can be mitigated through the pavement of the roads around the plant. Alternatively, frequent cleaning of the PV panels will be required using large quantities of fresh water. Given that water is scarce in Gaza it might add additional pressure on the already strained water resources and will require more analysis in terms of potential impact.

8.4.5 Impact of Political Conditions and War

The proximity of the plant to the border with Israel renders it vulnerable to any future armed conflict in the area. In fact some fractures of weapons found already around the administrative building resulted from the war of 2014 as reported in the inception report of this project. This triggers the possibility of damaging PVs in any future armed conflict or war.

8.4.6 Water for Cleaning

The water needed for cleaning the PV panels from the dusts will create an additional issue of concern especially in the context of Gaza water crisis. Freshwater availability is already lacking for drinking and domestic use. Therefore, any additional fresh water quantity will put more pressure on the already scarce resources and depends on the quantity needed may escalate the demand and hence increase the cost of water for domestic use inside Gaza.

Possible mitigation will only be possible in the case of ceasing the dust emission form the dirt roads or using the water from the recovery wells of the NGEST plant for cleaning. This later will be subject to the quality of water from the recovery wells.

8.4.7 Proposed Environmental Management Plan

Project Activity	Potential Impact	Proposed Mitigation Measure	Institutional Responsibility	Estimated Cost ($)	Comment
Preparation Stage					
Site clearance prior to installing the PV panels	Safety of workers	Safety procedures followed during the work	Contractor	0$, part of the contract	
	Damage to existing infrastructure inside the NGEST Plant	Review site plans, shop drawings, cross sections and maps available for the infrastructure prior site clearance	Contractor	0$, in case of no damage. Repair any damage at contractor cost.	
Construction Stage					
Dust emission	Ambient air quality		Contractor		limited
Hazardous waste handling, spills, emission (if any)	Impact on Groundwater, soil, air quality	Site waste management plan including collection, storage and proper disposal			No impact foreseen, because no hazardous material All waste must be collected and disposed.
Excavation for the base of the PV tracker systems and regular PV panels.	Disturbance of local fauna	Limit the excavation by using light machines with low vibration. Shorten the time of excavation as much as possible.	Contractor		
	Endangering workers from bites by local invertebrates	Safety procedures and precautions followed			
	Damaging local infrastructure at WWTP	Review site plants, shop drawings, cross sections and maps available for the infrastructure prior excava-			

Project Activity	Potential Impact	Proposed Mitigation Measure	Institutional Responsibility	Estimated Cost ($)	Comment
		tions			
Mounting PV cells and Steel carriers	Impact on workers, possible injury	Safety procedure and plan			
Operation Stage					
Recover water from wells for cleaning of PVs	Health impact on workers / operators	Check quality and ensure it is safe. Train operators on safety measures and procedures. Make proper drainage for the used water. Consider option of mechanical cleaning or pressure air blowers to reduce water use.	PWA	$20,000	Depending on the quantity needed and the quality of recovered water.
Maintenance of PVs and related inverters and other devices	Technician health, electric shock	Safety procedures to be followed. Training program on how to do maintenance is a must, Special cloths and protective means (gloves) to be used by them. Detailed operation and maintenance plan to be developed for the PV.	PWA		The contractor should make the training as part of the contract.

9. Economic and Financial Analysis

9.1 Costing

9.1.1 Diesel Generators

9.1.1.1 CAPEX

The price schedules from the tender process for NGEST (file: “Priced B.O.Q final.xlsx”[23]), conducted in 2010, were used as input for investment costs of the diesel gen-sets. The values quoted therein represent the actual amount spent on the generators. The additional electrical infrastructure contained in the price schedule was not considered as part of the generator’s specific costs because it is also required for the operation of the other parts of the WWTP. This price information obtained during the tender is based on offers obtained in 2010 since the equipment installed was procured under the same process as the WWTP. Using the numbers, capacity specific costs had been derived (220.82 USD/kW diesel capacity) which were then applied to the installed and planned diesel capacities at the WWTP and the recovery scheme (listed in 4.1**Error! Reference source not found.**). This pecific cost value includes material and works. This additional conversion was necessary because the future diesel engines planned for the recovery scheme do not have the same capacity as the current units at the WWTP. This method still carries a minor uncertainty because prices for diesel engines of different sizes do not scale proportionally. Additionally, a price escalation may need to be considered for the future installed diesel capacities. For the feasibility study, and especially this task, the approach is regarded as acceptable since the emphasis is put on the comparison of different supply options. A potential replacement of the generators after about 15 years was not taken into account.

Table 9-1: Actual and projected CAPEX disbursement for diesel engines

CAPEX	Unit Rate [USD/kW]	2016		2018		2025	
		Quantity [kW]	Total Amount [USD]	Quantity [kW]	Total Amount [USD]	Quantity [kW]	Total Amount [USD]
CAPEX additional units	242	5230	1,265,638	1,760	425,913	4,250	1,028,482
Total CAPEX (cumulated for all units installed)		5230	1,265,638	6990	1,161,580	11240	2,720,032

9.1.1.2 OPEX

The operational expenses were divided in the fixed or scheduled costs and the variable costs mainly influenced by the fuel consumption.

[23] Provided by PWA on 02.04.2015

The total annual maintenance costs for NGEST have been estimated in earlier assessments[24]. Using typical assumptions for simple routine maintenance works like filter changes, adjustment of valve-tappet clearance, oil change and major overhauls, corresponding annual costs for the maintenance of the diesels were estimated with 11,434 USD. The total fuel costs were calculated in the economic assessment using the estimated amount of annual fuel consumption obtained from the energy balance (see section 7.2 and the price for diesel per litre under consideration of the specific fuel consumption of the generator. At this stage, the reduced efficiency of the diesel engine under 75% or 50% load was neglected. The average diesel price 2013-2015 was estimated with 1.51 USD/l using information given by PWA as basis.

The total annual OPEX spending mounts to:

	2016	2017	2018	2025
Financial Analysis without PV	3,065,909	3,300,534	6,450,239	10,657,014
Fin Analysis P50 with PV opt	3,065,9093,208,895	1,463,081	4,496,849	8,834,483

9.1.2 Biogas generators

9.1.2.1 CAPEX

The same sources of information used for the diesel investment costs (see section **Error! Reference ource not found.**) were employed for pricing the biogas engine investment. Since the devices are all of the same rating and will all be installed at the WWTP, the unit rate of 872,076.51 USD was used for the installed device and the second machines to be added within Phase 2.

Table 9-2: Actual and projected CAPEX disbursement for biogas engines

CAPEX	Unit Rate [USD/kW]	2016		2018		2025	
		Quantity [kW]	Total Amount [USD]	Quantity [kW]	Total Amount [USD]	Quantity [kW]	Total Amount [USD]
CAPEX additional units	1090	800	872,077	–	–	800	872,077
Total CAPEX (cumulated for all units installed)		800	872,077	–	–	1600	1,744,153

9.1.2.2 OPEX

[24] *Aspa Utilities* (2013): Operation and Maintenance Requirements Review and Recommendations, (file: "O&M final report ASPA Report Jul 2013.docx"), provided by PWA on 02.04.2015

Likewise as performed for the diesel generators (see section 9.1.1.2), the maintenance costs were estimated yielding an annual value of 3,811.35 USD for included routine and overhaul works. The price for the electricity generated from biogas was taken over from the aforementioned O&M cost assessment which states a value of 0.07 USD/kWh.

Total annual costs in USD	**2016**	**2017**	**2018**	**2025**
Financial Analysis without PV	397,088	397,088	397,088	785,754
Fin Analysis P50 with PV opt	397,088	397,088	397,088	785,754

Although NGEST processing volume is scaled up during Phase 1, the biogas generation does not increase because it operates already from the start to its design load.

9.1.3 Solar PV Plant

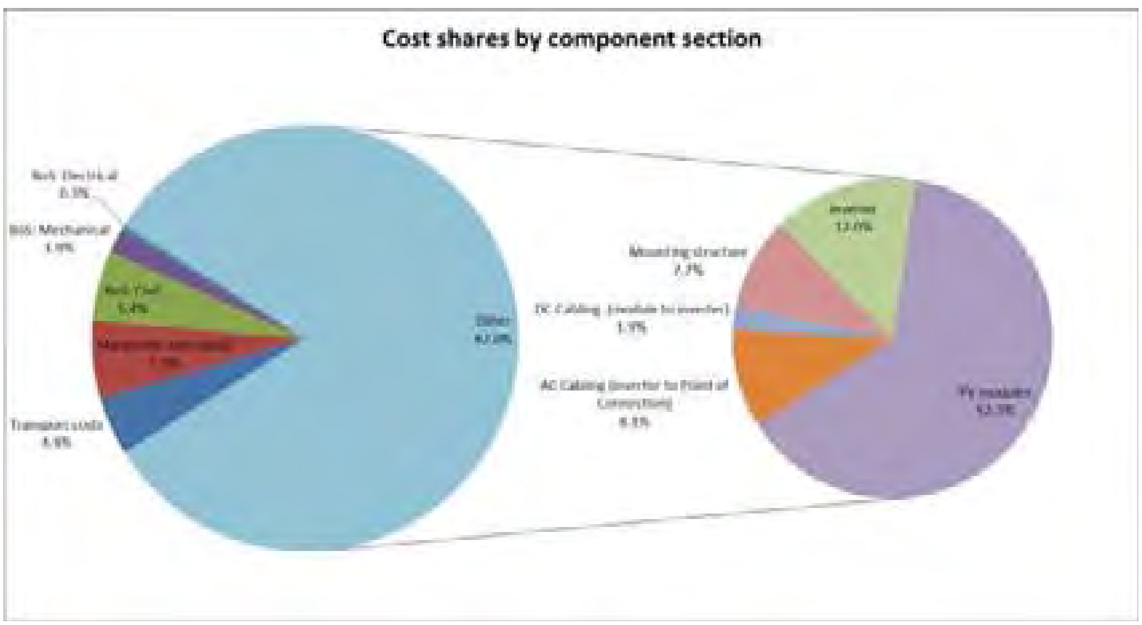
9.1.3.1 CAPEX

The cost estimate for the conceptual design is an upgrade up the preliminary cost evaluation used for the evaluation of the variants (see section 12.3.1.3). Based on the actual quantities used in the design and a revised breakdown, the total costs were estimated with 1,350 USD/kWp which amounts to a total value of 6,897,993 USD. This includes the main system and additional auxiliary facilities such as the monitoring devices. While the PV plant can save costs due to the existing electrical infrastructure, other parts such as SCADA integration to the facility control system were added to account for such interfacing efforts expected. This cost estate assumes the implementation under a typical EPC turnkey contract. Thus, the works and transport was included in addition to the mere equipment positions. The second-level breakdown of the costs is shown in Table 9-3 while Figure 9-1 provides an overview on the share of the different major positions on the total costs.

Table 9-3: CAPEX estimate of the PV system

		Total						
AREA		Sum: PV System						
kWp		5108.74						
Item	Description	Quantity	Spare Parts	Spare Parts [%]	Total	Total USD (incl Taxes)	Specific costs	Importation taxes (included in total)
1.0.0	Main PV system	272039	11062		283,101	5,144,183	1,007	170,095
1.2.0	*PV modules*	*19649*	*1376*	*0*	*21,025*	*3,279,900*	*642*	*163,995*
1.3.0	*Inverter*	*185*	*17*	*0*	*202*	*751,250*	*147*	*6,100*
1.2.0	*Mounting structure*	*898*	*19*	*0*	*917*	*484,783*	*95*	*0*
1.2.1	*DC Cabling (module to inverter)*	*185950*	*9298*	*0*	*195,248*	*117,903*	*23*	*0*
1.2.2	*AC Cabling (inverter to Point of Connection)*	*65357*	*352*	*0*	*65,709*	*510,347*	*100*	*0*
1.2.3	BoS: Electrical	30437	261		30,698	21,731	4	0
1.3.0	*Grounding*	*4394*	*0*	*0*	*4,394*	*2,413*	*0*	*0*
1.3.1	*Lightning protection system*	*72*	*0*	*0*	*72*	*3,220*	*1*	*0*
1.3.2	*Communication System*	*4579*	*47*	*0*	*4,626*	*9,616*	*2*	*0*
1.4.0	*Conduits*	*21392*	*214*	*0*	*21,606*	*6,482*	*1*	*0*
1.4.1	BoS: Mechanical	6162	0		6,162	121,598	24	0
1.4.2	Fence and Gates	*1053*	*0*	*0*	*1,053*	*117,000*	*23*	*0*
1.5.0	Miscellaneous	*5109*	*0*	*0*	*5,109*	*4,598*	*1*	*0*
1.5.1	BoS: Civil	4064	0		4,064	336,150	66	
1.5.2	*Cable trenches*	*3045*	*0*	*0*	*3,045*	*30,450*	*6*	*0*
1.5.3	*Roads*	*1019*	*0*	*0*	*1,019*	*305,700*	*60*	*0*
1.5.4	Manpower and labour	25544			25,544	368,596	72	
1.5.5	Transport costs	278645			0	278,645	55	
1.5.6	Total				6,360	6,897,993	1,350	
1.5.7	*Total installation costs*				*5,782*	*6,270,902*	*1,227*	
1.5.8	EPC Markup (handling fee/margin)	10%			578	627,090		0
2.0.0	*Grand total*				*6,360*	*6,897,993*	*1,350*	*0*
2.1.0	Portion of potential local content				0	2,069,676		

Figure 9-1: CAPEX shares per component category



9.1.3.2 OPEX

The estimated operational expenditures for the PV system are shown in Table 9-4. The cost has been gathered based on a database with typical PV project operational and maintenance costs. In addition, local labour and operations cost structures were considered. The OPEX does not yet consider the actual synergies which could be leveraged when the PV system is maintained by the same crew that maintains the rest of the facility. Such savings can be accounted for once the contract for is finally decided upon.

Table 9-4: Estimated specific OPEX for PV

OPEX for the PV plant	Unit	Quantity	Price/ Unit in NIS	NIS	€	$
Cleaning	[/kWp/a]	5,177	10.00	51770.00		12,943
Repair and Maintenance	[/kWp/a]	5,177	15.00	77655.00		19,414
Maintenance Tracking	[/kWp/a]			0.00		0
Operation	[/kWp/a]	13	4000.00	52000.00	10,400	13,000
Insurance	[/kWp/a]			0.00	0	0
Others (provision for repair)	[/kWp/a]	1	14000.00	14000.00	2,800	3,500
Total	**[/kWp/a]**	**100,000**	**18025.00**		**13,200**	**48,856**
Specific OPEX	**USD/kWp**					**9.44**

9.1.4 Modification on Power Relevant Infrastructure

If anything necessary:

- Biogas storage
- SCADA integration
- Batteries
- Upgrade to electrical infrastructure to share power, if proving to be of benefit is identified

The uncertainty is:

- when will the additional Biogas / Diesel installed?
  - 2025
  -

9.1.5 Other Power Relevant Infrastructure

- Diesel
- biogas

9.2 Economic Evaluation of Supply Options and Variants

The economic evaluation of possible supply options and variants has the objective to state the options available and to give an insight into which technical variants are economically the most attractive.

The considered power source options for NGEST are as follows:

1. Off-site:
   - Electricity supply through GEDCO (Israel, GPP, Egypt)

2. On-site:
   - Biogas
   - Diesel
   - Photovoltaic, with five possible technical variants that were also economically contemplated.
     - PV-Variant 1: True South
     - PV-Variant 2: Geometric Adaption
     - PV-Variant 3: 1-axis Tracker
     - PV-Variant 4: 2-axis Trackers
     - PV-Variant 5: Thin Film

In order to evaluate the different options the following input data was used:

Table 9-5: Input data[25]

Input Data	Unit	Amount
Economic conditions		
Assessment period (2016 – 2036, solar PV starting 2017)	years	20
Discount rate	%	7
Exchange rate (annual average 2015 as of 01.01.2015)	USD/ILS	3.9196
	ILS/USD	0.2499
Supply source 1: Off-site via GEDCO (refer to section on GEDCo)		
Energy (purchase price) GEDCO excl. VAT	USD/kWh	0.126
Supply Source 2:		
Current diesel price (03/2015)	ILS/L	5.69
Average Diesel price 2013 - 2015	ILS/L	6.04
Current diesel price (03/2015)	USD/L	1.42
Average Diesel price 2013-2015 excl. tax	USD/L	0.68
Gas excl. subsidies	USD/kWh	0.09

[25] Source: The data was compiled by the consultant through information and reports from the Palestinian Water Authority, the World Bank, and GEDCo. Also for some prices current tax rates, subsidies etc. were deducted/added.

9.2.1 Levelized Costs of electricity (LCOE) of the Different Supply Options

For all possible options including their variants an economic LCOE was calculated. The method of levelized cost of electricity (LCOE) makes it possible to compare technologies, different generation and cost structures with each other. The basic step is to form the sum of all accumulated costs for investing in and operating a plant/technology option and divide this figure by the sum of the annual power generation. This then yields the so-called LCOE in USD/kWh.

The different supply options were analysed according to their proportional share in the annual electricity supply to NGEST. This means the percentage of their part in power coverage.

Table 9-6: Overview of LCOE different supply options[26]:

Option	Power Coverage	LCOE in USD/ kWh
Biogas	17%	0.100
Diesel	44%	0.148
GEDCo	23%	0.126
PV	16%	0.061 ~ 0.129
Total	100%	Overall LCOE depends on the selected PV Variant

The highest LCOE has the electricity supply option with Diesel at a price of 0.148 USD/kWh. This is followed by the supply through GEDCo with 0.126 USD/kWh and biogas with 0.100 USD/kWh as the cheapest option.

9.2.2 Levelized Cost of Electricity (LCOE) for the Different PV Technological variants 1-5

The LCOE for the different PV variants resulted in the following amounts in USD/kWh:

Table 9-7: Overview of LCOE different PV variants:[27]

Variant	LCOE in USD/kWh	Installed Capacity (kWp)	Present value of Energy (kWh)
1. PV Variant: True South	0.061	4,821	87,749,302
2. PV Variant: Geometric Adaption	0.068	5,109	93,755,189
3. PV Variant: 1 Axis Tracker	0.071	2,059	40,096,237
4. PV Variant: 2 Axis Trackers	0.081	1,868	37,633,823
5. PV Variant: Thin Film	0.129	4,148	35,785,877

The highest LCOE has PV variant 5 "Thin Film" with 0.129 USD/kWh, followed by Variant 4 "2-axis Trackers" and Variant 3 "1-axis Tracker" with 0.081 and 0.071 USD/kWh. The lowest LCOE have the PV variant 2 "Geometric Adaption" and variant 1 "True South" with 0.068 and 0.061 USD/kWh.

[26] Full version of the calculation can be found in Annex 10.4 (preliminary cost estimates)
[27] Full version of the calculation can be found in Annex 10.3 (preliminary cost estimates)

For the choosing of the optimal PV option it should be considered that each variant generates a different amount of energy thus producing different costs of electricity, and of course different initial cost for the different types of technology.

The sensitivities of the PV options shown in Table 9-8 strengthen the recommendation for the installation of a PV power source installed as an on-site power supply solution for NGEST.

Table 9-8: Sensitivities of LCOEs PV Power Variant 1-5

	Decrease				Base Case	Increase			
General price comparison (linear)	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
Sensitivity in USD/kWh									
PV Variant 1: True South	0.049	0.052	0.055	0.058	0.061	0.064	0.055	0.052	0.049
PV Variant 2: Geometric Adaption	0.054	0.057	0.061	0.064	0.068	0.071	0.074	0.078	0.081
PV Variant 3: 1 Axis Tracker	0.057	0.060	0.064	0.067	0.071	0.074	0.078	0.081	0.085
PV Variant 4: 2 Axis Trackers	0.065	0.069	0.073	0.077	0.081	0.085	0.089	0.093	0.097
PV Variant 5: Thin Film	0.103	0.110	0.116	0.123	0.129	0.136	0.142	0.149	0.155

The sensitivities presented in the table above, show that economically the prices for electricity generated with a PV variant stay competitive with other supply options and are even less expensive with an increase of 20% than other supply options like diesel at a price of 0.148 USD/kWh and GEDCo with 0.126 USD/kWh.

Looking at the LCOE of the different variants, economically the prices are comparatively low, as taxes and financing costs were not considered. The variant that is economically the best priced is PV Variant 2 "Geometric Adaption". This variant has next to its relatively low USD price/kWh also the largest capacity (kWp) which holds the largest benefit among the PV variants for NGEST, even if it is not the cheapest version.

Considering the prices of the different LCOEs shown in Table 9-6, and considering the factors inaccessibility and shortfall of Diesel and GEDCo energy supply as in depth described in chapter 4.2, the installation of PV is recommended with the economically most attractive PV Variation 2 "Geometric Adaption", enabling a more independent energy supply of GEDCo including cost saving potential.

This recommendation is further supported by the sensitivities of the present value of energy (PV) in kWh, which show that the largest kWh production is enabled through PV variant 2 and that it is also competitive if the production decreases linear in comparison to the other variants.

Table 9-9: Sensitivities of Present Value of Energy (PV) in kWh

	Decrease				Base Case	Increase			
General comparison (linear)	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh	kWh
PV Variant 1	70,199,441	74,586,906	78,974,372	83,361,837	87,749,302	92,136,767	96,524,232	100,911,697	105,299,162
PV Variant 2	**75,004,151**	**79,691,910**	**84,379,670**	**89,067,429**	**93,755,189**	**98,442,948**	**103,130,708**	**107,818,467**	**112,506,226**
PV Variant 3	32,076,990	34,081,802	36,086,613	38,091,425	40,096,237	42,101,049	44,105,861	46,110,673	48,115,485
PV Variant 4	30,107,058	31,988,749	33,870,441	35,752,132	37,633,823	39,515,514	41,397,205	43,278,896	45,160,587
PV Variant 5	28,628,702	30,417,996	32,207,289	33,996,583	35,785,877	37,575,171	39,364,465	41,153,759	42,943,053

9.2.3 Total Levelized Costs of Electricity (LCOE) as per Current Design / after Installation of PV

The resulting total economic LCOE as per current design without PV would look as follows:

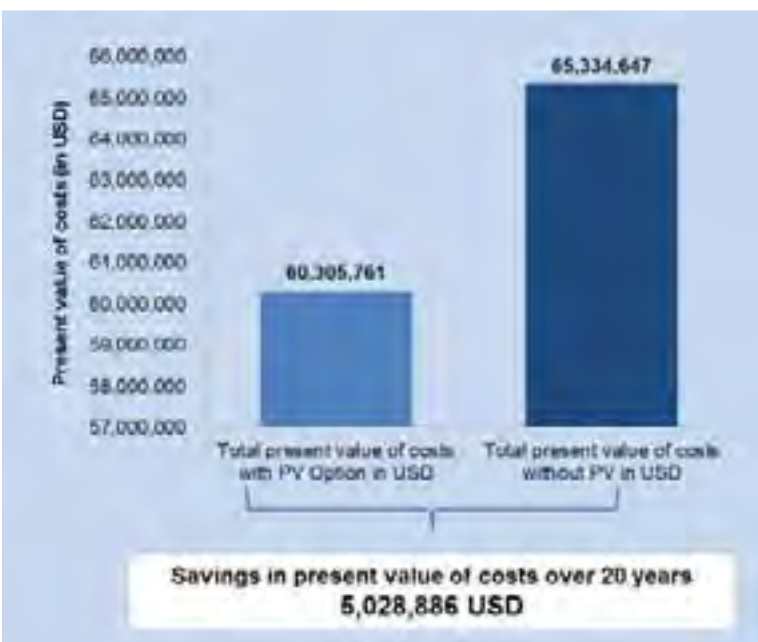
Table 9-10: Overview economic LCOE different supply options without PV/ with PV

Option	Power Coverage without PV	LCOE in USD/kWh without PV	Power Coverage with PV (variant 2)	LCOE in USD/ kWh with PV (variant 2)
Biogas	17%	0.100	17%	0.100
Diesel	54%	0.146	44%	0.148
GEDCo	28%	0.126	23%	0.126
PV	no PV	no PV	16%	0.068
Total LCOE	**100%**	**0.131**	**100%**	**0.121**

Without PV the combined electricity costs would be at 0.131 USD/kWh. When including the PV variant 2 into the power supply, the overall LCOE would be at 0.121 USD/kWh.

The comparison of the LCOEs without PV and with PV Variant 2 have also shown, that economically speaking the following total cost savings for NGEST would occur, over a period of 20 years:

Figure 9-2: Total difference/savings economic present value of costs over 20 years



The present economic evaluation gave an overview on the costs of the different power supply options and variants relevant for NGEST, allowing the conclusion that economically the most effective installation is Variant 2 "Geometric Adaption", for which in chapter 9.3 a financial analysis will be conducted.

9.3 Financial Analysis

The financial analysis of the investment into a PV system is conducted for the integration of the PV Variant 2 "Geometric Adaption" into the energy supply of NGEST. This financial analysis gives an insight into the total investment costs of such an installation, as well as the financial levelized costs of electricity (LCOE). Furthermore, three funding scenarios were calculated. These will be elaborated under chapter 9.3.2.

The input data used for the financial LCOE is as follows:

Table 9-11: Input data[28]

Input Data	Unit	Amount
Assessment period	years	20
Discount rate	%	7
Exchange rate (annual average 2015 as of 01.01.2015)	USD/ILS	3.9196
	ILS/USD	0.2499
Energy (purchase price) GEDCO incl. VAT	USD/kWh	0.150
Current diesel price (03/2015)	ILS/L	5.69
Average Diesel price 2013 - 2015	ILS/L	6.04
Current diesel price (03/2015)	USD/L	1.42
Average Diesel price 2013 - 2015 incl. tax	USD/L	1.51
Gas incl. tax	USD/kWh	0.07

9.3.1 Financial Calculation of Levelized Costs of Electricity

The financial LCOE was calculated to show how taxes influence the prices for the different power supply options and give an overview on the cost development on with and without the PV supply variant:

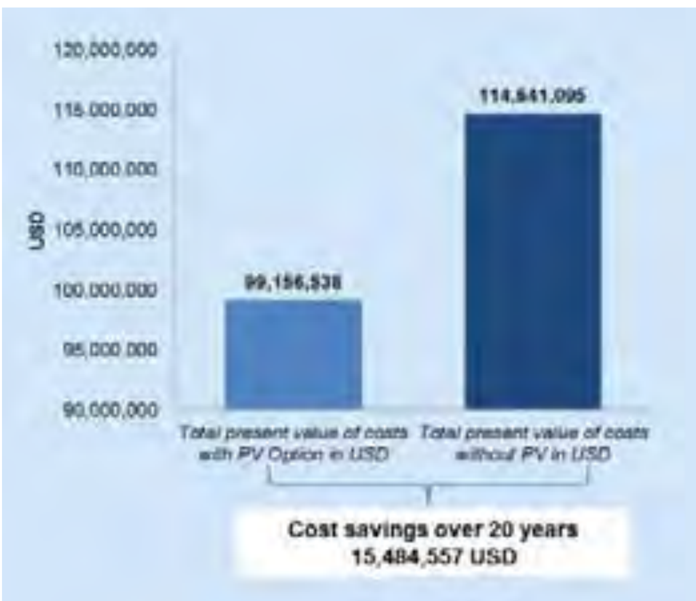
[28] Source: The data was compiled by the consultant through information and reports from the Palestinian Water Authority, the World Bank, and GEDCo. Also for some prices current tax rates were deducted/added.

Table 9-12: Overview financial LCOE different supply options without PV

Option	Power Coverage without PV	LCOE in USD/kWh without PV	Power Coverage with PV (variant 2)	LCOE in USD/ kWh with PV (variant 2)
Biogas	17%	0.085	17%	0.085
Diesel	54%	0.319	44%	0.319
GEDCo	28%	0.150	23%	0.150
PV	no PV	no PV	16%	0.081
Total LCOE	**100%**	**0.230**	**100%**	**0.199**

The addition of PV reduces the total levelized costs of electricity without PV by 0.03 USD/kWh. Thus, lowering the costs by 13% and allowing cost savings over a period of 20 years on the present value of costs of 15,484,557 USD:

Figure 9-3: Total difference/saving financial present value of costs over 20 years



The cost savings make the project and the investment into PV financially attractive and are proof for the competitiveness of the PV option vs. the power supply without PV. Furthermore, as mentioned before the power supply through PV is accessible and grants NGEST independence over 16% of its annual overall electricity need.

Also interesting and in favour of the PV option are the differences in costs with/without PV:

Table 9-13: Breakdown of energy costs and savings over lifetime

	Day	Month	Year
Total Ø costs with PV in USD	13,572	413,152	4,957,827
Total Ø costs without PV in USD	15,691	477,671	5,732,055
Ø cost savings with PV in USD	**2,119**	**64,519**	**774,228**

The total savings in costs over a period of 20 years of 15,484,557 USD, represent cost savings of 2,119 USD per day, 64,519 USD per month and 774,228 USD per year.

The sensitivity analysis concluded for the different supply options (including PV Variant 2), also shows that even with a linear increase and decrease of costs between 5-20%, the LCOE stays in an adequate cost frame.

Table 9-14: Sensitivities of LCOEs different supply options incl. PV - Variant 2

	Decrease				**Base Case**	Increase			
General price comparison (linear)	-20%	-15%	-10%	-5%	0%	5%	10%	15%	20%
LCOE in USD/kWh									
Biogas	0.068	0.073	0.077	0.081	0.085	0.090	0.094	0.098	0.102
Diesel	0.255	0.271	0.287	0.303	0.319	0.335	0.351	0.367	0.383
GEDCo	0.120	0.128	0.135	0.143	0.150	0.158	0.165	0.173	0.180
PV Variant 2	0.065	0.069	0.073	0.077	0.081	0.085	0.094	0.108	0.129

Furthermore, the sensitivity for diesel and GEDCo grid prices were tested. Both sensitivities also favour the solar PV option.

The Base Case represents the actual financial calculation that was effected for the NGEST project and uses the 2013-2015 average diesel price of 1.51 USD/litre incl. taxes. From this base case sensitivities are shown in the calculation below. The calculation includes a reduction of 55% (representing an exemption from Blue Tax) on the diesel price to show how this would affect the total savings in cost with PV over a time period of 20 years, as well as the overall LCOE with PV and without PV.

Table 9-15: Sensitivities diesel price[29]

	Decrease			Base Case	Increase	
	-55%	-20%	-10%	**0%**	10%	20%
Diesel price USD/litre	0.68	1.21	1.36	**1.51**	1.66	1.81
Overall LCOE without PV (USD/kWh)	0.138	0.197	0.214	**0.230**	0.247	0.264
Total costs in m/USD without PV Options (20 yrs.)	68,542,826	97,878,0 88	106,259,5 91	**114,641,0 95**	123,022,5 98	131,404,1 02
Overall LCOE with PV (USD/kWh)	0.128	0.173	0.186	**0.199**	0.212	0.225
Total costs with PV Options (20 yrs.)	63,444,489	86,170,3 38	92,663,43 8	**99,156,53 8**	105,649,6 38	112,142,7 38
Difference overall LCOE no PV/with PV	0.010	0.024	0.028	**0.031**	0.035	0.039
Relative difference of LCOE no PV/ with PV	7%	12%	13%	**13%**	14%	15%
Total Savings in cost with PV Option (20 yrs.)	5,098,337	11,707,7 50	13,596,15 3	**15,484,55 7**	17,372,96 0	19,261,36 4
	excl. Blue Tax					

The analysis shows, that the power supply with PV is, even with the deduction of 55% tax, the financially favourable option as it generates a lower LCOE with PV of 0.128 USD/kWh in comparison to 0.138 USD/kWh without PV. The total savings in costs with PV options would be at USD 5 million over a period of 20 years. Even though these savings are not as high as the Base Case scenario, it still favours solar.

Additionally, the annual production from Diesel Generators at NGWWTP alone in 2018 without PV system is calculated to be 5,522,000.00 kWh and the cost per kWh produced using none exempted diesel is USD 0.23, the total annual cost will be ØUSD 5,732,054. In case the diesel is exempt from Blue Tax, the cost per kWh produced will be USD 0.13 and the total annual operational cost will be ØUSD 3,427,141.

On the opposite, increasing fuel prices make the PV option even more attractive and could raise the cost savings over 20 years up to USD 19.2 million if the diesel price were to increase by 20%. This is not an all too unlikely scenario – given the fluctuations in diesel price in the last two years.

The impact of fluctuating prices for power supply through GEDCo's grid, are less impactful, representing the lower percentage of power coverage through GEDCo. However, this could change significantly if the external supply will be improved. In this case the technical availability of the network in terms of supply capacity is more important than actual costs.

[29] More sensitivities of the diesel price can be found in the annex 12.6.6

Table 9-16: Sensitivities GEDCo grid price[30]

	Decrease		**Base Case**	Increase	
	-20%	-10%	**0%**	10%	20%
GEDCo grid price	0.120	0.135	**0.150**	0.165	0.180
Overall LCOE without PV(USD/kWh)	0.222	0.226	**0.230**	0.235	0.239
Total costs in m/USD without PV Options (20 yrs.)	110,440,349	112,540,722	**114,641,095**	116,741,468	118,841,840
Overall LCOE with PV (USD/kWh)	0.193	0.196	**0.199**	0.203	0.206
Total costs in m/USD with PV Options (20 yrs.)	95,776,233	97,466,385	**99,156,538**	100,846,691	102,536,843
Difference overall LCOE no PV/with PV	0.0290	0.0300	**0.0310**	0.0320	0.0330
Relative difference of LCOE no PV/ with PV	13%	13%	**13%**	14%	14%
Total Savings in cost with PV Option (20 yrs.)	14,664,116	15,074,337	**15,484,557**	15,894,777	16,304,997

The base case represents the purchase price from GEDCo of 0.150 USD/kWh and the sensitivity testing shows that if this price is increased the investment in PV becomes yet more favourable. Nonetheless, even if the price was to be decreased by 20%, the investment into PV would still generate cost savings of USD 14.6 million over a period of 20 years.

9.3.2 Different Financing Options and Sensitivities

Three different financing options were considered for the project:

1. Commercial funding scenario
2. 50% grant scenario
3. Green funding scenarios

What should be understood concerning the calculation of the financing options is the fact that the power supply options are interrelated and can only together generate enough electricity for the energy demand of NGEST. Therefore, all financing scenarios were calculated for the total future investment costs of USD 9.7 million. However, for the green funding scenario, the investment costs of PV and biogas were used for the grant and the diesel costs are to be financed with a loan and thus separated into renewable energy components (keeping it "green") and conventional energy component.

[30] Further sensitivities of GEDCo's grid price can be found in the annex 12.6.7

Table 9-17: Investment costs NGEST

	Unit	Grand total
Total Energy demand NGEST (20 yrs.)	kWh	1,062,279,708
Investment (CAPEX PV)	USD	7,423,868
Investment (CAPEX biogas)	USD	872,077
Investment (CAPEX diesel)	USD	1,454,395
Total investment costs (PV, biogas, diesel)	**USD**	**9,750,340**
Total investment costs (only PV and biogas)	USD	8,295,945

9.3.2.1 Commercial funding scenario

For the commercial funding scenario the following financing parameters were applied (the full calculation including the different sensitivities can be found in the annex 12.7.1):

Table 9-18: Commercial funding financing parameters

Parameters*	Unit			
Grant 20%	USD	1,950,068		
Loan 80%	USD	7,800,272		
Debt repayment per year	%	5%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	20		
Grace period	year(s)	1		

For the commercial funding scenario the option a loan term 15 years and 3% interest rate was the most favourable in terms of total debt, with 8,997,545 USD

9.3.2.2 50% grant scenario

For the 50% grand scenario the following parameters were applied (the full calculation including the different sensitivities can be found in the annex 0):

Table 9-19: Grant scenario financing parameters

Parameters*	Unit			
Grant 50%	USD	4,875,170		
Loan 50%	USD	4,875,170		
Debt repayment per year	%	5%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	20		
Grace period	year(s)	1		

For the 50% grant scenario the option the loan term 20 years and 3% interest rate was the most favourable in terms of total debt, with 6,009,238 USD.

9.3.2.3 Green funding scenarios

For the green funding scenario the following parameters were applied (the full calculation including the different sensitivities can be found in the annex 0):

Table 9-20: Green funding scenario financing parameters

Parameters*	Unit	
Grant 15%	USD	1,462,551
Loan 85%	USD	8,287,789
Debt repayment per year	%	6%
Interest rate	%	0%
Management fee	%	0.25%
Service fee	%	0.18%
Total financing fees	%	0.43%
Loan term	year(s)	20
Grace period	year(s)	3

Only one option was calculated for the green funding scenario, resulting in a loan term of 20 years with3% interest rate and a debt of 8,508,124 USD.

9.3.3 Summary of outcomes different funding scenarios

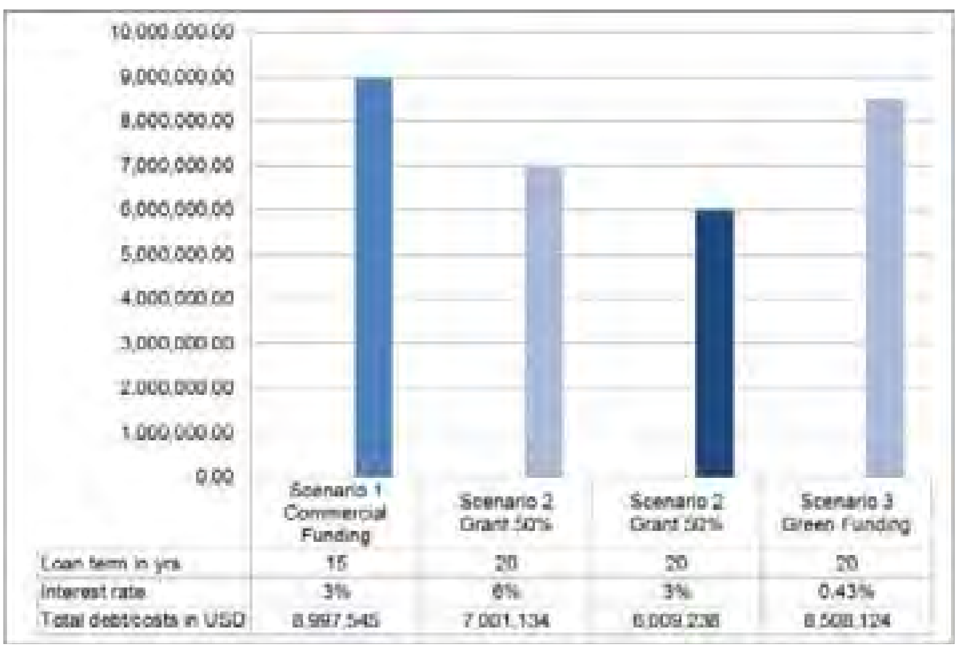
The three different funding scenarios that were calculated for NGEST look as follows combined:

Table 9-21: Summary of outcomes different funding scenarios

Scenario 1: Commercial Funding Grant 20%, Loan 80%, Grace period 1 year				
	Loan term 20 years			
Interest rate	0.43%	4%	3%	6%
Total debt/costs		10,143,792	9,614,781	11,201,815
	Loan term 15 years			
Total debt/costs		9,346,604	**8,997,545**	10,044,722
	Loan term 25 years			
Total debt/costs		10,811,053	10,131,419	12,170,322
Scenario 2: Grant 50% Grant 50%, Loan 50%, Grace period 1 year				
	Loan term 20 years			
Total debt/costs		6,339,870	**6,009,238**	**7,001,134**
Scenario 3: Green Funding (only PV and Biogas) Loan 100%, Grace period 3 years, no interest but annual service & management fee				
Total debt/costs	**8,508,124**			

Total debt/cost for the most favourable options is the following:

Figure 9-4: Most favourable funding options



The four funding scenarios presented are the most favourable ones in terms of overall costs.

Scenario 1, commercial funding, represents a convincing approach with a 20% grant, 80% loan structure, a common way of funding. The addition of 20% grant allows costs of USD 8.9 million, fixing the costs for the beneficiary below the overall investment costs of USD 9.7 million.

Scenario 2, 50% grant, is the cheapest option for the beneficiary as 50% of the costs are financed by a grant. Even with an interest rate of 6%, which is most accurate for Palestine, the costs are low with USD 7 million. Even more favourable, yet less realistic with an interest rate of 3% is also scenario 2 with costs of USD 6 million.

Scenario 3, Green Funding (only PV and Biogas), is also beneficial in terms of costs to be paid by the beneficiary. The Green Funding allows a grant for the "green" components of the project, biogas and PV and offers a loan for the conventional energy component diesel - 15% grant, 75% loan. Due to a marginal management fee of 0,43% instead if an interest rate it allows costs of USD 8.5 million, still below the overall investment costs of USD 9.7 million.

The "best" scenario is a different one for each donor, depending on their financing habits and abilities, thus the consultant refrains from making any definite recommendation on one specific scenario, however the scenarios presented represent a variety from which an option might be chosen. Of course other financing options are possible but were not further highlighted in this report, as that would go beyond the scope. An additional calculation including further contingencies of 10% is included in the annex, section 12.8 to broaden the options and the perspective on the investment. Further they highlight adequate consideration of project risks.

9.4 Summary Economic and Financial Assessment

An economic and financial analysis was conducted with the objective to identify the costs and benefits of the installation of a Solar PV plant as a power supply option for NGEST. The financial analysis in particular examines closely the investment's profitability and different financing scenarios.
The economic assessment was used to determine the relevant costs and benefits of the different energy flows, excluding taxes to better represent the opportunity costs for the country. It assessed the costs of electricity for biogas, diesel and GEDCo grid connection as well as the addition of PV options into the power supply mix. For the PV options 5 technical variants were analysed and their energy generation costs quantified. The economic assessment closely examined the options available and gave an insight into which variants are economically the most attractive.
For this purpose, two main scenarios were compared: NGEST with a PV option and NGEST without a PV option. This allowing the conclusion which scenario is economically the more cost effective and favourable. The economically most attractive PV option was found out through a thorough analysis of costs and by using the method of levelized costs of electricity (LCOE). This assessment provided the information that among the PV variants, variant 2 "Geometric Adaption", is the most beneficial in terms of, costs of electricity (USD/kWh) and capacity output.[31]

From the results of the economic analysis, the financial analysis was conducted including the PV option variant 2 "Geometric Adaption".[32] A cost assessment and the calculation of the levelized costs of

[31] Variant 2, has an economic LCOE of 0.068 USD/kWh and an installed capacity of 5,109 (kWp). For further detail concerning this analysis please refer to chapter 9.2.2).
[32] For the complete calculations please refer to the annex 12.6 et al.

electricity were conducted in a cost based approach.

The financial assessment is also comparing the two scenarios NGEST with the PV supply option and NGEST without the PV supply option. The financial assessment was effectuated over a period of 20 years (2016 – 2036), based on real prices including taxes, subsidies etc.

. NGEST without PV and the current supply options (biogas, diesel, and GEDCo grid connection) lead to an overall LCOE of 0.23 USD/kWh. NGEST with the PV option installed has an overall LCOE of 0.20 USD/kWh, making it 0.03 USD/kWh cheaper than the no PV option. Regarding the project life-time of 20 years these 0.03 USD/kWh generate a saving in the present value of costs of 15,484,557 USD.

Sensitivity testing of the different LCOEs of the supply options, the diesel prices as well as the price of GEDCo's grid connection also favoured the installation of solar PV. Even if the diesel price were to be exempt from 55% Blue Tax, the PV solar option would still generate cost savings.[33]

An overall investment sum of USD 9.7 million, including three funding scenarios (commercial funding, 50% grant and green funding), were calculated for NGEST. The investment was assessed as a whole including the conservative power supply options and the solar option. This is owed to the fact that the supply for NGEST can only be sufficiently guaranteed through a mix of all supply options. Sensitivities such as different interest rates and grace periods were included. Depending on the type of financing, a total costs/debt was established to be in range from USD 6 million to USD 12.1 million.[34] A recommendation for one specific scenario was not given as each donor/ investor prefers and sets different financing parameters.

As an overall conclusion, the cost savings as well as the sensitivities examined are proof for the competitiveness of the PV option vs. the power supply without PV. Furthermore, it is highly beneficial that the power supply through PV is secure and grants NGEST independence over 16% of its annual overall electricity need, liberating it further from power cuts and diesel shortages. Thus aiding to the relief of the water sector, allowing resolving some of its problems such as e.g. overflow sewage and ameliorating the life conditions in Gaza. Therefore, due to the cost effectiveness, the savings and the heightened independence in power supply, the investment is deemed favourable and recommendable.

[33] Detailed assessment can be found under chapter 9.3.1

[34] For the detailed assessment please refer to chapters 9.3.2 and 9.3.3 as well as for the detailed calculations annex 12.7)

9.5 Commercial Structure of Project Implementation

Given that the addition of a PV plant and the identified modifications of the power supply are finally evaluated as feasible and the stakeholders take a positive decision towards implementation, the commercial structure has to be defined. The commercial structure of implementation involves mainly the ownership and responsibility for operation of the PV systems. Depending on the general structure, connected aspects will have to be specified involving mainly the procurement strategy and the financial setup as well as maintenance and support.

The first decision is the question of ownership. The first option (1) is ownership by the NGEST project and consequently PWA. The second option would be to keep the ownership with a private entity.

In case of such private participation, the external participation could be achieved by (2) merely outsourcing installation and operation (i.e. BOOT or alike), also called contracting, or (3) to lease the services from a completely independent party by buying the actual end product the generated energy under a IPP model.

The decision is mainly influenced by the following criteria: political preference (i.e. provision services by public utilities), economic and financial attractiveness which is not only determined by the direct (financial) benefits but also the indirect risks such as control on operation and stability of demand and power sales.

Looking at the political aspect as policy gate for the main direction, there are currently no direct partnerships on operating assets between the public utilities of PA and the private sector. This is understandable given the constrained – island-like – conditions of the economy on Palestine and the even more limited economic situation in Gaza[35]. The PA may want to maintain direct control on the utilities in order to react to the political changes, develop a coherent infrastructure, increase capacity employment and capacity of the local workforce and to be able to achieve financing of these basic investments together with its partners. Regardless of such political and institutional structures would a financial calculation need to show if the project in itself is viable. In case support by an external partner is searched for, the financials must allow for the incentive that renders participation by a private entity attractive. During the commercial assessment, the financial benefits and trade-offs would need to be evaluated. A state-financing of the investment would benefit from the access to external capital at good conditions but is often constrained by the lack of equity resources. Although a private investor may have easier access to equity, such institutions would regard the venture as vehicle to realize a certain amount of profit – usually defined by the requirements of the shareholders. Consequently, the financials must be able to provide room for stable and reliable revenues which allow generating these earnings with the targeted margin. But the solar PV plant does not generate revenues or surplus of energy for feed-in purposes. Thus the private investment possibilities are very limited. If a private investment were to be considered, e.g. with a margin imposed on the price/kWh through an investor, this would largely reduce the savings in costs. Additionally, a management fee would be imposed by the investor, further lowering the savings potential. For these reasons private investment options were not further exploited further.

In addition, the private entities would scrutinize the risks associated with the undertaking. In the case of NGEST, the main risks are the lack of control over the operation of the whole NGEST power system driven by the needs of the treatment plant and recovery scheme loads, the general political situation

[35] World Bank (2015): Economic monitoring report to the ad hoc liaison committee, http://documents.worldbank.org/curated/en/2015/05/24525116/economic-monitoring-report-ad-hoc-liaison-committee

and its potential that the whole facility is damaged, the influence of stakeholders (i.e. participants of local sewage system, GEDCo and IEC, farmers) on operation as well as the general timeline of implementation. The single biggest risk is actually the initial purpose of the whole idea behind a modification of the power supply: The whole operation is not driven by the power availability but rather the demand required for the daily operation. This puts the supervision over the electrical system as well into the hands of the NGEST operators making the energy supply totally dependent of the primary processes in the facility. Although a typical operation pattern was assumed and also NGEST aims to stabilize the power supply over the lifetime as well as to turn its operation more autonomous an uncertainty would remain on the actual operation pattern. This applies especially in the years until 2025. During this period, NGEST would still be in expansion while the actual timeline remains uncertain and the operation scheme may therefore be subject to change. Uncertainty arises furthermore from the fact that NGEST has not started its operation, yet, and thus no experience on its actual performance is available.

The power supply is set up in a form of an integrated hybrid supply of the different sources mentioned in this assessment. Thus, any external entity contract would also need to define the level of integration with the other power sources in order to deliver a combined product: the energy. As explained above, any control on utilization but also availability and price of these components is rather impossible for an external party. The biomass is driven by the sludge and gas production, the grid is a source with high uncertainty and the diesel depends on the import to the strip. Technical aspects of the local supply such as changes in power factor or heat production in case of black start of the treatment plant are another commercial hurdle. Under such circumstance, the definition of technical guarantees required for as basis a commercial agreement but also compliance and its control are very difficult or rather impossible. If only the participation of a private entity would be focusing on the power from the PV system corresponding technical performance conditions for a PV system can be stipulated. But in the end its verification would suffer from the same constraints outlined.

The characteristics and conditions of the mentioned options are summarized in Table 9-22.

Under the described conditions, an ownership by NGEST/PWA and procurement via an EPC tender would be recommended. Such tender would need to choose a sound middle course between a detailed technical specification defining interfaces and requirements of NGEST well and a functional minimum requirement for the PV plant allowing to the contractor a certain level of freedom to bring in own innovation. Such contract could contain requirements for training of local craftsmen and technicians during construction and operation in order to achieve replication of the project at other facilities, e.g. the desalination plant. In addition, local private sector could be supported by contracting skilled companies for the maintenance works.

Table 9-22: Comparison of EPC and IPP approach

Option	1	2	3
Criterion / Model	**NGEST**	**BOO(T)**	**IPP**
		General	
Description	NGEST contracts a skilled installation company and takes over at commissioning. The contractor could even be a subcontractor of the principal NGEST contractor	The contractor is responsible for installation, commissioning and operation of the PV part. The savings in energy costs are shared between the contractor and NGEST budget according to a defined value The contractor could also be charged with the responsibility to constantly audit and optimize the power supply of NGEST	The (PV) power supplier is all-in-all responsible for the power supply.
Ownership	PWA/PEA	Privately owned	Privately owned
		Financing	
Financing: CAPEX / Equity	Funds, via balance sheet	Own capital, Shareholders	Shareholders
Financing: CAPEX / debt	Public debt or institutional bonds	Commercial banks	Commercial banks, capital market bonds
Financing: OPEX	User fees	Contracting premium	Sales tariff
Financing: Revenues	Economic savings over life-time	Service fee as contracting premium taken from the total savings per energy unit by adding PV and the final benefit passed on to NGEST budget	Margin between purchase costs (LCOE) and sales tariff
		Commercial	
Procurement	EPC	Service contract	Commodity purchase
Principal technical guarantees	Mainly workmanship and performance at commissioning.	Regularly verified energy saving results	Minimum energy delivery
Commercial / corporate structure	Part of NGEST as project of PWA	Project run by the contractor	Independent project company (SPV)
		O&M	

Option	**1**	**2**	**3**
Criterion / Model	**NGEST**	**BOO(T)**	**IPP**
Operational respon-sibility	NGEST staff	Contractor in cooperation with NGEST staff	IPP
Maintenance	NGEST staff a contracting of technical maintenance is possible	Contractor or sub-contractor	IPP or sub-contractor
		Summary	
Requirements	• Equity or funds →to be arranged by PWA/PA with partners • Capacity to manage the project →possible with some training	• Enough energy saving to allow share of benefits →see financial analysis • Control over minimum output to guarantee the business model →not very likely	• Allowance for an attractive tariff →see financial analysis →not complaint with the requirement of low end user fees and the tight budget. • Control over minimum output to guarantee the business model →not very likely
Likeliness of imple-mentation	High	Medium	Low
Degree of participa-tion by private sector	Low: • Installation • Low-level maintenance	Medium: • Installation • Principal operation • Maintenance	Full • Installation • Operation • Maintenance

10. Potential Impact on the Local Political Economy

10.1 Impact on GEDCo Network

GEDCo as supplying utility is directly affected by the planned modifications to the power supply.

The first and direct impact arises from potential feed-back of excess power to GEDCo network. As explained in section 7.2 on the energy balance there are time when excess energy from RE generation occurs. The concept for an optimised utilisation of this energy is laid out in section 7.2.5.It foresees to keep impact the planned network connection and to operations of GEDCo as low as possible. Since the NGEST facilities remain at any time a net-consumer of energy, no export to the wider network is expected under normal operations of NGEST, e.g. when WWTP or the pumps and well are not in maintenance.

Consequently, PWA and GEDCo would need to append the existing network connection agreement with details on the proposed concept for coupling of the two project locations. This includes finding a consent on metering issues and isolation of the facility via the proposed breaker at the point of common coupling.

The reduction of net energy drawn from the grid is an indirect impact. In the constrained distribution network with limited capacity this will relieve the situation, especially for the suppressed demand. Thus, the electricity supply and service hours to the local communities in Gaza especially the adjacent Jabalia community can be increased. The increase in service hours will allow for more productive use and will therefore, improve overall livelihood and economy in Gaza.

10.2 Options for Fostering Local Content

As by Palestinian regulations any tender above a volume of 5 Mio. USD must be an international tender request. But during procurement (supply), installation and O&M phase support of local companies from Gaza will be needed.

Based on the CAPEX estimate for the PV system, the amount of goods and works procured in Palestine could approximately be to a value of around 2 Mio. USD. This estimate includes supplies for mechanical structures, civil works and labour. The final value depends on the actual sourcing of the selected contractor. It may be considered to require a certain minimum portion in the tender documents.

Such procurement volume would first increase the technical capabilities of the local companies and therewith it could potentially encourage local companies to start or develop their business in the direction to supply and support facility power systems.

10.3 Competences and Capacity of the Local Economy

The project will use local technicians for the installation of the PV arrays from local PV firms and companies specialised in electro-technical installations. This will ensure building the capacity of those technicians and qualify them to implement similar projects. Based on the available information there is 25-30 technicians and engineers who already working in this issue in Gaza. It is likely that they will be the ones benefiting from this project in terms of implementation and capacity development. In addition, the capacity of the three small companies in Gaza to deliver and deal with such large projects in this field will be upgraded and will potentially qualify them for other similar contracts. All these will ensure business development and boosting of economy in Gaza.

Today there are three main local firms that work in renewable energy in Gaza, shown in Table 10-1 they are as follows:

Table 10-1: Overview on local PV companies

Name	Size	Comment
Atallah Company	Small	11 employees, of which 2 Engineers
Tic Land	Small	6 employees of which 3 engineers
Annid (Al nid)	Small	5 employees of which 2 engineers

In addition, there are number of smaller companies who work as subcontractor for these three main ones in Gaza.

Moreover, the project itself may encourage adopting solar energy at wider scale by the government to produce clean energy and reduce the dependence on the external energy sources even those produced locally since they depend on imported fossil fuel.

10.4 Potential for Replication

Although there are smaller scale PV plants in Gaza but the scale of this plant will be definitely seen as a case model to be replicated should it prove feasible and successful. Moreover, the project is in line with national strategic objective related to ensure the generation of electricity from renewable sources. In this line, PENRA has signed a new agreement with an International firm to generate electricity from PV in Gaza. This project will definitely be as a guide for the development of similar initiatives in the future.

Similar projects with integrated power supply are already in planning:

- the Gaza Central Desalination Plant, or
- the Gaza Central Wastewater Project

For both projects the use of solar power is planned right from the beginning as part of the system. Again, what makes NGEST a special case is actually the fact that it is already (partially) implemented. By this, a reference case is generated for the refurbishment and upgrade of existing government and public facilities, especially those with constant and high energy demand. With NGEST being ahead in time on the other projects, all stakeholders can gain valuable experience with implementation and operation. If being implemented by the responsible institutions, the transfer of acquired knowledge to other projects can be facilitated.

11. Conclusion and Recommendation

11.1 Conclusion Feasibility of PV System

On the technical side, the study has confirmed the planning and current design of power supply system of the facility – always under the condition that load assumptions on water intake and consumption of components are correct. The quality workmanship is a big plus and proves the possibility to implement a complex project in the adverse conditions of the area and the capability of PWA to supervise large construction activities. This is regarded as a sound basis for modifications and inclusion of additional components, even if there are new to Gaza and innovative in their application as power saver in a public service facility with high energy demand.

The conditions at the site and the selected areas allow for the installation of PV systems of different sizes. All together these result in a medium sized PV installation which contributes a considerable amount of energy to the annual supply of the project. Together with the biogas generator, the other renewable energy source, PV generation even leads to an excess of energy at the WWTP site. A technical solution was identified that optimises the use of this excess in such way that additional expenses and impact to the network is minimised.

The preliminary environmental and social impact assessment had shown no blockers regarding external stakeholders but rather effects of the environment on the system itself. A set of preliminary mitigation measures was identified which help to address the associated sources of impact.

The use of PV withstands the economic comparison with the costs of the other generation sources. This means the addition of PV to public facilities does not only add toward the independence from the constraint network and consequently increasing the security of supply. It also can in net-metering fashion alleviate the administration's budget. Financial analysis has also shown that an investment into the planned system can be recommended and financing through different arrangements is possible.

It can be expected that such system would generate an overall positive impact on the local economy through participation during construction or operation. A more indirect effect is attributed to the chance to gain real local experience with net-metering and power-saving systems on larger scale. This would benefit integrated energy planning of other facilities as well as GEDCo in their efforts to improve the general supply situation.

11.2 Recommendations for Implementation

Based on the findings of the assessment, the following principal recommendations can be provided:

- Technical
    - A standard fixed mounted system with distributed inverter configuration shall be used to reduce the complexity to a minimum.
    - The orientation can be either geometry adapted as in the presented Conceptual design, True South or even E-W as long as capacities and energy generation in the same range as presented in this study can be confirmed.
    - Within these limits, effort could be undertaken to raise efficiency and optimise performance. But the final objective of the design shall be a reliable and trouble-free operation. This would exclude experiments such as using trackers or similar components requiring higher attention during maintenance. This means the simpler the design the better – NGEST is not a power generation facility since its core business activity is the water treatment and sanitation.
    - The system shall be specified to use quality and durable components adequate to the local environment.
    - The integration into the facility control system shall be given high importance because this interface guarantees a seamless operation of all power system components.
    - A simple but functional solution for the safe isolation and power share among the two locations will allow to leverage further energy saving and safer operation. This shall be sought after and agreed on with GEDCo.

- Financial and commercial
    - Looking at the results of the economic evaluation and financial analysis, the choice of adding a PV system can be recommended for the economy of Palestine and the budget of NGEST as the numbers show positive impact in both cases.
    - Given the control and risk structures at the project the implementation via an EPC-turnkey contract under management of PWA is preferred. In addition, does the function of the facility as public service for the civil society not provide mush room for involvement of private sector players through other contract forms such as commodity contracting or even purchase of the PV –generated energy from an IPP.
    - The possibility of subcontracting the PV system to the main NGEST contract maybe worth a closer look. Such configuration would offer the advantage of merging all technical guarantees into one contract and reducing interface coordination tremendously.
    - In the short-term, GEDCo's consent on the proposed power share solution shall sought as the utility must give consent to the proposed new point of common coupling. In the mid-term, a regulatory solution via a net-metering scheme is regarded as more suitable. It can be expected that all parties will grow confidence in such solutions once having gained experience with the operation and performance of the system and its impacts to the network.
    - During the selection of a financing scenario, a sound level of contingency may be included to cover for unforeseen impacts from both the complexity of the project itself, the lack of experience of PV installations of such magnitude in Gaza and the actual location in a constrained area.

11.3 Potential Timeline for Implementation

A tentative time schedule has been developed and discussed with the stakeholders. The set of milestones listed in Table 11-1 and outlined in Figure 11-1 may guide the stakeholders through the next steps of decision making and implementation. As emphasised, the tight coordination the remaining NGEST construction activities and external approval procedures will be crucial.

Table 11-1: Tentative milestone table

Milestone	Time	Comment / Risk
PV: Feasibility Study on Power Supply to NGEST	**Q1-Q2/2015**	**Delay in financing agreements**
PV: Decision & Financing	**Q3-Q4/2015**	**Delay in financing agreements**
PV: Specification & Tender Docs	**Q4/2015**	**Interface w/ NGEST contractor**
NGEST Pre-Commissioning	Q4/2015	
NGEST Commissioning	Q2/2016	
PV: Tendering	**Q1-Q2/2016**	**Depends on response from market**
NGEST in operation	Q2/2016	
PV: Award	Q3/2016	
PV: Executive Design & Permits	Q4/2016	
Recovery Scheme I	Q4/2016	Precondition for PV at RS Area
PV: Construction	**Q1-Q2/2017**	Depends on local security and restrictions
PV: Commissioning	**Q3/2017**	
Recovery Scheme II	Q4/2017	minor impacts on PV system

NOTE:

- The timeline for the implementation of Phase 2, foreseen for the years between 2018 and 2014, is still uncertain. Currently, the funding for Stage 1 of Phase 1 is being applied for and arranged.

Figure 11-1: High-level milestone diagram

Milestone	2015				2016				2017			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
PV: Feasibility Study on Power Supply to NGEST												
PV: Decision & Financing												
PV: Specification & Tender Docs												
NGEST Pre-Commissioning												
NGEST Commissioning												
PV: Tendering												
NGEST in operation												
PV: Award												
PV: Executive Design & Permits												
Recovery Scheme I												
PV: Construction												
PV: Commissioning												
Recovery Scheme II												

12. ANNEX

12.1 Detailed Site Description

12.1.1 Areas designated for PV systems

12.1.1.1 Areas within treatment plant boundary

The largest area is A1 in the South of the facility. It is currently unused and covered with grass and small bushes. A slight slope of about 2-3° towards the inner area of the plant is observed (Figure 12-1 and Figure 12-2).

Figure 12-1: A1 viewing towards West

Figure 12-2: A1 viewing towards East/A10

Since the project had initially been planned to be supplied only by the feeder line and on-site biogas with additional support by the emergency diesel when needed, cable trenches are reported to be full and without room for additional cables. The electrical connections of roof-top facilities have been guided into buildings through internal inlets. Consequently, cables for connecting the PV plant to the electrical infrastructure would need to be run down at the outer side of the building, e. g. as seen in Figure 12-3. An option to avoid long cabling for the connection of the PV sub-systems to the power house would be the connection of the smaller roof-top sub-systems directly to the LV panels of the respective building. In this case, the PV system would represent a negative load reducing the net draw of energy from NGEST's power supply.

Figure 12-3: Backward of the Sludge Dewatering Building

Figure 12-4: Embankment South of IB

The plant still has many but small open areas between the single sewage processing steps as shown in Figure 12-4. These areas could be used to install two axis trackers, if such technology is opted for.

The roofs of all buildings have been used to place typical facilities such as air-condition outlets and water tanks. These are present on all buildings as shown in Figure 12-6 and Figure 12-7. The PV design will have to deduct these areas from the total available area and consider some buffer space for maintenance access to this equipment.

Figure 12-5: Roofs of Digester & Thickener Building, and power house

Figure 12-6: Roof panorama

There is a second large brown-field area (A2) located closed to the road on the West of the plant pictured in Figure 12-7 and Figure 12-8. Its rectangular shape and size makes it a perfect place for a larger and well performing ground-mounted array. This is the sub-system which would be affected most by the dust emitted from the refuse collection lorries passing on the road outside the fence. Fortunately, maintenance access for cleaning will be easy at this place.

Figure 12-7: A2 towards IB

Figure 12-8: A2 towards the main gate

12.1.1.2 Areas at recovery scheme

The second location with designated PV areas is the effluent recovery scheme behind the cemetery as shown in Figure 12-12. It can be reached either via a untarred road from Jibaliya or by following the road along the plant’s fence and then branching left at the Northern site corner as illustrated in Figure 12-9.

Figure 12-9: View from Administration Building towards the recovery scheme

Since the recovery scheme is scheduled to be constructed in after commissioning of the WWTP in stage 1 and stage 2 of phase 1 and then expanded in phase 2, no structures can be currently found. The view from corner closed to the cemetery towards the town and the view toward the treatment plant are shown in Figure 12-10 and Figure 12-11.

Figure 12-10: Recovery scheme area towards Jibaliya

Figure 12-11: Recovery scheme area towards East to the plant

Apart from the mechanical and electrical buildings, PWA also identified a larger area of about 32,000 m² on top of the recovery fields for a PV system. The places are currently lease on seasonal basis to local farmers and covered with grass or other crops as depicted in . A challenge for these areas will be to plan and coordinate the installation of a potential ground-mounted PV system in such way that the construction of the facilities for the recovery scheme is not hindered.

Figure 12-12: Effluent recovery scheme area with cemetery to the left

Figure 12-13: Effluent recovery scheme area towards Jibaliya

12.1.1.3 External obstacles

Since the NGEST project is located closed to the border, the land around is mainly used for agricultural purposes – mainly the cultivation of seasonal crops or forage as seen in Figure 12-16. This is generally of advantage because such land cover prevents development of dust which would in return lead to soiling losses.

A few activities around the area are potential sources of dust and dirt, such as the landfill site in the North-East of the treatment plant site and the dust-carts which regularly pass the site on the untarred road as shown in

.

Figure 12-14: Refuse collection vehicle using dirt road at NW

Further, low-intensive human activity which are probably always present in the densely populated Gaza strip, may have an impact on the operation and performance like the charcoal production closed to the cemetery shown in . Proper mitigation strategies will have to be found during the development of the O&M strategy.

Figure 12-15: Charcoal production closed to Northern site corner

Another external source of potential high impact which affects the whole region is the proximity to the border to Israel. Fractures from the armed conflict in 2014 have been observed at the NGEST administration building. Ricochets or other similar objects would obviously also affect PV arrays and may lead to glass breakage on larger scale.

Figure 12-16: Land adjacent to the plant at the Southern border

12.1.2 Electrical infrastructure

12.1.2.1 Network power supply

The treatment plant is currently services by an over-head feeder line branched off from the main network in Jibaliya and then guided along the secondary road towards the site (see Figure 12-17 and
Figure 12-18). The supply voltage is 22 kV which is usually considered as medium voltage but due to lack of higher voltage levels in Gaza also referred to as high voltage.

Figure 12-17: OHL GEDCo feeder from Jibaliya

Figure 12-18: OHL towards the plant

It is then received by a steel tower with a CB at the Western border of the plant next to PV areas A2, shown in Figure 12-19. This tower is currently equipped with a temporary transformer used by the Contractor of the plant. Within the treatment plant, the underground cables are used to guide the power to the Energy Building pictured in Figure 12-20. The localisation of these cables will be important during the potential construction of the PV system on A2 in order to avoid damage of the main power cables.

The effluent recovery scheme is not yet connected to the MV network because these facilities are scheduled to be constructed in phase 2 of the NGEST project. In case that the PV system is installed in the period between the NGEST project phases 1 and phase 2 in order to supply the treatment plant, the contractor of these sub-systems would also need to set-up at least a temporary grid connection in the absence of the main electrical infrastructure and additional generators at that location. Such situation may happen if the PV systems are planned to be procured altogether as one lot. Since the PV systems will be planned as grid-connected plants, either a stable network connection or local generator is required to build the grid.

Figure 12-19: A2 with power supply OHL (22 kV) from GEDCo network

Figure 12-20: The Blower and energy building

12.1.2.2 Energy Building

12.1.2.2.1 On-site generation facilities

The Blower and Energy Building shown in Figure 12-20 has separated compartments for the two different generation sources.

Figure 12-21: Outside of the blower and electrical building

A spark ignited gas generator set is installed with a capacity of 830 kVA produced by the manufacturer MWM, Germany (refer to
Figure 12-22 and
Figure 12-23). The cooling water piping of this generator is not yet finished.

Figure 12-22: Biogas-engine

Figure 12-23: Biogas-engine

Three containerised diesel generating sets with 800kVa each from FG Wilson with Perkins engines are installed as emergency diesel gensets.

Figure 12-24: Containerised diesel gen-set

Figure 12-25: Perkins engine

12.1.2.2.2 LV and HV electrical installations

The energy building has separate rooms for HV connection and LV connection. These were inspected in order to determine the possibility for the connection of the PV systems, especially the larger subsystems.

The existent energy Siemens Ring-Main-Feeder switchgear (see **Error! Reference source not ound.**) is planned to control the connection to the grid and to the on-site diesel and biogas generators. Currently, the installed switch gear is only connected to public grid.

Figure 12-26: Ring-Main-Feeder switchgear

The LV supply consists of various switchboards for the main consumers and the incoming supply pictured in

Figure 12-27 and

Figure 12-28. LV cabling is not yet finished for distributions and supply panels.

Figure 12-27: LV-distribution

Figure 12-28: LV-panels

Both rooms are equipped with sufficient spare space for the installation of additional feeders and switchboards for both feeding high voltage from the larger ground-mounted field PV sub-systems to the HV room and feeding low voltage from the rooftop PV systems directly to the LV system in the LV room.

The rooms have clean cable routing provided by the large underground distribution chambers beneath the floor (**Error! Reference source not found.**).

The building also accomodates the fire protection system whoose control unit is shown in

Figure 12-30: Cable trays and channels beneath the floor of the electrical room

Figure 12-29: Fire detection unit

Figure 12-30: Cable trays and channels beneath the floor of the electrical room

12.1.2.3 Main consumers of the treatment plant

Within the treatment plant's sewage processing chain there is different energy consuming equipment installed. These were looked at during the site walk-through in order to be able to relate their status and construction to the process description and drawings. Selected steps of the process are briefly described.

For the digester zone, there are no special remarks with related to the electrical infrastructure. The digesters are important for the production of the biogas.

Figure 12-31: Future gas holder; storage Facility for biogas

Figure 12-32: Flare near to the gas holder. Sludge silos in the background

The civil works of the gas holder (
Figure 12-31) and gas torch (
Figure 12-32) seem not to be totally accomplished. Before start of operation a membrane system with a steel plate protection must be mounted. Purpose of the membrane is to keep the gas-pressure constant.

Figure 12-33: Basins for activated sludge on the left side

At the other main processing steps of the treatment plant, the sludge silos and sludge dewatering system, the sludge activating basins (
Figure 12-36,
Figure 12-37), the sand washing zone (Figure 12-38, Figure 12-39) and the final clarifiers (
Figure 12-40,
Figure 12-41), no specific observations were made regarding the electrical aspects of these energy consumers.

Figure 12-34: Sludge silos and sludge de-watering building – outside equipment

Figure 12-35: Sludge silos and sludge de-watering building – screw pumps for sludge

Figure 12-36: Sludge handling

Figure 12-37: Sludge activating basin (1 of 3)

Figure 12-38: Sand washing zone

Figure 12-39: Sand washing zone

Figure 12-40: Final clarifier (1 of 3)

Figure 12-41: Final clarifier (1 of 3)

The electrical power demand of the plant together with the application of a factor for simultaneous run ning of electrical consumers under several power conditions will be assessed. The blowers (Figure 1 2-42, Figure 12-43) are one of main consumers running rather continuously.

Figure 12-42: Blowers

Figure 12-43: Blowers

On the generation site, the biogas production and its differing for the LHV will need to be analysed.

12.1.3 Additional site infrastructure

The design of the treatment plant contains all necessary infrastructure required for the operation. A few aspects may be mentioned here which are important for a PV system and the power supply as a whole.

A meteorological station operated as part of the regional measurement network has been installed (refer to **Error! Reference source not found.**). The equipment could be easily complemented by radiation measurement sensors for the reference monitoring of the PV system.

Figure 12-44: On-site meteorological station (no radiation measured)

The road network, as shown in **Error! Reference source not found.**, is well established which facilitates installation and maintenance. The PV installation company will have to consider the normal operation of the treatment plant and ensure that these existing structures are not damaged.

Figure 12-45: Internal road network on site

12.1.4 External Interfaces

Any further expansion of the electrical infrastructure or change in power supply will share the interfaces with the NGEST locations themselves. These are:

- The treatment plant receives external power supply from GEDCo via a 22 KV MV OHL feeder;
- Telecommunication is provided by the DSL line for the NGEST SCADA, no information is currently available on bandwidth and availability of this line;

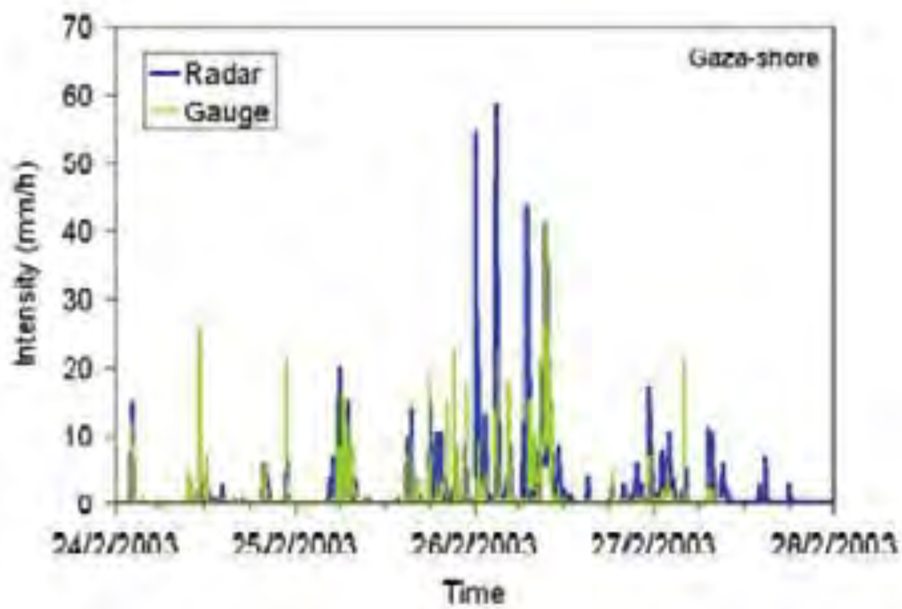
- Fresh water currently taken from ground water wells but can be directly taken from NGEST once the systems are up and running.

12.2 Detailed Description of Environmental Conditions

12.2.1 General Climate Conditions

12.2.1.1 Rainfall

Rainfall occurs during winter between the months October - April each year. The annual average rainfall in the project location (Northern Part of Gaza) is nearly 390 mm / year according to Qahman, et al (2011). In addition, the average recorded rainfall intensity over 30 years of record in Gaza was 45.1 mm/hr while this average is exceeded often in storm events such as the case of 2003 as shown in figure 1 where the intensity was close to 60 mm/hour, Exact (2006).



12.2.1.2 Temperatures

The project sites have a typical semi-arid Mediterranean climate with long hot and dry summer (from 25°C in summer and 13°C in winter with maximum daily temperature can reach 31°C and the minimum temperature is around 11.6°C). The proximity of the Mediterranean Sea has a moderating effect on temperatures and promotes high humidity throughout the year.

Table 12-1: Temperature profile using data from the Solar Atlas of Palestine

Month	Temperature °C at 2 m		
	Min	Max	Average
January	11.7	17.4	14.3
February	11.6	18	14.5
March	12.5	20.1	16
April	14.3	23.2	18.5
May	16.8	26.1	21.2
June	20.1	28.6	24
July	22.3	30.6	25.9
August	23	31.1	26.5
September	22.2	29.9	25.6
October	20.4	27.6	23.6
November	17.1	23.6	20
December	13.4	19.3	16

Assessing the effect of temperature on PV-plant we can conclude that the maximum power point (MPP) can have attenuation of about 5% in a form of voltage drop on the mid-day time only when temperature reaches its maximum value in summer. In the early hours of summer day as well as in late hours MPP is minimally affected. The last minimal effect of temperature is correct too for winter, spring and autumn seasons.

Air should be allowed to circulate behind the back of each PV-module, so the temperature doesn't rise. This is essential procedure to conserve the electrical output of the modules. For the detailed design of NGEST PV-plant the influence of temperature should be considered. Related data can be found[36].

12.2.1.3 Relative Humidity

Gaza is a humid area with average monthly relative humidity of nearly 68%. Particles of water vapor are highly concentrated in the lower layers of the coastal atmosphere of Gaza. In the same time the concentration of vapor had no permanent character, it changes by time and air spot. Mediterranean Sea west to Gaza is the huge water surface increasing the humidity. Wind directions limit the concentration of vapours in Gaza atmosphere. Table 1 below shows some available measurements of evaporation from Gaza metrological station[37]:

[36]R.Foster,M.Ghassami, A.Cota. Solar energy: Renewable energy and the environment.CRS press. Taylor & Francis Group. ISBN: 978-1-4200-7566-3.Pages:138-144

[37]Palestinian Bureau of Statistics, annual report 2008. Arabic edition

Table 12-2: Evaporation rates in Gaza

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Rate
Evaporation mm/year	1603	1672	1645	1635	1909	-	1583	1698	1543	-	1583	1652

12.2.1.4 Wind

Gaza is the windiest area in Palestine. The prevailing wind direction is South West with an average speed of 11 km/hour (winter) and from North West (summer) and sometimes from the east. Depending on wind direction, when it blows from the south or west it carries light solid particles from the sandy beach in the west as well as from dry fields in eastern areas of the strip to the atmosphere. Mixing with air the solid particles become as a fixed component of the atmosphere "aerosols". Diffuse of radiation by aerosols occurs in the visible region in addition to ultraviolet region of the solar spectrum. Under high aerosols concentrations the normal blue colour of the sky changes into white and in few cases in Gaza the sky has a colour closer to yellow when southern winds and air temperatures are too high in summer.

12.2.1.5 Storms and lightning risk

Storm occurrence has no fixed return period but generally follows the general cycle of nearly 10 years for extreme wet events or storms. However, lightning and thunder occurs during normal rainy days not only during the extreme storms. Therefore, it important to consider protective measures through thunder / lightning absorption devices in the plant to ensure safety.

12.2.2 Soil Conditions

12.2.2.1 Subsoil

The soil cover of the NGEST site is dark brown loamy clay of 7-23 m depth with a well-developed structure laying over marine Kurkar Formation (Calcareous sandstone).

12.2.2.2 Vegetation and land cover

The areas surrounding the NGEST site is nearly empty and not cultivated. The nearest tree lines to the site are at 3000 m toward the west. The site is encircled with dirt roads which is heavily used by solid waste collection trucks and therefore, is likely to create dust and affect the PV plant.

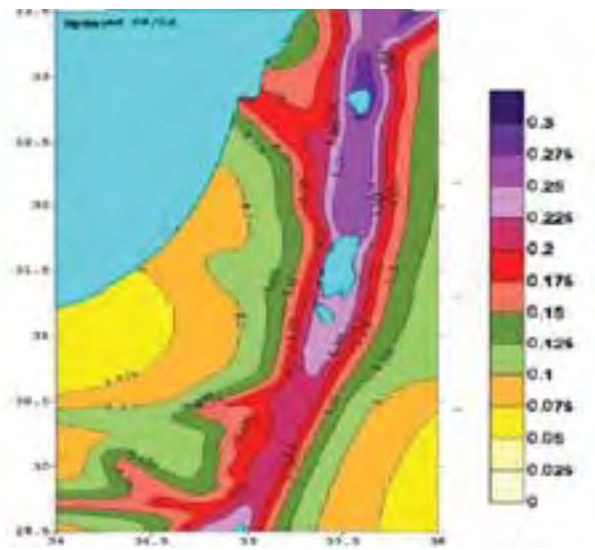
12.2.3 Geotechnical data and foundation considerations

The typical surface and subsurface geological setting of Gaza strip is composed of mainly Kurkar group with a thickness of 200 m and composed of marine and Aeolian calcareous sandstone, silty reddish sandstone and silt inter layers. There is no major structural or faults presence in the area and the foundation is therefore considered stable in a sense that all designs for any overland structure should be based on loose soil foundation criteria.

12.2.4 Seismological risk

Palestine in general has medium to low seismicity with recorded earthquake of 6 degree of magnitude near Jerusalem early 2000. In addition, for costal area there are no major structural features or faults that may create some potential seismic activity and is classified as inactive seismic area as shown in Figure 3, the design factor considered for the NGEST plant was 0.075 as reported in the ESIA (2006)

Figure 12-46: Seismicity Zones in the Region



12.2.5 Solar resource and meteorological input

Solar radiation data and the amount of solar energy intercept Gaza area are collected and analysed here. This is an essential step for modelling NGEST PV-plant. Precise knowledge of available historical solar radiation in Gaza is assessed to determine the technical parameters of NGEST.

Analysed data was acquired from:

1. PENRA issues including Solar Atlas, 2014
2. Palestinian Bureau of Statistics
3. Scientific papers,
4. Reports on measured data from the nearest to Gaza Israeli meteorological station.

The PENRA data are taken in 1998, International Journal data are dated from 2013, Bet Dajan measurements were published in 2010. The period of measurements and data coverage is not clear for all data sources.

No measured solar irradiation data was available from PA central meteorological department in Ramallah. Due to wars on Gaza local meteorological stations had destroyed or were not functional, we found no access even to old locally measured irradiation data.

A comparative study of the existing solar irradiation data sources is shown in table 4.1.5.1. These sources show an irradiation daily rate of 5.25 kWh/m^2.day.

Table 12-3: Daily average of solar radiation on Gaza surface during the year by different references:

Month	PENRA 1998[38]		International journal[39]		Bet Dajan[40]** (measurements)	
	Daily sum [kWh/m²]	Monthly sum [kWh/m²]	**Daily sum [kWh/m²]**	Monthly sum [kWh/m²]	**Daily sum [kWh/m²]**	Monthly sum [kWh/m²]
January	3	91.3	3.36	102.2	2.61	90.9
February	3.9	118.6	3.97	120.8	3.4	114.3
March	5	152.1	4.33	131.7	4.7	142.2
April	6.1	185.5	5.19	157.9	5.86	173.9
May	6.9	209.9	6.46	196.5	6.88	205.2
June	7.9	240.3	7.78	236.6	7.55	235.5
July	7.5	228.1	7.4	225.1	7.29	225.0
August	6.9	209.9	6.76	205.6	6.67	206.1
September	5.8	176.4	5.88	178.9	5.69	176.1
October	4.3	130.8	4.73	143.9	4.25	134.6
November	3.1	94.3	4.31	131.1	3.09	106.5
December	2.5	76.0	5.53	168.2	2.48	106.6
Annual	**2.24**	1913.2	**5.34**	1998.4	**5.04**	1917.0

**Bet Dajan is the nearest to Gaza Israeli metrological station. The solar radiation level of both areas Gaza strip and Bet Dajan are similar according to Ahmed Rabai, Potential of application of PV system for BWRO desalination in Gaza. Jordan, 2009.

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[38] Palestinian Energy Authority.1999-1998 report, page 8.
[39] JumaYousufAlayadi. A parametric study of solar and wind energy in Gaza strip. International journal of scientific engineering research, Volume 4, Issue 12, December 2013.
[40] Mohammed T. Hussein and Sahdi N. Albarqouni.Developing empirical models for estimating global solar radiation in Gaza strip, Palestine.The Islamic university journal Vol. 18.No.2, page 80. 2010

Basic solar parameters for Gaza are presented in table Table 12-4. Direct Normal Irradiation (DNI), Global Horizontal Irradiation (GHI) and Global Tilted Irradiation (GTI). Data in this table were collected based on the Atlas of Solar Resources of the State of Palestine 2014.

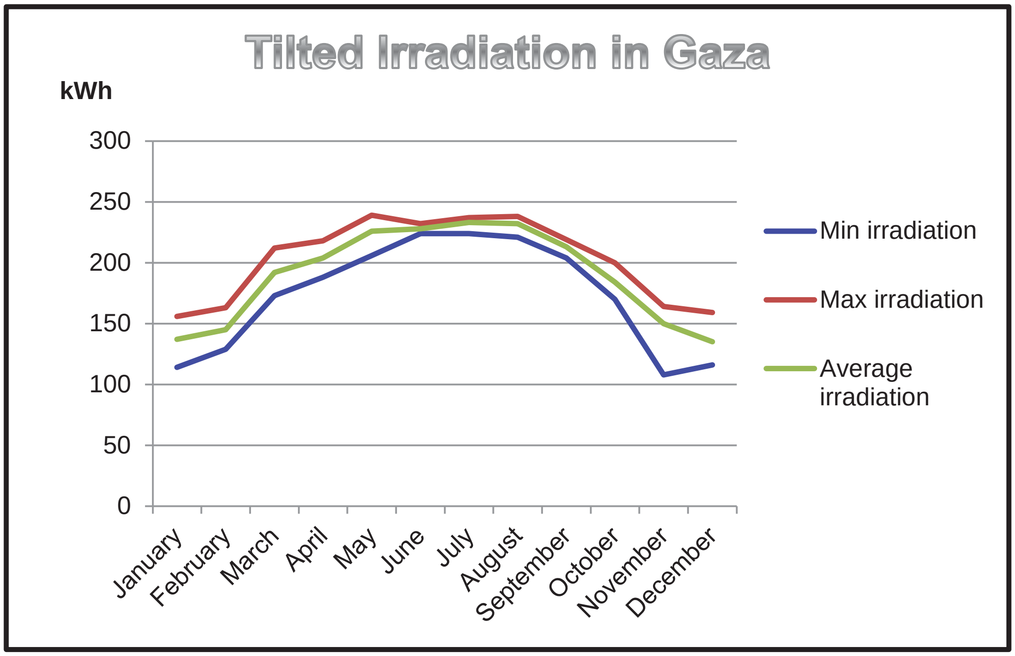
When comparing the data from the Solar Atlas to the local measurement sources and evaluation efforts presented above no significant deviations are found which. This conclusion confirms that the Solar Atlas can be regarded as reliable long-term data source for PV system design.

Table 12-4: Gaza basic solar parameters

Month	Global Horizontal Irradiation (kWh/m^2)			Global Tilted Irradiation (kWh/m^2)		
	Min	Max	Average	Min	Max	Average
January	83	107	96	114	156	137
February	100	124	113	129	163	145
March	150	181	165	173	212	192
April	180	208	195	188	218	204
May	214	249	235	206	239	226
June	243	253	248	224	232	228
July	237	253	248	224	237	233
August	218	235	229	221	238	232
September	182	193	189	204	219	213
October	137	158	148	170	200	184
November	80	117	108	108	164	150
December	80	103	91	116	159	135
Year			**2065**			**2279**

The most important parameter for NGEST PV-plant is Global Tilted Irradiation (GTI) that is presented in Figure 12-47 with its minimal, maximal and averaged values during the year.

Figure 12-47: Global Tilted Irradiation (GTI)



The influence and relation with other relevant parameters such as humidity, ambient air temperature is analysed:

Gaza is a humid area. Particles of water vapour are highly concentrated in the lower layers of the coastal atmosphere of Gaza. In the same time the concentration of vapour had no permanent character, it changes by time and air spot. Mediterranean Sea west to Gaza is the huge water surface increasing the humidity. Wind directions limit the concentration of vapours in Gaza atmosphere. Table Table 12-5: Evaporation rates in Gaza below shows some available measurements of evaporation from Gaza metrological station[41]:

Table 12-5: Evaporation rates in Gaza

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	Rate
Evaporation mm/year	1603	1672	1645	1635	1909	-	1583	1698	1543	-	1583	1652

Particles of water vapour are invisible, and absorption of solar radiation occurs in the invisible infrared region of the solar spectrum.

[41] Palestinian Bureau of Statistics, annual report 2008. Arabic edition

Diffuse radiation is intensive under high concentrated aerosols. Radiation attenuates by aerosols depending on the Aerosol Optical Depth (AOD). There are no measurements in Gaza for the AOD. It can be only estimated together with other factors in the Strip increasing the diffuse radiation such as water vapour, industrial dust, pollution caused by burning of agricultural waste and any other air polluting factor.

The data assessment criteria are application-specific and are selected here according to the planned use of the data for NGEST. Data of Global Tilted Irradiance (GTI) in Gaza has a major importance of the NGEST PV-plant. Data of Direct Normal Irradiance (DNI) is valuable for the tracking part of NGEST PV-plant. NGEST solar power plant uses no concentrated solar technologies (CSP) and therefore the diffuse radiation caused by aerosols and water vapour has no considerable effect on plant's performance. The main radiation indicator for NGEST plant remains GTI.

The influence of air temperature on irradiation is analysed from collected data in Table 12-6 below. Average of air temperature on 2m height shows two important indicators:

1. The average temperature all over the year is below 40°C. Performance of PV arrays is in the safe range and nominal capacity of PV plant in general can be ensured.
2. The general tendency of temperature increase from January to August is in accompany with the GTI increase. Only DNI indicates little declination after June, this has a little effect on the tracking part of the NGEST PV plant as this tracking part is small.

Table 12-6: Gaza irradiation averages and temperature values

Month	Average Irradiation (kWh/m^2)			Temperature °C at 2 m		
	DNI	GHI	GTI	Min	Max	Average
January	124	96	137	11.7	17.4	14.3
February	126	113	145	11.6	18	14.5
March	163	165	192	12.5	20.1	16
April	174	195	204	14.3	23.2	18.5
May	220	235	226	16.8	26.1	21.2
June	253	248	228	20.1	28.6	24
July	246	248	233	22.3	30.6	25.9
August	232	229	232	23	31.1	26.5
September	201	189	213	22.2	29.9	25.6
October	159	148	184	20.4	27.6	23.6
November	139	108	150	17.1	23.6	20
December	130	91	135	13.4	19.3	16

Assessing the effect of temperature on PV-plant we can conclude that the maximum power point (MPP) can have attenuation of about 5% in a form of voltage drop on the mid-day time only when temperature reaches its maximum value in summer. In the early hours of summer day as well as in late hours MPP is minimally affected. The last minimal effect of temperature is correct too for winter, spring and autumn seasons.

Air should be allowed to circulate behind the back of each PV-module, so the temperature doesn't rise. This is essential procedure to conserve the electrical output of the modules. For the detailed design of NGEST PV-plant the influence of temperature should be considered. Related data can be found[42].

The clearness index for Gaza strip indicates that the Strip in general has a clear sky conditions most of the year. The maximum values of the clearness index are obtained during the period from June to August with maximum shining hours as shown in Figure 4.5.1-2:

Fig.4.1.5-2: Clearness index in Gaza[43]

[42]R.Foster,M.Ghassami, A.Cota. Solar energy: Renewable energy and the environment.CRS press. Taylor & Francis Group. ISBN: 978-1-4200-7566-3.Pages:138-144

[43]Mohammed T. Hussein and Sahdi N. Albarqouni.Developing empirical models for estimating global solar radiation in Gaza strip, Palestine.The Islamic university journal Vol. 18.No.2, page 80. 2010.

12.3 PV System Variants

12.3.1 Methodology for analysis of the potentially feasible variants

12.3.1.1 Sources of information and input data

The following information and input data have been used to develop preliminary solar array layouts as well as to assess plant production and system costs.

- The Solar Atlas of Palestine provides
  - general resources information
  - indication on tilt angle
  - data sets as input for the simulation
- NGEST project documents
  - Contractor's design (nearly as-built)
  - Elevation map
  - Designated PV areas
  - Further drawings on the building (roof facilities, height), electrical infrastructure, etc.
- Further data specially for the PV components
  - Market information on technology market share, suitability of components and cost structures
  - Manufacturer's information
    - Data sheets
    - Installation manuals
  - Preliminary price quotes
- Consultant's initial findings and assumptions on
  - System losses (detailed further in the next section)
  - Market share and suitability of components
  - Findings of the site visit including photos
  - Analysis of system costs for Palestine including fees and levies for Gaza

12.3.1.2 Approach and assumption for design and modelling

The actual configuration for each variant was defined using the CAD software for measuring the dimensions and geometry of the areas as well as the simulation tool PVSyst for simulating the performance and output of the PV generator. P50 TMY dataset described in section 2.6.2 was used as meteorological input data.

In the next step, the orientation was added to the configuration. The geometrical parameters were measured out of the correspondent CAD designs. Exemplar values for the Variant 1 are shown in Table 12-7.

Table 12-7: Values for roof-top and ground Mounted

Parameter	Value	Unit
	Roof-top	
Pitch	2,79	m
Coll. Band Width	1,49	m
Azimuth	0	°
Module tilt	25	°
	Ground Mounted	
Pitch	5,17	m
Coll. Band Width	2,97	m
Azimuth	0	°
Module tilt	25	°
With:		
Pitch	*Rows distance (lower front edge of module of first row to lower front edge of module of subsequent row)*	
Collector band width	*the height of the effective PV module area (excluding frame)*	

The spacing between rows was defined in such a way that the yield is maximised while a good accessibility is still maintained. As a general rule the spacing was designed to keep the module tables free of shadow for at least 4 hours on the shortest day of the year (21st of December) corresponding to a shading angle of 27°. A module tilt of 25° is considered as the optimum between yield, racking costs and row spacing.

Any obstacles such as roof-top facilities (e.g. water tanks, HVAC outlets) were excluded from the design.

The PV generator set-up using exemplary components and a typical configuration is shown in Table 12-8.

Table 12-8: Key components and string configuration

Component	Technology	Type	Explanation
Module	c-Si	CS6P 260P (Canadian Solar)	A typical crystalline silicon module as commonly found in the market.
	thin-film	SF160-S (Solar Frontier)	A CIS thin-film module with one of the highest efficiency among thin-film modules and dimensions suitable for installation on roof-top.
Inverter	Multi-string / multi-MPP	STP 25000 (SMA)	High performing device compliant to most grid codes.
Configuration	String with 22 modules 5 strings per inverter		

In some cases shorter strings had to be added in order to fill the complete area with PV panels.

Smaller inverters down to the size of 25 kVA were used in this case in order to ensure efficient conversion performance.

For the performance calculations the system losses shown in Table 12-9 were estimated and applied. The Perez-Model was used to transpose the GHI values to the titled module surface.

Table 12-9: Applied losses

Type of loss	Value	Unit
Field Thermal Loss factor	29,0	W/m²k
Ohmic losses (DC+AC)	2	%
Module efficiency loss	-0,5	%
LID loss factor	2	%
Mismatch losses	1	%
Soiling losses	3	%
IAM Curve (10 to 90°)	1/1/1/1/1/0,99/0,92/0,73/0	
Average output reduction due degradation over 25 years	9	% below initial output

An initial light-induced degradation (LID) of 2% and an annual degradation of 0.72% corresponding to typical manufacturer performance guarantees in the market were assumed for the calculation of the average production over 25 years of project lifetime. In order to simplify the calculation, the different areas with similar characteristics were grouped together. This reduced the need to run many simulations with just minor variations in the input and output values.

12.3.1.3 Cost estimation for potentially feasible variants

A preliminary cost estimate was developed breaking the total system costs down to the second level. The CAPEX are split in 15 sub-groups whereas the OPEX were separated in 4 categories. These sub-groups represent the major cost factors of the PV system. All sub-groups were priced separately.

For materials and equipment quotations and databases of similar projects were used, e.g. in case of the PV modules standard pricing from an international Tier 1 manufacturer provided a good basis. The values had then been adapted for import duties and local fees. Information from existing solar PV projects in Palestine were used as input for the local portion of the costing. Since most systems are rather smaller systems, the quotations were adjusted for economies of scale effects that are expected to be leveraged when procuring a larger system like planned for NGEST. Examples for such systems are a few relatively small 2-5 kWp grid connected PV systems and the medium-sized PV plant in Jericho (300 kWp). These sources have been supplemented by quotations from local and regional suppliers like Brothers Engineering Co., Bethlehem. Further fees (i.e. importing to Gaza) and local labour costs have been considered.

For items with higher share of labour like installation or maintenance the necessary man-hours were estimated and then multiplied with the cost of the corresponding local man-hour depending on the required skill level. In certain topics safety margins were applied due to the fact that PV is a new technology in the region and delays and costs will occur because of local staff being unfamiliar with larger commercial scale PV systems.

There are a few places where the costs differ in respect to other recent estimates, such as the reports cited at the beginning of this section on PV or recent similar feasibility studies[44]. This applies especially for modules prices – PV panels are still the largest cost portion – which had been adjusted to reflect the current world market prices. The operation is supposed to be executed by a skilled technician only. A dedicated engineer is not regarded as necessary and will be available for general supervision as part of NGEST operations. The resulting values seem reasonable also accounting for the fact that transformer and switchgear as well as a large part of the electrical infrastructure already exists, in the case of the treatment plant, or will be installed as part of the recovery scheme. Cost differences between the fixed mounting and the tracked mounted variants is in line what is usually observed at other projects.

12.3.2 Configuration and analysis for potentially feasible variants

12.3.2.1 Variant 1 – fixed structures with orientation true south

Variant 1 is a PV system with a fixed 25° racking structure orientated towards South. A typical string has 22 modules of 260 Wp. In general 5 strings are connected to one decentralized 25 kVA inverter. The total rated DC power of the plant is 4821.44 kWp.

An overview of the preliminary array layout for the designated areas within the WWTP site is shown in Figure 12-48 likewise are the arrays for the areas at the recovery scheme shown in Figure 12-49 while Figure 12-50 illustrates an exemplary roof-top space.

The key parameters of the system configuration and obtained results are summarised in Table 12-10.

[44] Fichtner and Madar Consulting Engineers (2014): Assistance to the Palestinian Water Authority (PWA) for the implementation of the Water Supply to Gaza, Seawater Desalination Project (Phase A), EIB Proj. Code: TA2012033 PS F10

Figure 12-48: Variant 1 – overview of the sub-systems at the WWTP

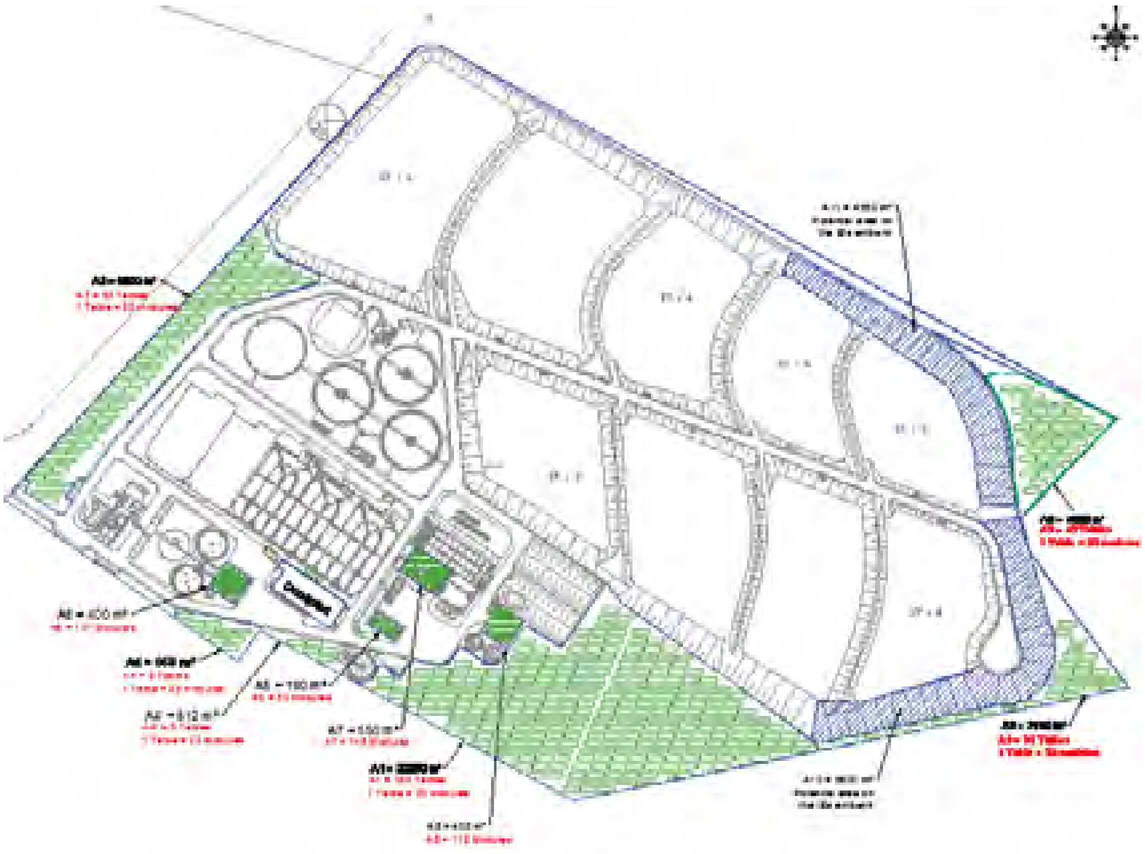
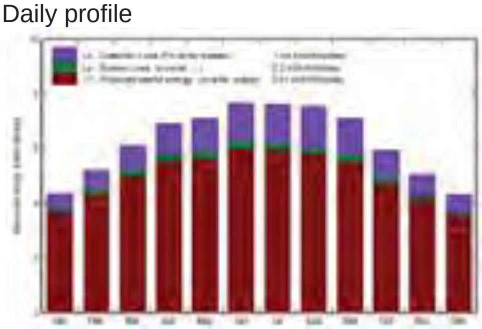


Figure 12-49: Variant 1 – overview of the sub-systems at the recovery scheme

Figure 12-50: Variant 1 – example of a PV array on a roof-top area

Table 12-10: Variant 1 – key system data

Parameter	Value	Unit
Terrain		
Total area	7,80	ha
Effective ground area for PV	5,65	ha
Remaining area	2,15	ha
Orientation		
Tilt angle	25	[°]
Azimuth	0	[°]
Mounting system type	Fixed	
Proposed foundation/fixation Free Field Rooftop	 Ramming posts Anchor	
System configuration		
Total number of modules	18544	
Total number of inverters	175 (5, 10, 12, 15,20, 25 kVA)	
DC/AC ratio	1,14	

Parameter	**Value**	**Unit**
Key system indicators		
Parameter	Value	Unit
Total capacity	4821,44	[kWp]
Specific results		
Capacity / Area Free Field Roof-top	 0,087 0,082	 [kWp/m²/]
Yield Factor Production / Capacity	1668,39	[kWh/kWp/year]
Energy production and power output		
Daily profile 		
Energy generation	21976,35	[kWh/day]
Peak power (annual minimum)	253,17	[kW/peak time]
Highest daily peak power (annual maximum (h))	4207,98	[kW/peak time]
Annual profile (25yrs average, 25 yrs.)		
Energy generation	8021,37	[MWh/year]
Performance Ratio	80,28	%
Contribution to power supply		
Capacity share on total		%
Daily energy production share		%
Annual energy production share		%
Preliminary cost estimate		
CAPEX – specific	1001.78	USD/kWp
CAPEX – total	4.830.002	USD
OPEX – specific	9.67	USD/kWp (annum)
OPEX – total	46.631	USD/annum
DUC (over 25yrs.)		USD/kWh

12.3.2.2 Variant 2 – fixed structures with geometric adaptation

The PV arrays of Variant 2 have been aligned to be geometrically adapted to the areas by modifying the plane azimuth accordingly. A fixed racking structure with 25° tilt angle is used. One string has 22 modules of 260 Wp. In general 5 strings are connected to one decentralized 25 kVA inverter. The total rated DC power of the plant is 5177.12 kWp.

An overview of the preliminary array layout for the designated areas within the WWTP site is shown in Figure 12-51 likewise are the arrays for the areas at the recovery scheme shown in Figure 12-52 while Figure 12-53 illustrates an exemplary roof-top space.

The key parameters of the system configuration and obtained results are summarised in Table 12-11.

Figure 12-51: Variant 2 – overview of the sub-systems at the WWTP

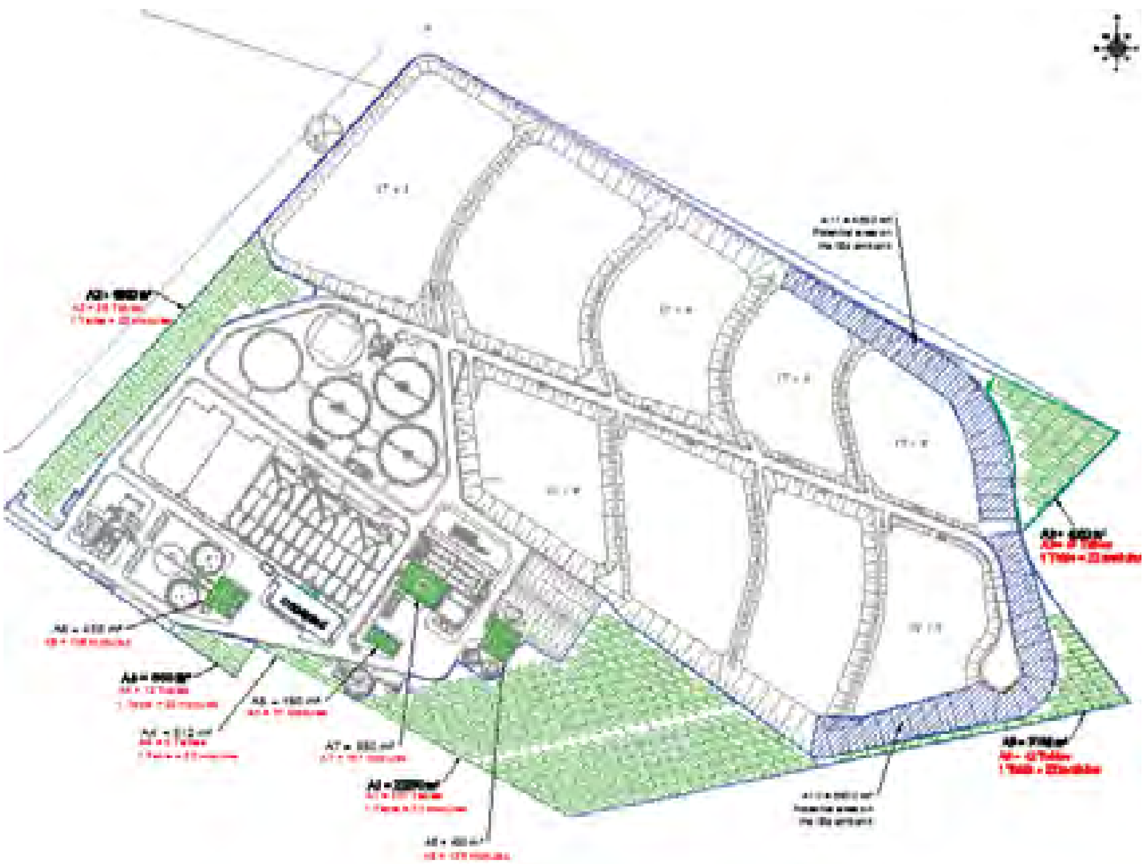


Figure 12-52: Variant 2 – overview of the sub-systems at the recovery scheme

Figure 12-53: Variant 2 – example of a PV array on a roof-top area

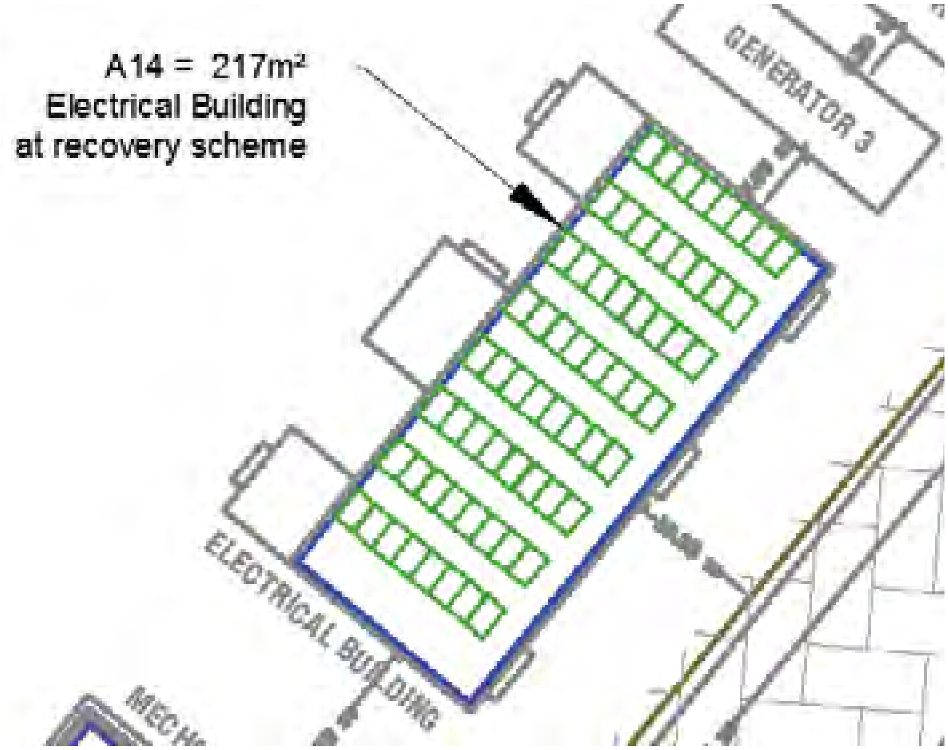
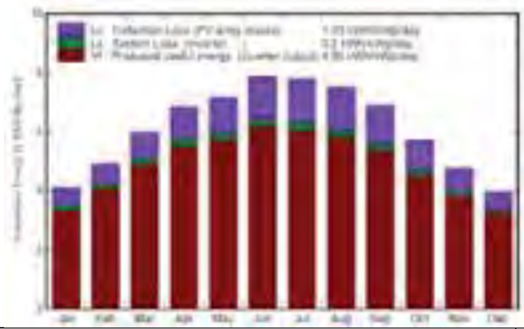


Table 12-11: Variant 2 – key system data

Parameter	Value	Unit
Terrain		
Total area	7,80	ha
Effective ground area for PV	5,73	ha
Remaining area	2,07	ha
Orientation		
Tilt angle	25	[°]
Azimuth	11,5 to 42,3	[°]
Mounting system type	Fixed	
Proposed foundation/fixation Free Field Rooftop	 Ramming posts Anchor	
System configuration		
Total number of modules	19912	
Total number of inverters	187 (5, 10, 12, 15,20, 25 kVA)	
DC/AC ratio	1,14	
Key system indicators		
Parameter	Value	Unit
Total capacity	5177,12	[kWp]
Specific results		
Capacity / Area		

Parameter	Value	Unit
Free Field Roof-top	0,099 0,096	[kWp/m²]
Yield Factor Production / Capacity	1635,76	[kWh/kWp/year]
Energy production and power output		
Daily profile 		
Energy generation	23294,94	[kWh/day]
Peak power (annual minimum)	274,51	[kW/peak time]
Highest daily peak power (annual maximum (h))	4503,27	[kW/peak time]
Annual profile (25yrs average, 25 yrs.)		
Energy generation	8502,65	[MWh/year]
Performance Ratio	80,08	%
Contribution to power supply		
Capacity share on total		%
Daily energy production share		%
Annual energy production share		%
Preliminary cost estimate		
CAPEX – specific	1001.13	USD/kWp
CAPEX – total	5.182.972	USD
OPEX – specific	9.44	USD/kWp (annum)
OPEX – total	48.856	USD/annum
DUC (over 25yrs.)		USD/kWh

12.3.2.3 Variant 3 – one-axis tracker

In Variant 3 East-West tracking PV arrays have been placed on the free-field areas. The trackers perform an elevation angle of movement with the range of -45 to 45°. One string has 22 modules of 260 Wp and 5 strings are connected to one decentralized 25 kVA inverter. Since the idea of the tracker configuration seeks to optimize the output, the same approach was taken for the roof-top spaces by directing the modules towards South with a fixed racking structure of 25° tilt. There one array has 22 modules of 260 Wp and 5 strings are connected to one decentralized 25 kVA inverter. The rated DC power of this variant totals to 2058.68 kWp.

An overview of the preliminary array layout for the designated areas within the WWTP site is shown in Figure 12-54, likewise are the arrays for the areas at the recovery scheme shown in Figure 12-55 whle Figure 12-56 illustrates an exemplary roof-top space.

The key parameters of the system configuration and obtained results are summarised in Table 12-12.

Figure 12-54: Variant 3 – overview of the sub-systems at the WWTP

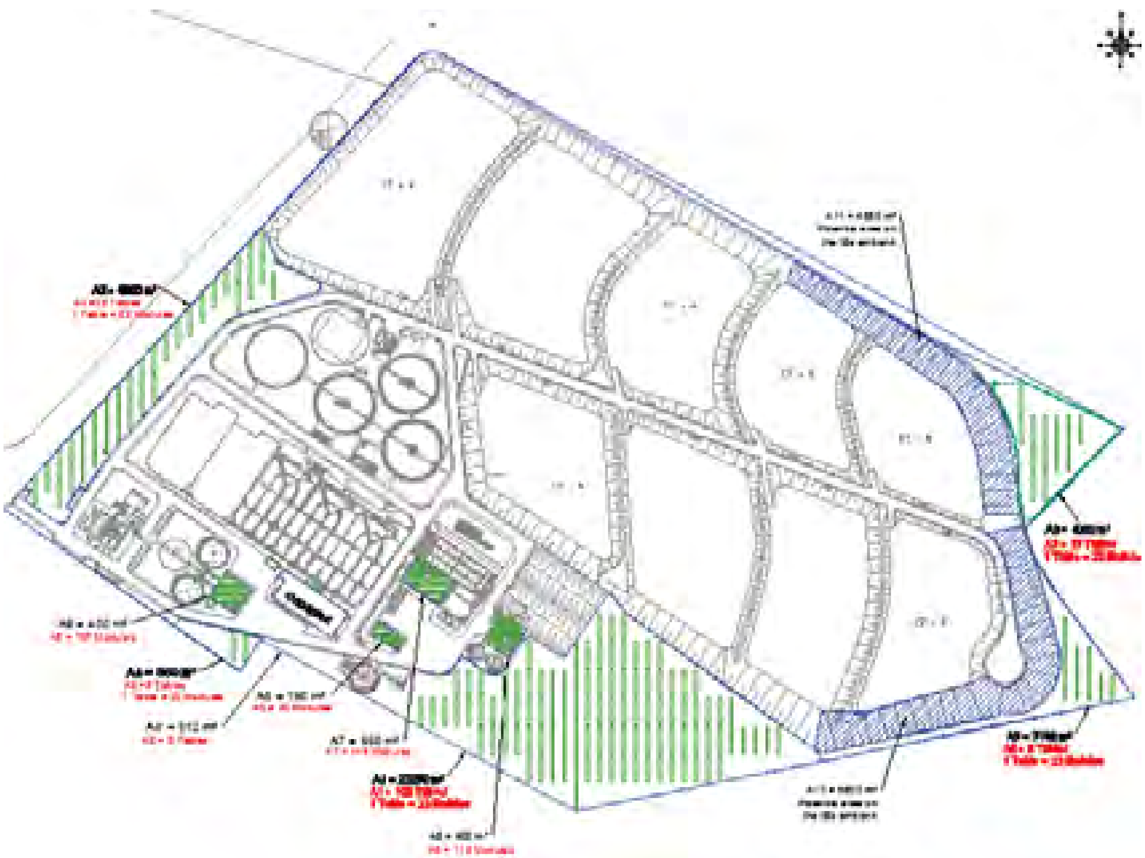
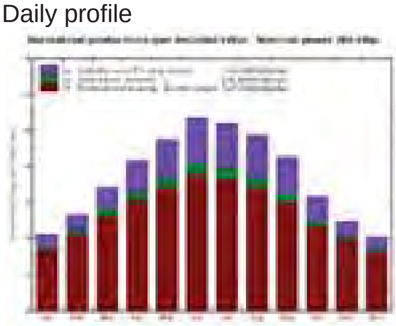


Figure 12-55: Variant 3 – overview of the sub-systems at the recovery scheme

Figure 12-56: Variant 3 – example of a PV array on a roof-top area

Table 12-12: Variant 3 – key system data

Parameter	Value	Unit
Terrain		
Total area	7,80	ha
Effective ground area for PV	5,36	ha
Remaining area	2,44	ha
Orientation		
Tilt angle Free Field Roof-top	 -45 to 45 25	[°]
Azimuth Free Field Roof-top	 90 to -90 0	[°]
Mounting system type Free Field Roof-top	 1 axis tracker Fixed	
Proposed foundation/fixation Free Field Roof-top	 posts anchor	
System configuration		
Total number of modules	7918	
Total number of inverters	78 (5, 10, 12, 15,20, 25 kVA)	

Parameter	Value	Unit
DC/AC ratio	1,14	
Key system indicators		
Parameter	Value	Unit
Total capacity	2058,68	[kWp]
Specific results		
Capacity / Area Free Field Roof-top	 0,045 0,082	 [kWp/m²/]
Yield Factor Production / Capacity	1744,68	[kWh/kWp/year]
Energy production and power output		
Daily profile 		
Energy generation	10041,89	[kWh/day]
Peak power (annual minimum)	113,37	[kW/peak time]
Highest daily peak power (annual maximum (h))	1494,57	[kW/peak time]
Annual profile (25yrs average, 25 yrs.)		
Energy generation	3665,29	[MWh/year]
Performance Ratio	77	%
Contribution to power supply		
Capacity share on total		%
Daily energy production share		%
Annual energy production share		%
Preliminary cost estimate		
CAPEX – specific	1133.17	USD/kWp
CAPEX – total	2.332.830	USD
OPEX – specific	22.56	USD/kWp (annum)
OPEX – total	46.435	USD/annum
DUC (over 25yrs.)		USD/kWh

12.3.2.4 Variant 4 – 2-axis tracker

Variant 4 uses a 2-axis tracker instead of the 1-axis tracker on the open space areas. As shown in Figure 12-57, the embankment and dams have also been considered as installation area because the one pole foundations of the 2-axis tracker allow a very flexible installation while the areas underneath remain still accessible for the WWTP staff. The tracker has a 2-dimensional movement with an azimuth angle range of -120 to 120° and a tilt angle movement of 0 to 80°. One string has 21 modules of 260Wp. In general 2 strings are connected to one decentralized 12 kVA inverter. The same configuration as in Variant 1 and Variant 3 was chosen for the roof-top areas in order to achieve maximized performance on the overall plant. Thus fixed structures with 25° tilt angle have been put on the roof-top areas. One array has 22 modules of 260 Wp and 5 strings are connected to one decentralized 25 kVA inverter. The DC power of the plant sums up to 1868.36 kWp.

An overview on the preliminary array layout for the designated areas within the WWTP site is shown in Figure 12-57, likewise are the arrays for the areas at the recovery scheme shown in Figure 12-58 while Figure 12-59 illustrates an exemplary roof-top space.

The key parameters of the system configuration and obtained results are summarised in Table 12-13.

Figure 12-57: Variant 4 – overview of the sub-systems at the WWTP

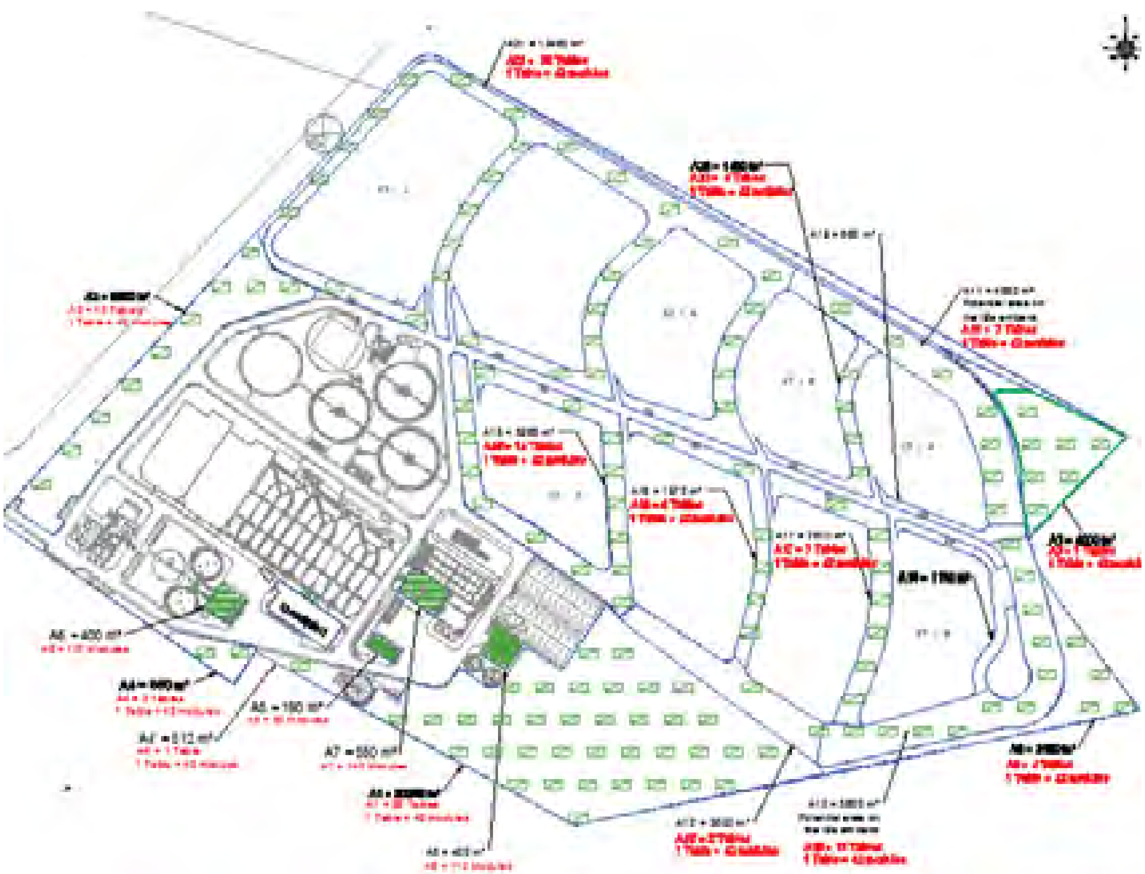


Figure 12-58: Variant 4 – overview of the sub-systems at the recovery scheme

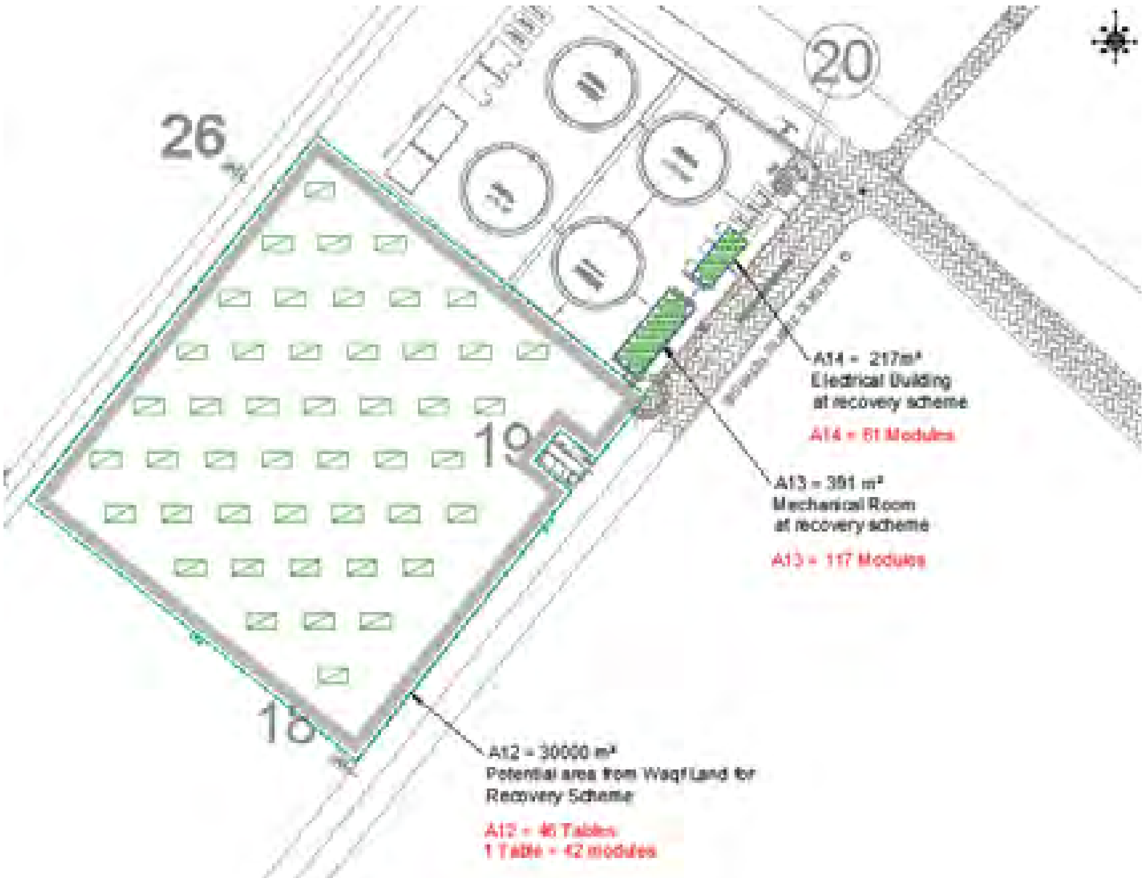
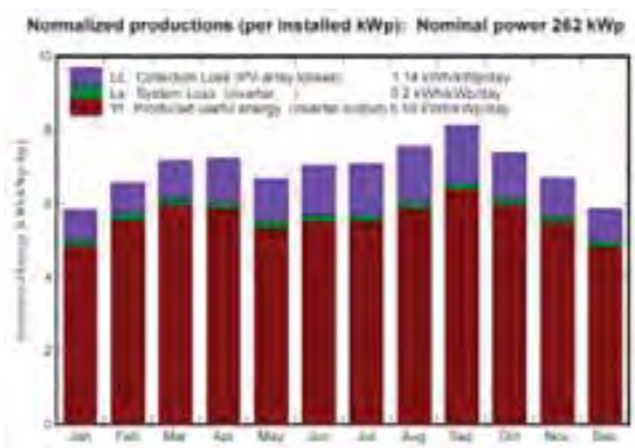


Figure 12-59: Variant 4 – example of a PV array on a roof-top area

Table 12-13: Variant 4 – key system data

Terrain	Value	Unit
Total area	9,43	ha
Effective ground area for PV	6,84	ha
Remaining area	2,59	ha
Orientation		
Tilt angle Free Field: North-South East-West Roof-top	 0 to 80 120 to -120 25	[°]
Azimuth Free Field Roof-top	 120 to -120 0	[°]
Mounting system type Free Field Roof-top	 2 axis tracker Fixed	
Proposed foundation/fixation Free Field Rooftop	 posts anchor	

Terrain	Value	Unit
System configuration		
Total number of modules	7186	
Total number of inverters	166 (5, 10, 12, 15,20, 25 kVA)	
DC/AC ratio	0,91	
Key system indicators		
Parameter	Value	Unit
Total capacity	1868,36	[kWp]
Specific results		
Capacity / Area Free Field Roof-top	 0,053 0,082	 [kWp/m²/]
Yield Factor Production / Capacity	1783,04	[kWh/kWp/year]
Energy production and power output		
Daily profile  		
Energy generation	9425,19	[kWh/day]
Peak power (annual minimum)	90,29	[kW/peak time]
Highest daily peak power (annual maximum (h))	1731,15	[kW/peak time]
Annual profile (25yrs average, 25 yrs.)		
Energy generation	3440,19	[MWh/year]
Performance Ratio	80,56	%
Contribution to power supply		
Capacity share on total		%
Daily energy production share		%
Annual energy production share		%
Preliminary cost estimate		
CAPEX – specific	1521.39	USD/kWp
CAPEX – total	2.842.506	USD
OPEX – specific	27.21	USD/kWp (annum)
OPEX – total	50.830	USD/annum
DUC (over 25yrs.)		USD/kWh

12.3.2.5 Variant 5 – fixed structures with geometric adaptation using thin film modules

Variant 5 is a modification of Variant 1. The geometrically adapted PV arrays are fitted with thin-film solar modules instead of the previously used c-Si panels. Likewise, a fixed 25°-tilted racking structure is used. Due to different dimensions and electrical characteristics of these modules the string configuration was adapted too. One sting consists of 8 modules of 160 Wp and 18 strings are connected to one decentralized 25 kVA inverter. The resulting rated DC power sums up to 4148 kWp.

An overview on the preliminary array layout for the designated areas within the WWTP site is shown in Figure 12-60, likewise are the arrays for the areas at the recovery scheme shown in Figure 12-61 while Figure 12-62 illustrates an exemplary roof-top space.

The key parameters of the system configuration and obtained results are summarised in Table 12-14.

Figure 12-60: Variant 5 – overview of the sub-systems at the WWTP

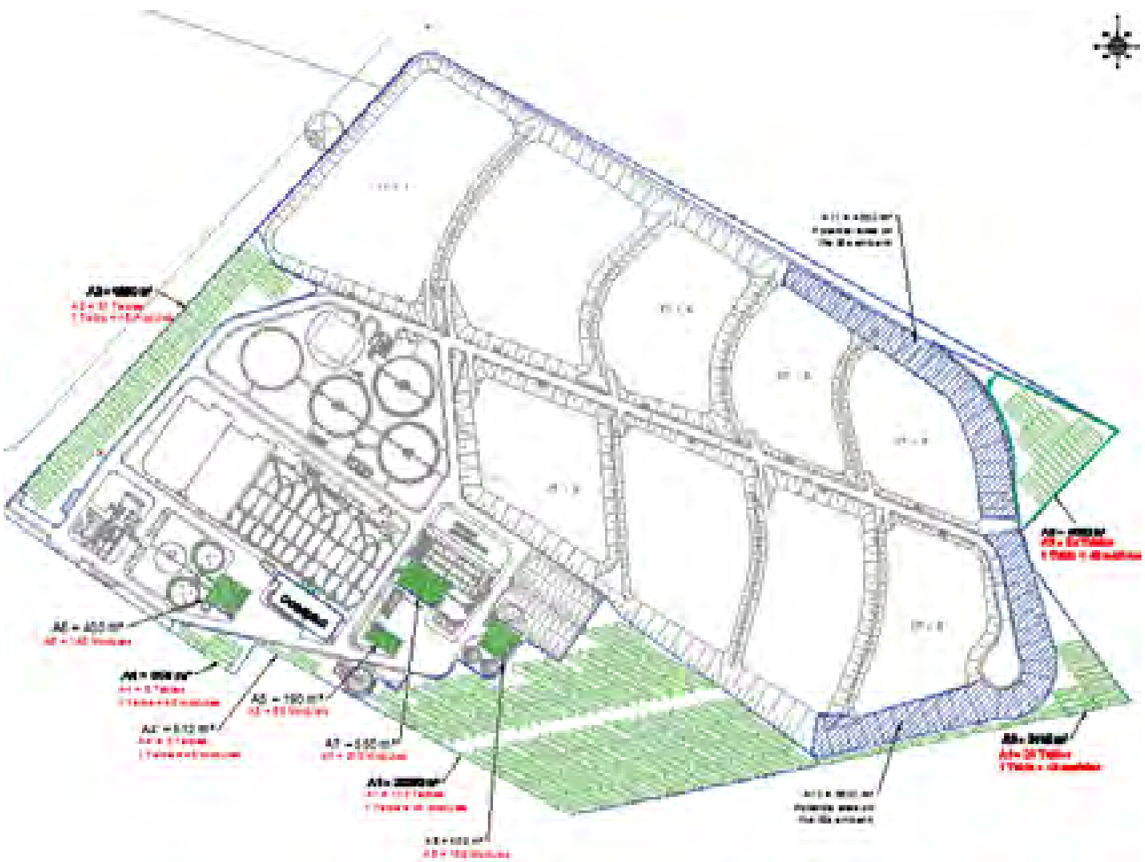


Figure 12-61: Variant 5 – overview of the sub-systems at the recovery scheme

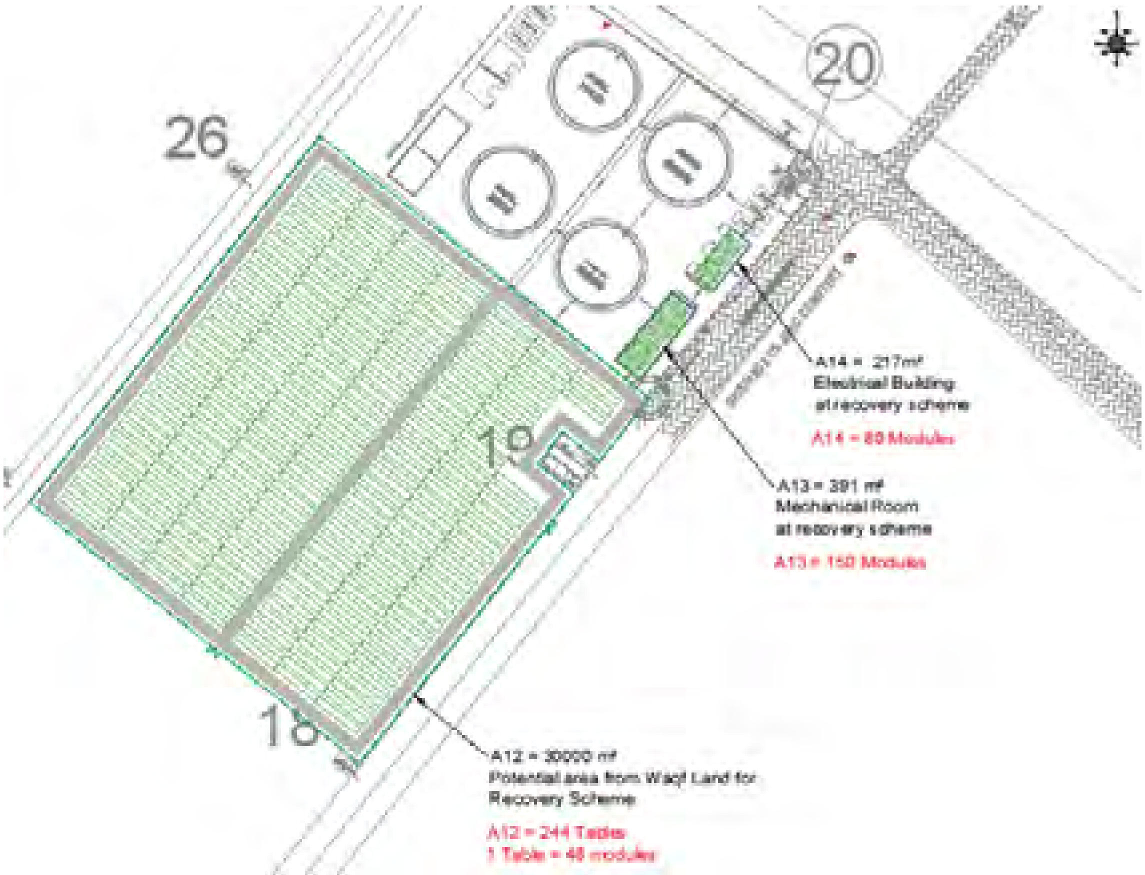


Figure 12-62: Variant 5 – example of a PV array on a roof-top area

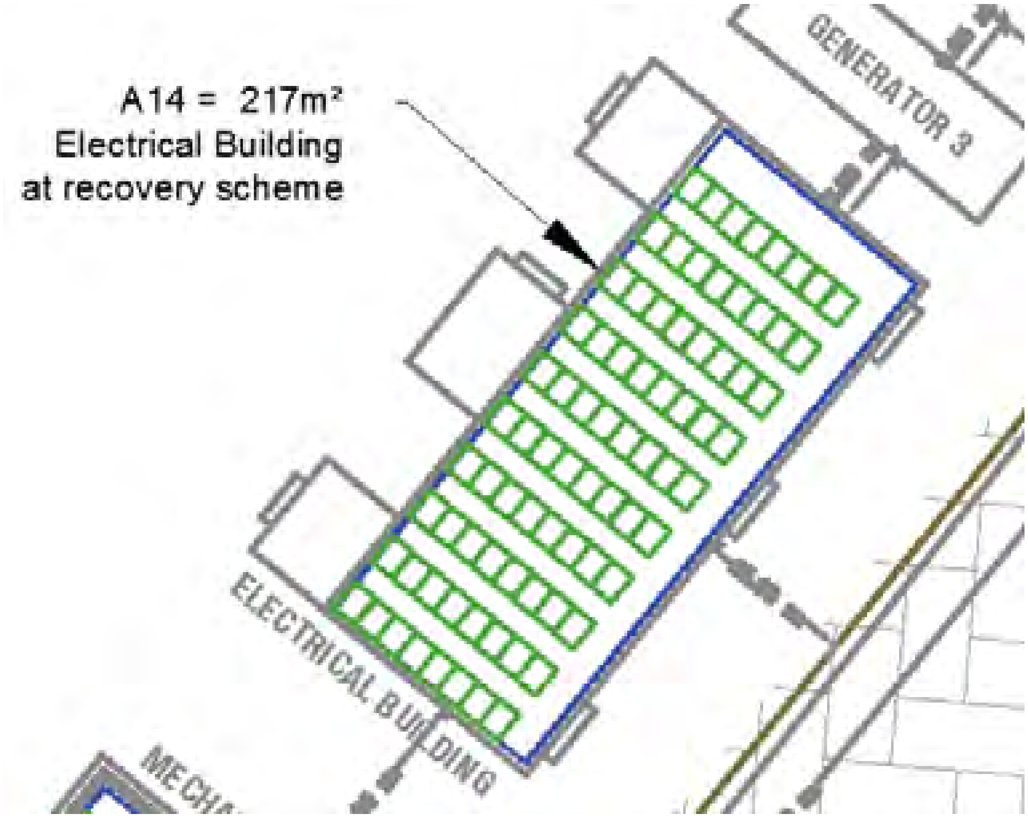
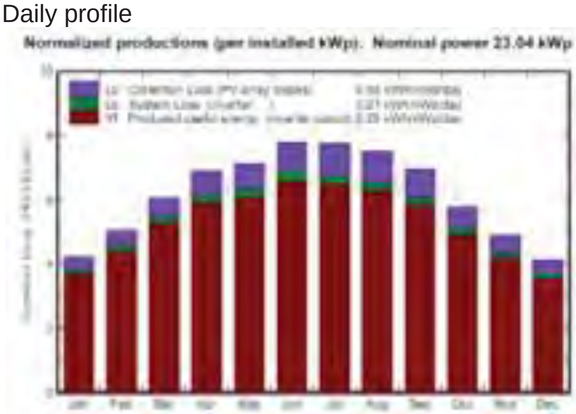


Table 12-14: Variant 5 – key system data

Parameter	Value	Unit
Terrain		
Total area	7,80	ha
Effective ground area for PV	5,49	ha
Remaining area	2,31	ha
Orientation		
Tilt angle	25	[°]
Azimuth	34,18	[°]
Mounting system type	Fixed	
Proposed foundation/fixation Free Field Rooftop	 Ramming posts Anchor	
System configuration		
Total number of modules	25925	
Total number of inverters	185 (5, 10, 12, 15,20, 25 kVA)	
DC/AC ratio	0,91	
Key system indicators		
Parameter	Value	Unit
Total capacity	4148	[kWp]

Parameter	Value	Unit
Specific results		
Capacity / Area Free Field Roof-top	 0,082 0,073	 [kWp/m²/]
Yield Factor Production / Capacity	1726,62	[kWh/kWp/year]
Energy production and power output		
Daily profile 		
Energy generation	19578,17	[kWh/day]
Peak power (annual minimum)	201,90	[kW/peak time]
Highest daily peak power (annual maximum (h))	4067,40	[kW/peak time]
Annual profile (25yrs average, 25 yrs.)		
Energy generation	7146,03	[MWh/year]
Performance Ratio	85,51	%
Contribution to power supply		
Capacity share on total		%
Daily energy production share		%
Annual energy production share		%
Preliminary cost estimate		
CAPEX – specific	1010.27	USD/kWp
CAPEX – total	4.190.601	USD
OPEX – specific	10.23	USD/kWp (annum)
OPEX – total	42.425	USD/annum
DUC (over 25yrs.)		USD/kWh

12.4 Long-Term Expected Energy Production

Table 12-15: AEP during project lifetime

Variant 2	Fixed Structures

PoE	P50		P90	
Year (end of operational year)	Specific Yield [kWh/kWp]	Annual Net Energy Output [MWh/a]	Specific Yield [kWh/kWp]	Annual Net Energy Output [GWh/a]
0	1,790	9,147	1,625	8,981
1	1,755	8,964	1,593	8,802
2	1,744	8,909	1,584	8,749
3	1,733	8,854	1,575	8,695
4	1,722	8,799	1,565	8,642
5	1,712	8,744	1,555	8,588
6	1,701	8,689	1,546	8,534
7	1,690	8,634	1,536	8,480
8	1,679	8,580	1,526	8,426
9	1,669	8,525	1,516	8,373
10	1,658	8,470	1,507	8,319
11	1,647	8,415	1,497	8,265
12	1,636	8,360	1,487	8,211
13	1,626	8,305	1,477	8,157
14	1,615	8,250	1,468	8,103
15	1,604	8,195	1,458	8,049
16	1,593	8,141	1,448	7,995
17	1,583	8,086	1,438	7,941
18	1,572	8,031	1,429	7,888
19	1,561	7,976	1,419	7,834
20	1,550	7,921	1,409	7,780
Project Lifetime				
Average	1,653	8,442	1,502	8,292
Sum [GWh]		214,291		174,812

12.5 Hybrid Plant Operation

12.5.1 Possible Operation Modes

The analysis of the energy balance shows that there will be no or hardly any time when the PV system alone can sustain the energy demand of the project sites. Since the plant power supply is provided by a combination of fuel-based sources (diesel and biogas) as well as variable and intermittent sources (grid, PV) the interaction needs to be evaluated.

It has to be ensured that the power supply can easily switch over from the on-grid supply into the off-grid supply with the different sources. In case of the off-grid situation, the grid must be maintained (frequency, operating voltage, power level). Since the power supply system as well as sewage treatment plant are not yet commissioned many parts remain to be looked at from a study perspective, only.

In order to assess the capability of the existing design to support the integration of the PV plant into the power supply set-up, the different operational situations were evaluated under the following assumptions for the combustion engines:

- 1 gas engine set at max 800 kVA (COP) – power factor 1, as described in Chapter 4.8.1
- 3 containerised diesel gen-sets at max. 800 kVA (Prime) each and 730 kVA (standby) – power factor 0.8, as described in Chapter 4.8.1.

On the basis of the designed power supply (refer to Chapter 5.1) and its planned extension (refer to Chapter 5.1) the following three operational situations are theoretically possible when operating in the off-grid mode:

1. 100% supply by the photovoltaic system
2. a hybrid system comprising the photovoltaic system and the gas engine
3. a hybrid system comprising the photovoltaic system and the gas engine and/or the diesel gen-sets.

The overall objective is to achieve a minimum generation by the diesel engines in order to reduce fuel costs and to limit the exhaust gas emissions – especially the burning of gas via the flare.

The operation modes can be split up in “island modes” and “Connected-to-the-grid modes”. Not all conceivable island modes are feasible, due to the fact, that a compensation of the reactive component cannot be realized by the PV-system. In addition the gas-generator can only create cos φ = 1.

1) Island mode with the conceivable sub-modes
   a) photovoltaic is running alone, 100% - not possible due to a non-existing compensation of the reactive component. **Not acceptable**!
   b) photo-voltaic and the gas engine in parallel- not possible due to a non-existing compensation of the reactive component. **Not acceptable**
   c) photovoltaic and the gas engine and the diesel gen-sets are producing – only possible if a minimum power of diesel gen-sets is respected. **- <u>Acceptable</u>**
   d) gas-engine running alone - not possible due to a non-existing compensation of the reactive component. **Not acceptable**
   e) gas-engine and diesel engines running in parallel - only possible if a minimum power of diesel gen-sets is respected. **<u>Partially acceptable.</u>**

f) diesel engines are running alone – this solution is of special interest for periods, when the gas engine is in maintenance. **Partially Acceptable**

The evaluation of these results shows that 3 of 6 modes are acceptable or partially acceptable. The only real acceptable mode for longer application is (1c), because it allows producing a large portion of electricity with the solar panels and the biogas engine, while 1 or 2 Diesel engines are turning near to 30% load for compensation of the reactive component.

2) Connected to the grid, e.g. Gaza Power plant, and the sub-modes
   a) photovoltaic in parallel to the grid – Compensation of the reactive component only possible by the grid. An agreement with the electrical network operator is necessary – **Partially acceptable**.
   b) photovoltaic and the gas engine in parallel to the grid - Compensation of the reactive component only possible by the grid. An agreement with the electrical network operator is necessary – **Partially acceptable**
   c) photovoltaic, the gas engine and/or the diesel gen-sets in parallel to the grid - possible if a minimum power of diesel gen-sets is respected. **– Acceptable –** similar to mode 1c
   d) gas-engine running alone in parallel to the grid - Compensation of the reactive component only possible by the grid. An agreement with the electrical network operator is necessary – **Partially acceptable**
   e) gas-engine and diesel engines running in parallel to the grid. No compensation of the electric component by the grid is necessary – sewage gas will be burnt. An easy switch-over to mode 2c is possible. **Acceptable**
   f) diesel generators are running in parallel to the grid. Compensation of the reactive component by the grid not necessary. Diesel oil is used as the only energy source and is expensive. – **Partially acceptable**
   g) Black start mode – The Diesel generators will produce for a short period the electricity for a start-up of the plant - no connection to the grid.
   h) Emergency mode – similar to 1f and 2f - only diesel-engines are running for electricity supply – for example during fire.

All operation modes with grid-connection make an export and an import of electricity possible as seen from NGEST.

The only real acceptable mode for longer application is (2c) due to similar reasons mentioned already for (1c).

12.5.2 Electrical Requirements and Grid Operation

12.5.2.1 Dispatchability

With regard to the fact that NGEST and GPP have different interests, a direct order or telecomm and from GPP to NGEST or reverse may not be possible. Under the agreement to help each other a solution will be discussed via telephone and confirmed by fax and email. According to our information a national control centre which would take over the responsibility does not exist.

NGEST can support the national grid with its diesel engines in periods of mode 2c. NGEST needs the support of the external grid in phases when a compensation of the reactive component does not exist, i.e. modes 2a, b and d.

12.5.2.2 Black Start Capability

The black start capability can only be guaranteed by diesel engines. The gas-engine is too slow in its response. After a total plant shutdown a signal will start 1 of the 3 engines as black start diesel. The first task is energising the plant grid within a few seconds, followed by a period of sequential starting of pumps and blowers. The plant status will go over in emergency status. After attaining a stable process situation the emergency status is finished. For the black start interval and the emergency period the gen-set will run at maximum with standby-power. The stand-by power will reduce to prime power after attaining normal situation.

12.5.2.3 Frequency/Voltage Regulation

The tolerated frequency range shall be + /- 2% giving an alarm when out of this zone. The generator tension shall allow a deviation of +/- 5%.

The compensation of the reactive component seems to be an important issue at NGEST. In order to gain some experience the plant shall be operated during commissioning at different power factors; from 0.8 lagging to 0.9 leading.

12.5.2.4 Ability to run in partial load and limitations on its share for each engine

The minimum load shall be at 30 %. An operation below this value shall be prevented, because of internal soothing. The effect of soothing is stronger at diesel engines than at gas engines. The reduced 30% load will be run by the diesel engines, when used for the compensation of the reactive component.

All 4 engines must be capable to run in parallel. A certain difference exists in power between the gas-engine and the diesel engines.

In case a difference in power is present the danger exists that one engine takes too much load and trips. The installed load sharing can prevent this.

12.5.2.5 Start/stop Times of Engines

Different start and stop times have to be considered for diesel and gas engines. The gas engine has a slower response and needs longer intervals, see estimated values below for 1500 rpm engines in seconds.

Action	Diesel	Gas
Starting	20	40
Synchronising	5	5
Charging	10	25
Decharging and stop	10	15

12.5.2.6 Ability to run the NGEST autonomous of the grid

The pre-condition is: at least 3 of 4 gen-sets are available. The situation of one gen-set is under repair or at maintenance must be considered. The max electrical power demand shall be below this value.

12.5.2.7 Issues related to grid re-synchronisation

A syncronoscope on each feeder line to and from the grid is necessary.

Energy meters for effective power and reactive power for imported and exported energy are needed.

12.6 Economic and financial analysis

12.6.1 Economic analysis without PV

%	Item	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand Total
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
	Base Data																								
	Energy consumption NGEST	kWh		20,448,614	21,583,386	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	1,062,279,708
	Discount rate	%	7%																						
17%	**Biogas**																								
	Installed capacity	kWP		800	800	800	800	800	800	800	800	800	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	
	Generated energy	kWh		5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	184,611,439
	Tax reduction																								
	CAPEX			(715,103)										(715,103)											
	OPEX																								
	Price per kWh	USD	0.09	491,596	491,596	491,596	491,596	491,596	491,596	491,596	491,596	491,596	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	16,153,501
	Maintenance	USD		3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	80,038
	Total CAPEX + OPEX			1,210,510	495,407	495,407	495,407	495,407	495,407	495,407	495,407	495,407	981,240	1,696,342	981,240	981,240	981,240	981,240	981,240	981,240	981,240	981,240	981,240	981,240	17,663,745
	Discounted generation	kWh		5,618,235	5,224,959	4,859,212	4,519,067	4,202,732	3,908,541	3,634,943	3,380,497	3,143,862	5,813,309	5,406,378	5,027,931	4,675,976	4,348,658	4,044,252	3,761,154	3,497,873	3,253,022	3,025,311	2,813,539	2,616,591	86,776,043
	Discounted costs	USD		1,210,510	460,728	428,477	398,484	370,590	344,649	320,523	298,087	277,221	510,648	821,000	441,659	410,743	381,991	355,252	330,384	307,257	285,749	265,747	247,145	229,844	8,696,690
	Present value of costs (PV)	USD	8,696,690																						
	Present value of energy (PV)	kWh	86,776,043																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.10																						
54%	**Diesel**																								
	Annual diesel consumption	litre		2,022,896	2,178,282	4,264,247	4,264,247	4,264,247	4,264,247	4,264,247	4,264,247	4,264,247	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	
	Generated energy	kWh		9,858,000	10,615,000	20,780,000	20,780,000	20,780,000	20,780,000	20,780,000	20,780,000	20,780,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	578,217,000
	CAPEX			(1,037,823)		(349,248)							(843,355)												
	OPEX																								
	Maintenance	USD		11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	240,115
	Annual cost of diesel (cal. Ø2013-2015)	USD		1,374,514	1,480,095	2,897,462	2,897,462	2,897,462	2,897,462	2,897,462	2,897,462	2,897,462	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	4,790,511	80,622,976
	Total CAPEX + OPEX			2,423,771	1,491,529	3,258,145	2,908,896	2,908,896	2,908,896	2,908,896	2,908,896	2,908,896	5,645,300	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	4,801,945	83,093,518
	Discounted generation	kWh		9,858,000	9,871,950	17,972,622	16,714,538	15,544,521	14,456,404	13,444,456	12,503,344	11,628,110	17,879,764	16,628,180	15,464,208	14,381,713	13,374,993	12,438,744	11,568,032	10,758,269	10,005,190	9,304,827	8,653,489	8,047,745	270,499,099
	Discounted costs	USD		2,423,771	1,387,122	2,817,969	2,339,791	2,176,006	2,023,685	1,882,027	1,750,286	1,627,766	2,937,877	2,324,056	2,161,372	2,010,076	1,869,371	1,738,515	1,616,819	1,503,642	1,398,387	1,300,500	1,209,465	1,124,802	39,623,305
	Present value of costs (PV)	USD	39,623,305																						
	Present value of energy (PV)	kWh	270,499,099																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.15																						
28%	**GEDCo**																								
	Generated energy	kWh		497,200	5,317,000	10,854,000	10,854,000	10,854,000	10,854,000	10,854,000	10,854,000	10,854,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	294,708,200
	OPEX																								
	Tariff GEDCo - NGEST	USD/kWh		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	
	Cost p.a. of electr. Supplied by GEDCo	USD		62,410	667,406	1,362,427	1,362,427	1,362,427	1,362,427	1,362,427	1,362,427	1,362,427	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	36,992,661
	Total OPEX			62,410	667,406	1,362,427	1,362,427	1,362,427	1,362,427	1,362,427	1,362,427	1,362,427	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	2,227,155	36,992,661
	Discounted generation	kWh		497,200	4,944,810	9,387,625	8,730,491	8,119,357	7,551,002	7,022,431	6,530,861	6,073,701	9,233,654	8,587,298	7,986,187	7,427,154	6,907,253	6,423,746	5,974,083	5,555,898	5,166,985	4,805,296	4,468,925	4,156,100	135,550,056
	Discounted costs	USD		62,410	620,687	1,178,363	1,095,878	1,019,166	947,824	881,477	819,773	762,389	1,159,036	1,077,904	1,002,450	932,279	867,019	806,328	749,885	697,393	648,575	603,175	560,953	521,686	17,014,651
	Present value of costs (PV)	USD	17,014,651																						
	Present value of energy (PV)	kWh	135,550,056																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.13																						
	LCOE total	USD/kWh	**0.13**																						

12.6.2 Economic analysis with chosen PV option

%	Item	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand Total
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
	Base Data																								
	Energy consumption NGEST	kWh		20,448,614	21,583,386	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	1,062,279,708
	Discount rate	%	7%																						
	Exclusion	%	18%																						
16%	**PV chosen variant**																								
	Installed capacity	kWP			5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	
	Generated energy	kWh			8,963,755	8,908,875	8,853,995	8,799,115	8,744,234	8,689,354	8,634,474	8,579,594	8,524,714	8,469,834	8,414,954	8,360,074	8,305,193	8,250,313	8,195,433	8,140,553	8,085,673	8,030,793	7,975,913	7,921,032	168,847,874
	CAPEX				(5,656,354)														(431,218)						(6,087,572)
	OPEX				48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	964,530
	Total CAPEX + OPEX				5,704,581	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	479,445	48,227	48,227	48,227	48,227	48,227	7,052,102
	Discounted generation	kWh			8,963,755	8,285,254	7,657,820	7,077,629	6,541,142	6,045,083	5,586,420	5,162,349	4,770,275	4,407,795	4,072,689	3,762,899	3,476,523	3,211,802	2,967,107	2,740,931	2,531,881	2,338,668	2,160,098	1,995,069	93,755,189
	Discounted costs	USD			5,704,581	44,851	41,711	38,791	36,076	33,551	31,202	29,018	26,987	25,098	23,341	21,707	20,187	18,774	173,580	16,238	15,101	14,044	13,061	12,147	6,340,045
	Present value of costs (PV)	USD	6,340,045																						
	Present value of energy (PV)	kWh	93,755,189																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.07																						
17%	**Biogas**																								
	Installed capacity	kWP		800	800	800	800	800	800	800	800	800	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	
	Generated energy	kWh		5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	184,611,439
	Tax reduction																								
	CAPEX			(715,103)										(715,103)											
	OPEX																								
	Price per kWh	USD	0.09	491,596	491,596	491,596	491,596	491,596	491,596	491,596	491,596	491,596	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	977,428	16,153,501
	Maintenance	USD		3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	80,038
	Total CAPEX + OPEX			1,210,510	495,407	495,407	495,407	495,407	495,407	495,407	495,407	495,407	981,240	1,696,342	981,240	981,240	981,240	981,240	981,240	981,240	981,240	981,240	981,240	981,240	17,663,745
	Discounted generation	kWh		5,618,235	5,224,959	4,859,212	4,519,067	4,202,732	3,908,541	3,634,943	3,380,497	3,143,862	5,813,309	5,406,378	5,027,931	4,675,976	4,348,658	4,044,252	3,761,154	3,497,873	3,253,022	3,025,311	2,813,539	2,616,591	86,776,043
	Discounted costs	USD		1,210,510	460,728	428,477	398,484	370,590	344,649	320,523	298,087	277,221	510,648	821,000	441,659	410,743	381,991	355,252	330,384	307,257	285,749	265,747	247,145	229,844	8,696,690
	Present value of costs (PV)	USD	8,696,690																						
	Present value of energy (PV)	kWh	86,776,043																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.10																						
44%	**Diesel**																								
	Annual diesel consumption	litre		2,117,592	961,386	2,970,569	2,979,142	2,987,715	2,996,288	3,004,862	3,013,435	3,022,008	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	
	Generated energy	kWh		10,319,373	4,684,994	14,476,071	14,517,849	14,559,627	14,601,406	14,643,184	14,684,962	14,726,741	28,475,199	28,530,079	28,584,959	28,639,839	28,694,719	28,749,600	28,804,480	28,859,360	28,914,240	28,969,120	29,024,000	29,078,880	462,538,683
	CAPEX			(1,037,823)		(349,248)							(843,355)												
	OPEX																								
	Maintenance	USD		11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	240,115
	Annual cost of diesel (cal. Ø2013-2015)	USD		1,438,857	653,241	2,018,437	2,024,262	2,030,087	2,035,912	2,041,738	2,047,563	2,053,388	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	3,970,372	63,987,947
	Total CAPEX + OPEX			2,488,114	664,675	2,379,119	2,035,696	2,041,521	2,047,346	2,053,172	2,058,997	2,064,822	4,825,161	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	3,981,806	66,458,489
	Discounted generation	kWh		10,319,373	4,357,044	12,520,354	11,677,534	10,891,359	10,158,028	9,473,996	8,835,955	8,240,816	14,818,809	13,808,054	12,866,192	11,988,531	11,170,698	10,408,618	9,698,493	9,036,783	8,420,190	7,845,640	7,310,268	6,811,404	210,658,138
	Discounted costs	USD		2,488,114	618,148	2,057,700	1,637,426	1,527,164	1,424,315	1,328,382	1,238,900	1,155,437	2,511,067	1,927,124	1,792,225	1,666,769	1,550,095	1,441,589	1,340,677	1,246,830	1,159,552	1,078,383	1,002,896	932,694	31,125,489
	Present value of costs (PV)	USD	31,125,489																						
	Present value of energy (PV)	kWh	210,658,138																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.15																						
23%	**GEDCo**																								
	Generated energy	kWh		4,511,006	2,283,471	8,249,574	8,262,676	8,275,778	8,288,879	8,301,981	8,315,083	8,328,185	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	246,018,268
	OPEX																								
	Tariff GEDCo - NGEST	USD/kWh		0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	
	Cost p.a. of electr. Supplied by GEDCo	USD		566,235	286,628	1,035,511	1,037,156	1,038,801	1,040,445	1,042,090	1,043,734	1,045,379	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	30,880,954
	Total OPEX			566,235	286,628	1,035,511	1,037,156	1,038,801	1,040,445	1,042,090	1,043,734	1,045,379	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	1,895,415	30,880,954
	Discounted generation	kWh		4,511,006	2,123,628	7,135,056	6,646,141	6,190,712	5,766,477	5,371,300	5,003,193	4,660,301	7,858,278	7,308,199	6,796,625	6,320,861	5,878,401	5,466,913	5,084,229	4,728,333	4,397,350	4,089,535	3,803,268	3,537,039	112,676,844
	Discounted costs	USD		566,235	266,564	895,614	834,244	777,077	723,826	674,222	628,016	584,975	986,395	917,347	853,133	793,414	737,875	686,223	638,188	593,515	551,969	513,331	477,398	443,980	14,143,537
	Present value of costs (PV)	USD	14,143,537																						
	Present value of energy (PV)	kWh	112,676,844																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.13																						
	LCOE total	USD/kWh	0.12																						

12.6.3 Economic Analysis different PV options

Item	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
			1	2	3	4	5	6	7	8	9	10	11
Base Data													
Energy consumption NGEST	kWh		20,448,614	21,583,386	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	63,270,659	63,270,659
Discount rate	%	7%											
PV Variant 1													
Installed capacity	kWp			4,821	4,821	4,821	4,821	4,821	4,821	4,821	4,821	4,821	4,821
Generated energy	kWh			8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367
CAPEX	USD			-4,830,002									
OPEX	USD			46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631
Total CAPEX + OPEX	USD			4,876,633	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631
Discounted generation	kWh			8,021,367	7,459,871	6,937,680	6,452,043	6,000,400	5,580,372	5,189,746	4,826,464	4,488,611	4,174,408
Discounted costs	USD			4,876,633	43,367	40,331	37,508	34,882	32,441	30,170	28,058	26,094	24,267
Present Value of Costs (PV)	USD	5,340,119											
Present Value of Energy (PV)	kWh	87,749,302											
Levelized Costs of Electricity (LCOE)	USD/kWh	0.06											
PV Variant 2													
Installed capacity	kWp			5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109
Generated energy	kWh			8,963,755	8,908,875	8,853,995	8,799,115	8,744,234	8,689,354	8,634,474	8,579,594	8,524,714	8,469,834
CAPEX	USD			(5,656,354)									
OPEX	USD			48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227
Total CAPEX + OPEX	USD			5,704,581	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227
Discounted generation	kWh			8,963,755	8,285,254	7,657,820	7,077,629	6,541,142	6,045,083	5,586,420	5,162,349	4,770,275	4,407,795
Discounted costs	USD			5,704,581	44,851	41,711	38,791	36,076	33,551	31,202	29,018	26,987	25,098
Present Value of Costs (PV)	USD	6,340,045											
Present Value of Energy(PV)	kWh	93,755,189											
Levelized Costs of Electricity (LCOE)	USD	0.07											
PV Variant 3													
Installed capacity	kWp			2,059	2,059	2,059	2,059	2,059	2,059	2,059	2,059	2,059	2,059
Generated energy (16 MWh p.d.)	kWh			3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290
CAPEX	USD			(2,332,830)									
OPEX	USD			46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435
Total CAPEX + OPEX	USD			2,379,265	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435
Discounted generation	kWh			3,665,290	3,408,720	3,170,109	2,948,202	2,741,828	2,549,900	2,371,407	2,205,408	2,051,030	1,907,458
Discounted costs	USD			2,379,265	43,185	40,162	37,350	34,736	32,304	30,043	27,940	25,984	24,165
Present Value of Costs (PV)	USD	2,840,803											
Present Value of Energy (PV)	kWh	40,096,237											
Levelized Costs of Electricity (LCOE)	USD	0.07											
PV Variant 4													
Installed capacity	kWp			1,868	1,868	1,868	1,868	1,868	1,868	1,868	1,868	1,868	1,868
Generated energy	kWh			3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195
CAPEX	USD			(2,842,506)									
OPEX	USD			19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109
Total CAPEX + OPEX	USD			2,861,615	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109
Discounted generation	kWh			3,440,195	3,199,381	2,975,425	2,767,145	2,573,445	2,393,304	2,225,772	2,069,968	1,925,071	1,790,316
Discounted costs	USD			2861615	17771.37	16527.3741	15370.45791	14294.52586	13293.90905	12363.3354	11497.9019	10693.0488	9944.53538
Present Value of Costs (PV)	USD	3,051,548											
Present Value of Energy (PV)	kWh	37,633,823											
Levelized Costs of Electricity (LCOE)	USD	0.08											
PV Variant 5													
Installed capacity				4,148	4,148	4,148	4,148	4,148	4,148	4,148	4,148	4,148	4,148
Generated energy	kWh			3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270
CAPEX				(4,190,601)									
OPEX				42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425
Total CAPEX + OPEX	USD			4,233,026	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425
Discounted generation	kWh			3,271,270	3,042,281	2,829,321	2,631,269	2,447,080	2,275,784	2,116,480	1,968,326	1,830,543	1,702,405
Discounted costs	USD			4,233,026	36,693	34,125	31,736	29,515	27,449	25,527	23,740	22,078	20,533
Present Value of Costs (PV)	USD	4,625,189											
Present Value of Energy (PV)	kWh	35,785,877											
Levelized Costs of Electricity (LCOE)	USD	0.13											

Item	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand Total
	12	13	14	15	16	17	18	19	20	21	
Base Data											
Energy consumption NGEST	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	1,062,279,708
Discount rate											
PV Variant 1											
Installed capacity	4,821	4,821	4,821	4,821	4,821	4,821	4,821	4,821	4,821	4,821	96,429
Generated energy	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	8,021,367	160,427,342
CAPEX											-4,830,002
OPEX	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	932,620
Total CAPEX + OPEX	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	46,631	5,762,622
Discounted generation	3,882,200	3,610,446	3,357,715	3,122,675	2,904,087	2,700,801	2,511,745	2,335,923	2,172,408	2,020,340	87,749,302
Discounted costs	22,569	20,989	19,520	18,153	16,882	15,701	14,602	13,580	12,629	11,745	5,340,119
PV Variant 2											
Installed capacity	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	102,175
Generated energy	8,414,954	8,360,074	8,305,193	8,250,313	8,195,433	8,140,553	8,085,673	8,030,793	7,975,913	7,921,032	168,847,874
CAPEX					(431,218)						(6,087,572)
OPEX	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	964,530
Total CAPEX + OPEX	48,227	48,227	48,227	48,227	479,444	48,227	48,227	48,227	48,227	48,227	7,052,102
Discounted generation	4,072,689	3,762,899	3,476,523	3,211,802	2,967,107	2,740,931	2,531,881	2,338,668	2,160,098	1,995,069	93,755,189
Discounted costs	23,341	21,707	20,187	18,774	173,580	16,238	15,101	14,044	13,061	12,147	6,340,045
PV Variant 3											
Installed capacity	2,059	2,059	2,059	2,059	2,059	2,059	2,059	2,059	2,059	2,059	41,180
Generated energy (16 MWh p.d.)	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	3,665,290	73,305,800
CAPEX											-2,332,830
OPEX	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	928,700
Total CAPEX + OPEX	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	46,435	3,261,530
Discounted generation	1,773,936	1,649,760	1,534,277	1,426,877	1,326,996	1,234,106	1,147,719	1,067,379	992,662	923,176	40,096,237
Discounted costs	22,474	20,901	19,438	18,077	16,812	15,635	14,540	13,522	12,576	11,696	2,840,803
PV Variant 4											
Installed capacity	1,868	1,868	1,868	1,868	1,868	1,868	1,868	1,868	1,868	1,868	37,360
Generated energy	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	3,440,195	68,803,900
CAPEX											-2,842,506
OPEX	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	382,180
Total CAPEX + OPEX	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	19,109	3,224,686
Discounted generation	1,664,994	1,548,444	1,440,053	1,339,249	1,245,502	1,158,317	1,077,234	1,001,828	931,700	866,481	37,633,823
Discounted costs	9248.41791	8601.02865	7998.95665	7439.02968	6918.29761	6434.01677	5983.6356	5564.78111	5175.24643	4812.97918	3,051,548
PV Variant 5											
Installed capacity	4,148	4,148	4,148	4,148	4,148	4,148	4,148	4,148	4,148	4,148	82,960
Generated energy	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	3,271,270	65,425,400
CAPEX											
OPEX	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	848,500
Total CAPEX + OPEX	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	42,425	5,039,101
Discounted generation	1,583,237	1,472,410	1,369,342	1,273,488	1,184,343	1,101,439	1,024,339	952,635	885,951	823,934	35,785,877
Discounted costs	19,096	17,759	16,516	15,360	14,285	13,285	12,355	11,490	10,686	9,938	4,625,189

12.6.4 Financial Analysis without PV

%	Item	Unit		2016 1	2017 2	2018 3	2019 4	2020 5	2021 6	2022 7	2023 8	2024 9	2025 10	2026 11	2027 12	2028 13	2029 14	2030 15	2031 16	2032 17	2033 18	2034 19	2035 20	2036 21	Grand Total
	Base Data																								
	Energy consumption NGEST	kWh		20,448,614	21,583,386	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	1,062,279,708
	Discount rate	%	7%																						
17%	**Biogas**																								
	Installed capacity	kWP		800	800	800	800	800	800	800	800	800	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	
	Generated energy	kWh		5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	184,611,439
	CAPEX			-872,077										-872,077											-1,744,153
	OPEX																								
	Price per kWh	USD	0.07	393,276	393,276	393,276	393,276	393,276	393,276	393,276	393,276	393,276	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	12,922,801
	Maintenance			3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	80,038
	Total OPEX			397,088	397,088	397,088	397,088	397,088	397,088	397,088	397,088	397,088	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	13,002,839
	Total CAPEX + OPEX			1,269,164	397,088	397,088	397,088	397,088	397,088	397,088	397,088	397,088	785,754	1,657,831	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	14,746,992
	Discounted generation	kWh		5,618,235	5,224,959	4,859,212	4,519,067	4,202,732	3,908,541	3,634,943	3,380,497	3,143,862	5,813,309	5,406,378	5,027,931	4,675,976	4,348,658	4,044,252	3,761,154	3,497,873	3,253,022	3,025,311	2,813,539	2,616,591	86,776,043
	Discounted costs	USD		1,269,164	369,292	343,441	319,400	297,042	276,249	256,912	238,928	222,203	408,915	802,361	353,671	328,914	305,890	284,477	264,564	246,045	228,821	212,804	197,908	184,054	7,411,056
	Present value of costs (PV)	USD	7,411,056																						
	Present value of energy (PV)	kWh	86,776,043																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.09																						
54%	**Diesel**																								
	Annual diesel consumption	litre		2,022,896	2,178,282	4,264,247	4,264,247	4,264,247	4,264,247	4,264,247	4,264,247	4,264,247	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	7,050,280	
	Generated energy	kWh		9,858,000	10,615,000	20,780,000	20,780,000	20,780,000	20,780,000	20,780,000	20,780,000	20,780,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	34,357,000	578,217,000
	CAPEX			-1,265,638		-425,913							-1,028,482												-2,720,032
	OPEX																								
	Maintenance	USD		11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	240,115
	Annual cost of diesel (cal. Ø2013-2015)	USD		3,054,475	3,289,100	6,438,805	6,438,805	6,438,805	6,438,805	6,438,805	6,438,805	6,438,805	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	10,645,580	179,162,169
	Total OPEX			3,065,909	3,300,534	6,450,239	6,450,239	6,450,239	6,450,239	6,450,239	6,450,239	6,450,239	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	179,402,284
	Total CAPEX + OPEX			4,331,546	3,300,534	6,876,152	6,450,239	6,450,239	6,450,239	6,626,861	6,450,239	6,450,239	11,685,496	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	10,657,014	182,298,938
	Discounted generation	kWh		9,858,000	9,871,950	17,972,622	16,714,538	15,544,521	14,456,404	13,444,456	12,503,344	11,628,110	17,879,764	16,628,180	15,464,208	14,381,713	13,374,993	12,438,744	11,568,032	10,758,269	10,005,190	9,304,827	8,653,489	8,047,745	270,499,099
	Discounted costs	USD		4,331,546	3,069,496	5,947,184	5,188,295	4,825,115	4,487,357	4,287,514	3,881,115	3,609,437	6,081,262	5,157,806	4,796,760	4,460,986	4,148,717	3,858,307	3,588,226	3,337,050	3,103,456	2,886,214	2,684,179	2,496,287	86,226,310
	Present value of costs (PV)	USD	86,226,310																						
	Present value of energy (PV)	kWh	270,499,099																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.32																						
28%	**GEDCo**																								
	Generated energy	kWh		4,972,000	5,317,000	10,854,000	10,854,000	10,854,000	10,854,000	10,854,000	10,854,000	10,854,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	17,743,000	299,183,000
	OPEX																								
	Tariff GEDCo - NGEST	USD/kWh		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
	Cost p.a. of electr. Supplied by GEDCo	USD		745,800	797,550	1,628,100	1,628,100	1,628,100	1,628,100	1,628,100	1,628,100	1,628,100	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	44,877,450
	Total OPEX			745,800	797,550	1,628,100	1,628,100	1,628,100	1,628,100	1,628,100	1,628,100	1,628,100	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	2,661,450	44,877,450
	Discounted generation	kWh		4,972,000	4,944,810	9,387,625	8,730,491	8,119,357	7,551,002	7,022,431	6,530,861	6,073,701	9,233,654	8,587,298	7,986,187	7,427,154	6,907,253	6,423,746	5,974,083	5,555,898	5,166,985	4,805,296	4,468,925	4,156,100	140,024,856
	Discounted costs	USD		745,800	741,722	1,408,144	1,309,574	1,217,903	1,132,650	1,053,365	979,629	911,055	1,385,048	1,288,095	1,197,928	1,114,073	1,036,088	963,562	896,113	833,385	775,048	720,794	670,339	623,415	21,003,728
	Present value of costs (PV)	USD	21,003,728																						
	Present value of energy (PV)	kWh	140,024,856																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.15																						
	LCOE total	USD/kWh	0.230																						

12.6.5 Financial Analysis with PV

%	Item	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand Total
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
	Base Data																								
	Energy consumption NGEST	kWh		20,448,614	21,583,386	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	37,285,686	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	63,270,659	1,062,279,708
	Discount rate	%	7%																						
16%	**PV chosen variant**																								
	Installed capacity	kWP			5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	5,109	
	Generated energy	kWh			8,963,755	8,908,875	8,853,995	8,799,115	8,744,234	8,689,354	8,634,474	8,579,594	8,524,714	8,469,834	8,414,954	8,360,074	8,305,193	8,250,313	8,195,433	8,140,553	8,085,673	8,030,793	7,975,913	7,921,032	168,847,874
	CAPEX				(6,897,993)														(525,875)						(7,423,868)
	OPEX				48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	964,530
	Total CAPEX + OPEX				6,946,219	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	48,227	574,102	48,227	48,227	48,227	48,227	48,227	8,388,398
	Discounted generation	kWh			8,963,755	8,285,254	7,657,820	7,077,629	6,541,142	6,045,083	5,586,420	5,162,349	4,770,275	4,407,795	4,072,689	3,762,899	3,476,523	3,211,802	2,967,107	2,740,931	2,531,881	2,338,668	2,160,098	1,995,069	93,755,189
	Discounted costs	USD			6,946,219	44,851	41,711	38,791	36,076	33,551	31,202	29,018	26,987	25,098	23,341	21,707	20,187	18,774	207,850	16,238	15,101	14,044	13,061	12,147	7,615,954
	Present value of costs (PV)	USD	7,615,954																						
	Present value of energy (PV)	kWh	93,755,189																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.08																						
17%	**Biogas**																								
	Installed capacity	kWP		800	800	800	800	800	800	800	800	800	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	1600	
	Generated energy	kWh		5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	5,618,235	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	11,170,610	184,611,439
	CAPEX			(872,077)										(872,077)											(1,744,153)
	OPEX																								
	Price per kWh	USD	0.07	393,276	393,276	393,276	393,276	393,276	393,276	393,276	393,276	393,276	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	781,943	12,922,801
	Maintenance	USD		3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	3,811	80,038
	Total OPEX	USD		397,088	397,088	397,088	397,088	397,088	397,088	397,088	397,088	397,088	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	13,002,839
	Total CAPEX + OPEX			1,269,164	397,088	397,088	397,088	397,088	397,088	397,088	397,088	397,088	785,754	1,657,831	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	785,754	14,746,992
	Discounted generation	kWh		5,618,235	5,224,959	4,859,212	4,519,067	4,202,732	3,908,541	3,634,943	3,380,497	3,143,862	5,813,309	5,406,378	5,027,931	4,675,976	4,348,658	4,044,252	3,761,154	3,497,873	3,253,022	3,025,311	2,813,539	2,616,591	86,776,043
	Discounted costs	USD		1,269,164	369,292	343,441	319,400	297,042	276,249	256,912	238,928	222,203	408,915	802,361	353,671	328,914	305,890	284,477	264,564	246,045	228,821	212,804	197,908	184,054	7,411,056
	Present value of costs (PV)	USD	7,411,056																						
	Present value of energy (PV)	kWh	86,776,043																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.09																						
44%	**Diesel**																								
	Annual diesel consumption	litre		2,117,592	961,386	2,970,569	2,979,142	2,987,715	2,996,288	3,004,862	3,013,435	3,022,008	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	5,843,267	
	Generated energy	kWh		10,319,373	4,684,994	14,476,071	14,517,849	14,559,627	14,601,406	14,643,184	14,684,962	14,726,741	28,475,199	28,530,079	28,584,959	28,639,839	28,694,719	28,749,600	28,804,480	28,859,360	28,914,240	28,969,120	29,024,000	29,078,880	462,538,683
	CAPEX			(1,265,638)		(425,913)							(1,028,482)												(2,720,032)
	OPEX																								
	Maintenance	USD		11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	11,434	240,115
	Annual cost of diesel (cal. Ø2013-2015)	USD		3,197,461	1,451,647	4,485,415	4,498,360	4,511,305	4,524,250	4,537,195	4,550,140	4,563,085	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	8,823,049	142,195,438
	Total OPEX			3,208,895	1,463,081	4,496,849	4,509,794	4,522,739	4,535,684	4,548,629	4,561,574	4,574,519	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	142,435,554
	Total CAPEX + OPEX			4,474,532	1,463,081	4,922,761	4,509,794	4,522,739	4,535,684	4,548,629	4,561,574	4,574,519	9,862,965	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	8,834,483	145,155,586
	Discounted generation	kWh		10,319,373	4,357,044	12,520,354	11,677,534	10,891,359	10,158,028	9,473,996	8,835,955	8,240,816	14,818,809	13,808,054	12,866,192	11,988,531	11,170,698	10,408,618	9,698,493	9,036,783	8,420,190	7,845,640	7,310,268	6,811,404	210,658,138
	Discounted costs	USD		4,474,532	1,360,665	4,257,696	3,627,484	3,383,244	3,155,422	2,942,918	2,744,703	2,559,818	5,132,796	4,275,733	3,976,432	3,698,082	3,439,216	3,198,471	2,974,578	2,766,357	2,572,712	2,392,623	2,225,139	2,069,379	67,228,002
	Present value of costs (PV)	USD	67,228,002																						
	Present value of energy (PV)	kWh	210,658,138																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.32																						
23%	**GEDCo**																								
	Generated energy	kWh		4,511,006	2,283,471	8,249,574	8,262,676	8,275,778	8,288,879	8,301,981	8,315,083	8,328,185	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	15,100,136	246,018,268
	OPEX																								
	Tariff GEDCo - NGEST	USD/kWh		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
	Cost p.a. of electr. Supplied by GEDCo	USD		676,651	342,521	1,237,436	1,239,401	1,241,367	1,243,332	1,245,297	1,247,262	1,249,228	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	36,902,740
	Total OPEX			676,651	342,521	1,237,436	1,239,401	1,241,367	1,243,332	1,245,297	1,247,262	1,249,228	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	2,265,020	36,902,740
	Discounted generation	kWh		4,511,006	2,123,628	7,135,056	6,646,141	6,190,712	5,766,477	5,371,300	5,003,193	4,660,301	7,858,278	7,308,199	6,796,625	6,320,861	5,878,401	5,466,913	5,084,229	4,728,333	4,397,350	4,089,535	3,803,268	3,537,039	112,676,844
	Discounted costs	USD		676,651	318,544	1,070,258	996,921	928,607	864,972	805,695	750,479	699,045	1,178,742	1,096,230	1,019,494	948,129	881,760	820,037	762,634	709,250	659,602	613,430	570,490	530,556	16,901,527
	Present value of costs (PV)	USD	16,901,527																						
	Present value of energy (PV)	kWh	112,676,844																						
	Levelized costs of electricity (LCOE)	USD/kWh	0.15																						
	LCOE total	USD/kWh	0.199																						

12.6.6 Sensitivity diesel price

	Decrease					Base Case	Increase			
	-55%	-20%	-15%	-10%	-5%	**0%**	5%	10%	15%	20%
Overall LCOE without PV (USD/kWh)	0.138	0.197	0.205	0.214	0.222	**0.230**	0.239	0.247	0.256	0.264
Total costs in m/USD without PV Options (20 yrs.)	68,542,826	97,878,088	102,068,840	106,259,591	110,450,343	**114,641,095**	118,831,846	123,022,598	127,213,350	131,404,102
Overall LCOE with PV (USD/kWh)	0.128	0.173	0.180	0.186	0.193	**0.199**	0.206	0.212	0.219	0.225
Total costs with PV Options (20 yrs.)	63,444,489	86,170,338	89,416,888	92,663,438	95,909,988	**99,156,538**	102,403,088	105,649,638	108,896,188	112,142,738
Difference overall LCOE no PV/with PV	0.010	0.024	0.025	0.028	0.029	**0.031**	0.033	0.035	0.037	0.039
Relative difference of LCOE no PV/ with PV	7%	12%	12%	13%	13%	**13%**	14%	14%	14%	15%
Total Savings in cost with PV Option (20 yrs.)	5,098,337	11,707,750	12,651,951	13,596,153	14,540,355	**15,484,557**	16,428,759	17,372,960	18,317,162	19,261,364
	excl. Blue Tax									

12.6.7 Sensitivity GEDCo grid price

	Decrease				**Base Case**	*Increase*			
	-20%	*-15%*	*-10%*	*-5%*	**0%**	*5%*	*10%*	*15%*	*20%*
Overall LCOE with-out PV(USD/kWh)	*0.222*	*0.224*	*0.226*	*0.228*	**0.230**	**0.233**	*0.235*	*0.237*	*0.239*
Total costs in m/USD without PV Options (20 yrs.)	*110,440,349*	*111,490,535*	*112,540,722*	*113,590,908*	***114,641,095***	***115,691,281***	*116,741,468*	*117,791,654*	*118,841,840*
Overall LCOE with PV (USD/kWh)	*0.193*	*0.194*	*0.196*	*0.198*	**0.199**	**0.201**	*0.203*	*0.204*	*0.206*
Total costs in m/USD with PV Options (20 yrs.)	*95,776,233*	*96,621,309*	*97,466,385*	*98,311,462*	***99,156,538***	***100,001,614***	*100,846,691*	*101,691,767*	*102,536,843*
Difference overall LCOE no PV/with PV	0.0290	0.0300	0.0300	0.0300	**0.0310**	0.0320	0.0320	0.0330	0.0330
Relative difference of LCOE no PV/ with PV	13%	13%	13%	13%	**13%**	14%	14%	14%	14%
Total Savings in cost with PV Option (20 yrs.)	14,664,116	14,869,227	15,074,337	15,279,447	**15,484,557**	15,689,667	15,894,777	16,099,887	16,304,997

12.7 Funding Scenarios

12.7.1 Commercial funding scenario

Financing Commercial 20 yrs

Parameters*	Unit			
Grant	%	20%		
Loan	%	80%		
Debt repayment per year	%	5%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	20		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
			1	2	3	4	5	6	7	8	9	10	11
Investment costs	USD			(6,897,993)	(425,913)							(1,028,482)	(872,077)
Cumulative debt	USD			(6,897,993)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(8,352,388)	(9,224,465)
Grant	USD			(1,379,599)	(85,183)							(205,696)	(174,415)
Loan	USD			(5,518,394)	(340,730)							(822,786)	(697,662)
1 Interest rate	4%												
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)
Repayment of loan (excl. financing fees)	USD				413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414
Cost financing fees for repayment of loan	USD				241,245	222,931	204,616	186,302	167,988	149,674	131,359	149,495	162,087
Total debt (incl. financing fees)	USD												
Repayment of loan incl. financing fees	USD				654,659	636,345	618,031	599,717	581,402	563,088	544,774	562,909	575,501
Debt balance	USD			(10,143,792)	(9,489,133)	(8,852,788)	(8,234,757)	(7,635,040)	(7,053,638)	(6,490,550)	(5,945,776)	(5,382,867)	(4,807,366)
2 Interest rate	3%												
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)
Repayment of loan (excl. financing fees)	USD				413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414
Cost financing fees for repayment of loan	USD				186,788	172,608	158,428	144,248	130,067	115,887	101,707	115,749	125,498
Total debt (incl. financing fees)	USD												
Repayment of loan incl. financing fees	USD				600,202	586,022	571,842	557,662	543,482	529,302	515,122	529,163	538,913
Debt balance	USD			(9,614,781)	(9,014,579)	(8,428,556)	(7,856,714)	(7,299,052)	(6,755,571)	(6,226,269)	(5,711,147)	(5,181,984)	(4,643,072)
3 Interest rate	6%												
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)
Repayment of loan (excl. financing fees)	USD				413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414
Cost financing fees for repayment of loan	USD				350,159	323,577	296,994	270,412	243,829	217,246	190,664	216,986	235,264
Total debt (incl. financing fees)	USD												
Repayment of loan incl. financing fees	USD				763,574	736,991	710,408	683,826	657,243	630,661	604,078	630,401	648,678
Debt balance	USD			(11,201,815)	##########	(9,701,250)	(8,990,842)	(8,307,016)	(7,649,773)	(7,019,112)	(6,415,033)	(5,784,633)	(5,135,955)

	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand total
	12	13	14	15	16	17	18	19	20	21	
Investment costs					(525,875)						(9,750,340)
Cumulative debt	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	
Grant					(105,175)						(1,950,068)
Loan					(420,700)						(7,800,272)
1 Interest rate											
Cumulative loan share	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	358,813	0
Cost financing fees for repayment of loan	143,772	125,458	107,144	88,830	89,152	70,838	52,524	34,210	15,895	0	2,343,520
Total debt (incl. financing fees)											**(10,143,792)**
Repayment of loan incl. financing fees	557,187	538,873	520,558	502,244	502,567	484,253	465,938	447,624	429,310	358,813	10,143,792
Debt balance	(4,250,179)	(3,711,306)	(3,190,748)	(2,688,504)	(2,185,937)	(1,701,685)	(1,235,746)	(788,122)	(358,813)	(0)	
2 Interest rate											
Cumulative loan share	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	358,813	0
Cost financing fees for repayment of loan	111,318	97,138	82,958	68,778	69,028	54,848	40,667	26,487	12,307	0	1,814,509
Total debt (incl. financing fees)											**(9,614,781)**
Repayment of loan incl. financing fees	524,733	510,552	496,372	482,192	482,442	468,262	454,082	439,902	425,722	358,813	9,614,781
Debt balance	(4,118,339)	(3,607,787)	(3,111,414)	(2,629,222)	(2,146,780)	(1,678,518)	(1,224,436)	(784,534)	(358,813)	0	
3 Interest rate											
Cumulative loan share	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	413,414	358,813	0
Cost financing fees for repayment of loan	208,681	182,098	155,516	128,933	129,402	102,819	76,237	49,654	23,072	0	3,401,543
Total debt (incl. financing fees)											**11,201,815**
Repayment of loan incl. financing fees	622,095	595,513	568,930	542,348	542,816	516,234	489,651	463,069	436,486	358,813	11,201,815
Debt balance	(4,513,859)	(3,918,346)	(3,349,416)	(2,807,068)	(2,264,252)	(1,748,018)	(1,258,367)	(795,299)	(358,813)	0	

Financing Commercial 15 yrs

Parameters*	Unit			
Grant	%	20%		
Loan	%	80%		
Debt repayment per year	%	7%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	15		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Grand total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Investment costs	USD			(6,897,993)	(425,913)							(1,028,482)	(872,077)					(525,875)		(9,750,340)
Cumulative debt	USD			(6,897,993)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(8,352,388)	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,750,340)	(9,750,340)	
Grant	USD			(1,379,599)	(85,183)							(205,696)	(174,415)					(105,175)		(1,950,068)
Loan	USD			(5,518,394)	(340,730)							(822,786)	(697,662)					(420,700)		(7,800,272)
1 Interest rate	4%																			
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	USD				546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	702,024	0	7,800,272
Cost financing fees for repayment of loan	USD				235,371	211,182	186,993	162,805	138,616	114,427	90,239	102,499	109,217	85,029	60,840	36,651	12,463	0		1,546,332
Total debt (incl. financing fees)																				**(9,346,604)**
Repayment of loan incl. financing fees	USD				781,390	757,201	733,012	708,824	684,635	660,446	636,258	648,519	655,236	631,048	606,859	582,670	558,482	702,024		9,346,604
Debt balance	USD			(9,346,604)	(8,565,214)	(7,808,013)	(7,075,001)	(6,366,177)	(5,681,542)	(5,021,096)	(4,384,838)	(3,736,319)	(3,081,083)	(2,450,035)	(1,843,177)	(1,260,506)	(702,024)	0		
2 Interest rate	3%																			
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	USD				546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	702,024	0	7,800,272
Cost financing fees for repayment of loan	USD				182,240	163,511	144,783	126,054	107,326	88,597	69,869	79,362	84,563	65,835	47,106	28,378	9,649	0		1,197,273
Total debt (incl. financing fees)																				**(8,997,545)**
Repayment of loan incl. financing fees	USD				728,259	709,530	690,802	672,073	653,345	634,616	615,888	625,381	630,582	611,854	593,125	574,397	555,668	702,024		8,997,545
Debt balance	USD			(8,997,545)	(8,269,286)	(7,559,756)	(6,868,954)	(6,196,881)	(5,543,536)	(4,908,920)	(4,293,032)	(3,667,651)	(3,037,069)	(2,425,215)	(1,832,090)	(1,257,693)	(702,024)	0		
3 Interest rate	6%																			
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	USD				546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	546,019	702,024	0	7,800,272
Cost financing fees for repayment of loan	USD				341,633	306,524	271,415	236,306	201,197	166,088	130,979	148,775	158,525	123,416	88,307	53,198	18,089	0		2,244,450
Total debt (incl. financing fees)																				**(10,044,722)**
Repayment of loan incl. financing fees	USD				887,652	852,543	817,434	782,325	747,216	712,107	676,998	694,794	704,544	669,435	634,326	599,217	564,108	702,024		10,044,722
Debt balance	USD			(10,044,722)	(9,157,070)	(8,304,527)	(7,487,094)	(6,704,769)	(5,957,553)	(5,245,447)	(4,568,449)	(3,873,656)	(3,169,111)	(2,499,676)	(1,865,350)	(1,266,133)	(702,024)	0		

Financing Commercial 25 yrs

Parameters*	Unit			
Grant	%	20%		
Loan	%	80%		
Debt repayment per year	%	4.4%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	25		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Grand Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Investment costs	USD			(6,897,993)	(425,913)							(1,028,482)	(872,077)					(525,875)										(9,750,340)
Cumulative debt	USD			(6,897,993)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(8,352,388)	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	
Grant	USD			(1,379,599)	(85,183)							(205,696)	(174,415)					(105,175)										(1,950,068)
Loan	USD			(5,518,394)	(340,730)							(822,786)	(697,662)					(420,700)										(7,800,272)
1 Interest rate	**4%**																											
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	USD				343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	249,609	0
Cost financing fees for repayment of loan	USD				244,355	229,151	213,946	198,742	183,538	168,333	153,129	174,374	190,076	174,872	159,668	144,464	129,259	132,692	117,488	102,283	87,079	71,875	56,671	41,466	26,262	11,058	0	2,931,995
Total debt (incl. financing fees)	USD																											**(10,811,053)**
Repayment of loan incl. financing fees	USD				587,567	572,363	557,158	541,954	526,750	511,545	496,341	517,586	533,288	518,084	502,880	487,676	472,471	475,904	460,700	445,495	430,291	415,087	399,882	384,678	369,474	354,270	249,609	10,811,053
Debt balance	USD			(10,811,053)	(10,223,486)	(9,651,124)	(9,093,965)	(8,552,011)	(8,025,262)	(7,513,716)	(7,017,375)	(6,499,789)	(5,966,500)	(5,448,416)	(4,945,536)	(4,457,861)	(3,985,390)	(3,509,486)	(3,048,786)	(2,603,291)	(2,173,000)	(1,757,913)	(1,358,030)	(973,352)	(603,878)	(249,609)	0	
2 Interest rate	**3%**																											
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	USD				343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	249,609	0
Cost financing fees for repayment of loan	USD				189,196	177,424	165,651	153,879	142,107	130,335	118,563	135,012	147,170	135,398	123,625	111,853	100,081	102,739	90,967	79,195	67,422	55,650	43,878	32,106	20,334	8,562	0	2,270,145
Total debt (incl. financing fees)	USD																											**(10,131,419)**
Repayment of loan incl. financing fees	USD				532,408	520,636	508,863	497,091	485,319	473,547	461,775	478,224	490,382	478,610	466,837	455,065	443,293	445,951	434,179	422,407	410,634	398,862	387,090	375,318	363,546	351,774	249,609	10,131,419
Debt balance	USD			(10,131,419)	(9,599,011)	(9,078,375)	(8,569,512)	(8,072,421)	(7,587,101)	(7,113,555)	(6,651,780)	(6,173,556)	(5,683,174)	(5,204,564)	(4,737,727)	(4,282,662)	(3,839,369)	(3,393,418)	(2,959,239)	(2,536,832)	(2,126,198)	(1,727,336)	(1,340,246)	(964,928)	(601,382)	(249,609)	0	
3 Interest rate	**6%**																											
Cumulative loan share	USD			(5,518,394)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(5,859,125)	(6,681,910)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,379,572)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	(7,800,272)	
Repayment of loan (excl. financing fees)	USD				343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	343,212	249,609	0
Cost financing fees for repayment of loan	USD				354,673	332,605	310,536	288,468	266,399	244,331	222,262	253,099	275,890	253,821	231,753	209,684	187,616	192,598	170,530	148,461	126,392	104,324	82,255	60,187	38,118	16,050	0	4,255,695
Total debt (incl. financing fees)	USD																											**(12,170,322)**
Repayment of loan incl. financing fees	USD				697,885	675,817	653,748	631,680	609,611	587,542	565,474	596,311	619,102	597,033	574,965	552,896	530,828	535,810	513,742	491,673	469,604	447,536	425,467	403,399	381,330	359,262	249,609	12,170,322
Debt balance	USD			(12,170,322)	(11,472,437)	##########	##########	(9,511,193)	(8,901,582)	(8,314,039)	(7,748,566)	(7,152,255)	(6,533,153)	(5,936,120)	(5,361,156)	(4,808,259)	(4,277,432)	(3,741,622)	(3,227,880)	(2,736,207)	(2,266,603)	(1,819,067)	(1,393,600)	(990,201)	(608,870)	(249,609)	0	

12.7.2 50% grant scenario

Financing 50% Grant

Parameters*	Unit			
Grant	%	50%		
Loan	%	50%		
Debt repayment per year	%	5%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	20		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Investment costs	USD			(6,897,993)	(425,913)							(1,028,482)	(872,077)					(525,875)						(9,750,340)
Cumulative debt	USD			(6,897,993)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(7,323,906)	(8,352,388)	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,224,465)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	(9,750,340)	
Grant	USD			(3,448,996)	(212,957)							(514,241)	(436,039)					(262,938)						(4,875,170)
Loan	USD			(3,448,996)	(212,957)							(514,241)	(436,039)					(262,938)						(4,875,170)
1 Interest rate	4%																							
Cumulative loan share	USD			(3,448,996)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(4,176,194)	(4,612,232)	(4,612,232)	(4,612,232)	(4,612,232)	(4,612,232)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	
Repayment of loan (excl. financing fees)	USD				258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	224,258	0
Cost financing fees for repayment of loan	USD				150,778	139,332	127,885	116,439	104,992	93,546	82,100	93,434	101,304	89,858	78,411	66,965	55,519	55,720	44,274	32,827	21,381	9,935	0	1,464,700
Total debt (incl. financing fees)																								**(6,339,870)**
Repayment of loan incl. financing fees	USD				409,162	397,716	386,269	374,823	363,376	351,930	340,484	351,818	359,688	348,242	336,795	325,349	313,903	314,104	302,658	291,211	279,765	268,319	224,258	6,339,870
Debt balance				(6,339,870)	(5,930,708)	(5,532,992)	(5,146,723)	(4,771,900)	(4,408,524)	(4,056,594)	(3,716,110)	(3,364,292)	(3,004,604)	(2,656,362)	(2,319,567)	(1,994,218)	(1,680,315)	(1,366,211)	(1,063,553)	(772,341)	(492,576)	(224,258)	(0)	
2 Interest rate	3%																							
Cumulative loan share	USD			(3,448,996)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(4,176,194)	(4,612,232)	(4,612,232)	(4,612,232)	(4,612,232)	(4,612,232)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	
Repayment of loan (excl. financing fees)	USD				258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	224,258	0
Cost financing fees for repayment of loan	USD				116,742	107,880	99,017	90,155	81,292	72,430	63,567	72,343	78,436	69,574	60,711	51,849	42,986	43,142	34,280	25,417	16,555	7,692	0	1,134,068
Total debt (incl. financing fees)																								**(6,009,238)**
Repayment of loan incl. financing fees	USD				375,126	366,264	357,401	348,539	339,676	330,814	321,951	330,727	336,820	327,958	319,095	310,233	301,370	301,526	292,664	283,801	274,939	266,076	224,258	6,009,238
Debt balance				(6,009,238)	(5,634,112)	(5,267,848)	(4,910,446)	(4,561,908)	(4,222,232)	(3,891,418)	(3,569,467)	(3,238,740)	(2,901,920)	(2,573,962)	(2,254,867)	(1,944,634)	(1,643,264)	(1,341,737)	(1,049,074)	(765,272)	(490,334)	(224,258)	0	
2 Interest rate	6%																							
Cumulative loan share	USD			(3,448,996)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(3,661,953)	(4,176,194)	(4,612,232)	(4,612,232)	(4,612,232)	(4,612,232)	(4,612,232)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	(4,875,170)	
Repayment of loan (excl. financing fees)	USD				258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	258,384	224,258	0
Cost financing fees for repayment of loan	USD				218,849	202,235	185,621	169,007	152,393	135,779	119,165	135,617	147,040	130,426	113,812	97,197	80,583	80,876	64,262	47,648	31,034	14,420	0	2,125,964
Total debt (incl. financing fees)																								**7,001,134**
Repayment of loan incl. financing fees	USD				477,233	460,619	444,005	427,391	410,777	394,163	377,549	394,001	405,424	388,810	372,196	355,581	338,967	339,260	322,646	306,032	289,418	272,804	224,258	7,001,134
Debt balance				(7,001,134)	(6,523,901)	(6,063,281)	(5,619,276)	(5,191,885)	(4,781,108)	(4,386,945)	(4,009,396)	(3,615,395)	(3,209,972)	(2,821,162)	(2,448,966)	(2,093,385)	(1,754,418)	(1,415,157)	(1,092,511)	(786,479)	(497,062)	(224,258)	0	

12.7.3 Green funding scenario

[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	%	[illegible]
[illegible]	%	[illegible]
[illegible]	%	[illegible]
[illegible]	%	[illegible]
[illegible]	%	[illegible]
[illegible]	%	[illegible]
[illegible]	%	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

12.8 Funding scenarios incl. 10% contingency

12.8.1 Commercial funding scenario (10% contingency)

Financing Commercial 20 yrs

Parameters*	Unit			
Grant	%	20%		
Loan	%	80%		
Debt repayment per year	%	5%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	20		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Investment costs	USD			(7,587,792)	(425,913)							(1,028,482)	(872,077)					(578,463)						(10,492,727)
Cumulative debt	USD			(7,587,792)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(9,042,187)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	
Grant	USD			(1,517,558)	(85,183)							(205,696)	(174,415)					(115,693)						(2,098,545)
Loan	USD			(6,070,234)	(340,730)							(822,786)	(697,662)					(462,770)						(8,394,181)
1 Interest rate	4%																							
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	386,132	0
Cost financing fees for repayment of loan	USD				264,297	244,588	224,880	205,171	185,462	165,754	146,045	162,786	173,983	154,275	134,566	114,857	95,148	95,940	76,232	56,523	36,814	17,106	0	2,554,426
Total debt (incl. financing fees)	USD																							**(10,948,608)**
Repayment of loan incl. financing fees	USD				709,189	689,480	669,771	650,063	630,354	610,645	590,936	607,677	618,875	599,166	579,457	559,749	540,040	540,832	521,123	501,415	481,706	461,997	386,132	10,948,608
Debt balance	USD			(10,948,608)	(10,239,419)	(9,549,939)	(8,880,168)	(8,230,105)	(7,599,752)	(6,989,106)	(6,398,170)	(5,790,493)	(5,171,618)	(4,572,452)	(3,992,994)	(3,433,246)	(2,893,206)	(2,352,374)	(1,831,250)	(1,329,836)	(848,130)	(386,132)	(0)	
2 Interest rate	3%																							
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	386,132	0
Cost financing fees for repayment of loan	USD				204,636	189,377	174,117	158,857	143,597	128,337	113,078	126,039	134,709	119,450	104,190	88,930	73,670	74,283	59,024	43,764	28,504	13,244	0	1,977,806
Total debt (incl. financing fees)	USD																							**(10,371,988)**
Repayment of loan incl. financing fees	USD				649,528	634,268	619,008	603,749	588,489	573,229	557,969	570,931	579,601	564,341	549,081	533,822	518,562	519,175	503,915	488,656	473,396	458,136	386,132	10,371,988
Debt balance	USD			(10,371,988)	(9,722,460)	(9,088,192)	(8,469,183)	(7,865,435)	(7,276,946)	(6,703,717)	(6,145,748)	(5,574,817)	(4,995,216)	(4,430,875)	(3,881,793)	(3,347,972)	(2,829,410)	(2,310,235)	(1,806,320)	(1,317,664)	(844,268)	(386,132)	0	
3 Interest rate	6%																							
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	444,892	386,132	0
Cost financing fees for repayment of loan	USD				383,618	355,012	326,405	297,799	269,192	240,586	211,979	236,278	252,531	223,924	195,318	166,711	138,105	139,254	110,648	82,041	53,435	24,828	0	3,707,666
Total debt (incl. financing fees)	USD																							**12,101,848**
Repayment of loan incl. financing fees	USD				828,510	799,904	771,297	742,690	714,084	685,477	656,871	681,169	697,423	668,816	640,210	611,603	582,996	584,146	555,540	526,933	498,326	469,720	386,132	12,101,848
Debt balance	USD			(12,101,848)	(11,273,337)	(10,473,434)	(9,702,137)	(8,959,446)	(8,245,363)	(7,559,885)	(6,903,014)	(6,221,845)	(5,524,422)	(4,855,606)	(4,215,397)	(3,603,794)	(3,020,797)	(2,436,651)	(1,881,112)	(1,354,179)	(855,852)	(386,132)	0	

Financing Commercial 15 yrs

Parameters*	Unit			
Grant	%	20%		
Loan	%	80%		
Debt repayment per year	%	7%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	15		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	Grand total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	
Investment costs	USD			(7,587,792)	(425,913)							(1,028,482)	(872,077)					(578,463)		(10,492,727)
Cumulative debt	USD			(7,587,792)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(9,042,187)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(10,492,727)	(10,492,727)	
Grant	USD			(1,517,558)	(85,183)							(205,696)	(174,415)					(115,693)		(2,098,545)
Loan	USD			(6,070,234)	(340,730)							(822,786)	(697,662)					(462,770)		(8,394,181)
1 Interest rate	4%																			
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	755,476	0	8,394,181
Cost financing fees for repayment of loan	USD				257,975	231,945	205,915	179,884	153,854	127,824	101,793	112,212	117,088	91,058	65,028	38,997	12,967	0		1,696,540
Total debt (incl. financing fees)																				**(10,090,721)**
Repayment of loan incl. financing fees	USD				845,568	819,538	793,507	767,477	741,447	715,416	689,386	699,805	704,681	678,651	652,620	626,590	600,560	755,476		10,090,721
Debt balance	USD			(10,090,721)	(9,245,153)	(8,425,616)	(7,632,108)	(6,864,631)	(6,123,185)	(5,407,769)	(4,718,383)	(4,018,578)	(3,313,897)	(2,635,246)	(1,982,626)	(1,356,036)	(755,476)	0		
2 Interest rate	3%																			
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	755,476	0	8,394,181
Cost financing fees for repayment of loan	USD				199,742	179,587	159,433	139,278	119,124	98,969	78,815	86,882	90,658	70,503	50,349	30,194	10,040	0		1,313,574
Total debt (incl. financing fees)																				**(9,707,755)**
Repayment of loan incl. financing fees	USD				787,334	767,180	747,025	726,871	706,717	686,562	666,408	674,475	678,250	658,096	637,941	617,787	597,633	755,476		9,707,755
Debt balance	USD			(9,707,755)	(8,920,421)	(8,153,241)	(7,406,216)	(6,679,345)	(5,972,628)	(5,286,066)	(4,619,658)	(3,945,183)	(3,266,933)	(2,608,837)	(1,970,896)	(1,353,109)	(755,476)	0		
3 Interest rate	6%																			
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	587,593	755,476	0	8,394,181
Cost financing fees for repayment of loan	USD				374,443	336,661	298,878	261,096	223,314	185,532	147,750	162,872	169,950	132,168	94,385	56,603	18,821	0		2,462,473
Total debt (incl. financing fees)																				**(10,856,654)**
Repayment of loan incl. financing fees	USD				962,035	924,253	886,471	848,689	810,907	773,124	735,342	750,465	757,543	719,760	681,978	644,196	606,414	755,476		10,856,654
Debt balance	USD			(10,856,654)	(9,894,618)	(8,970,365)	(8,083,894)	(7,235,205)	(6,424,299)	(5,651,174)	(4,915,832)	(4,165,367)	(3,407,824)	(2,688,064)	(2,006,086)	(1,361,890)	(755,476)	(0)		

Financing Commercial 25 yrs

Parameters*	Unit			
Grant	%	20%		
Loan	%	80%		
Debt repayment per year	%	4.4%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	25		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	Grand Total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
Investment costs	USD			(7,587,792)	(425,913)							(1,028,482)	(872,077)					(578,463)										(10,492,727)
Cumulative debt	USD			(7,587,792)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(9,042,187)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	
Grant	USD			(1,517,558)	(85,183)							(205,696)	(174,415)					(115,693)										(2,098,545)
Loan	USD			(6,070,234)	(340,730)							(822,786)	(697,662)					(462,770)										(8,394,181)
1 Interest rate	4%																											
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	268,614	0
Cost financing fees for repayment of loan	USD				267,644	251,282	234,920	218,558	202,196	185,834	169,472	189,560	204,104	187,742	171,380	155,018	138,656	142,795	126,433	110,071	93,709	77,347	60,985	44,623	28,262	11,900	0	3,187,708
Total debt (incl. financing fees)	USD																											**(11,666,674)**
Repayment of loan incl. financing fees	USD				636,988	620,626	604,264	587,902	571,540	555,178	538,816	558,904	573,448	557,086	540,724	524,362	508,000	512,139	495,777	479,415	463,053	446,691	430,329	413,967	397,606	381,244	268,614	11,666,674
Debt balance	USD			(11,666,674)	(11,029,686)	(10,409,060)	(9,804,796)	(9,216,894)	(8,645,354)	(8,090,176)	(7,551,360)	(6,992,457)	(6,419,008)	(5,861,922)	(5,321,198)	(4,796,836)	(4,288,836)	(3,776,697)	(3,280,919)	(2,801,504)	(2,338,451)	(1,891,760)	(1,461,430)	(1,047,463)	(649,857)	(268,614)	0	
2 Interest rate	3%																											
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	268,614	0
Cost financing fees for repayment of loan	USD				207,228	194,559	181,891	169,222	156,554	143,885	131,217	146,770	158,031	145,362	132,694	120,025	107,357	110,561	97,893	85,224	72,556	59,887	47,219	34,550	21,882	9,213	0	2,468,135
Total debt (incl. financing fees)	USD																											**(10,927,962)**
Repayment of loan incl. financing fees	USD				576,572	563,903	551,235	538,566	525,898	513,229	500,561	516,114	527,375	514,706	502,038	489,369	476,701	479,905	467,237	454,568	441,900	429,231	416,563	403,894	391,226	378,557	268,614	10,927,962
Debt balance	USD			(10,927,962)	(10,351,390)	(9,787,487)	(9,236,253)	(8,697,687)	(8,171,789)	(7,658,560)	(7,158,000)	(6,641,886)	(6,114,511)	(5,599,805)	(5,097,767)	(4,608,397)	(4,131,697)	(3,651,791)	(3,184,554)	(2,729,986)	(2,288,086)	(1,858,854)	(1,442,292)	(1,038,397)	(647,171)	(268,614)	0	
3 Interest rate	6%																											
Cumulative loan share	USD			(6,070,234)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(6,410,964)	(7,233,750)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(7,931,411)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	(8,394,181)	
Repayment of loan (excl. financing fees)	USD				369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	369,344	268,614	0
Cost financing fees for repayment of loan	USD				388,476	364,727	340,979	317,230	293,481	269,732	245,983	275,140	296,250	272,502	248,753	225,004	201,255	207,262	183,514	159,765	136,016	112,267	88,518	64,770	41,021	17,272	0	4,626,853
Total debt (incl. financing fees)	USD																											**(13,144,097)**
Repayment of loan incl. financing fees	USD				757,820	734,071	710,323	686,574	662,825	639,076	615,327	644,484	665,594	641,846	618,097	594,348	570,599	576,606	552,858	529,109	505,360	481,611	457,862	434,113	410,365	386,616	268,614	13,144,097
Debt balance	USD			(13,144,097)	(12,386,277)	(11,652,205)	(10,941,883)	(10,255,309)	(9,592,484)	(8,953,408)	(8,338,081)	(7,693,597)	(7,028,003)	(6,386,158)	(5,768,061)	(5,173,713)	(4,603,114)	(4,026,507)	(3,473,650)	(2,944,541)	(2,439,181)	(1,957,570)	(1,499,708)	(1,065,594)	(655,230)	(268,614)	0	

12.8.2 50% grant scenario (10% contingency)

Financing 50% Grant

Parameters*	Unit			
Grant	%	50%		
Loan	%	50%		
Debt repayment per year	%	5%		
Interest rate	%	4%	3%	6%
Management fee	%	0.25%	0.25%	0.25%
Service fee	%	0.18%	0.18%	0.18%
Total financing fees	%	4.43%	3.43%	6.43%
Loan term	year(s)	20		
Grace period	year(s)	1		

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Investment costs	USD			(7,587,792)	(425,913)							(1,028,482)	(872,077)					(578,463)						(10,492,727)
Cumulative debt	USD			(7,587,792)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(9,042,187)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	
Grant	USD			(3,793,896)	(212,957)							(514,241)	(436,039)					(289,231)						(5,246,363)
Loan	USD			(3,793,896)	(212,957)							(514,241)	(436,039)					(289,231)						(5,246,363)
1 Interest rate	4%																							
Cumulative loan share	USD			(3,793,896)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,521,094)	(4,957,132)	(4,957,132)	(4,957,132)	(4,957,132)	(4,957,132)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	
Repayment of loan (excl. financing fees)	USD				278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	241,333	0
Cost financing fees for repayment of loan	USD				165,186	152,868	140,550	128,232	115,914	103,596	91,278	101,741	108,740	96,422	84,104	71,786	59,468	59,963	47,645	35,327	23,009	10,691	0	1,596,516
Total debt (incl. financing fees)																								**(6,842,880)**
Repayment of loan incl. financing fees	USD				443,243	430,925	418,607	406,289	393,971	381,653	369,335	379,798	386,797	374,479	362,161	349,843	337,525	338,020	325,702	313,384	301,066	288,748	241,333	6,842,880
Debt balance				(6,842,880)	(6,399,637)	(5,968,712)	(5,550,105)	(5,143,816)	(4,749,845)	(4,368,192)	(3,998,856)	(3,619,058)	(3,232,261)	(2,857,782)	(2,495,622)	(2,145,779)	(1,808,254)	(1,470,233)	(1,144,531)	(831,147)	(530,081)	(241,333)	0	
2 Interest rate	3%																							
Cumulative loan share	USD			(3,793,896)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,521,094)	(4,957,132)	(4,957,132)	(4,957,132)	(4,957,132)	(4,957,132)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	
Repayment of loan (excl. financing fees)	USD				278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	241,333	0
Cost financing fees for repayment of loan	USD				127,898	118,360	108,823	99,286	89,748	80,211	70,673	78,775	84,193	74,656	65,119	55,581	46,044	46,427	36,890	27,352	17,815	8,278	0	1,236,129
Total debt (incl. financing fees)																								**(6,482,492)**
Repayment of loan incl. financing fees	USD				405,955	396,418	386,880	377,343	367,805	358,268	348,731	356,832	362,251	352,713	343,176	333,639	324,101	324,484	314,947	305,410	295,872	286,335	241,333	6,482,492
Debt balance				(6,482,492)	(6,076,537)	(5,680,120)	(5,293,240)	(4,915,897)	(4,548,091)	(4,189,823)	(3,841,092)	(3,484,261)	(3,122,010)	(2,769,297)	(2,426,121)	(2,092,482)	(1,768,381)	(1,443,897)	(1,128,950)	(823,540)	(527,668)	(241,333)	0	
2 Interest rate	6%																							
Cumulative loan share	USD			(3,793,896)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,006,853)	(4,521,094)	(4,957,132)	(4,957,132)	(4,957,132)	(4,957,132)	(4,957,132)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	(5,246,363)	
Repayment of loan (excl. financing fees)	USD				278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	278,057	241,333	0
Cost financing fees for repayment of loan	USD				239,762	221,882	204,003	186,124	168,245	150,366	132,487	147,674	157,832	139,953	122,074	104,195	86,316	87,034	69,155	51,276	33,397	15,518	0	2,317,291
Total debt (incl. financing fees)																								**7,563,655**
Repayment of loan incl. financing fees	USD				517,819	499,940	482,061	464,182	446,302	428,423	410,544	425,731	435,889	418,010	400,131	382,252	364,373	365,091	347,212	329,333	311,454	293,575	241,333	7,563,655
Debt balance				(7,563,655)	(7,045,836)	(6,545,896)	(6,063,836)	(5,599,654)	(5,153,352)	(4,724,928)	(4,314,384)	(3,888,653)	(3,452,764)	(3,034,754)	(2,634,623)	(2,252,371)	(1,887,998)	(1,522,907)	(1,175,695)	(846,362)	(534,908)	(241,333)	(0)	

12.8.3 Green funding scenario (10% contingency)

Financing Green Funding

Parameters*	Unit	
Grant	%	15%
Loan	%	85%
Debt repayment per year	%	6%
Interest rate	%	0%
Management fee	%	0.25%
Service fee	%	0.18%
Total financing fees	%	0.43%
Loan term	year(s)	20
Grace period	year(s)	3

	Unit		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Grand total
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Investment costs	USD			(7,587,792)	(425,913)							(1,028,482)	(872,077)					(578,463)						(10,492,727)
Cumulative debt	USD			(7,587,792)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(8,013,705)	(9,042,187)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(9,914,264)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	(10,492,727)	
Grant	USD			(1,138,169)	(63,887)							(154,272)	(130,812)					(86,769)						(1,573,909)
Loan	USD			(6,449,623)	(362,026)							(874,210)	(741,265)					(491,693)						(8,918,818)
Cumulative loan share	USD			(6,449,623)	(6,811,649)	(6,811,649)	(6,811,649)	(6,811,649)	(6,811,649)	(6,811,649)	(6,811,649)	(7,685,859)	(8,427,124)	(8,427,124)	(8,427,124)	(8,427,124)	(8,427,124)	(8,918,818)	(8,918,818)	(8,918,818)	(8,918,818)	(8,918,818)	(8,918,818)	
Repayment of loan (excl. financing fees)	USD						535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	535,129	356,753	0
Cost financing fees for repayment of loan	USD						26,989	24,688	22,387	20,086	17,785	19,243	20,129	17,828	15,527	13,226	10,925	10,738	8,437	6,136	3,835	1,534	0	239,494
Total debt (incl. financing fees)																								**(9,158,311)**
Repayment of loan incl. financing fees	USD						562,118	559,817	557,516	555,215	552,914	554,372	555,258	552,957	550,656	548,355	546,054	545,867	543,566	541,265	538,964	536,663	356,753	9,158,311
Debt balance				(9,158,311)	(9,158,311)	(9,158,311)	(8,596,193)	(8,036,376)	(7,478,860)	(6,923,645)	(6,370,732)	(5,816,360)	(5,261,101)	(4,708,144)	(4,157,488)	(3,609,133)	(3,063,079)	(2,517,211)	(1,973,645)	(1,432,380)	(893,416)	(356,753)	(0)	

12.9 NGEST Power Requirements

Table 12-16: Projected design load as of current planning supplied by PWA on 10.04.2015

No.	Components Description	Required Power (MVA) Phase 1 (treatment capacity up to 35,600 m^3/d) Horizon 2018				Phase 2 (treatment capacity 65,700 m^3/d) Horizon 2025
		2015	2016	2017	2018	2025
1	**TPS** (5 pumps, conveyors and 2 racked screens) Pressure line (7 km) 9 Infiltration Basins	1.75	2	2	2	3
2	Waste Water Treatment Plant (includes pretreatment, activated sludge, final clarifiers, digesters, sludge silos, power building, dewatering and sludge storage area)	2.5	2.75	3	3	5
3	Recovery and Reuse Scheme: Stage 1* (under Phase 1) (includes: 15 Recovery Wells,5 monitoring wells, 5 booster pumps, 1 tank and irrigation network for 500 hectares with connections and valves) (this stage will recover 16,500 m^3/day)	0	2	2	2	2
	Stage 2* (under Phase 1) (includes: 14 Recovery Wells, 5 monitoring wells, 5 booster pumps, 1 tank and irrigation network for 1000 hectares with connections and valves) (this stage will recover 39,160 m^3/day)	0	0	0	4	4
4	Recovery Scheme (extension) (under Phase 2)** (includes: additional 24 Recovery Wells, monitoring wells, booster pumps, collection tanks and irrigation network for additional agricultural land) (this stage planned to recover 72,270 m^3/day)	0	0	0	0	4
	Total	4.25	6.75	7	11	18

State of Palestine

Palestinian Water Authority

دولـــــة فلسطيـن
سلطة المياه الفلسطينية

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Palestinian Water Authority

Effluent Recovery and Irrigation Scheme of North Gaza Emergency Sewage Treatment –NGEST

Design Criteria and Technical Report for Additional Work Related to the

REDESIGN OF THE RECOVERY SCHEME

Consultant

Joint Venture Association of the ALMADINA –TIMESIS S.r.l.

MAY 2018

ALMADINA - CONSULTANTS
Environmental Management and Urban Planning
TIMESIS
TIMESIS srl

Table of Content

1 INTRODUCTION

The design criteria and technical report is considered a technical tender document for the implementation of a two-phased Irrigation Project in Northern Gaza.

This report includes the technical hypothesis, considerations and assumptions related to the design of the irrigation network. It presents also the results of engineering calculations which are at the base of the final configuration of the proposed works.

2 PROJECT BACKGROUND

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. The first phase (**Phase A)** was comprised of four construction stages: (1) a terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), (2) a pressure pipeline linked to a new site about seven kilometres East of Jabalia, (3) nine infiltration ponds at the new site, and (4) the commissioning of the pipeline to allow a large emergency partial-effluent pond at Beit Lahia to be drained. Phase A was completed in 2010.

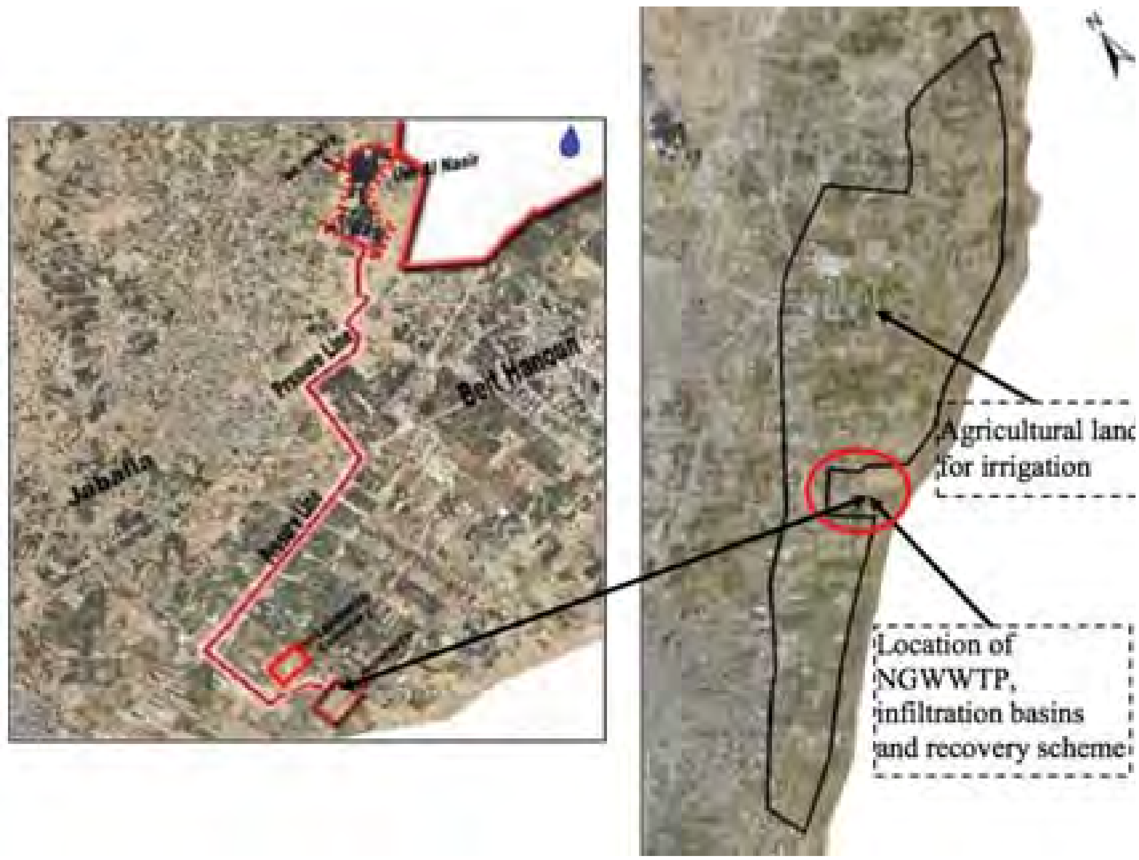


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is now completed, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

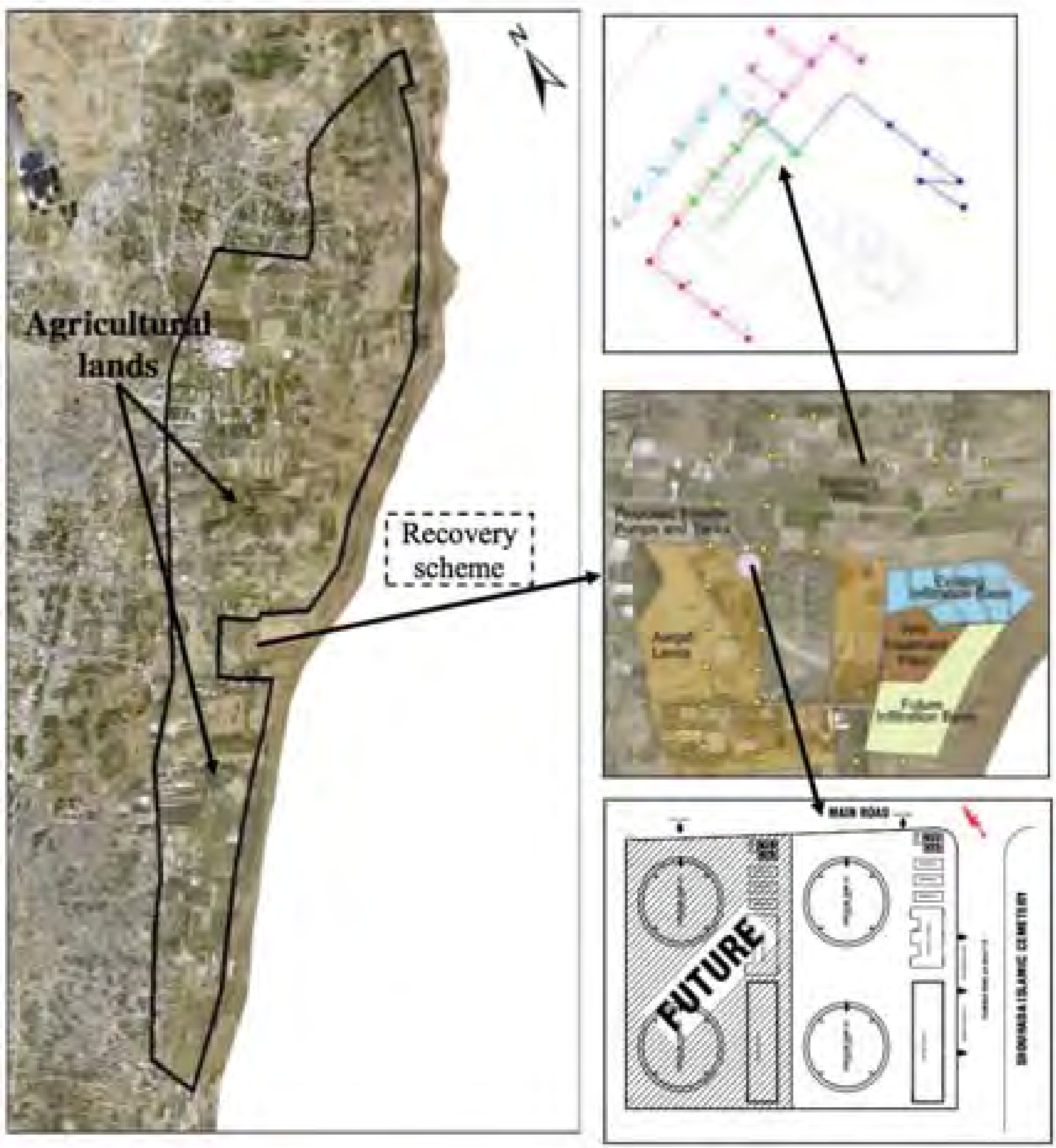


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, **supplementary phase** was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The overall concept is for the treated sewage effluent to be disposed of from the WWTP into infiltration ponds. From there, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 27 recovery wells, put into a storage reservoir, and distributed throughout the network for irrigated agriculture.

3 THE PRESENT STUDY

The present study has been conducted preparing a final design of the irrigation scheme in Northern Gaza.

The agricultural area that is intended to receive the recycled water from this system has been divided into two main sectors: “Zone A”, which is an area of about 1,070 ha (10,700 du) and located in northeastern Gaza at the north of the infiltration basin; and “Zone B”, an area of 417 ha (4,700 du), located in southeastern Gaza at south of infiltration basin.

The present study has taken into account the cropping pattern required by the Client and has taken into consideration all technical aspects required to implement this project.

Based on existing cadastral survey and topographic information, a new network pipeline is required (preferably located along the current street) which will pump water from the existing booster pumping station to the cadastral parcels, as indicated from PWA. An Epanet hydraulic model has been implemented to correctly size all pipes to guarantee a minimum pressure of 2.5 bars at the farm gate.

To control the outlet flow, control flow valves must be installed near each farm gate. Each control flow valve must be calibrated to irrigate sufficient volume to the cropland, i.e. the designed demand. In addition, a flow meter has been foreseen to take into account the amount of water used by each farmer.

In the future, additional areas will likely require irrigation such as the areas to the north and south of the present agricultural areas (respectively of about 4,367 donum and 7,362 donum). Therefore, the design of the system has taken into account future water requirements with the same main primary pipeline leaving the booster pumping station. The main primary pipeline along Al Karama road will be over-sized.

4 BASELINE CONDITIONS

4.1 PROPOSED CROPPING PATTERN

The cropping pattern shown below is proposed to be implemented through the new irrigation scheme, in the entire target area. It is important to note that 65% of the cropping pattern is represented by tree crops.

Table 1: Proposed Crops and Crop Groups

Crops and crop groups	%
Citrus	22
Olive	23
Almond	10
Peach	7
Other fruit tree crops	3
Grains	12
Winter vegetables	4
Winter vegetables (GH)	3
Summer vegetables	6
Alfalfa (green fodder)	10
Total	**100**

4.2 WATER CONSUMPTION IN THE INDUSTRIES

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du. Generally, most of these facilities are small factories (less than 10 employees) operating only a few days a week. The industrial facilities use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%)

uses private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

4.2.1 Water Demand

Based on the proposed cropping pattern, a net daily water requirement for irrigation has been calculated as shown in the following table. Minimum demands occur during winter season, maximum demands occur in the summer season in the month of May.

Table 2: Net daily water requirement for proposed Cropping Pattern

Net daily water requirement for irrigation (m^3/day)	
month	m^3/day
Jan	48
Feb	53
Mar	24,297
Apr	45,401
May	56,469
Jun	53,538
Jul	52,099
Aug	44,272
Sep	23,817
Oct	12,869

Net daily water requirement for irrigation (m^3/day)	
Nov	2,878
Dec	0
Average	26,312

The water requirements presented in the previous table defines the net irrigation water requirements but do not consider the additional water that might be required by the local industries as well as the one needed for uses not directly connected to irrigation practices (such as the one required for washing, the one required for sanitary uses, etc.). Finally, it does not consider the impact of climate change to the irrigation water requirements.

For industrial activities, an overall demand volume of 70,000 m^3/year has been proposed, including a progressive increase from the current water use of 30,000 m^3/year over a period of 25 years). For other uses, an overall demand volume of 830,375 m^3/year has been considered, based on as 500 liters per habitants/day including about 650 families with 7 people per family. These overall volumes are considered to be sustainable throughout the year. It is important to note that this volume corresponds to approximately 10% of the total irrigation demand per year.

5 PROJECT REUSE SCHEME

The total irrigated area is 1,488 ha. The net irrigated area is approximately 1,280 ha (12,800 donum) whereas the remaining hectares of land is mainly for other uses such as industrial or residential areas. To optimize construction and operation scheduling, the entire project is subdivided into two Parts (A and B) relative to their locations with the infiltration basins. Part A has an area of about 1,070 ha (10,700 du), while Part B is an additional 417 ha (4,700 du), and are respectively located to the north and to the south of the infiltration basins.

5.1.1 Irrigation Scheduling

Based on effective water requirement and the necessity of daily irrigation for the crops, the consultant wants to propose an irrigation pattern in which all sectors are evenly irrigated at the same time for 10 hours during low demand months (from October to February) and 12 hours during high-demand months (from March to September).

Table 3: Irrigation scheduling

Daily irrigation schedule for all irrigation area	
month	Pumping hours
Jan	10
Feb	10
Mar	12
Apr	12
May	12
Jun	12
Jul	12
Aug	12
Sep	12

Daily irrigation schedule for all irrigation area	
Oct	10
Nov	10
Dec	10

5.1.2 irrigation efficiency

The efficiency of the network has been divided into two terms: the efficiency of the pipelines equal to 5% (i.e. to consider lacks water during the transmission pipelines, for example in the joints, valves, etc.) and the efficiency of irrigation method equal to 80% (i.e. the lack of water from the gate farm to the roots of crops.

The gross water requirement i.e. the recovered water has been calculated and shown in the following tables.

Table 4: Water recovered for proposed Cropping Pattern

Water recovered (m^3/day)			**Water recovered (Mm^3/month)**	
month	m^3/day		month	Mm^3/month
Jan	4,401		Jan	0.14
Feb	4,408		Feb	0.12
Mar	36,308		Mar	1.13
Apr	64,076		Apr	1.92
May	78,639		May	2.44
Jun	74,783		Jun	2.24
Jul	72,890		Jul	2.26
Aug	62,591		Aug	1.94
Sep	35,676		Sep	1.07
Oct	21,271		Oct	0.66
Nov	8,125		Nov	0.24
Dec	4,338		Dec	0.13
Average	34,621		Total (Mm^3/year)	14.30

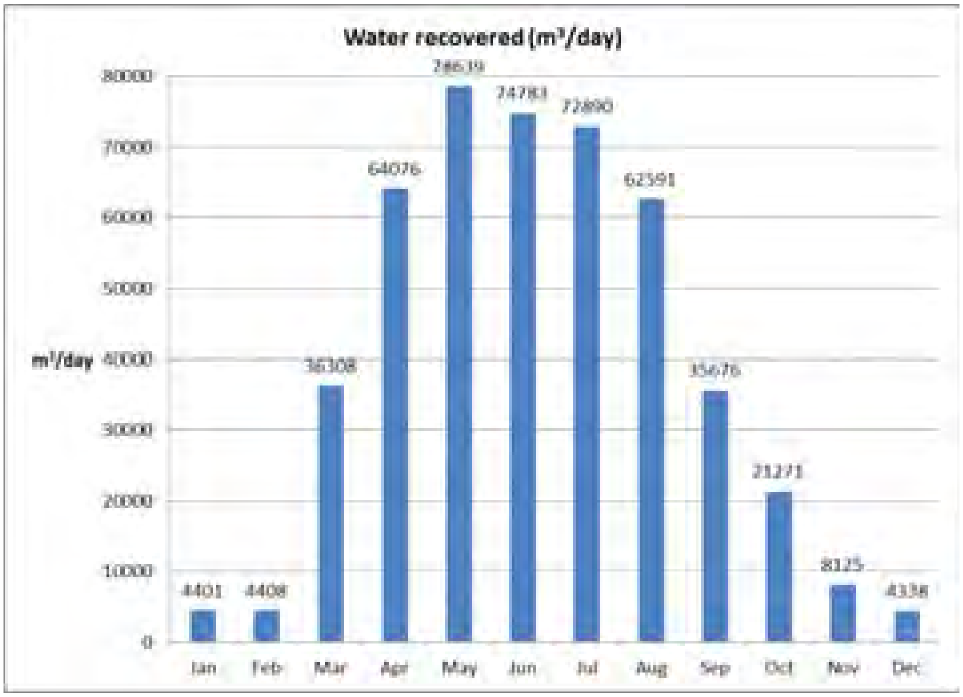


Figure 3: Histogram of water recovered (m^3/day)

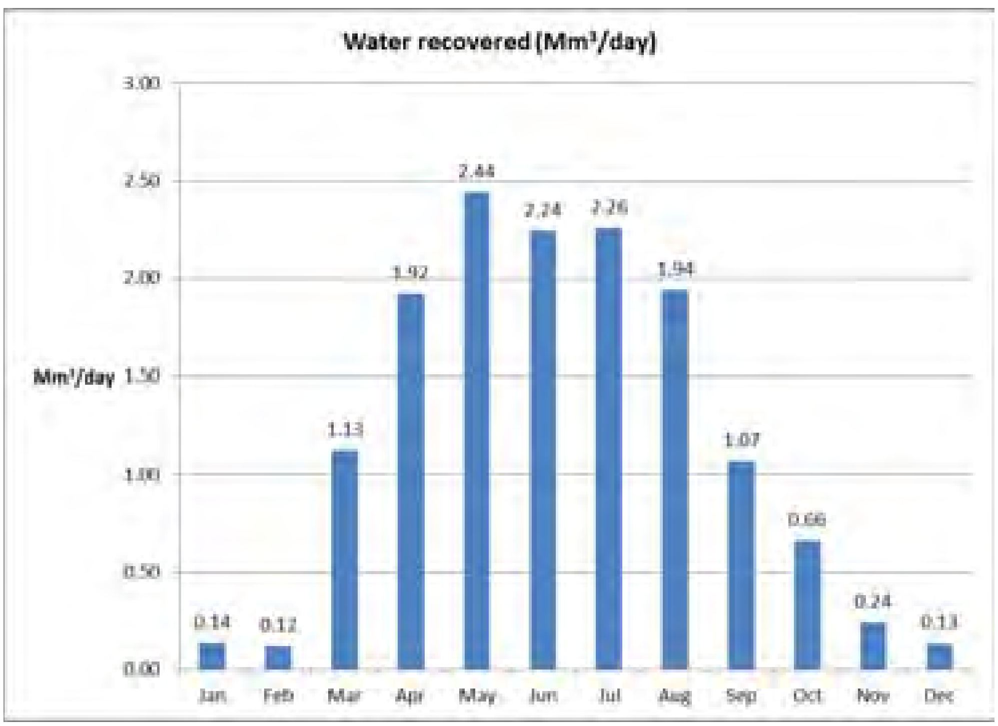


Figure 4 – Histogram of water recovered (Mm^3/Month)

As is demonstrated, the total water recovered per year is lower than total infiltrated waste water so the yearly water balance is positive.

Table 5: Hourly Water recovered for proposed Cropping Pattern according the proposed irrigation scheduling[1]

Water Recovered (m^3/h)	
month	m^3/h
Jan	440
Feb	441
Mar	3026
Apr	5340
May	6553
Jun	6232
Jul	6074
Aug	5316
Sep	2973
Oct	2127
Nov	812
Dec	434
Average	3306

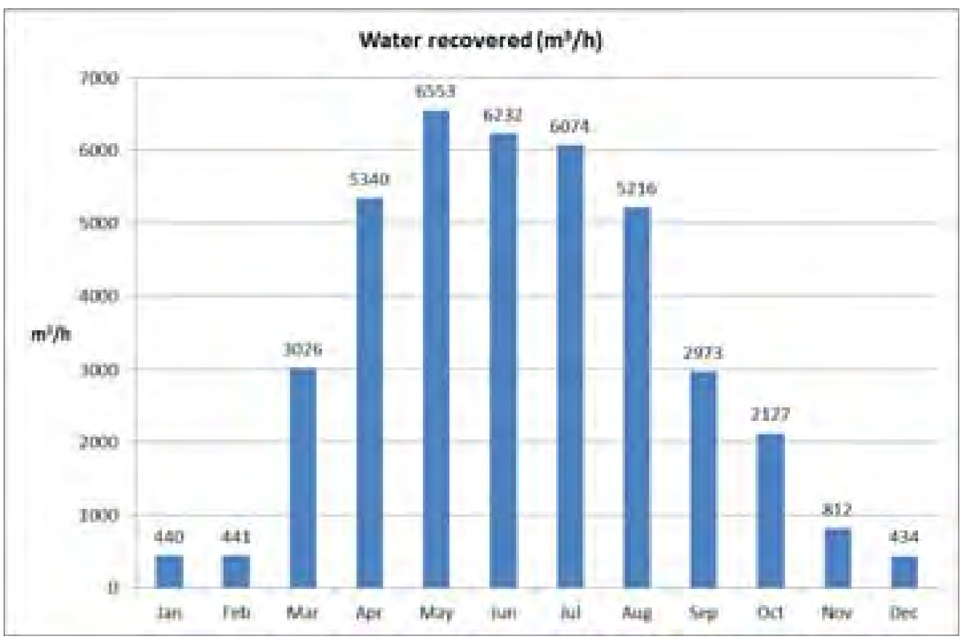


Figure 5 – Histogram of water recovered (m^3/hour) according the selected cropping pattern and irrigation scheduling.

[1] white cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

Figure 6: Histogram of the water (overaged over the day) recovered (m^3/hrs)

5.1.3 Irrigation Methods

The selection of the most appropriate irrigation method inside the farms depends on:

- Crop type,
- Soil characteristics,
- Investment costs of system.
- Ability of farmers to manage the system.

The common method of irrigation used by farmers in the Gaza Strip is surface irrigation, which entails the complete coverage of soil surface around the tree (small basin) with water. As the price of certain vegetables have risen, some farmers have adopted more efficient (and costly) irrigation methods, such as drip irrigation. This project recommends the use of sprinkler and localized irrigation systems (bubbler and drippers) as the method most suited to local conditions.

- *Sprinkler systems:* These systems disburse irrigation water to the soil in the form of a spray, mimicking the behavior of natural rain. There are a variety of sprinkler systems including mini-sprinkler (30-80 l per hr.) which is used for irrigation of most citrus, olive and fruit trees. Macro-sprinklers can be used to irrigate cereals, fodder crops and industrial crops. Much can be lost to evaporation with these systems; the overall efficiency ranges from 70-80%.
- *Localized systems:* These systems apply water more efficiently near the plant root zone so that only the root zone gets wet and avoiding overlapping or redundancy. These systems have low energy requirements (1-3 bar) but require high-quality irrigation water to prevent clogging problems. Thus, good filtration (90- 120 mesh screen or disc filter) unit is required.
- *Drip (Trickle) irrigation:* These systems apply water (4-8 l per hr.) continuously through drippers to each individual plant at limited rates. Their efficiency is very high (up to 90%) and can be used for high value crops (vegetables and citrus). Drip irrigation requires clean water without any particles or algae on it. Hazard categories include sand grains, precipitation of carbonates and algae.
- *Bubbler irrigation:* This system is more recommended as an irrigation method for reclaimed water because exit openings are wider than of a dripper and thus experiences less clogging. These systems can be used to irrigate citrus trees under local conditions. The irrigation efficiency is slightly lower than drip irrigation.
- *Sub-surface drip irrigation (SDI): This system type has not been tested in the local conditions.*

Appropriate irrigation systems for proposed crops:

- *Citrus and fruit trees:* bubblers, drippers and mini-sprinklers.
- *Fodder and grains:* macro-sprinklers

- *Vegetables and row crops:* In-line drippers

The rate of irrigation can be controlled accurately and nutrients can be also added with irrigation water (fertigation).

5.1.4 Farm gate outlet

The farm gate outlet consists of the following:

- Gate valve for closing and/or downstream appurtenant maintenance
- Regulating flow valve for limiting the flow at the farm gate at the design value (1.23 l/(s ha) and reported in Annex 1 of this report.
- Flow Meter that takes into account the amount of water used by the farmers.

Each farmer is responsible for purchasing of any equipment and whatever necessary for farm irrigation at his field.

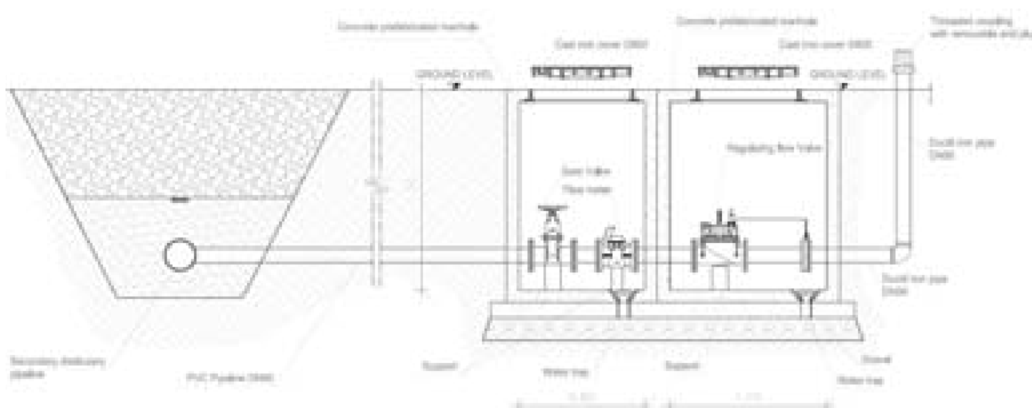


Figure 7: Typical Farm Connection

5.1.5 Pipe material

Different pipe material can be used for water pipelines network and can be divided mainly into three categories:

- Metallic pipes: includes steel pipes, galvanized iron pies and cast iron pipes)
- Cement: pipes include concrete cement pipes and asbestos
- Plastic pipes: include HDPE

Recently, the choice for irrigation network is usually made considering three materials: HDPE or UPVC (for smaller diameter), Steel and Ductile Iron (for grater diameter).

The comparison between different pipe materials in terms of advantage or disadvantage in their use is summarized in the table below, extracted from the original project:

Table 6: Comparison between HDPE, Steel and Ductile Iron

Criteria	HDPE	Steel	Ductile Iron
Capital Cost	Low	High	Moderate
Operation and Maintenance Cost	Low	High	Moderate
Corrosion control	NA	Difficult	Easier
Chemical characteristics of the conveyed fluid	Not influenced	Not influenced	Not influenced
The source of pipes	Not local	Not local	Not local
Environment of the project area where the transmitted water is partially treated waste water	Can be used	Can be used	Can be used
Available experience	High	High	High
Pressure of pipeline	Moderate resistant	High resistant	High resistant
Field condition	Low adapted	Moderate adapted	High resistant

The use of HDPE pipes is selected with a diameter less that 600mm and Ductile Iron pipes with external coating of Zinc-aluminum (85Zn-15Al) with a finishing Bituminous layers, and Internal lining with Sulfate resistant cement mortar pipe lining for diameter greater than 600mm.

The table below summarizes the advantages of using HDPE and Ductile Iron pipe, based on existing project literature.

Table 7: Advantages in using HDPE and Ductile Iron pipes.

HDPE	Ductile Iron
1. Favorable initial and maintenance cost compared with other pipes of traditional materials for smaller sizes. **2. Longer length, depending on type and ease of joining reduce jointing costs. It is easy to bend.** **3. Light weights resulting in lower handling and transporting costs and make it easier and faster to install.** **4. Lower coefficient of friction permitting greater flows through a particular size.** **5. Resistance to corrosion and built-up of deposits.** **6. Good chemical resistance with non-absorbent walls.** **7. Lower modulus of elasticity giving an advantage where there is soil movement or vibration.** **8. Good tensile strength.** **9. Thermal and electrical insulator.** **10. No danger to health (non-toxic) and internationally approved for potable water use and for stormwater and wastewater**	1. It is easier and less expensive to control corrosion on ductile iron pipe than it is on steel pipe, where Ductile Iron Pipe Corrosion Control is accomplished with Polyethylene Encasement 2. The largest practical advantage of Ductile Iron pipe compared with steel pipe is that Ductile Iron pipe is much easier to install properly. Handling, assembling, backfilling, and adapting to field conditions all are areas in which Ductile Iron pipe offers distinct benefits 3. Ductile Iron Pipelines Adapt to Field Conditions in Installation more than steel pipes. 4. Since Ductile Iron pipe design results in a thicker wall for a given set of parameters, Ductile 5. In all normally specified pipe sizes, cement-mortar lined Ductile Iron pipe has an inside diameter that is larger than the nominal pipe size. 6. Pumping costs are lower for Ductile Iron pipelines, this reduction in pumping costs will save the system owner significantly over the life of the pipeline 7. Protection systems, often a requirement for steel pipelines, involve higher design and installation costs. They require monitoring and maintenance over the lifetime of the pipeline. There are also costs associated with pumping water through a pipeline and these costs are directly related to pipe inside diameters.

5.1.6 Hydraulic verifications

One of the key design requirements for the irrigation system is the ability to deliver water at a pressure of at least 2.5 bar at each farm's gate. The verification of such hydraulic parameter has been performed with an Epanet model of the proposed irrigation network (the model encompasses the network from the downstream connection with the water tanks to the farm gates).

In particular, the model has been built according to the following considerations:

- Topography has been taken from updated topographic and cadastral maps;
- Hydraulic parameters and geometric characterization of the network have been taken according to the type of material chosen (as explained in the present report) and to the geometric configurations or irrigation network.
- Water demand at the various networks' nodes was assigned to be congruent with the areas of the parcels and the proposed Cropping Pattern.
- The proposed irrigation system pattern is based on a uniform irrigation across the entire agricultural area at a rate of 10-12 hours per day.

The functioning of irrigation network has been verified to function in the case of maximum demands from the system, which generally occurs during the month of May.

5.1.6.1 Friction losses

Friction losses through pressure piping are based on Hazen-Williams formula:

$$V = 0.849\, C\, R^{0.63} S^{0.54}$$

Where:

V=velocity (m/s)

C=roughness coefficient

R=hydraulic radius (m)

S=friction head loss per unit length

Pipe roughness coefficient has been chosen according the following table:

Table 8: Roughness Coefficient

Pipe Material	New Pipe	Old Pipe
HDPE	150	130
PE	150	130
Steel (cement lined)	150	120
Asbestos, Cement	140	130

5.1.7 Note about pumps and future configurations

The booster pumps are located in a pumping hall together with the suction and pressure manifolds and with all necessary pipe works. The pumping station will serve both irrigation network, the south area with three pumps and north area with five pumps. The pumps are installed parallel and pumping from a common suction manifold into a common pressure manifold.

Table 9: Number of operating pumps and irrigation zones

Irrigation zone	Number of pumps	
North	5	Simultaneous pumping
South	3	

Finally, the client asks to consider for the design of irrigation network two additional area located at north and south of Gaza city respectively of 4,367 donum and 7,362 donum. This fact in order to consider future agricultural areas expansion, as highlighted in different development planning studies.

Doing so, the following points have to be considered:

- Nowadays the amount of water extracted from wells are not sufficient to feed all proposed area. A total number of 52 well with operating point 200 m3/h and 4 tanks of 4,000 m3 are necessary to irrigate these areas simultaneously with the same cropping pattern.
- The size of pipe, in particular the primary pipeline along AL KARAMA road, have to be for the present project over sized, resulting idoneous in the future.
- The total number of pumps in booster pumping station will be 9 for North sector and 7 for South sector with operating point during peak flow respectively at 10bar for north and 9 bar for south sector.

The project tender documents represent the Actual Proposed Irrigation Network size considering future additional areas. The results of hydraulic model applying the proposed Cropping Pattern is also shown in tender drawings. Pressure values at gate farm are related to peak flow in the month of May considering the additional areas simultaneously fed.

5.1.8 Water Hammer

The pipelines operating pressure sums up the guaranteed irrigation pressure at the farm level, the head losses along the pipelines themselves and the surge pressure. Water hammer is the name given to the pressure surges caused by sudden changes in flow velocity, caused by valve opening or closing. The phenomenon can be described in term of the Joukowsky or Allievi-Michaud laws. These laws state that the piezometric head rise ΔH resulting from a fast closure of a valve ($T_c = 2L/a$), is given by:

$$\Delta H = \frac{aV_0}{g}$$

Where:

T_c = closing time;

a = pressure wave speed, depending on the physical characteristics of the pipe and of water;

V_0 = flow velocity;

g = gravitational acceleration;

L = pipe length.

For pipelines made of different reaches of length L_n:

$$L = \sum_n L_n$$

An equivalent pipe can be substituted with the real pipe, having constant pressure wave velocity *a* and constant area *A*. These two values can be derived by the equations:

$$\frac{L}{a} = \sum_n \frac{L_n}{a_n}$$

$$\frac{L}{A} = \sum_n \frac{L_n}{A_n}$$

Considering as time of closure in the critical points of the network (in the primary pipelines with biggest diameters) to be about 30s, the maximum surge pressure will be about 3 bar. PN16 is so recommended for the entire network.

5.1.9 Thrust block

Unbalanced thrust forces occur in pressure pipelines at any changes in direction (i.e., elbows, wyes, tees, etc.), at changes in cross-sectional area (i.e., reducers), or at pipeline terminations (i.e. dead head). These forces, if not adequately restrained, may cause pipeline movements resulting in separated joints and/or pipes damages. Primarily, thrust forces are considered as hydrostatic thrust due to internal pressure of the pipeline and hydrodynamic thrust due to changing momentum of flowing fluid. Since most pressure lines operate at relatively low velocities, the hydrodynamic force is very small and is usually ignored.

The calculation of the hydrostatic thrust for a bend is shown below. The resultant thrust at a bend is a function of the deflection angle Δ and is given by:

$$T = 2.P.A.sin\left(\frac{\Delta}{2}\right)$$

Where:

T = hydrostatic thrust, kN

P = internal pressure, kPa

A =cross-sectional area of pipe joint, m^2

Δ= bend angle, degrees

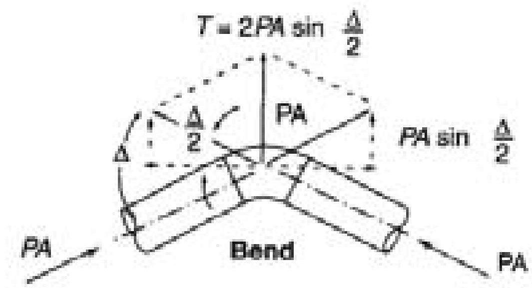


Figure 8: Hydrostatic Thrusts force on a block

Concrete thrust blocks increase the ability of fittings to resist movement by increasing the bearing area and the dead weight of the fitting. Ignoring the dead weight of the thrust block, the block size can be calculated based on the bearing capacity of the soil:

Area of block = $H.B = \left(\frac{T.FS}{\sigma}\right)$

Where:

H . B = area of bearing surface of thrust block, m^2

T =thrust force, kN

FS = design factor, 1.5

σ= bearing strength of soil, kPa.

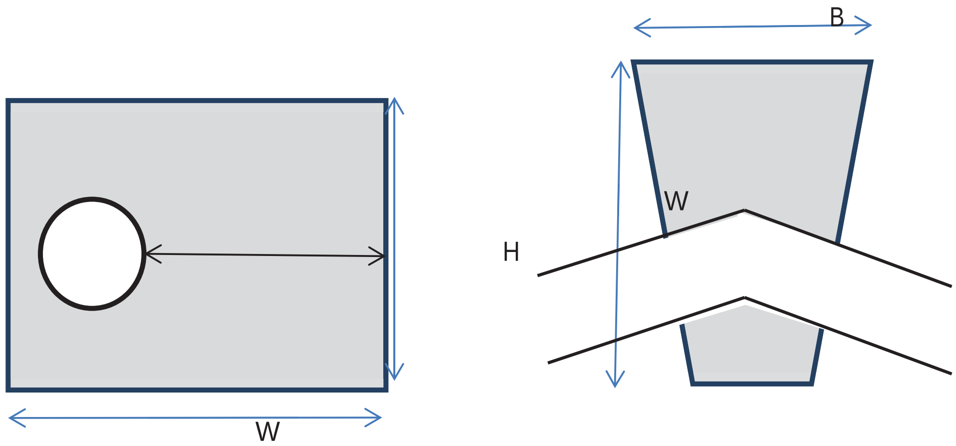


Figure 9: Dimensions of Thrusts Blocks

Similarly, is possible to calculate:

- Thrust forces for Tees: $T = P.A$ where P = internal pressure and A = branch pipe cross sectional area

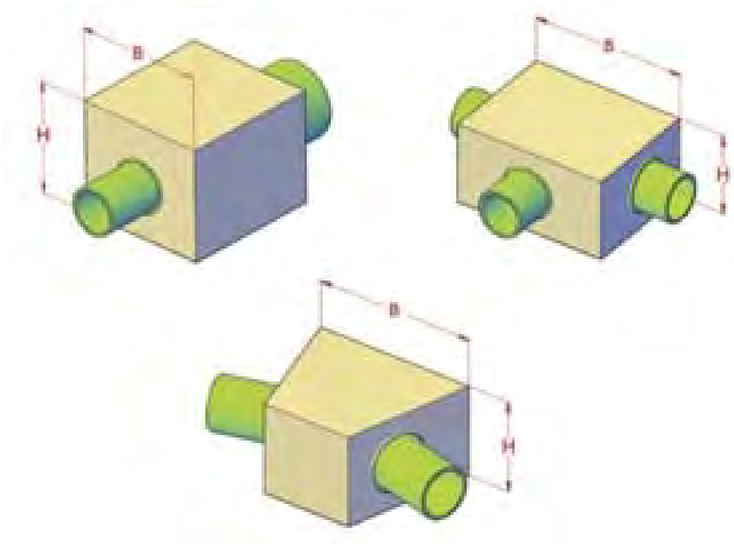
- Thrust force at Reducers: $T = P.(A_1 - A_2)$ where P = internal pressure and A_1 = bigger diameter pipe cross sectional area and A_2 = smaller pipe cross sectional area

- Thrust force at Dead End: $T = P.A$ where P = internal pressure and A = branch pipe cross sectional area;

and then design the adequate thrust blocks.

The minimum dimensions of thrust blocks have been calculated for secondary distribution network pipeline for each change in flow direction, supposing a bearing strength of soil of 300 kPa. This value must be strictly verified in situ; if necessary, the thrust block dimensions may vary in function of local soil characteristics.

Figure 10: Thrusts Blocks sketch for Reducers, Tees and bends



Typical dimension for thrust block have been calculated for each diameter, supposing a pressure equal to the maximum pressure calculated for distributary pipeline (surge pressure plus irrigation pressure plus friction losses).

6 FIRE HYDRANTS

Simultaneously at irrigation pipeline laying, a fire fighting network is going to be collocated using the same excavation. Being the source of water suitable for fire controlling purposes

After discussions with the civil defense, the following main criteria has been highlighted for the location of fire hydrants:

- hydrants will be located at the four corners of the main industrial areas in zone A

- hydrant will be located about every 2 km near build up areas

-In proximity of agricultural area, the fire hydrants will be installed about each 3km.

The following main characteristics of street fire hydrants have been proposed:

- nominal flange 80mm diameter
- pressure rated to PN 16
- 3-inch Round Thread Outlet
- Direction of opening to be anti-clockwise as viewed from the top
- Operating nut key-bar operated
- Ductile iron body and cap

Assuming that a fire hydrant with these characteristics has the capacity of 120 l/min, the size of the network pipeline has been estimated. Pipes will be in Polyethylene PE100 PN16 as usually utilize for such application guaranteeing both durability, facility of transportation and installation and finally low costs respect to other materials. The pressure guarantee at the hydrant range from minimum of 6 to 10 bar accordingly to the maximum capacity of installed pumps.

The final design shall be performed by the contractor and implemented after approval from the engineers. It will comprise an alarm system which will be able to deviate, in case of fire, the flow only to firefighting network, opening the dedicated gate valve and at the same time closing the motorized gate valves at the head of irrigation network. The pressure of pumps at the outlet will raise their maximum capacity of 10.5 bar.

Figure 11: Fire Fighting Network

7 NOTES AND RECCOMANDATIONS

The minimum diameter of pipeline feeding the farm has been fixed to be DN90. This permits to have a management flexibility from the authority. In fact, the owners of the farms differs from the farmers and in many cases they can change during the years. So is important to give the option of closing, for example, some outlets to allow farmers to control how to cultivate in shared areas with multiple parcels.

Depending both from the pipeline length (distance from header pipe), the position inside the agricultural area (i.e. more or less head at that point), as indicative information it's possible to guarantee that a DN90mm outlet at farm can serve an area up to maximum 3.5 ha without a considerable drop of pressure at the hydrant. It's to remember also that flow control valve must be calibrated whenever the agricultural area fed by each single hydrant varies.

8 ANNEX 1 – FARM GATE DEMAND AND PRESSURE

The following table summarizes the values of demand (liter per second), pressure (mH_2O) and geodetic elevation of each gate farm considered in the project according to cadastral survey. The demand is, according to proposed cropping pattern, equal to 1.23 l/(s ha). The pressures are estimated considering the maximum flow in the pipes i.e. during the peak demand in the month of May feeding the future additional areas in the North and in the South of Gaza.

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n125	9.5	46.60	94.4
n126	3.2	46.25	93.4
n127	5.7	47.52	90.8
n128	3.2	47.47	91.0
n129	2.1	46.83	91.8
n13	0.2	55.94	56.7
n130	2.2	46.95	91.7
n131	2.5	46.93	91.7
n1316	0.7	49.14	82.2
n132	0.6	45.76	94.1
n133	0.3	45.47	94.2
n134	0.6	45.94	93.6
n135	0.6	47.11	91.6
n136	0.4	47.54	90.9
n137	0.4	48.17	90.0
n138	0.7	48.45	89.5
n1382	1.4	72.52	59.0
n1386	0.1	75.30	57.6
n139	0.4	48.77	89.0
n1395	1.2	66.46	66.7
n14	0.3	55.00	67.0
n140	0.9	48.98	88.5
n1407	0.3	62.96	70.6
n141	0.4	49.47	87.9
n142	1.2	49.68	87.4
n143	9.5	49.20	78.6
n144	1.8	50.26	75.9
n145	0.1	50.15	76.1
n146	1.7	50.21	76.0
n1462	0.3	71.85	61.2
n1468	0.6	69.27	64.6
n147	0.3	50.00	76.1
n1479	1.2	63.51	70.4
n148	0.7	50.13	76.0
n1480	1.2	62.25	71.6
n1485	1.2	66.80	66.2
n1486	1.2	63.06	69.8
n1487	1.2	69.69	63.6

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n149	0.9	50.59	75.4
n15	0.2	55.00	67.0
n150	0.2	50.89	75.1
n1504	1.6	79.76	48.0
n1509	1.8	84.58	42.6
n151	0.4	51.21	74.6
n1519	2.5	67.36	63.0
n152	0.2	50.72	75.2
n153	0.4	51.76	74.0
n154	0.1	51.88	73.9
n155	0.1	51.89	73.9
n1558	2.0	48.71	86.8
n156	0.2	51.87	73.9
n1560	2.0	45.66	90.6
n157	0.1	51.72	74.1
n158	0.4	51.70	73.9
n159	0.2	51.83	72.5
n1592	2.2	76.50	54.0
n160	0.4	52.41	71.7
n1608	0.4	73.43	60.1
n161	0.8	53.11	70.6
n162	0.4	53.31	70.4
n163	0.1	53.64	69.9
n164	0.1	53.68	69.7
n165	0.6	53.20	70.2
n1651	2.1	76.32	55.6
n1657	2.1	74.19	57.6
n1658	2.1	73.70	58.0
n1659	2.1	73.87	58.4
n166	0.4	53.43	69.8
n167	2.9	52.97	70.2
n168	0.1	52.95	70.2
n169	0.6	52.34	73.1
n17	1.4	56.58	69.9
n170	0.4	52.85	72.6
n171	0.3	53.19	72.2
n172	0.9	51.15	74.5
n1723	0.3	62.58	79.0

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n1728	0.2	62.54	77.0
n173	0.7	51.08	74.6
n1734	2.0	69.41	69.1
n174	0.1	51.10	73.4
n1743	2.0	70.88	66.9
n1746	0.6	46.51	103.5
n1747	0.5	46.44	103.5
n1748	0.9	46.80	103.0
n1749	0.3	46.85	102.8
n175	0.5	51.22	72.8
n1750	0.4	47.25	102.4
n1751	0.1	47.45	102.1
n1752	0.4	47.96	101.6
n1753	0.6	49.00	100.4
n1754	0.4	50.15	99.2
n1755	0.7	46.14	103.8
n1756	1.3	46.35	103.3
n1757	1.1	46.37	102.8
n1758	1.1	45.96	102.8
n1759	0.3	45.44	103.0
n1760	0.7	45.91	102.3
n1761	0.2	46.31	101.5
n1762	0.5	45.20	102.3
n1763	0.5	45.70	101.7
n1764	0.2	45.72	101.6
n1765	0.7	45.80	101.3
n1766	0.7	45.95	101.3
n1767	0.7	46.16	100.4
n1768	0.4	46.72	99.7
n1769	0.4	46.46	100.0
n177	0.4	46.25	90.2
n1770	0.4	45.96	100.7
n1771	0.7	45.76	101.0
n1772	0.7	45.44	101.4
n1773	0.4	45.77	101.1
n1774	1.1	45.85	101.1
n1775	0.2	47.44	99.0
n1776	0.2	48.18	98.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n1777	0.2	49.16	97.2
n1778	0.3	50.30	95.9
n1779	0.2	53.86	91.9
n178	1.0	46.18	90.9
n1780	0.3	51.76	94.3
n1781	0.3	52.71	93.2
n1782	0.5	45.67	101.7
n1783	0.3	44.73	102.7
n1784	0.3	45.59	101.8
n1785	0.5	45.64	101.7
n1786	0.6	45.69	101.6
n1787	0.2	45.97	101.2
n1788	0.3	45.96	101.2
n1789	0.2	45.79	101.3
n1790	0.4	45.88	101.2
n1791	0.7	45.85	101.1
n1792	0.8	45.72	101.2
n1793	0.5	45.39	101.4
n1794	0.2	45.66	101.1
n1795	0.4	45.83	100.9
n1796	0.2	46.01	100.6
n1797	0.5	46.29	100.2
n1798	0.5	47.12	99.3
n1799	0.3	49.07	97.3
n1800	0.1	50.26	96.0
n1801	0.1	51.44	94.7
n1802	0.2	53.19	92.7
n1811	0.4	47.75	98.0
n1812	0.1	49.10	96.7
n1813	0.1	48.59	97.2
n1814	0.5	47.73	98.0
n1815	0.3	49.63	96.1
n1816	0.3	51.12	94.6
n1817	0.3	50.24	95.5
n1818	0.3	51.67	94.0
n1819	0.1	51.06	94.6
n1820	0.5	45.75	101.4
n1821	0.5	44.68	102.1

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n1822	0.5	44.95	101.7
n1823	0.2	45.28	101.3
n1824	0.2	45.16	101.3
n1825	0.2	45.30	101.1
n1826	0.2	45.24	101.2
n1827	0.2	45.27	101.1
n1828	0.3	45.40	100.9
n1829	0.3	45.42	100.8
n1830	0.5	44.96	101.0
n1831	0.5	45.57	100.2
n1832	0.4	46.14	99.5
n1833	0.2	46.78	98.8
n1834	0.2	47.29	98.2
n1835	0.1	47.66	97.8
n1836	0.2	51.62	93.5
n1837	1.1	45.08	101.0
n1838	1.1	45.07	100.8
n1839	0.9	49.15	96.1
n1840	0.5	53.22	91.8
n1841	0.4	55.29	89.6
n1842	0.4	57.06	87.8
n1843	0.9	59.66	84.8
n1844	0.4	63.22	80.9
n1848	0.2	45.28	101.6
n1849	0.1	45.40	101.5
n1851	0.6	45.20	101.4
n1852	0.1	45.10	102.0
n1853	0.3	45.54	101.4
n1854	0.2	45.11	102.0
n1856	0.7	45.47	99.5
n1865	0.4	45.51	99.4
n1866	0.2	45.63	99.4
n1867	0.2	45.90	99.2
n1868	0.4	46.47	98.7
n1869	0.2	47.78	97.5
n1870	0.2	49.39	96.3
n1871	0.1	49.52	96.1
n1872	0.1	50.63	95.4

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n1873	0.0	50.65	95.3
n1880	0.1	51.23	94.9
n1881	0.1	51.60	94.5
n1882	0.1	51.90	94.2
n1883	0.1	52.62	93.4
n1884	0.1	52.95	93.0
n1885	0.1	53.24	92.8
n1886	0.5	54.34	91.4
n1887	0.4	45.95	99.6
n1889	0.4	46.19	99.4
n1891	0.4	49.53	96.0
n1892	0.2	45.83	99.7
n1893	0.4	51.68	93.8
n1894	0.8	54.72	90.2
n1895	0.4	59.84	83.8
n1896	0.2	60.48	83.2
n19	1.4	57.83	69.2
n1900	0.1	56.80	86.7
n1901	0.2	57.59	85.9
n1902	0.1	56.43	87.0
n1912	0.5	50.71	98.6
n1913	0.4	51.18	98.1
n1914	0.4	52.44	96.7
n1915	0.5	54.01	95.0
n1916	0.5	55.30	93.6
n1917	1.0	57.51	91.3
n1918	0.6	60.21	88.5
n1919	0.8	62.81	85.8
n1920	0.2	65.12	83.4
n1921	0.5	66.70	81.8
n1923	1.0	55.04	90.4
n1925	0.7	56.86	88.2
n1927	0.6	58.77	86.1
n1929	0.6	60.84	83.8
n193	0.5	50.14	83.9
n1931	0.5	62.87	81.6
n1933	0.7	65.06	79.3
n1935	1.0	68.35	75.7

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n1937	0.3	56.42	88.8
n1939	0.3	58.23	86.7
n194	0.5	50.27	83.7
n1940	0.3	60.83	83.8
n1942	0.3	63.74	80.7
n1944	0.2	66.72	77.5
n1946	0.3	69.16	74.9
n1948	0.8	72.25	71.5
n1949	0.8	70.67	72.7
n195	2.3	52.55	83.0
n1950	0.8	72.21	70.6
n1951	0.8	74.85	67.0
n1952	0.8	65.53	77.6
n1953	0.8	61.47	81.9
n1954	0.1	59.33	84.3
n1955	0.8	57.89	85.6
n1956	0.2	57.58	85.9
n1957	0.5	61.92	81.5
n1958	0.8	65.90	77.2
n1959	0.8	72.20	70.6
n196	0.4	49.96	84.1
n1960	0.3	65.93	77.5
n1961	0.3	69.39	73.7
n1962	0.5	63.09	80.8
n1963	0.5	67.60	75.6
n1964	0.5	67.42	75.8
n1965	0.6	70.74	72.3
n1966	0.2	71.17	71.9
n1967	0.5	65.71	73.3
n1968	0.5	68.31	70.5
n1969	1.2	67.90	71.8
n197	0.8	54.06	81.3
n1970	2.0	68.28	71.4
n1971	2.0	67.01	72.6
n1972	2.0	68.17	71.6
n1973	2.0	75.00	67.4
n1974	1.1	46.10	100.7
n1975	0.3	46.21	100.4

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n1976	0.6	46.53	100.0
n1978	1.1	44.35	101.7
n198	0.8	51.29	83.1
n1980	0.4	44.91	100.0
n1982	0.4	44.57	100.0
n1984	0.5	44.39	99.9
n1986	0.5	44.73	99.3
n1988	0.7	44.66	99.1
n199	1.1	51.10	84.8
n1990	0.2	44.55	98.9
n1992	1.2	44.35	98.7
n1993	0.8	45.09	101.4
n1994	0.8	45.30	101.0
n1995	0.4	45.32	100.8
n1996	0.9	44.91	101.1
n1997	0.1	45.03	100.9
n1998	0.2	44.72	101.2
n1999	0.5	45.18	100.7
n2	0.2	57.00	66.9
n2000	0.4	45.54	100.2
n2001	0.3	45.99	99.7
n2002	0.6	46.63	99.0
n2003	0.2	47.41	98.1
n2004	0.1	48.17	97.2
n2005	0.5	50.09	95.1
n2006	0.2	53.59	91.4
n2007	0.4	55.92	89.0
n2008	0.3	57.89	86.9
n2009	0.3	58.71	85.9
n201	2.3	49.37	85.8
n2010	0.3	59.71	84.8
n2011	0.4	61.08	83.3
n2012	0.3	62.34	81.9
n2013	0.4	63.42	80.7
n2014	0.2	64.63	79.1
n2016	0.3	44.43	98.9
n2018	0.5	44.93	97.6
n202	2.3	49.44	85.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2020	0.3	45.03	97.3
n2022	0.3	45.42	96.6
n2024	0.3	46.09	95.7
n2026	1.1	47.73	93.4
n2028	0.3	49.13	91.7
n2030	0.6	50.46	90.1
n2032	0.1	52.06	88.3
n2034	0.1	52.69	87.6
n2036	0.2	53.43	86.7
n2038	0.2	54.73	85.2
n2040	0.2	56.14	83.6
n2042	0.1	57.47	82.2
n2044	0.2	58.77	80.8
n2046	0.4	60.34	79.1
n2048	0.3	61.78	77.3
n2050	0.4	61.65	77.2
n2052	0.4	61.16	77.5
n2057	0.1	47.67	97.8
n2058	0.3	49.33	96.0
n2059	0.2	50.87	94.4
n2060	0.2	52.80	92.5
n2067	0.3	57.17	83.2
n2068	0.1	54.95	85.4
n2069	0.1	53.98	86.4
n2070	0.1	52.92	87.5
n2071	0.1	52.36	88.0
n2072	0.1	58.99	81.4
n2075	0.3	45.52	96.4
n2076	0.3	45.49	96.4
n2078	0.1	44.97	97.5
n2079	0.4	63.51	80.4
n2081	0.8	60.81	77.8
n2082	0.4	64.82	74.3
n2084	0.7	44.82	100.4
n2086	0.5	44.18	100.2
n2087	0.7	44.57	99.2
n2089	0.1	44.29	99.1
n2091	0.2	44.11	99.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2093	0.4	44.33	98.7
n2094	0.6	44.90	97.6
n2095	0.4	45.46	96.6
n2096	0.3	46.12	95.6
n2098	0.4	46.77	94.6
n21	1.4	61.16	67.3
n210	1.5	55.93	79.0
n2100	0.4	48.07	93.0
n2102	0.5	49.35	91.3
n2104	0.3	50.80	89.7
n2106	0.1	51.62	88.8
n2108	0.1	52.17	88.1
n211	1.5	51.76	82.6
n2110	0.3	53.31	86.8
n2112	0.3	55.13	84.7
n2114	0.2	56.65	83.0
n2116	0.2	57.70	81.9
n2118	0.3	59.04	80.4
n2119	0.8	60.88	78.2
n212	0.2	54.13	80.1
n2122	1.0	57.76	80.6
n2123	1.0	58.13	80.3
n2124	1.0	56.84	85.3
n2125	1.0	54.82	87.6
n2126	0.2	55.49	85.6
n2127	0.2	54.52	86.7
n2128	0.1	53.71	87.5
n2129	0.2	53.06	88.2
n213	0.5	51.61	81.8
n2130	0.2	51.93	89.4
n2131	0.1	51.26	90.1
n2132	0.1	50.90	90.5
n2133	0.3	49.82	91.7
n2134	0.1	49.03	92.7
n2135	0.1	48.51	93.3
n2136	0.4	47.66	94.5
n2137	0.1	46.87	95.8
n2138	0.4	44.34	99.9

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2139	0.1	43.92	100.6
n214	0.3	49.71	81.3
n2140	0.0	43.97	100.6
n2141	0.1	44.11	100.7
n2142	0.4	44.31	100.9
n2143	0.1	43.85	101.5
n2144	0.5	44.24	101.3
n2145	0.2	44.01	101.8
n2146	0.5	45.09	98.5
n2147	0.5	46.12	96.9
n2148	0.5	44.34	101.1
n2149	0.5	43.89	101.4
n215	0.2	49.09	79.7
n2150	0.5	43.78	102.0
n2151	0.5	43.98	101.3
n2152	0.2	44.20	100.9
n2153	0.2	44.12	100.8
n2154	0.2	44.08	100.7
n2155	0.5	43.93	100.6
n2156	0.5	44.44	99.8
n2157	0.2	44.66	99.3
n2158	0.2	44.92	98.8
n2159	0.4	45.10	98.5
n216	0.2	48.87	78.7
n2160	0.1	45.49	97.9
n2161	0.2	45.68	97.6
n2162	0.4	45.97	97.1
n2163	0.5	46.92	95.9
n2164	0.1	47.29	95.2
n2165	1.0	48.15	93.7
n2166	0.5	49.69	91.8
n2167	0.9	51.65	89.6
n2168	0.9	54.88	86.2
n2169	0.2	43.60	101.6
n217	1.0	53.22	80.7
n2170	0.4	43.64	101.4
n2171	0.4	43.73	101.0
n2172	0.2	43.84	100.7

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2173	0.7	44.16	100.2
n2174	0.7	44.88	99.2
n2175	0.3	45.57	98.3
n2176	0.5	46.70	97.0
n2177	0.2	47.65	95.9
n2178	0.2	48.27	95.3
n2179	0.1	48.52	95.0
n218	1.0	49.14	78.9
n2180	0.1	48.90	94.5
n2181	0.2	49.61	93.8
n2182	0.2	50.13	93.2
n2183	0.1	50.53	92.8
n2184	0.2	51.12	92.0
n2185	0.2	51.89	91.1
n2186	0.3	52.70	90.1
n2187	0.3	53.65	89.0
n2188	0.5	50.56	92.1
n2189	0.5	53.15	89.6
n219	0.7	48.97	79.8
n2191	0.4	49.88	92.8
n2193	0.2	48.79	94.0
n2195	0.7	47.48	95.4
n2197	0.2	46.15	97.0
n2199	0.3	45.59	97.8
n220	0.7	54.19	80.0
n2201	0.4	44.95	98.8
n2202	0.1	47.39	95.2
n2203	0.4	58.29	83.7
n2204	0.8	60.16	81.7
n2205	0.6	62.40	79.4
n2206	0.5	63.93	77.5
n2207	0.2	59.60	82.1
n2208	0.3	60.13	81.6
n2209	0.2	61.00	80.7
n221	2.1	50.36	80.5
n2210	0.1	61.43	80.2
n2211	0.2	61.95	79.7
n2212	0.4	62.78	78.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2213	0.6	63.36	76.2
n2214	0.6	66.47	73.4
n2215	0.5	68.71	71.6
n2216	0.6	65.42	75.7
n2217	0.6	67.71	73.0
n2218	0.8	63.78	75.8
n2219	0.8	66.86	72.8
n222	0.4	58.96	75.6
n2220	0.2	58.72	83.1
n2221	0.4	44.45	101.7
n2222	0.2	46.00	100.4
n2223	1.4	46.13	100.1
n2224	0.5	59.21	82.5
n2225	0.5	60.44	78.2
n2227	0.2	43.88	101.3
n2228	0.2	43.87	101.3
n2230	0.4	43.66	101.5
n2231	0.3	43.66	101.5
n2232	0.2	43.54	101.0
n2233	0.4	45.31	100.6
n2234	0.4	43.68	101.8
n2235	0.1	43.47	101.8
n2236	0.8	43.39	101.8
n2237	0.3	43.96	100.6
n2238	0.6	44.16	100.2
n2239	0.4	44.52	99.7
n2240	0.3	44.88	99.2
n2241	0.2	45.18	98.9
n2242	0.2	45.03	99.0
n2243	0.1	45.50	98.4
n2244	0.2	45.60	98.3
n2245	0.3	45.73	98.1
n2246	0.6	45.96	97.9
n2249	0.2	45.16	100.5
n2251	0.4	44.27	101.0
n2252	0.3	43.72	101.5
n2253	0.4	45.13	100.5
n2255	0.1	44.18	101.3

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2256	0.7	43.69	101.5
n2257	0.7	44.26	101.1
n2259	0.7	44.64	100.9
n2262	0.6	43.86	101.3
n2264	0.6	43.53	101.2
n2265	0.1	42.94	101.8
n2266	0.7	44.05	101.4
n2267	0.8	43.89	101.2
n2268	1.1	43.46	101.2
n2269	1.6	45.18	100.0
n2270	0.3	44.79	100.1
n2271	0.3	43.75	101.1
n2272	0.3	43.37	101.4
n2273	0.3	42.78	101.8
n2274	1.5	43.37	101.3
n2281	1.5	42.85	99.5
n2287	0.6	42.77	99.6
n2288	1.7	42.79	99.6
n2289	0.5	43.92	99.1
n2290	0.1	44.01	99.6
n2291	0.1	43.93	99.5
n2292	1.5	42.34	102.1
n2293	0.9	43.09	101.1
n2294	0.3	43.56	100.5
n2295	0.5	43.72	100.3
n2296	0.3	43.94	99.9
n2297	0.6	45.51	98.0
n2298	1.5	44.75	98.9
n2299	0.6	46.33	97.0
n23	1.4	61.00	67.9
n2300	0.6	47.70	95.6
n2301	0.6	49.25	93.9
n2302	0.4	50.52	92.5
n2303	1.2	52.35	90.6
n2304	0.3	53.58	89.2
n2305	0.5	54.12	88.6
n2306	1.3	56.06	86.5
n2307	0.6	60.15	82.1

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2308	1.0	62.40	79.6
n2309	0.2	63.75	78.1
n231	1.0	57.61	76.3
n2310	1.4	66.51	75.1
n2311	0.6	70.42	71.0
n2312	0.4	72.18	69.1
n2313	0.6	73.75	67.5
n2314	1.0	76.22	64.8
n2315	0.3	44.48	99.1
n2316	0.2	44.32	99.1
n2317	0.2	44.26	99.3
n2318	0.3	44.63	98.8
n2319	0.2	44.75	98.7
n232	0.3	54.65	78.2
n2320	0.2	44.08	99.5
n2321	0.2	44.10	99.4
n2322	0.2	44.71	98.8
n2326	0.4	45.21	97.9
n2327	0.3	44.98	98.2
n2328	0.6	45.75	97.4
n2329	0.5	45.79	97.4
n233	0.4	53.35	79.1
n2330	0.6	45.90	97.6
n2332	0.3	47.89	95.1
n2337	0.2	46.61	97.0
n2338	0.4	46.48	97.2
n2339	0.5	47.58	95.4
n234	0.9	51.05	79.2
n2340	0.9	47.99	95.2
n2341	0.2	47.76	95.3
n2342	0.2	47.75	95.4
n2343	0.2	48.04	95.0
n2344	0.2	47.56	95.5
n2345	0.2	47.50	96.1
n2348	0.3	47.69	95.5
n2349	0.3	49.50	93.7
n235	0.1	48.68	78.6
n2350	0.4	48.17	95.1

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2351	0.4	50.00	93.2
n2353	0.3	52.53	89.8
n2357	0.5	50.17	93.2
n2358	0.4	51.12	91.5
n2359	0.1	51.50	91.0
n236	0.1	49.16	77.4
n2360	0.9	51.85	90.4
n2361	0.5	51.66	90.9
n2362	0.6	52.02	90.3
n2364	0.5	53.46	89.1
n2365	0.4	53.80	88.7
n2367	0.5	53.21	89.4
n2368	0.4	53.56	89.1
n2369	0.1	43.65	99.5
n237	1.0	55.07	78.0
n2370	0.9	43.26	99.3
n2371	1.1	43.47	99.1
n2372	1.5	43.81	100.9
n2377	0.7	55.58	86.4
n2378	0.7	56.00	86.0
n2379	0.7	54.28	87.9
n238	0.7	61.41	72.9
n2380	0.7	54.85	87.4
n2381	0.6	56.23	85.8
n2382	1.4	56.77	85.3
n2383	0.6	57.43	84.2
n2384	1.3	58.02	83.6
n2385	0.3	58.87	83.1
n2386	0.6	57.99	84.1
n2387	0.6	61.64	80.2
n2388	2.3	60.68	81.2
n2389	2.3	67.68	73.9
n239	0.9	54.79	78.1
n2390	1.7	64.74	76.6
n2391	0.6	66.63	74.4
n2392	3.0	69.27	71.2
n2394	2.3	66.83	74.2
n2399	1.3	74.39	66.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n240	0.9	51.16	79.1
n2400	1.3	77.48	62.2
n2401	1.2	72.18	67.7
n2402	1.2	78.89	60.3
n2403	1.2	76.64	62.1
n2404	1.2	70.48	69.4
n2406	1.7	43.12	99.7
n2407	1.7	40.48	102.8
n2408	1.7	44.58	99.7
n2409	1.0	43.11	100.5
n241	0.1	49.33	78.7
n2410	0.6	42.34	101.1
n2411	1.6	44.95	99.8
n2412	1.6	43.83	101.0
n2413	1.6	43.08	101.5
n2414	1.1	43.61	100.0
n2415	0.1	43.12	100.5
n2416	0.3	43.03	100.6
n2417	0.5	42.61	100.9
n2418	1.2	42.94	99.6
n2419	1.2	42.74	99.5
n242	0.1	48.81	78.5
n2420	1.2	40.49	101.5
n2422	1.2	42.93	99.5
n2423	0.2	40.92	102.5
n2424	1.1	43.40	99.6
n2426	0.4	41.73	101.7
n2427	0.3	40.95	102.5
n2428	1.0	41.59	101.6
n2429	0.5	41.43	101.8
n243	0.2	49.17	77.4
n2430	0.3	42.37	100.7
n2431	0.4	42.89	100.0
n2432	0.4	43.34	99.5
n2433	0.2	43.62	99.1
n2434	0.3	43.93	98.7
n2435	0.2	44.43	98.1
n2436	0.1	44.66	97.9

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2437	0.2	44.93	97.6
n2438	0.1	45.14	97.3
n2439	0.3	45.53	96.9
n244	0.9	49.41	76.9
n2440	0.5	46.02	96.3
n2441	0.2	46.47	95.8
n2442	0.2	46.87	95.4
n2443	0.4	47.36	94.8
n2444	0.1	47.86	94.3
n2445	1.0	49.65	92.3
n2446	0.5	51.87	89.8
n2447	0.6	53.41	88.1
n2448	0.7	55.58	85.7
n2449	0.9	58.25	82.8
n2450	0.6	59.75	80.9
n2451	1.5	61.34	78.6
n2452	0.4	63.47	76.1
n2453	0.2	64.51	74.8
n2454	0.5	65.92	73.1
n2455	0.5	68.40	70.0
n2456	0.4	70.46	67.6
n2457	0.3	71.97	65.8
n2458	0.3	73.35	64.2
n2459	0.6	74.59	62.7
n2460	0.9	76.78	59.9
n2461	2.1	42.73	100.2
n2462	0.4	43.49	99.3
n2463	0.4	43.80	98.9
n2464	1.7	44.71	97.8
n2465	0.2	45.48	96.9
n2466	0.2	45.83	96.5
n2467	0.1	46.12	96.2
n2468	2.3	48.14	94.0
n2469	1.4	52.18	89.4
n2470	2.2	57.02	84.2
n2471	2.0	61.07	79.1
n2472	0.7	63.48	76.2
n2473	1.7	67.10	71.6

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2474	0.2	74.33	63.0
n2475	0.8	76.10	60.5
n2476	0.4	78.22	58.0
n2477	0.8	72.06	65.8
n2478	2.9	84.16	54.1
n2479	2.9	78.02	59.4
n2480	2.9	72.97	64.0
n2481	2.0	68.10	70.0
n2482	2.0	67.73	71.0
n2483	2.9	78.29	62.2
n2484	2.9	75.71	64.7
n2485	0.2	41.82	102.7
n2486	0.6	42.76	101.6
n2487	1.8	43.61	100.4
n2488	2.2	45.49	98.0
n2490	0.3	41.89	102.5
n2492	0.2	42.14	102.2
n2493	0.5	42.35	102.0
n2494	0.3	47.91	95.3
n2495	1.1	49.84	93.3
n2496	0.3	51.48	91.5
n2497	0.3	51.98	91.0
n2498	0.4	52.86	90.0
n2499	1.9	56.07	86.6
n25	1.4	59.93	69.3
n2500	0.5	61.00	81.2
n2501	0.3	62.20	79.9
n2502	1.3	63.75	78.0
n2503	0.2	66.75	74.8
n2504	1.0	69.93	71.5
n2505	0.3	72.79	68.5
n2506	0.5	73.84	67.4
n2507	0.8	75.53	65.6
n2508	0.6	77.66	63.3
n2509	1.2	40.49	101.4
n2510	0.3	41.62	100.1
n2511	0.1	41.90	99.8
n2512	0.2	42.29	99.3

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2513	0.5	42.72	98.8
n2515	0.3	41.45	100.0
n2521	0.3	46.10	95.0
n2524	0.6	41.31	100.5
n2525	0.2	41.85	99.6
n2526	0.2	42.32	99.1
n2527	0.6	42.77	98.6
n2528	0.6	42.25	99.2
n2530	0.5	43.38	97.9
n2531	0.9	43.06	98.2
n2532	0.8	44.67	96.5
n2533	0.8	44.47	96.9
n2534	0.4	46.20	95.2
n2535	0.6	47.46	93.8
n2536	0.3	48.28	93.0
n2537	0.9	44.99	96.1
n2538	0.2	41.80	99.8
n2541	0.2	49.94	91.0
n2542	0.4	48.87	91.8
n2543	0.5	48.17	92.4
n2544	0.5	48.40	92.2
n2545	0.5	49.96	90.8
n2546	0.7	50.36	90.3
n2547	0.2	51.26	89.2
n2548	0.7	49.17	92.0
n2549	0.3	49.87	91.2
n2551	0.3	47.15	95.0
n2552	0.7	46.76	95.4
n2553	0.2	48.14	92.5
n2556	0.5	53.03	86.9
n2557	1.3	52.16	87.7
n2558	0.3	52.61	87.5
n2561	0.2	53.81	86.3
n2562	0.2	54.24	85.8
n2563	1.0	54.96	84.7
n2564	0.7	55.28	84.4
n2565	0.1	55.96	83.7
n2566	0.9	56.88	83.0

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2568	0.9	58.72	80.3
n2569	0.5	59.05	80.0
n2570	1.2	59.51	79.6
n2571	1.2	61.43	78.3
n2575	0.5	65.57	74.0
n2576	0.5	68.17	71.2
n2577	0.4	70.66	68.6
n2578	0.6	74.38	64.8
n2579	0.1	78.23	60.8
n2580	2.9	74.71	59.8
n2581	2.9	73.34	60.9
n2582	0.3	68.70	70.7
n2586	0.4	78.13	60.4
n2587	0.8	76.49	62.0
n2588	0.8	66.03	73.3
n2589	0.7	78.84	59.8
n2590	0.8	81.24	57.6
n2591	2.9	77.75	58.0
n2592	0.4	75.66	62.8
n2594	0.2	74.74	62.4
n2595	0.2	74.69	62.4
n2597	0.2	77.67	58.8
n2598	0.2	76.70	59.8
n2599	1.5	42.64	99.9
n2600	1.5	42.70	99.6
n2601	1.5	42.29	99.8
n2602	1.2	41.25	100.5
n2603	1.2	42.11	99.5
n2604	1.0	44.34	97.1
n2605	0.9	47.57	93.7
n2606	0.9	49.47	91.7
n2607	0.8	50.22	90.8
n2608	0.9	50.92	89.9
n2610	0.7	52.06	88.5
n2611	0.3	52.12	88.5
n2613	0.7	42.48	98.8
n2614	0.9	42.08	99.3
n2615	0.4	47.96	93.3

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2617	0.7	54.20	86.0
n2619	0.3	53.15	87.1
n2620	0.0	53.71	86.5
n2621	1.4	51.68	88.8
n2622	0.8	41.07	98.8
n2623	1.1	41.10	98.7
n2624	0.8	41.65	97.8
n2625	0.7	42.42	96.8
n2626	0.7	41.69	97.8
n2627	1.1	45.18	93.8
n2628	0.7	45.59	93.3
n2629	0.1	48.22	90.5
n2630	0.6	50.28	88.3
n2631	0.3	53.02	85.5
n2633	0.4	57.39	80.1
n2634	1.2	58.57	79.3
n2635	2.0	53.78	86.3
n2636	1.0	55.65	84.3
n2637	0.2	57.39	82.5
n2638	0.6	58.34	81.5
n2639	0.3	59.91	77.6
n2640	0.6	60.76	76.5
n2641	0.3	61.73	75.4
n2642	0.3	62.88	74.1
n2643	0.1	63.90	73.0
n2644	0.3	64.96	71.9
n2645	0.3	66.41	70.4
n2646	0.8	69.72	66.8
n2647	1.8	61.57	78.1
n2649	1.8	67.31	72.1
n265	0.1	59.18	72.8
n2650	0.2	71.23	68.0
n2651	0.9	73.73	65.4
n2652	0.3	77.19	61.9
n2653	0.3	78.20	60.8
n2654	0.2	79.69	59.3
n2655	0.5	80.98	57.9
n2656	0.2	82.78	55.9

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2657	0.2	82.18	56.6
n2658	1.1	84.27	54.1
n266	0.5	57.57	74.0
n2660	1.8	75.52	60.1
n2662	0.7	78.68	56.3
n2664	0.7	81.90	52.0
n2666	0.2	74.35	61.4
n2668	0.2	72.98	63.0
n267	0.8	61.84	71.0
n2670	0.3	71.85	64.4
n2671	0.5	67.84	68.9
n2672	0.2	65.46	71.4
n2673	0.4	63.37	73.6
n2674	0.4	61.16	76.0
n2675	0.8	60.13	77.5
n2676	0.1	59.24	78.6
n2677	0.7	57.17	80.9
n2678	0.2	53.88	84.5
n2679	0.8	50.92	87.7
n268	0.5	64.96	68.6
n2680	0.4	48.15	90.6
n2681	0.3	46.62	92.2
n2682	0.1	45.80	93.1
n2683	1.0	43.71	95.4
n2684	1.0	41.78	97.7
n2685	0.7	40.98	98.9
n2687	0.1	38.39	101.5
n2689	1.0	40.06	99.8
n269	0.5	59.96	72.3
n2690	1.0	41.23	98.5
n2692	0.8	38.42	101.4
n2693	0.5	41.89	97.8
n2694	1.8	43.30	96.1
n2695	1.2	46.13	92.9
n2696	1.0	47.80	91.0
n2697	1.0	49.82	88.8
n2698	0.4	50.65	87.6
n2699	0.7	51.26	86.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n27	2.6	70.67	72.6
n2700	0.5	52.04	85.7
n2701	0.6	53.03	84.6
n2702	0.1	57.37	79.4
n2703	1.0	55.19	82.0
n2704	1.0	57.57	78.9
n2705	1.0	59.63	76.3
n2706	1.0	61.89	73.6
n2707	1.0	64.41	70.8
n2708	1.0	67.50	66.9
n2709	1.0	71.28	62.9
n2712	0.5	75.86	57.9
n2713	0.4	75.99	57.8
n2714	0.4	73.13	61.1
n2716	1.0	74.52	59.5
n2718	1.0	78.67	55.0
n2720	1.0	82.76	50.8
n2722	1.3	82.52	51.5
n2723	0.3	38.13	101.8
n2725	0.1	40.90	99.6
n2726	0.9	40.98	99.5
n2727	0.9	38.29	101.5
n2728	0.9	41.82	99.4
n2729	0.5	39.12	100.9
n2731	0.5	39.50	99.3
n2732	0.9	40.44	99.4
n2733	0.6	41.56	98.2
n2734	0.8	41.80	97.9
n2736	0.9	41.18	97.3
n2738	0.6	42.04	96.2
n2739	0.3	42.19	97.5
n2741	0.3	42.60	95.5
n2743	0.4	43.27	94.6
n2745	0.2	50.97	88.3
n2750	0.1	43.89	95.5
n2751	0.2	42.90	96.7
n2752	0.2	43.59	95.9
n2753	0.1	44.54	94.9

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2754	0.1	45.33	94.0
n2755	0.4	47.44	91.9
n2756	0.3	50.07	89.2
n2757	1.4	46.53	92.5
n2758	0.5	49.89	88.8
n2760	0.5	44.60	93.0
n2762	0.8	47.54	89.7
n2764	0.2	49.07	87.9
n2766	0.4	49.46	87.4
n2768	0.2	50.47	86.3
n2770	0.4	51.31	85.4
n2772	0.3	51.77	84.8
n2773	0.8	51.70	86.3
n2774	0.4	50.95	87.4
n2775	1.3	53.45	84.0
n2777	1.3	51.37	85.0
n2779	0.3	51.79	84.4
n278	1.0	65.78	67.6
n2780	1.0	56.20	80.7
n2781	1.3	55.76	81.1
n2782	1.3	57.11	79.4
n2783	1.3	59.48	76.4
n2784	1.3	62.03	73.4
n2785	1.3	64.71	70.5
n2786	1.3	66.98	67.5
n2787	1.3	70.25	63.9
n2789	1.3	53.17	82.8
n2791	1.3	55.91	79.8
n2792	1.3	60.64	74.6
n2793	0.5	41.24	99.0
n2795	0.5	40.90	98.7
n2797	1.9	40.46	99.0
n2799	1.2	40.96	99.0
n280	1.0	51.07	77.2
n2800	1.2	40.64	98.9
n2801	0.5	41.48	98.9
n2803	1.3	40.50	99.6
n2805	0.1	40.54	99.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2806	0.3	40.67	99.5
n2807	0.6	41.72	98.5
n2808	0.3	40.57	99.2
n2809	1.4	40.59	99.1
n281	1.2	58.68	73.2
n2810	0.9	40.12	99.4
n2811	0.4	40.15	99.4
n2812	0.4	40.14	99.8
n2815	0.9	40.01	99.5
n2816	0.1	39.69	99.7
n2818	0.4	38.70	100.5
n282	0.5	50.64	77.7
n2820	0.2	40.62	99.2
n2821	0.3	40.69	99.0
n2822	0.4	39.42	100.0
n2823	2.1	40.72	98.9
n2824	0.8	39.94	99.4
n2825	1.1	39.17	99.9
n2826	0.6	39.17	99.7
n2827	0.3	39.15	99.5
n2829	0.7	39.86	98.9
n2831	0.8	40.98	97.6
n2833	0.8	41.56	96.9
n2834	0.8	41.53	96.5
n2835	0.9	41.87	95.6
n2836	0.4	41.96	95.4
n2837	0.3	41.97	95.3
n2838	0.4	41.91	95.4
n2839	0.3	41.91	95.4
n2840	0.3	40.65	97.2
n2841	1.3	36.65	102.7
n2842	1.3	39.10	100.0
n2843	0.7	41.77	95.9
n2844	1.7	42.06	95.2
n2845	1.7	43.16	93.6
n2846	1.7	43.42	94.0
n2847	1.7	43.10	94.5
n2848	1.1	43.42	94.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2849	1.1	43.60	93.8
n2850	1.1	43.33	93.4
n2851	1.1	44.69	92.0
n2852	1.1	45.33	91.8
n2853	0.3	46.57	90.4
n2854	0.2	45.85	90.9
n2855	0.5	45.40	91.0
n2856	0.6	46.40	90.4
n2857	1.1	44.94	91.3
n2859	0.3	48.67	88.3
n2860	0.6	46.78	90.0
n2861	0.2	46.38	90.3
n2862	0.6	45.84	90.7
n2863	0.3	45.53	90.9
n2864	0.4	46.01	90.5
n2865	0.3	46.58	90.1
n2866	0.4	47.07	89.7
n2868	0.2	49.63	87.2
n2870	0.6	51.09	85.6
n2871	0.4	48.81	87.5
n2872	0.2	48.63	87.6
n2873	0.4	48.40	87.8
n2874	0.7	48.00	88.1
n2875	0.3	47.97	88.0
n2876	0.9	48.10	87.7
n2877	0.1	47.92	87.8
n2878	0.6	48.14	87.5
n2879	1.4	48.51	87.2
n2880	1.4	48.22	87.7
n2881	1.4	48.80	87.4
n2882	1.4	50.96	85.4
n2884	1.4	51.78	84.4
n2886	1.4	53.47	82.4
n2887	1.4	53.97	81.6
n2888	1.4	54.10	81.1
n2889	0.3	54.38	80.6
n289	2.8	66.17	67.0
n2890	1.2	54.42	81.0

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2892	0.2	60.23	75.1
n2893	1.4	59.35	75.7
n2894	1.4	57.85	77.0
n2895	1.4	59.03	75.6
n2897	1.4	58.37	77.1
n2898	0.6	62.08	73.1
n2899	0.6	60.15	74.9
n29	2.6	67.00	81.3
n290	1.0	52.42	75.9
n2900	2.1	58.28	76.6
n2901	2.1	58.99	75.7
n2903	0.3	39.05	99.3
n2904	0.9	39.30	99.0
n2905	0.3	40.08	98.3
n2906	0.8	38.77	99.8
n2907	0.8	39.33	98.9
n2908	0.8	40.09	98.0
n2909	0.8	41.18	96.8
n291	0.5	58.10	73.2
n2911	1.0	42.19	95.6
n2913	1.6	44.09	93.5
n2915	6.2	40.85	96.9
n2916	6.2	40.29	97.6
n2917	6.2	42.15	95.1
n2919	6.2	43.30	93.3
n292	3.9	51.26	77.3
n2920	0.7	42.97	94.8
n2921	1.6	44.72	92.8
n2922	1.6	45.84	91.6
n2923	0.9	39.20	99.0
n2924	0.9	40.17	97.9
n2925	0.9	41.31	96.7
n2926	0.6	39.27	98.9
n2927	0.6	40.21	97.7
n2928	0.6	41.91	95.8
n293	0.8	66.00	67.1
n2930	0.7	41.57	96.1
n2932	0.7	39.73	98.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2933	0.7	40.37	97.3
n2934	0.6	39.87	98.1
n2935	0.2	40.52	97.2
n2936	0.2	40.85	96.7
n2937	0.4	41.67	95.8
n2938	0.0	41.97	95.4
n2939	0.2	42.34	95.0
n294	3.9	65.66	67.2
n2940	0.1	42.80	94.4
n2941	0.0	42.97	94.3
n2942	0.1	43.36	93.9
n2943	0.6	43.84	93.6
n2944	1.6	43.50	94.0
n2945	0.7	43.45	93.6
n2946	2.5	44.97	91.6
n2947	2.5	46.35	89.8
n2948	1.4	47.20	88.6
n2949	1.4	49.90	85.6
n295	3.9	51.82	77.1
n2950	1.5	49.88	81.4
n2951	0.5	50.82	81.1
n2952	0.5	49.83	85.3
n2953	1.8	48.38	87.0
n2954	1.8	50.15	81.3
n2955	2.5	51.90	81.8
n2956	0.7	51.23	83.7
n2957	2.5	55.53	78.4
n2958	1.6	53.77	80.9
n2959	1.6	53.78	80.1
n296	1.5	52.13	77.3
n2960	0.9	58.01	76.4
n2961	0.5	57.19	76.8
n2962	2.6	45.94	90.3
n2963	2.6	48.94	86.9
n2964	2.6	50.20	85.3
n2965	2.6	51.18	84.1
n2966	2.6	54.04	80.9
n2967	2.6	57.51	77.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n2968	0.9	60.35	74.1
n2969	0.3	61.61	72.8
n297	1.5	65.49	67.2
n2970	0.4	62.82	71.6
n2971	0.3	64.03	70.4
n2972	2.0	48.71	87.2
n2973	2.0	50.03	85.5
n2974	2.0	51.17	84.2
n2975	2.0	53.92	81.0
n2976	2.0	57.26	77.4
n2977	1.4	59.68	74.8
n2978	0.2	60.92	73.5
n2979	0.5	63.13	71.3
n298	2.3	65.39	67.0
n2980	0.5	63.18	71.3
n2981	1.2	62.29	72.2
n2982	0.8	60.82	73.8
n2983	1.2	57.43	77.0
n2984	1.1	40.42	97.1
n2987	1.1	41.94	94.7
n2988	0.1	41.53	95.2
n2989	0.1	41.31	95.7
n299	2.3	52.67	77.2
n2990	0.3	41.16	96.0
n2991	0.1	42.00	95.4
n2992	1.5	42.71	94.5
n2993	1.9	45.16	91.4
n2996	2.0	44.46	90.5
n2997	2.0	41.84	94.5
n2998	2.0	44.03	91.5
n2999	1.9	44.81	90.2
n300	0.6	55.22	76.2
n3000	1.9	43.78	91.8
n3004	0.5	45.61	89.8
n3005	1.2	46.55	88.7
n3006	0.8	46.45	88.8
n3007	1.0	47.04	88.8
n3008	1.9	46.89	88.5

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3009	1.9	48.46	86.8
n301	1.3	54.05	77.2
n3010	2.0	50.59	84.5
n3011	2.0	53.58	81.4
n3012	1.9	45.98	89.2
n3015	1.9	48.53	85.5
n3016	2.0	48.70	85.4
n3017	0.5	47.82	87.2
n302	2.3	59.01	72.7
n3020	1.0	48.28	86.8
n3021	2.2	48.41	86.6
n3022	0.3	50.50	84.5
n3023	2.2	50.48	84.4
n3024	2.2	53.99	80.5
n3025	2.2	58.83	75.3
n3027	2.0	55.13	79.3
n303	0.3	51.00	77.8
n3030	0.6	58.17	76.7
n3031	0.3	57.39	77.1
n3032	0.3	55.82	78.6
n3033	0.6	58.42	76.1
n3034	0.5	60.51	74.3
n3035	0.3	63.60	71.2
n3036	0.9	61.56	72.5
n3037	1.0	65.16	69.2
n3038	0.4	63.76	70.2
n3039	1.4	60.00	74.1
n304	2.3	59.11	72.6
n3040	1.0	59.40	74.8
n3041	1.5	60.09	74.1
n3042	0.3	58.57	75.6
n3043	0.4	58.65	75.3
n3044	0.4	59.15	74.7
n3045	0.1	59.86	73.8
n3046	0.5	60.52	73.1
n3047	2.0	62.99	69.5
n3048	1.2	64.51	67.9
n3049	0.2	67.38	65.5

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3050	0.5	68.35	64.5
n3051	0.5	65.26	67.7
n3052	0.6	67.08	66.1
n3053	1.6	66.74	66.6
n3054	0.6	67.26	66.3
n3055	1.1	65.86	68.0
n3056	1.1	68.17	65.3
n3057	1.1	67.55	66.2
n3058	1.1	70.11	63.6
n3059	0.4	75.06	58.5
n3060	0.4	73.87	59.7
n3061	0.2	73.30	60.2
n3062	0.9	77.72	55.1
n3063	0.9	78.16	54.4
n3064	0.3	76.84	55.7
n3065	0.5	72.79	59.6
n3066	0.2	68.47	64.0
n3067	0.4	67.02	65.7
n3068	0.2	65.55	67.3
n3069	0.1	63.56	69.5
n307	2.3	55.18	75.1
n3070	0.1	63.92	69.1
n3071	0.9	71.52	60.8
n3072	0.5	68.13	64.6
n3073	0.2	68.55	64.3
n3074	0.2	68.28	64.6
n3075	0.2	64.74	68.2
n3076	0.5	69.07	63.7
n3077	0.6	68.83	62.6
n3078	1.5	71.80	58.6
n3079	0.5	69.44	61.9
n308	0.2	56.02	74.6
n3080	0.5	73.70	56.7
n3081	0.4	71.64	61.5
n3082	1.0	76.43	56.5
n3083	0.8	77.59	54.9
n3084	0.2	72.38	60.5
n3085	0.2	74.36	58.5

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3086	0.1	73.87	59.0
n3087	0.4	69.69	61.7
n3088	0.4	74.67	55.7
n309	2.6	63.64	68.3
n3090	0.2	66.09	66.5
n3091	0.2	66.36	66.1
n3092	0.1	66.84	65.5
n3093	0.7	71.15	60.8
n3094	0.7	74.40	57.2
n3095	0.7	74.19	57.3
n3096	0.4	71.28	60.7
n3097	0.4	74.16	57.4
n3098	0.4	74.09	57.4
n3099	0.4	71.02	60.6
n31	1.4	46.25	93.4
n310	2.6	60.78	70.9
n3100	0.6	69.54	62.6
n3101	1.2	67.55	64.5
n3102	1.4	68.30	64.3
n3103	1.4	70.22	61.6
n3104	1.4	70.25	61.5
n3105	0.7	68.65	63.6
n3106	0.4	69.42	62.7
n3107	0.9	74.16	57.2
n3108	0.3	74.98	56.3
n3109	0.5	77.56	53.5
n311	2.6	58.89	72.4
n3116	0.2	69.73	62.4
n3117	0.2	70.92	61.0
n3118	0.4	68.63	63.0
n3119	0.4	71.34	60.5
n312	0.3	52.66	76.1
n3120	1.0	70.62	60.6
n3121	1.2	74.14	56.6
n3122	1.0	72.72	59.0
n3123	1.2	74.59	57.0
n3124	0.8	72.81	58.9
n3125	0.1	72.84	58.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3126	0.8	75.47	54.9
n3128	0.5	77.22	52.5
n313	0.4	56.03	72.7
n3130	0.4	77.09	52.6
n3132	1.0	77.84	52.1
n3133	1.0	75.51	56.1
n3134	0.9	71.27	60.7
n3135	1.3	74.70	55.3
n3137	1.3	75.76	53.9
n3138	1.3	76.76	52.8
n3140	1.0	78.89	51.5
n3141	1.0	73.08	58.5
n3142	1.0	79.34	51.1
n3143	0.5	78.86	51.5
n3144	0.5	75.32	55.9
n3145	0.1	75.12	56.1
n3146	0.3	74.16	57.0
n3147	2.6	57.89	76.3
n3148	2.6	56.74	76.4
n3149	0.1	56.56	77.6
n315	1.2	51.65	77.1
n3150	0.7	56.58	77.6
n3151	0.7	58.10	76.1
n3152	0.0	59.64	74.6
n3153	0.1	61.37	72.9
n3154	0.7	63.59	70.8
n3155	0.1	64.29	70.1
n3156	0.5	59.31	74.2
n3157	0.2	58.13	75.7
n3158	0.7	58.73	75.0
n3159	1.4	67.71	66.4
n316	1.2	55.51	75.1
n3160	0.7	67.17	66.7
n3161	1.7	61.44	71.9
n3162	0.4	62.28	70.8
n3163	0.5	65.92	66.9
n3164	0.6	72.07	60.4
n3165	0.4	67.72	66.4

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3166	0.2	62.60	72.0
n3167	0.6	61.64	73.0
n3169	0.2	63.96	69.8
n317	1.2	51.52	77.9
n3170	0.3	70.58	61.8
n3172	0.3	70.55	61.8
n3174	0.1	69.68	63.1
n3175	0.5	70.17	62.6
n3176	1.2	69.86	62.4
n3177	0.6	62.96	70.0
n3178	0.4	64.98	67.9
n3179	0.7	64.48	68.2
n318	1.2	50.63	77.7
n3180	0.7	69.19	63.0
n3181	0.7	75.33	56.7
n3182	0.3	64.78	67.9
n3183	0.3	69.25	62.9
n3184	0.3	75.11	56.9
n3185	0.2	68.86	63.3
n3186	0.2	65.17	67.5
n3187	0.2	73.97	58.1
n3188	0.2	65.67	66.9
n3189	0.2	68.16	64.2
n3190	1.1	67.03	65.3
n3191	0.5	71.36	60.9
n3192	0.5	70.36	61.6
n3193	1.2	70.24	61.7
n3194	0.4	70.39	61.0
n3195	0.4	74.16	56.7
n3196	0.5	69.63	61.7
n3197	0.5	73.39	57.4
n3198	0.9	74.77	56.1
n3199	0.9	70.93	60.4
n320	2.1	51.34	76.7
n3200	1.1	71.98	59.0
n3202	0.4	74.91	54.8
n3203	1.6	78.88	51.5
n3204	1.6	77.72	52.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3205	1.0	78.89	49.5
n3206	1.0	78.37	50.3
n3207	1.6	78.21	50.4
n3208	1.6	78.81	49.6
n3209	0.7	80.19	48.3
n3210	1.5	79.88	48.6
n3211	0.7	80.19	47.8
n3212	1.5	80.01	47.9
n3213	1.2	81.03	46.7
n3214	0.3	81.46	46.7
n3215	0.6	80.42	48.1
n3216	1.8	81.92	46.2
n3217	1.8	81.32	46.4
n3218	1.8	82.64	45.4
n3219	2.7	76.31	55.8
n322	1.3	51.39	75.4
n3220	2.7	78.00	54.5
n3221	2.7	76.95	55.4
n3222	2.7	80.15	52.4
n3223	2.7	83.60	49.2
n3224	2.7	86.12	46.7
n3225	2.7	89.08	43.9
n3226	2.7	89.26	43.8
n3228	1.7	75.90	56.3
n323	1.5	49.79	79.1
n3230	1.7	72.71	58.4
n3231	1.7	76.61	55.7
n3233	1.7	73.98	57.5
n3235	1.7	76.74	55.0
n3236	1.7	79.87	52.3
n3237	1.7	81.00	51.5
n3238	1.7	83.16	49.8
n3239	1.7	83.90	49.2
n324	1.3	50.16	78.8
n3240	1.7	76.59	56.1
n3241	1.7	77.92	55.1
n3242	1.7	79.51	53.7
n3243	1.7	80.91	52.4

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3244	1.7	70.97	60.9
n3245	1.7	72.49	59.2
n3246	1.7	68.86	63.0
n3247	1.7	68.39	63.0
n3248	1.7	69.58	61.4
n3249	1.7	77.79	54.7
n3250	1.7	79.96	52.6
n3251	1.7	83.41	49.3
n3252	1.7	85.89	47.0
n3253	1.7	88.70	44.2
n3254	1.7	88.66	44.4
n3255	1.6	76.15	56.0
n3256	1.6	77.71	53.1
n3257	3.5	83.75	49.5
n3258	3.5	79.15	54.4
n3259	3.5	81.50	51.9
n326	1.5	51.59	73.8
n3260	3.5	88.50	44.6
n3261	0.3	81.04	51.4
n3262	0.3	80.13	52.3
n3263	2.1	79.71	53.1
n3264	0.2	76.50	56.7
n3265	2.6	78.97	53.5
n3266	1.2	80.25	52.4
n3267	1.2	78.44	54.6
n3268	1.2	80.41	52.4
n3269	1.7	81.01	52.0
n3270	0.5	78.94	53.9
n3271	0.8	77.10	55.5
n3272	1.3	80.85	52.2
n3273	1.3	73.26	59.8
n3274	0.3	75.29	57.6
n3275	0.6	80.83	52.1
n3276	0.6	74.74	58.1
n3277	0.3	74.53	58.2
n3278	0.9	73.82	58.8
n3279	0.3	79.93	53.0
n328	0.4	50.69	69.3

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3280	0.9	78.39	54.5
n3281	0.1	72.87	59.7
n3282	2.1	70.89	61.4
n3283	1.9	66.27	67.6
n3284	0.3	69.22	64.6
n3285	0.6	68.22	65.7
n3286	0.5	69.45	64.4
n3287	0.5	64.59	69.4
n3288	0.5	61.64	72.5
n3289	0.5	61.53	72.7
n329	0.4	51.73	72.7
n3290	0.7	58.13	76.4
n3291	1.2	68.82	65.9
n3292	1.2	68.52	66.2
n3293	1.2	62.90	71.7
n3294	0.4	63.08	70.7
n3295	0.4	64.21	69.6
n3296	0.4	68.48	65.5
n3297	0.6	69.22	64.0
n3298	1.0	64.86	68.0
n3299	0.3	68.07	65.2
n33	0.3	48.00	89.3
n3300	0.1	71.64	61.7
n3301	0.6	70.57	62.6
n3302	0.1	63.45	69.4
n3303	1.3	64.40	68.3
n3304	0.1	65.97	66.5
n3305	1.2	68.92	63.9
n3306	1.2	65.09	67.0
n3307	0.6	67.65	64.9
n3308	0.7	68.43	63.9
n3309	1.0	67.72	64.1
n3310	0.9	66.70	64.7
n3311	0.4	65.36	66.5
n3312	0.4	65.20	66.8
n3313	0.1	73.91	59.1
n3314	0.3	70.94	62.8
n3315	0.4	69.74	64.0

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3316	0.1	69.93	63.8
n3317	0.1	72.02	61.7
n3318	0.1	70.34	63.4
n3319	0.1	70.90	63.0
n332	0.4	51.70	73.0
n3320	0.1	72.26	61.8
n3321	0.1	72.25	61.9
n3322	0.1	71.58	62.3
n3323	0.3	73.54	60.6
n3324	0.5	75.08	58.2
n3325	0.3	70.86	63.0
n3326	0.6	69.83	63.9
n3327	0.3	68.89	64.4
n3328	0.3	70.49	63.1
n3329	0.7	68.96	64.3
n3330	0.7	70.72	62.8
n3331	0.7	71.50	62.4
n3332	0.2	73.54	60.4
n3333	0.6	71.48	62.2
n3334	0.4	71.91	61.8
n3335	0.4	72.42	61.4
n3336	0.2	74.46	59.5
n3338	1.5	73.98	59.5
n3339	2.6	51.35	77.2
n334	0.3	51.77	73.2
n3340	2.6	51.40	75.0
n3342	2.6	52.02	77.0
n3343	0.7	73.28	60.9
n3344	0.7	68.28	65.6
n3345	1.1	71.72	61.3
n3346	1.1	74.99	58.3
n3348	1.8	60.71	73.7
n3349	0.5	61.70	72.7
n335	0.4	49.87	79.1
n3350	0.3	62.33	72.0
n3351	0.1	59.57	74.9
n3352	0.6	59.86	74.6
n3353	0.3	61.02	73.4

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3354	1.8	61.73	72.6
n3355	1.2	63.59	70.6
n3356	0.3	65.16	69.1
n3357	0.4	63.15	71.1
n3358	0.3	68.05	66.2
n3359	0.2	71.11	63.1
n336	1.3	51.01	69.0
n3360	0.3	64.20	70.1
n3361	0.4	64.90	69.4
n3362	0.1	67.09	67.1
n3363	1.8	74.40	59.7
n3364	1.8	72.71	61.4
n3365	1.8	72.66	61.4
n3366	1.5	65.92	68.4
n3367	1.5	68.34	65.9
n3368	1.5	71.07	63.1
n3369	2.1	74.73	59.2
n3370	0.7	74.73	59.2
n3371	0.8	78.13	55.8
n3372	0.9	77.70	56.2
n3373	1.3	79.03	54.6
n3374	2.9	72.12	62.0
n3375	1.7	72.81	61.3
n3376	3.5	75.17	58.7
n3377	0.8	71.25	62.9
n3378	2.5	72.21	61.6
n3379	2.5	71.89	61.6
n338	2.9	52.66	70.5
n3380	0.3	75.88	58.2
n3381	0.5	73.39	60.4
n3382	2.1	73.42	60.5
n3383	2.1	71.16	62.6
n3384	0.9	73.47	60.0
n3385	1.1	69.00	64.7
n3386	2.3	68.77	64.5
n3387	1.7	73.32	60.6
n3388	1.7	73.18	60.0
n3389	1.7	68.91	63.9

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3390	1.7	72.92	60.1
n3391	1.7	74.30	58.5
n3392	1.7	73.64	59.0
n3393	1.7	71.71	60.8
n3394	1.7	69.05	62.9
n3395	1.7	65.91	65.8
n3396	1.7	66.31	65.3
n3397	1.7	66.69	64.9
n3398	1.7	69.66	62.4
n3399	1.7	68.52	63.5
n3400	1.7	65.89	65.8
n3401	1.7	66.34	65.3
n3402	1.7	66.78	64.8
n3404	1.7	65.79	66.4
n3405	1.7	67.90	64.7
n3406	1.7	67.64	64.1
n3407	1.7	67.45	63.7
n3408	1.7	63.15	67.7
n3409	1.7	61.04	69.7
n3410	1.7	60.39	71.0
n3411	1.7	60.08	71.1
n3412	1.7	59.73	71.2
n3413	1.7	59.20	71.6
n3414	1.7	69.65	62.5
n3415	1.7	67.77	64.0
n3416	1.7	67.55	63.6
n3417	1.7	63.26	67.6
n3418	1.7	61.11	69.6
n3419	0.8	67.26	61.7
n3420	0.5	65.26	64.1
n3421	1.7	60.56	69.6
n3422	1.7	65.24	64.2
n3423	1.7	64.51	65.1
n3424	1.0	64.75	67.4
n3426	1.7	63.25	68.6
n3427	1.0	62.97	69.0
n3428	1.7	67.92	65.4
n3429	1.7	67.73	65.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3430	1.7	69.14	64.6
n3431	1.7	72.01	61.7
n3432	1.7	75.02	58.7
n3433	1.7	73.47	58.7
n3434	1.7	68.28	63.7
n3435	1.7	63.98	68.1
n3436	1.7	63.69	68.3
n3437	1.7	65.19	66.8
n3438	1.0	61.68	70.0
n3439	1.0	63.17	68.6
n3440	1.0	66.62	65.3
n3441	1.0	65.19	66.9
n3442	1.0	63.51	68.5
n3443	1.0	63.86	68.3
n3444	1.7	68.16	64.6
n3445	1.7	67.10	65.5
n3446	1.7	74.66	58.4
n3447	1.7	75.39	57.3
n3448	1.7	73.63	59.4
n3449	1.7	74.75	57.9
n3450	1.7	69.96	62.8
n3451	1.7	65.19	67.0
n3452	1.7	70.63	61.4
n3453	1.7	67.91	64.1
n3454	1.7	63.83	68.2
n3456	2.9	51.28	71.0
n3459	0.7	50.90	75.1
n3460	1.1	51.94	74.6
n3462	0.4	56.28	70.2
n3465	0.4	53.48	92.5
n3466	0.1	52.22	93.9
n3467	0.3	52.68	93.0
n3468	0.1	46.90	98.8
n3469	0.2	45.23	101.7
n3470	2.0	72.42	69.1
n3471	0.2	55.82	87.6
n3472	0.4	55.50	89.8
n3473	1.7	43.69	99.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n3474	0.1	50.03	93.1
n3475	0.1	61.38	80.3
n3476	2.0	66.03	73.2
n3477	1.2	70.09	69.6
n3478	1.3	76.20	63.5
n3479	0.8	42.25	102.3
n3480	2.9	72.68	67.4
n3481	1.2	72.80	65.8
n3482	0.8	42.55	100.3
n3483	1.0	78.28	60.3
n3484	0.2	65.44	73.8
n3486	0.6	62.63	76.6
n3487	0.9	50.14	90.3
n3488	0.4	56.05	81.4
n3490	1.4	54.90	80.0
n3491	0.5	44.51	91.8
n3492	1.1	44.13	92.5
n3493	0.9	67.74	66.1
n3494	0.7	39.48	100.0
n3496	2.6	44.00	92.3
n3497	0.7	59.69	73.8
n3498	0.3	66.16	66.3
n3499	0.2	72.66	59.6
n35	0.7	46.25	90.2
n3500	1.5	42.33	94.2
n3501	0.2	65.44	67.1
n3502	0.7	73.59	59.9
n3503	0.2	70.83	62.9
n3504	0.7	67.05	66.2
n3505	1.7	74.59	57.9
n3506	1.7	72.13	58.7
n3507	2.1	70.58	61.6
n3508	1.7	66.77	62.7
n3509	1.7	69.21	59.7
n3510	0.1	63.04	76.4
n3511	0.1	64.60	74.7
n3512	0.2	44.61	99.1
n366	0.3	55.14	75.4

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n367	1.1	53.77	76.2
n368	1.1	52.71	76.7
n369	2.5	52.09	76.9
n37	0.7	48.09	90.2
n370	2.3	51.31	77.0
n371	0.5	51.08	76.9
n372	1.5	51.14	76.6
n373	1.1	51.18	76.4
n374	0.5	51.22	76.1
n376	0.2	51.38	76.3
n377	7.0	51.57	75.5
n378	0.4	51.57	75.4
n379	0.4	51.71	73.7
n381	0.5	52.13	71.6
n383	0.4	52.01	74.6
n384	2.6	51.73	75.0
n385	2.6	51.56	75.6
n388	2.4	51.10	76.4
n389	3.0	51.85	76.6
n39	0.2	49.57	95.9
n390	2.6	51.71	76.2
n391	2.6	52.85	76.8
n393	1.1	51.75	73.5
n395	1.1	51.66	72.5
n396	0.1	54.87	75.7
n4	0.4	64.16	59.2
n41	0.3	45.46	101.4
n414	0.2	52.40	78.0
n415	0.2	52.14	78.2
n416	0.1	52.38	77.9
n417	0.5	52.45	77.8
n425	0.1	54.45	75.4
n426	0.1	54.08	75.6
n427	0.4	53.44	75.8
n428	0.5	52.42	76.2
n429	0.4	52.63	76.2
n43	0.4	51.07	92.1
n430	0.1	52.65	76.1

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n431	0.3	54.15	76.1
n432	0.3	53.20	76.7
n433	0.1	53.10	76.7
n434	0.5	52.64	76.2
n435	0.6	52.55	77.6
n437	0.4	51.34	77.1
n439	0.2	51.87	76.7
n440	0.2	52.63	77.4
n441	0.1	52.33	76.1
n442	0.5	51.38	77.1
n443	0.5	53.05	76.7
n444	0.5	52.43	77.0
n445	0.6	52.14	77.1
n446	0.2	52.32	76.1
n447	1.1	52.56	77.4
n448	1.1	52.10	76.9
n449	0.8	52.48	77.4
n45	1.0	42.59	99.2
n450	1.0	52.29	77.5
n451	1.0	51.94	76.8
n452	0.3	52.14	77.5
n453	2.4	51.99	76.7
n454	2.4	51.78	77.8
n455	2.4	51.47	77.1
n456	0.5	52.46	77.9
n457	1.0	52.33	77.9
n458	0.5	52.40	77.8
n459	0.1	52.41	77.6
n46	1.1	42.59	99.2
n460	0.3	52.48	77.5
n461	1.8	52.45	77.4
n462	1.8	51.30	78.2
n463	1.3	51.26	78.3
n465	1.8	52.26	76.5
n467	1.8	52.13	76.7
n469	1.8	52.63	76.4
n471	0.8	52.56	76.6
n473	1.5	52.90	76.4
n475	1.8	55.96	74.6
n477	1.4	55.04	75.2
n479	1.4	53.34	76.2
n48	0.6	44.16	102.4
n481	0.6	52.37	76.4
n483	0.4	51.95	76.8
n485	0.2	51.83	76.9
n487	1.2	51.71	76.9
n489	0.7	51.66	76.9
n491	0.7	51.72	76.8
n493	0.6	51.64	76.8
n495	0.6	51.68	76.7
n497	0.6	51.80	76.5
n499	1.1	51.96	76.1
n50	0.4	39.96	99.5
n512	0.4	55.81	73.9
n514	0.1	54.16	75.6
n516	0.9	53.89	75.8
n518	0.4	54.52	75.4
n519	0.4	57.98	71.5
n52	0.6	41.88	96.3
n520	1.2	53.44	76.1
n523	0.4	53.27	76.2
n524	0.1	56.54	69.9
n525	0.2	57.14	69.6
n526	1.7	57.83	69.2
n527	1.7	52.83	76.4
n534	1.7	52.20	76.4
n535	0.3	52.56	75.9
n536	0.2	53.25	75.1
n537	0.3	54.06	73.9
n538	1.7	55.06	72.6
n539	0.9	52.13	76.5
n54	0.1	53.76	83.7
n540	0.9	54.23	73.6
n541	2.4	58.52	67.6
n542	2.4	51.95	76.9
n544	2.4	52.27	76.8

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n551	0.2	51.99	76.8
n552	1.7	56.69	67.3
n554	1.7	53.52	70.7
n555	2.4	58.72	65.8
n557	1.7	52.06	76.7
n558	1.7	52.18	74.4
n559	0.1	51.91	74.3
n56	1.1	67.72	66.1
n560	0.5	51.90	74.3
n561	0.3	52.19	74.0
n562	0.5	52.27	74.1
n563	0.5	52.13	75.1
n564	0.5	51.87	76.8
n565	0.5	51.73	76.9
n566	0.5	51.96	74.2
n567	1.4	53.94	67.0
n568	1.4	51.72	76.8
n570	0.7	51.84	76.6
n571	1.4	52.01	74.1
n573	0.2	52.03	75.0
n574	2.6	53.09	65.9
n575	2.6	51.94	76.3
n577	2.6	52.05	73.9
n578	1.3	51.41	77.2
n58	1.1	62.60	71.9
n6	0.2	60.99	64.2
n60	0.2	64.39	68.6
n6000	0.3	48.10	89.0
n6001	1.1	56.30	66.8
n618	1.2	56.92	66.9
n62	0.7	67.00	67.1
n620	1.2	55.76	67.2
n621	0.3	56.23	66.8
n623	0.7	62.72	64.0
n624	0.3	62.64	64.1
n625	0.0	63.40	63.4
n626	0.5	64.50	62.2
n627	0.8	64.06	62.6

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n628	0.2	63.72	62.9
n629	0.7	63.24	63.2
n630	1.3	63.77	62.5
n631	0.4	61.55	63.9
n632	0.1	60.75	64.6
n633	0.4	60.22	64.9
n634	0.4	59.00	65.8
n635	0.2	59.38	65.5
n636	0.4	58.63	66.1
n637	1.2	58.03	66.5
n638	0.7	57.53	66.9
n64	0.0	38.98	99.3
n640	0.8	56.96	65.7
n641	0.2	57.09	65.6
n642	0.7	57.15	65.5
n643	0.2	57.24	67.0
n644	0.2	56.89	67.2
n651	0.1	55.26	67.2
n652	0.4	55.12	66.9
n653	0.4	55.44	63.9
n654	0.3	55.77	63.1
n655	0.7	55.86	63.0
n656	0.3	56.61	67.3
n657	0.1	56.40	67.4
n659	0.2	54.93	65.0
n660	0.1	54.86	65.1
n661	0.2	55.82	67.9
n662	1.1	55.81	66.7
n663	4.8	55.54	66.4
n664	0.9	55.33	66.5
n665	0.6	55.68	59.5
n666	2.4	55.20	66.4
n667	1.1	66.57	57.7
n669	1.1	64.84	58.6
n67	0.1	38.98	99.3
n670	1.1	60.75	64.5
n671	1.1	61.08	64.1
n674	0.4	61.67	62.9

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n675	0.2	62.14	62.4
n676	1.0	60.50	64.1
n677	1.0	60.19	64.9
n678	2.1	58.26	66.3
n679	2.1	58.15	66.4
n681	2.1	62.36	60.7
n682	0.2	58.96	66.0
n684	0.8	60.75	62.2
n685	2.1	57.78	66.2
n686	1.6	57.65	66.3
n687	1.6	57.17	66.9
n689	0.3	60.39	62.5
n69	0.1	40.98	96.8
n691	0.7	60.25	62.6
n692	0.3	56.14	66.9
n693	2.0	56.49	67.2
n694	0.2	55.88	66.6
n695	0.8	55.76	66.4
n697	0.6	59.86	62.9
n699	0.3	59.66	63.0
n7000	2.4	49.07	71.1
n7004	2.1	54.10	56.4
n7005	2.1	54.70	55.0
n7006	2.4	54.50	55.5
n7007	2.4	53.34	57.8
n7009	2.1	54.90	65.0
n701	1.4	59.38	63.2
n7010	2.1	53.30	65.7
n7011	2.1	54.05	66.9
n7012	2.1	56.90	67.2
n7013	2.1	56.03	62.8
n7016	0.7	59.52	66.2
n7018	0.2	59.20	65.9
n702	1.4	55.98	66.7
n7020	0.7	58.75	65.9
n7021	0.5	56.95	66.8
n7023	0.3	56.15	67.4
n7025	0.2	55.89	67.6

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n7027	0.3	55.84	67.6
n7029	0.3	56.08	67.2
n7031	0.1	55.89	67.2
n7034	2.1	59.82	66.0
n7037	2.1	59.90	67.1
n704	2.1	59.28	63.1
n7044	0.7	62.33	65.7
n7046	0.5	60.45	67.5
n7048	0.7	58.89	69.0
n7049	0.2	59.05	68.9
n7050	0.7	59.50	68.4
n7052	0.3	60.32	67.3
n7054	0.6	59.58	68.0
n7055	0.5	59.70	67.8
n7056	0.3	59.55	68.0
n7058	0.4	57.60	69.9
n7059	0.3	57.62	69.9
n706	1.0	59.32	62.8
n7060	0.1	57.48	70.0
n7062	0.1	63.20	64.1
n7064	0.4	62.70	64.5
n7066	0.3	60.50	66.7
n7068	0.4	59.45	67.7
n7069	0.2	59.68	67.5
n707	1.0	55.53	66.3
n7070	0.3	57.80	69.4
n7072	0.1	65.58	61.5
n7073	0.2	65.80	61.3
n7074	0.2	65.69	61.4
n7076	0.4	59.82	67.2
n7077	0.2	59.12	67.9
n7078	0.6	59.88	67.1
n708	1.3	55.26	66.2
n7080	0.1	56.12	70.9
n7081	0.2	56.24	70.8
n7083	0.3	64.80	62.0
n7084	0.2	57.47	69.6
n7085	0.6	63.20	64.3

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n7086	0.4	60.25	67.3
n7088	1.9	54.55	76.0
n7089	2.2	54.62	76.0
n709	2.6	54.92	65.3
n7091	4.3	47.92	85.6
n7094	4.3	48.45	81.8
n7095	4.3	48.60	79.0
n7096	4.3	49.42	78.7
n7098	4.3	49.96	77.0
n71	0.1	42.23	94.4
n7100	4.3	50.35	75.1
n7101	4.3	51.12	73.2
n7102	4.3	51.32	70.9
n7103	4.3	51.45	68.6
n7104	4.3	51.80	71.7
n7105	4.3	51.95	67.9
n7106	4.3	49.95	79.4
n7107	4.3	56.05	74.4
n7108	4.3	62.80	69.9
n7109	4.3	49.65	75.8
n711	1.3	59.28	62.6
n7111	4.3	49.35	77.7
n7112	2.2	46.00	90.2
n7114	4.3	50.03	86.4
n713	2.6	59.24	62.2
n714	1.0	55.69	62.7
n715	0.2	55.77	62.6
n716	1.3	55.65	62.8
n718	2.6	55.63	62.8
n7201	0.8	71.96	69.3
n7203	1.2	41.50	99.5
n7205	0.4	41.80	98.9
n7207	0.2	41.52	99.0
n7208	1.2	41.53	99.0
n7210	0.3	40.90	99.5
n7211	0.2	40.90	99.5
n7213	0.2	41.95	98.5
n7215	0.2	40.64	99.7

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n7216	0.1	40.70	99.6
n7217	0.2	41.00	99.3
n7219	1.0	40.36	99.9
n7220	0.1	40.40	99.9
n7222	0.1	40.06	100.1
n7223	0.2	40.30	99.9
n7225	1.4	41.61	98.9
n7226	1.2	41.50	98.7
n7228	1.7	40.89	98.8
n7230	0.2	40.68	98.8
n7234	0.2	40.12	99.2
n7236	0.2	39.98	99.2
n7237	1.3	66.70	68.1
n7239	5.6	78.99	54.5
n7243	0.2	80.23	52.1
n7245	0.2	78.90	53.1
n7246	2.1	76.80	54.8
n7248	0.8	80.70	51.4
n7250	0.2	81.95	49.8
n7252	5.6	81.69	49.6
n7254	1.9	80.93	50.0
n7255	0.9	80.78	50.2
n7257	0.4	75.10	55.2
n7258	1.3	75.26	55.0
n7259	2.1	74.98	55.3
n7261	0.6	73.58	56.2
n7263	2.3	73.25	55.8
n7264	2.1	73.14	55.9
n7266	0.2	74.24	53.8
n7267	2.1	73.98	54.1
n7270	0.9	74.22	55.1
n7273	3.4	73.60	54.6
n7274	0.9	73.54	54.8
n7276	0.4	75.88	52.0
n7277	1.9	75.68	52.2
n7279	1.2	74.80	52.3
n7280	0.5	74.78	52.3
n7282	1.7	75.75	50.7

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n7283	0.9	75.91	50.5
n7285	1.0	80.12	46.0
n7286	1.7	81.95	44.1
n7287	2.5	75.84	53.7
n7289	0.5	76.50	53.0
n7291	3.0	75.85	52.2
n7293	3.0	78.48	50.3
n7295	0.6	79.75	48.8
n7298	0.4	79.75	47.1
n7299	3.6	79.65	47.1
n73	1.8	46.52	94.0
n7300	0.9	83.95	43.8
n7302	2.7	73.25	57.2
n7303	2.9	73.36	57.0
n7304	0.3	80.01	46.1
n7306	2.7	78.80	53.2

Gate Farm ID	Demand l/s	Elevation m asl	Pressure (m H_2O)
n7307	2.9	83.80	49.8
n7308	3.3	78.00	59.4
n7309	3.4	75.40	54.9
n7321	1.4	41.60	99.8
n7322	1.4	41.18	99.4
n7323	1.1	41.80	99.6
n7325	1.1	41.58	99.0
n7329	3.4	63.50	67.4
n7330	0.1	40.44	98.9
n7331	5.6	66.85	61.5
n7332	2.4	66.90	61.6
n7334	5.6	76.00	53.8
n7335	2.3	74.25	53.8
n9	1.3	65.10	60.0
n953	0.1	55.61	85.5

State of Palestine
Palestinian Water Authority

دولـــــــة فلـسـطـيـن
سـلطة الميـاه الفلسطينيـة

INCEPTION REPORT

Selection of Consulting Service for Complementary Feasibility Study for Irrigation Scheme

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

January 2017

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1 INTRODUCTION

The goals which are set by the Palestinian Water Authority (PWA) are to define the optimum way to regulate, manage, protect and conserve the limited water resources as well as to optimize the benefit from water resources development by raising water consumption to levels which provide for a healthy environment and economic development.

In an effort to relieve the pressure on the aquifer, the Palestinian Water Authority (PWA) focuses on the reuse component of the North Gaza Emergency Sewage Treatment project (NGEST), dealing with the recovery of the infiltrated effluent and its reuse in agriculture through the implementation of recovery wells and irrigation network. Detailed design, specifications and tender documents have been prepared for the effluent recovery and reuse scheme in 2010. In November 2013, the mission of French Development Agency (AFD) and World Bank (WB) reviewed the detailed designs of the proposed wastewater recovery and reuses scheme in accordance with the available information and experience in wastewater reuse, irrigation and agriculture in Palestine and Gaza.

The designs are of good quality, and the tendering of the civil works for the recovery wells could proceed. In contrast, the irrigation scheme needs further review of some infrastructure elements together with water scheduling requirements and institutional arrangement. Furthermore, the re-involvement of farmers in agriculture in the project area near the wall is an issue, and conditions to insure revitalization of agriculture in the area needs to be assessed. Since this is the first large-scale irrigation and reuse project in Palestine and the first scheme financed by both AFD and the World Bank in the region.

This inception report is prepared in accordance with the Terms of Reference and in the technical proposal submitted by the joint venture ALMADINA-TIMESIS for the “Selection of Consulting Service for Complementary Feasibility Study for Irrigation Scheme” project, RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060. The related contract with PWA has been signed on 15/12/2016, with the official starting date due on 07/01/2017.

This inception report includes the upon agreed work methodology, work-plan, project organization structure and findings. The methodology and work-plan presented here will been discussed during the kick off meeting with PWA representative.

1.1 Objectives of the project

The overall objective of this study is to establish complementary feasibility study for recovery reuse and irrigation scheme to address the technical aspects, socio-economical aspects and institutional framework for the wastewater reuse of NGEST project at the northern part of Gaza Strip which aims at minimizing the water stress. The specific objectives are:

1. Reviewing related studies about wastewater reuse in parallel with the proposed design for NGEST
2. Establishing water scheduling requirements based on the crops patterns and irrigation requirements
3. Re-involvement of farmers in agriculture in the project area and revitalization of agriculture
4. Updating the exact percentage of cultivated vs. uncultivated parcels
5. Assessing the relevance of reuse technical regulations in light of the quality of water after SAT process
6. Assessing the actually in place institutional framework and provide an appropriate institutional setup
7. Investigate the duplication on a large scale with reasonable financial resources in view of lessons learnt
8. Highlight the socio-economic analysis of wastewater reuse aspects
9. Introduce main safety guidelines measures

1.2 Start-up phase and negotiation

1.2.1 Start-up meeting with PWA, ALMADINA and Timesis staff

On the date of 7 December 2016, a start-up meeting was held at PWA premises, from 10:00- 11:00 am Gaza time.

The attendance consisted in:

- Ziad Kurraz – PWA procurement manager
- Yaser Kishawi – PWA-PMU Technical Representative
- Samir Afifi - ALMADINA
- Thaer Abushbak – ALMADINA
- Alaa Hassan – ALMADINA
- Reema Al Shurafa - ALMADINA
- Emanuele Sapino – Timesis, connected via Skype
- Enrico Quaglino- Timesis, connected via Skype
- Andrea Cattarossi- Timesis, connected via Skype

Mr. Ziad Kurraz started the meeting and congratulated the consultant for awarding the project and Eng. Yaser described the big picture of the NGEST project components and the importance of the feasibility study.

The following main issues were discussed during the meeting:

- Starting of the project:
  - Mr. Ziad expressed his expectations that the contract would be signed by the Minister on the same day or not longer than the day after. However, PWA would inform the consultant and confirm the starting of the project.
- Team Leader Replacement:
  - the consultant presented a letter from MOHAMMED SHABAN justifying that he will not be able to engage in this project, and the consultant presented ANDREA CATTAROSSI as replacement. PWA informed back that this must be approved by the technical committee for the project. (Mr Andrea Cattarossi has been accepted as Team Leader by PWA
- Permissions and the international team visit to Gaza:
  - Mr Ziad highlighted that there are two main things to be distinguished regarding the permissions: the first, which is the responsibility of the international team, is the coordination with the Israeli sides to get visa to reach Israel. However, PWA will provide letters to whom it may concern in order to facilitate this issue. The second, which is the PWA responsibility, is to coordinate with the Israeli side to facilitate entering the team to Gaza. However, PWA has enough experience in this issue and will provide TIMISIS team all templates required from them to be filled regarding this issue. He stressed that, the coordination and permissions will not take less than 15 working days based on PWA experience.
- The draft inception report:
  - The inception report will be submitted two weeks after signing the contract and a draft version of the questionnaire will be submitted with it to be modified or approved by stakeholders and PWA.
- Kickoff meeting
  - The date of kick-off meeting will be specified after confirming the start of the project from PWA. The consultant will discuss with PWA the list of stakeholders who should be involved in the kick-off meeting; however, PWA will help in coordination with them, sending invitations, provide proper place for a video conference of Skype meeting or other.

Closure of the meeting was at 11:00 AM.

1.2.2 Kick off meeting (first workshop) and official start of the project

A kick-off meeting is scheduled after the presentation of this document, in date 26/01/2017, with the following tentative agenda:

- Discussion and comments on the Inception Report
- Discussion and comments on the revised working schedule
- Presentation and discussion on the draft Farm Survey Questionnaire
- Requests and clarifications about new documentation

Also, a field visit to the project area has been scheduled, on 25/01/2017: the Team Leader will visit all the relevant infrastructure areas, such as the treatment plant, the infiltration basins, the recovery wells and the irrigation area.

1.3 Project's team of experts

1.3.1 Roles and responsibilities of the experts

Following the approved amendments, the revised composition of the team of experts is presented in the table below.

Key Expert		Role	Responsibilities - Deliverables
Ke1	ANDREA CATTAROSSI	**Team Leader** (in replacement of Mohammed Zuhdi Shaban) Irrigation design specialist Quality control manager	Team coordination Communication with PWA Quality assurance Output 1 Output 3 Output 4 Workshop Output 5 Output 6
Ke2	MATTEO BORZONI Proposed to be replaced by CLAUDIO CARPINETI – The CV was submitted to PWA on 15/01/2017 for approval	Agricultural Economist	Output 1 Output 2b Output 4 Workshop Output 5 Output 6
Ke3	CARLO PONZIO	Irrigation Agronomist	Field staff coordination Output 1 Output 2a Output 2b Output 3 Output 4 Output 6

Key Expert		Role	Responsibilities - Deliverables
Ke4	VIRGINIA TICE	Institutional and legal specialist	Output 4 Output 6
Ke5	SAMIR AFIFI	Effluent reuse management specialist Local contact person	Output 2b Output 4 Output 6
Ke6	THAER ABUSHBAK	Soil Scientist	Mapping of the quality of soils Output 2b Output 4 Output 6

Non-key Expert		Role	Responsibilities - Deliverables
Ne 1	AHMED MOHAMMED SHAQFA (GIS expert) ALAA HASSAN MOHAMMED EL-SHEIKH REEMAAL-SHURAFA	Field survey staff	Data gathering Field surveys Questionnaire administration Soil scientist support GIS analyses
Ne 2	MOHAMMED ABU HASHEM	Legal local Expert	Contact person for Ke4 Output 4 Output 6

(Ke: Key expert; Ne: Non-key expert)

2 DOCUMENTARY REVIEW

2.1 List and summary of reviewed documentation

Many studies and projects have highlighted new water supply and treated wastewater as high priorities for the sustainable development of the area and for public health. Several initiatives have been taken to achieve a sustainable and environmentally acceptable water balance, but the majority of the studies and designs have yet to be realized in practice.

A digital copy of all the reviewed documentation was shared in a cloud folder and made accessible to all experts for consultation.

The following list briefly summaries the principal aspects of the previous studies relevant to the current study:

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
Industrial wastewater standards, Palestinian National Authority, Ministry of Environmental Affairs	The document lists the standard values for industrial wastewaters.	Arabic language	Industrial wastewater standards
Treated wastewater standards, Palestinian National Authority, Ministry of Environmental Affairs	The document lists the standard values for treated wastewaters.	Arabic language	Treated wastewater standards
Field assessment and participatory mapping of the agricultural situation in the project area, North Gaza Emergency Sewage Treatment -Reuse Component	This document contains the results of an appraisal process for the NGEST project, executed by means of a land survey and a farm survey conducted in 2016, with interviews to 8 farmers. All the interviewed farmers expressed the interest in using project's water for irrigation; moreover, the interviews clarified the prevalent irrigation patterns.	Julie Trottier, 30 June 2016	NGEST field assessment
Draft final report - Feasibility study for the wastewater reuse at Southern part of Gaza Strip	This is the Feasibility study for wastewater reuse at southern part of Gaza strip (Khanyounis and Rafah). The project included the development of four options for the wastewater reuse in Khanyounis and Rafah, aiming to test the proposed institutional frameworks that have been developed. This report presents an assessment of the needed modifications on existing wastewater treatment plants to meet the effluent reuse standards and prepare feasibility study on wastewater reuse for the sites in Khanyounis and Rafah governorates.	January 2016	Southern Reuse

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
Northern Gaza WWTP Infiltration System - Final Report - Project No. 1701 269 012	The scope of the project is to provide a long-term and sustainable solution of the wastewater situation in Northern Gaza, with main projects' components being: pressure mains and gravity sewers, pumping stations, the new wastewater treatment plan, effluent infiltration basins for aquifer recharge. In the framework of the Northern Gaza Storm Water and Sewerage Project, this report summarises the preparatory investigations, detail design and tender documents. The conclusions highlight that the site is not ideal for infiltration, due to a clay layer in the soil, so that it is recommended that the infiltration in the NGWWTP is based on basins. Water quality in terms of chloride and nitrate concentrations is expected be the same after the native groundwater downstream of the infiltration site will be completely exchanged with water originating from the infiltration water.	Stockholm, 2003	Infiltration
Consulting services for Detailed Design and tender documents of effluent recovery and irrigation scheme of North Gaza Emergency Sewage Treatment (NGEST) - Design report	This draft design report includes the design criteria, inputs and outputs for the recovery and reuse schemes. As described in the introductory paragraphs, the effluent recovery and irrigation scheme is a part of North Gaza Emergency Sewage Treatment (NGEST) project which consists of two parts: Part A which has been completed includes the Terminal Pumping Station (TPS) located at Beit Lahya Wastewater Treatment Plant (BLWWTP), pressure main from TPS to the location of the Northern Gaza Wastewater Treatment Plant (NGWWTP) and infiltration basins located at NGWWTP. Part B of the project which is the NGWWTP is under construction. The current project comes as an integral part of the NGEST project to provide a detail design and tender documents for implementation of risk management facilities to: 1. Avoid a potential long term irreversible impact to the groundwater in the surrounding areas. 2. Implement mitigation measures against environmental, social and public health impacts to nearby communities.	Dec 2010	NGEST irrigation scheme design report

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	Among the findings of the report, the design of the reuse scheme was based on the amount of recovered water which was equal to 35,600 m3/day plus 10% extra to ensure groundwater direction towards the recovery wells. The components of reuse scheme included two 4000 m3water tanks each, ten variable speed booster pumps and associated facilities, and six irrigation zones of about 2500 donums each (Total agricultural area around 15,000 donums). The document recommended also four tender packages.		
Consulting services for detailed design and tender documents of effluent recovery and irrigation scheme of North Gaza Emergency Sewage Treatment (NGEST) – Appendix-2 – Well design	Well design calculations and schemes.		
Consulting services for detailed design and tender documents of effluent recovery and irrigation scheme of North Gaza Emergency Sewage Treatment (NGEST) – Appendix 3 – Drawings	Drawings and schemes.		
Consulting services for detailed design and tender documents of effluent recovery and irrigation scheme of North Gaza Emergency Sewage Treatment (NGEST) – Appendix 4 – Soil Survey			
Consulting services for detailed design and tender documents of effluent recovery and irrigation scheme of	CAD digital drawings.		

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
North Gaza Emergency Sewage Treatment (NGEST) – Appendix 5 – Digital Map			
Review of Recent Groundwater Situation around the NGEST based on previous and recent results from local laboratories	This document is a review and analysis of the environmental situation in the NGEST area, in particular the quality of the groundwater. Conclusion of the studies underline the indication of a possible contamination in the wells around the infiltration basins up to 700 m; beyond this distance, results showed relatively negligible amount of ammonia. Recommendations are to continue the groundwater monitoring program, to apply tracer dye tests for specifying the expansion of the plume, and to investigate nearby solid waste dumping sites in order to investigate if the expected leach plume did not affect the groundwater.	February 2016	NGEST groundwater
Decree 1664 for the year 2014 Relating to the Water Law			
Palestinian Standards for Treated Wastewater – Draft		Arabic Language	Treated wastewater, standards
Technical assistant on use of non-conventional water resources - reuse of treated wastewater, management of storm water harvesting in Gaza Strip - Review of national and international institutional and legal framework for treated wastewater reuse in agriculture	This study represents an assessment of wastewater reuse institutional and legal frameworks in Palestine, with international and regional institutional and legal wastewater reuse aspects. In the conclusions, the study highlights that, although a large potential resource, wastewater reuse in the region is less than 5% of water supplies. Wastewater reuse in agriculture requires appropriate legislation to regulate the use of this resource, using quality standards appropriate to local conditions. If standards are too strict, they are both costly and difficult to monitor. But serious consequences related to human health, soil productivity and crop market potential are found if standards are lacking or not properly enforced.	April, 2011	Institutional and legal framework

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	From the institutional point of view, major issues arise from the large number of institutions involved and the complication of the system of wastewater production and reuse, that may be overcome with a multi-institutional national committee for coordinating internal functions of the concerned departments as a part of the institutional framework. Legal regulations need to consider the purpose of reuse where the standards differ in purposes and organising the handling of wastewater such as treatment level and monitoring of the plant, storage of the reclaimed water, recharge of groundwater aquifer and irrigation methods and application rate. Also, a coordination among NGO and stakeholders would be a benefit.		
Determination of Physico-chemical Properties of Top Soil in Gaza Strip for Agricultural Purposes	Evaluation of soil characteristics in Gaza Strip, made through the collection and analysis of 100 samples. Main recommendations of the study are: 1 authorities should evaluate the cultivation of different crops based on characteristic needs and evaluable water resources. 2 soil type and chemical characteristic of soil should be considered as a vital topic for any future development of wastewater reuse activities for irrigation of different groups. 3 future further researches should consider analyses related to plant micronutrients and fertilizing approach. 4 studies on the use of organic fertilizers (such as compost) should be considered in order to help improving soil aggregates and plant nutrient dynamics of Gaza Strip soil.	Samah A. Abu Samra’s thesis, April 2014	Soil
Feasibility study for the wastewater reuse at southern part of Gaza Strip - Final report	This report assesses and identifies the needed modifications on existing wastewater treatment plants to meet the effluent reuse standards and to prepare feasibility study on wastewater reuse for the sites in Khanyounis and Rafah governorates. It also includes the development of four options for the wastewater reuse project in Khanyounis and Rafah, aiming to test the proposed	February 2016	Southern Gaza feasibility

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	institutional frameworks that have been developed through this study. This study proposes best practices to reduce the water consumption stress by studying the wastewater reuse options for providing the farmers in the southern parts of Gaza Strip with the required irrigation water quantity with the desired quality for irrigation, taking into consideration the environmental, socio-economic and technological aspects for wastewater reuse. Based on the related studies and projects in wastewater reuse and the proposed upgrading of the existing and proposed WWTPs in the southern parts of Gaza Strip, bridging-gap approach was used to design four reuse options during 2016 to 2040, which are illustrated in this study. 1 First phase (2016 to 2017) proposes direct reuse of 5,000 m3/day from the existing WWTPs in Rafah and Khanyounis to cultivate 1,240 dunum at Al Mawasi and Al Mohararat of Rafah and Khanyounis, with 1 million cubic meters of yearly water demand. Since no upgrading of Rafah is existing in this phase, salinity tolerance crops were proposed to be cultivated. 2-Second phase (2018 to2025) proposes water usage of 20,000 m3/day produced from the upgraded Rafah WWTP at Al Mawasi and Al Mohararat of Rafah and Khanyounis to irrigate 10,330 dunums of salt semi-tolerant crops, mainly olive, followed by citrus and other horticulture crops with 7.3 M m3 yearly water demand. 3 Third phase (2019 to2025) the effluent from proposed Khanyounis WWTP which is about 26,000 m3/d will be reused in Khanyounis Governorate excluding Al Mawasi and Al Mohararat area with 9.5 M m3 annual water requirement for 14,840 dunum of horticulture crops and alfalfa. 4 Fourth phase (2025 and upward): 21,920 dunums of horticulture trees and alfalfa in the eastern areas at Rafah and Khanyounis will be irrigated with 44,000 m3/day of treated		

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	effluent from New Khanyounis WWTP, with 16M m3totalannual water demand.		
Khanyounis wastewater treatment plant infiltration System - geotechnical and hydrological study - draft final report	This study is a geotechnical investigation on the geologic and hydrologic features and parameters in a 3 km radius area around the Khanyounis WWTP. The results of the study allowed the consultants to select 3 sites of potential rapid infiltration, with indications of low permeability deposits in the shallow vadose zone and beneath the superficial permeable zone:		Geotechnical hydrological study
Technical assistance on reuse of wastewater and storm water harvesting in the Gaza Strip - Wastewater reuse pilot project in Sheikh Ejleen - design of post treatment unit and irrigation network - draft report	This report relates to the project “Consultancy Services for Technical Assistance on Use of Non-Conventional Water Resources - Reuse of Treated Wastewater, Management of Storm Water Harvesting in the Gaza Strip”, focusing on building a Palestinian institutional and legal framework for management of nonconventional water resources, in particular reuse of treated wastewater and storm water harvesting. The project includes the development of two small scale (pilot) projects in Gaza Strip one for WW reuse and the other for stormwater harvesting, aiming at testing the proposed institutional frameworks that have been developed through this project. Through this project a site in Gaza City to demonstrate the reuse of treated wastewater in agriculture was selected by PWA, the Ministry of Agriculture, Coastal Municipal Water Utility, and the Municipality of Gaza. The criteria for selection was set in advance, taking into consideration that the demonstration site would be within one of the Gaza governorates where the project was active and it would be close to a wastewater treatment plant. The stakeholders approved designation of about 170 dunums as a pilot area to promote wastewater use in irrigation and to improve water reuse practices. The site is in Gaza City within Sheikh Ejleen area, close to the existing WWTP. The main requirements for the post-treatment system are removal of suspended solids. The main units were used in this are Slow sand filtration and Reed beds. The total capacity of the pilot post treatment	October 2011	Post treatment unit, irrigation network

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	system was 1,000m3/d. This equals 62.5 m3/h. 50% of this flow was treated in a sand filter and the remainder was treated in a reed bed system. The treated effluent from both sand filter and reed bed was stored in a 600 m3 reservoir prior to be used as irrigation water. The produced water was classified as class B water and was used for irrigating 170 dunums of olives and citrus treas. In the pilot project site, no difficulty to get the farmer acceptance about irrigating his farm with treated wastewater was detected. This report presents the design of post-treatment, delivery and irrigation system at a demonstration site in Sheikh Ejleen area.		
Technical assistant on use of non-conventional water resources - Reuse of treated wastewater, management of storm water harvesting in Gaza Strip - technical and institutional options for wastewater reuse in Palestine	This report illustrates overall reuse options for effluent from WWTPs from a technical and institutional point of view. It also presents a review of how wastewater reuse takes place in Gaza and in other countries and how this can lead to improvements, especially stating that generally, wastewater reuse standards in countries of the Region are either adopted from WHO standards or other international standards without adapting them to suit local conditions. It is important that such adopted guidelines be adapted to prevailing epidemiological, socio-cultural and environmental local conditions. Local studies are essential as they may result in a relaxation of the guidelines and thus augment the quantities of reclaimed water without compromising public health, or may result in the need for more stringent standards to protect public health. In either case, such studies are deemed necessary to ensure effective and safe implementation of wastewater reuse guidelines, as this will increase confidence in reclaimed water as a valuable resource. The consultant advises that adaptation of the standards to the local situation is essential. Unnecessary strict and complex requirements will frustrate the implementation and success of reuse. On the other hand, if the standards are not safe	June 2011	Wastewater reuse

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	enough for densely populated areas as the Gaza strip, public health might be compromised. The Consultant recommends for the Gaza strip to re-evaluate the current barrier system because it makes reuse complex for the farmers and it makes the monitoring and enforcement also extremely difficult.		
National water and wastewater strategy for Palestine - Towards building a Palestinian state from water perspective	This document outlines the Palestinian framework of action in the water sector, for the sustainable management of its water resources. The national strategy provides the planning and management framework necessary for the protection, conservation, sustainable management and development of water resources and for the improvement and sustainable management and provision of water supply and wastewater services and standards in the Palestinian Territories. The policy and the strategy aim to: (a) Reinforce the Palestinian Authority's approach to sustainable water resources management by ensuring that all arms of government work together in the pursuit of shared water resources management goals; and (b) Establish a framework for the coordinated development, regulation and financial sustainability of water supply and wastewater services to ensure concerted efforts towards improved water systems management, rehabilitation and maintenance. The National Water Policy and Strategy will also act as a platform for ensuring close collaboration and cooperation among all water-related agencies and stakeholders at the national, governorate, municipal and local levels. As such, the National Water Policy and Strategy should be treated as a living document to accommodate changes that will further strengthen the national framework and reflect water management at all levels. After a presentation of water policies and context, the demands for domestic, industrial, and irrigation water are calculated. In the light of this data, the document resumes resources and strategies	June 2013	Water strategy

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	for the sustainable development of water resources.		
Technical assistance on reuse of wastewater and storm water harvesting in the Gaza Strip - Assessment of wastewater treatment and reuse practices	This assessment analyses the state of wastewater management and reuse, in Palestine and other selected countries. Consistently with other reviewed documents in this list, this study conclusions highlight the primary need of a policy for wastewater reuse, with shared recommendations on proper planning, involvement of stakeholders, development of state-of-the art practices and technologies.	April 2011	Wastewater treatment and reuse practices
SESIA Supplementary Environmental and Social Impact Assessment for North Gaza Emergency Sewage Treatment Project (NGESTP), Effluent Recovery and Reuse System and Remediation works – Final Report	This study delivers the Supplementary Environmental and Social Impact Assessment (ESIA) results for the NGEST project, Effluent Recovery and reuse System and Remediation Works. the NGESTP initiated in 2004 and being implemented in two phases. Part A of the project is comprised of the construction of the terminal sewage Pumping Station (PS) at the Beit Lahia Wastewater Treatment Plant (BLWWTP) site, construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, construction of nine infiltration ponds at the new site, and commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at BLWWTP to be drained. This phase has been in operation since April 2009 and was entirely completed in 2010. Part B of the project includes constructing a wastewater treatment plant at the new site that will ultimately be capable of treating up to 70,000 cubic meters of sewage daily1. Funding has also been provided for remediation of the land that was formerly covered by a large partial effluent at Beit Lahia and for a pilot program to recover treated and infiltrated effluent from the ponds. The specific objectives of the SESIA addressed by the study are: to highlight the legislations under which the NGEST project is subject to be implemented; provide the baseline of the environment and socio economic conditions;	April 2013	

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	identify possible positive and negative social impacts with mitigation measures; identify land acquisition requirements; develop an Environmental and Social Management Plan (ESMP) and associated monitoring plan. After a general description of the project area, the report illustrates the environmental and social impacts, positive (increase in irrigation water, improvement of groundwater quality after drying of the lake, benefits of sludge reuse, increase in job opportunities and improvement of infrastructures) and negative (air quality and noise pollution, emissions, construction waste, soil contamination, changes in hydrology and groundwater, health and safety concerns, archaeological disturbance, impacts on ecosystems, land use and accessibility impacts). The Environmental and Social Management and Monitoring plans detail the possible impacts on the environment and on the affected part of the society, and describes the mitigation measures and the costs related to all the phases of the project, from pre-construction to operational phase. Strategies for institutional strengthening, and training and consultations for implementation complete the survey. Detailed results of the various sections are presented in the Annexes, the most prominent of which are summarised in the following paragraphs.		
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 1 – Consultancy Terms of References	ToRs identify the objective of the study as to undertake an independent Supplementary Environmental and Social Impact Assessment (SESIA) of the proposed Reuse system, Remediation Works and Decommissioning of Beit Lahia Wastewater Treatment Plant.		NGEST ToRs
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 2 – Layout plan of BLWWTP and Water Distribution Networks	This document contains layouts and schemes for the Beith Laia Wastewater Treatment Plan, Effluent Recovery and Reuse infrastructures, the Irrigation Network.		Layouts

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 3 – Environmental field measurement report – methodology, standard equipment used and measurement results	Annex 3 of SESIA project report presents the field measurements conducted for the study, in particular soil, sludge, water, noise, the results for groundwater analyses and modelling.		Field measurements
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 4 – Policy, legal and institutional framework	Annex 4 of SESIA project report includes a summary of the laws, regulations and institutional setup found relevant to environmental and social management in the Gaza Strip, with particular focus on sludge management, water reuse and social rights. National and international guidelines for environmental assessment, treatment plants and technical design requirements were reviewed also. A review of the most pertinent regulations and standards governing health and safety has been included. In addition, analysis for the gaps between Palestinian Laws and International Laws were presented in order to develop some mechanisms to fill in the gaps.		Policy, legal, institutional framework
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 5 – Groundwater Model Methodology	Annex 5 of SESIA project report includes the detailed description of the groundwater model used for the study.		Groundwater model
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 6 – Soil Remediation Assessment of Effluent Lake	This annex 6 of SESIA project study presents the soil remediation options of effluent lake.		Soil, remediation
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 7 – Special Report concerning Irrigation Scheme	Annex 7 of SESIA project study lists the recommended methods of irrigation resulting from the study, which comprise 1 sprinkler systems (citrus and fruit trees, fodder and grains), 2a drip irrigation (citrus and fruit trees, vegetables and row crops), 2b bubbler irrigation (citrus and fruit trees), 3 sub-surface drip irrigation. This documents provides also		Irrigation scheme

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
	model results for irrigations timing and quantities.		
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 8 – Public Health Concern of Using Treated Wastewater	Annex 8 of SESIA project study illustrates the elements of concern for public health safety that may arise from the use of wastewater, in particular the microbiological parameters (pathogens), chemical pollutants, heavy metals, crops uptake, with the additional evaluation of national and international irrigation water quality regulations and guidelines.		Public health
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 9 – Social assessment methodology, socio economic baseline assessment, willingness survey results, cost analysis and tariff surveys results	Annex 9 of SESIA project study highlights the methodology and results of the social and economic impact assessment. The Social Impact Assessment was made through stakeholders interviews and questionnaire administration: divided in quantitative tools (consumer structured questionnaire, wholesalers and retailers structured questionnaire, beneficiaries farmers who will use the reused water) and qualitative tools (focus groups, in-depth interviews, workshops). Target groups were represented by stakeholders affected by the effluent recovery and reuse scheme, land acquisition, decommissioning of sites. The socio-economic baseline conditions and analysis presents the description of the socio-economic environment (geography, demography, sociology). The willingness survey checked the propensity of the population to use recovered water and sludge. The results show that the majority of the farmers are inclined to use it. Cost analysis and tariff illustrates the methodology and results for tariffs calculations.		Social, economic assessment
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 10 – Copy of letters from Antiquity Authority and High Institute for Religion			

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
Study; Islamic University of Gaza			
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 11 – Institutional Capacity Assessment and Regulatory Needs	Annex 11 of SESIA project study reports the assessment of the organizational situation for water sector, the proposal of an appropriate organization to operate in order to sustain the operational process as well as achieve financial independence of the sector, proposal of needed capacity building activities for different stakeholders.		Institutional Capacity
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 12 – The Resettlement policy framework (RFP) and the resettlement action plan (RAP) tors	This Annex 12 of the SESIA study project reports the ToRs for the RFP and RAP		Resettlement, ToRs
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 13 – Copy of public consultations documentations			
SESIA for NGESTP, Effluent Recovery and Reuse System and Remediation works – Annex 14 – References			
SHAPEFILE: Parcels of the AOI	This file, in .shp format, contains the land parcels in the area of interest		

3 DATA TO BE COLLECTED

The review of the documentation highlights the update of the existing and published data and to collect some missing data that are still to be recovered mainly, but not limited, to the water rights in the project area, the type of crops and irrigation methods near the boarders. The consultant will focus on the participation of farmers feedback as part of public consultations. More than documentary reports and, the next phases of the project will call for digital and geographic data that can be used in the development of the further analyses, starting from the farm survey and the models for the irrigation detailed design.

Next table summarises the documents to be collected from PWA or other stakeholders if available, in the short term.

- DTM, digital terrain model, of the area of interest
- Land use digital map: this data will be needed for the development of the farm survey and value chain analysis, and if not already existing will be produced through photointerpretation and/or after the field surveys.
- Updated satellite/aerial imagery (needed for land use recognition)
- Most recent version of Agriculture Statistics Survey
- Most recent version of “West Bank and Gaza – expenditure and consumption survey”

4 ADJUSTED METHODOLOGY TIME SCHEDULE

Next table summarises the revised steps for the implementation of the project, highlighting due dates for the deliverables and the timeframes for each action of the activities.

	PHASES OF THE PROJECT	Months							
		0	1		2	3	4	5	6
		Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	Jul 2017
	Start-up and negotiation phase								
D-1	OUTPUT 1: Inception Report		21/1						
	1-1) data collection								
	1-2) data review								
	1-3) incorporating comments								
	1-4) report drafting								
	1-5) Inception report delivery								
M1	Milestone 1								
D-2a/b	OUTPUT 2a: Draft farm survey questionnaire and methodology			7/2					
	2a-1) data collection								
	2a-2) questionnaire preparation								
	2a-3) methodology review drafting								
	2a-4) Draft Farm survey questionnaire and methodology delivery								
M2	Milestone 2; review and acceptance by Client								
	OUTPUT 2b: Report on baseline survey, value-chain and economic analysis				21/3				
	2b-1) data collection								
	2b -2) data quality review and completeness check								
	2b -3) land survey inventory updating								

PHASES OF THE PROJECT	Months							
	0	1	2	3	4	5	6	
	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	Jul 2017
2b -4) GIS geodatabase with data on farms creation								
2b -5) farm survey questionnaire administration to stakeholders								
2b -6) farm types and cropping patterns typologies definition								
2b -6) crop and farm budget model development								
2b -7) assess the causes of current non-crop farms								
2b -8) economic activity and income of owners of uncultivated farms and opportunity cost of return to farming assessment								
2b -9) Industrial Zone water demand survey: assess water consumption								
2b -10) Industrial Zone water demand survey: assess potential demand								
2b -11) Industrial Zone water demand survey: assess preliminary infrastructures and contractual arrangements								
2b -12) Value chain analysis: review of the existing documentation								
2b -13) Value chain analysis: farmers' organisations description								
2b -14) Value chain analysis: best suited cropping patterns analysis								
2b -15) Micro -economic analysis, crop and farm models development								
2b -16) Macro-economic analysis, current and expected project's costs								
2b -17) Report production								

	PHASES OF THE PROJECT	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	Jul 2017
		Months							
		0	1	2	3	4	5		6
	2b -18) Report and GIS geodatabase delivery								
M3	Milestone 3, review and acceptance by Client								
	OUTPUT: soil quality map								
	1) data gathering and coordination with relevant Ministries								
	2) data interpretation and map production								
D-3	OUTPUT 3: Update report on the detailed irrigation main and sub mains design; review and recommendations					21/4			
	1) irrigation data gathering, review and update								
	2) Irrigation detailed design review								
	3) report update and production								
M4	Milestone 4, review and acceptance by Client								
D-4	OUTPUT 4: Phase 1 Report						21/5		
	1) Data gathering and check, experts' brainstorming								
	2) Institutional capacity assessment, stakeholders' capacity assessment								
	3) Legal and regulatory environment review								
	4) irrigation system operation and maintenance requirements review								
	5) model for O&M designing								
	6) model for quality control designing								
	7) technical assistance and capacity building needs assessment								
	8) technical assistance solutions, extension services and financing needs identification								
	9) project report writing and PowerPoint presentation								
M5	Milestone 5, review and acceptance by Client								

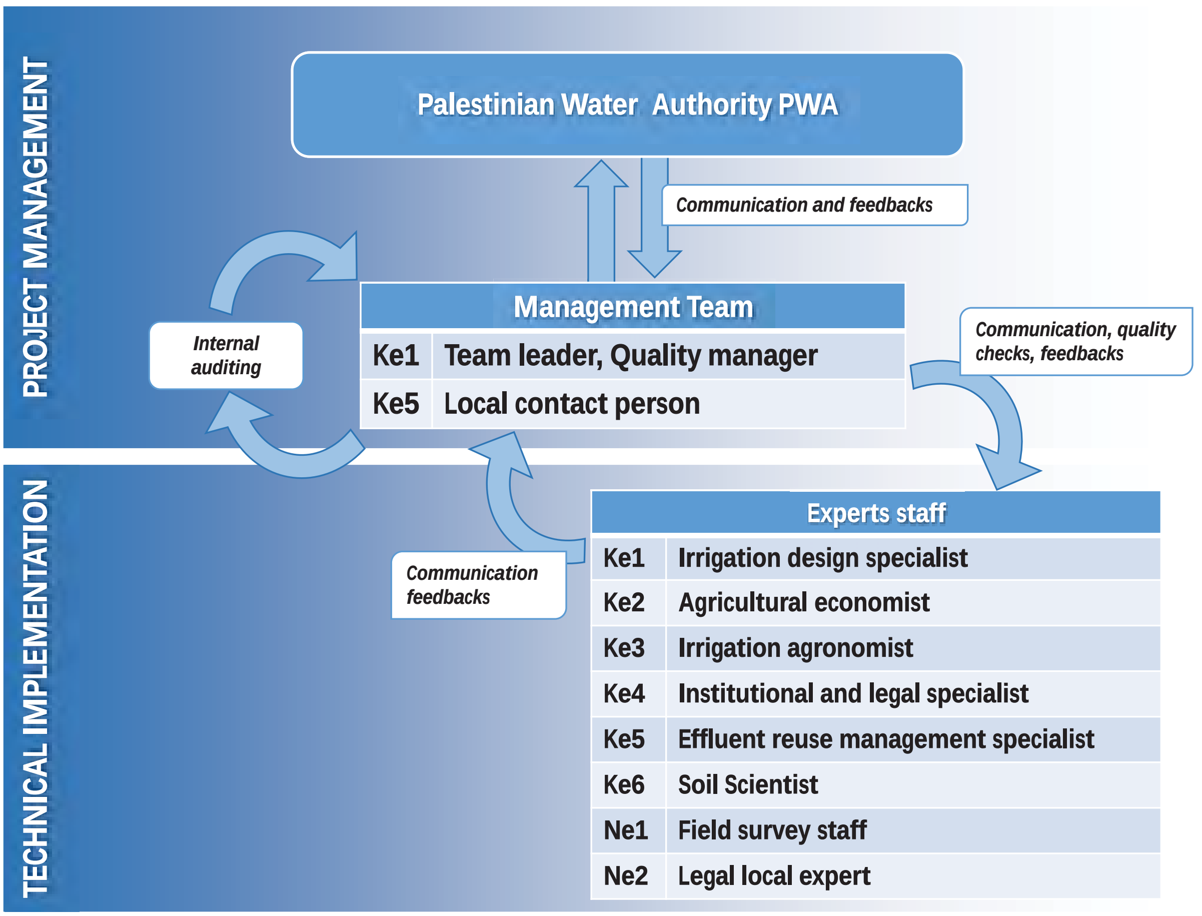
	PHASES OF THE PROJECT	Dec 2016	Jan 2017	Feb 2017	Mar 2017	Apr 2017	May 2017	Jun 2017	Jul 2017
	Months	0	1	2	3	4	5		6
D-5	OUTPUT 5: Workshop and minutes of the workshop							7/6	
	1) Workshop preparation								
	2) Workshop								
	3) report on workshop and minutes of workshop discussion								
M6	Milestone 6, feedbacks from Client								
D-6	OUTPUT 6: Phase 3 Report								7/7
	1) detailed project feasibility study reporting								
	2) Final Complementary Feasibility Study Report delivery								
M7	Milestone 7, Client's review and feedback								

5 DELIVERABLES

OUTPUT N.	DELIVERABLE	TIME OF DELIVERY
D-1 OUTPUT 1	Inception report with the list of documents reviewed and interviews carried out by the Consultant and production of an adjusted methodology for the feasibility study	Within two (2) weeks after signing the contract 21/01/2017
D-2a OUTPUT 2a	Draft Farm Survey questionnaire and methodology	Within one (1) month after signing the contract 07/02/2017
D-2b OUTPUT 2b	Report on comprehensive baseline survey, value-chain and economic analysis. Land survey GIS geodatabase Soil quality digital map	Within two and a half (2 $^{1/2}$) months after signing the contract 21/03/2017
D-3 OUTPUT 3	Update report on the detailed irrigation main and sub mains design: review and recommendations design amendments	Within three and half (3.5) months after signing the contract 21/04/2017
D-4 OUTPUT 4	Phase 1 Report: Draft Complementary Feasibility Study Report composed of the comprehensive report and project report and PowerPoint presentation	Within four and a half (4 $^{1/2}$) months after signing the contract 21/05/2017
D-5 OUTPUT 5	Workshop and Minutes of the workshop discussions and main output	Within five (5) months after signing the contract 07/06/2017
D-6 OUTPUT 6	Phase 3 Report: Final Complementary Feasibility Study Report that include the following elements	Within six (6) months after signing the contract 07/07/2017

Milestone	Time period after signing of contract	Quality monitoring activity
M1	2 weeks	Output 1; quality of the gathered documentation, quality of the output, discussion with PWA about subsequent steps
M2	1 month	Output 2a; quality of methodology and questionnaire evaluation; discussion with PWA about questionnaire administering and next steps
M3	2,5 months	Output 2b; baseline survey and economic analysis outputs quality assessment; discussion with PWA about results and subsequent steps
M4	3,5 months	Output 3; irrigation detailed design review outputs quality assessment; discussion with PWA about results and subsequent steps

M5	4,5 months	Output 4; quality assessment of the "Complementary feasibility study" draft and related outputs; discussion of results with PWA and subsequent steps
M6	5 months	Output 5; quality assessment of workshop and discussion of results of the meeting, sharing impressions with PWA
M7	6 months	Output 6; Final complementary Feasibility Study Report quality assessment; discussion with PWA about overall results, challenges and perspectives rising from all aspects of the Study



6 FARM SURVEY QUESTIONNAIRE (DRAFT)

The draft questionnaire will be the baseline for the field survey and it will be aimed at understanding the level of agriculture development in the project area and at assessing main limits and constraints that are currently affecting local farmers and relevant productions.

For the construction of the questionnaire we used the Mini-Survey approach that is based on the idea that it is necessary to focus the study on a narrowly defined issue, question, or problem.

Mini surveys, in fact, may be extremely useful when conducting feasibility studies, preparing project papers, assessing beneficiary responses, and preparing final and impact evaluations. Within such contexts, analysts are more interested in broad patterns, trends, and tendencies than in precise measurements. For example, in evaluating an agricultural project for small farmers, it is often immaterial if the beneficiary approval rating is 60 or 63 percent; the difference of 3 percent will hardly affect the conclusions and recommendations of the evaluation team.

Mini surveys can be used to develop questions, hypotheses, and propositions for further testing. They can be a prelude to more comprehensive, large-scale surveys, and their information may help to sharpen study questions, design relevant questionnaires, and develop sampling strategies.

The methodological approach for the implementation of the questionnaire therefore started from the identification of the mini survey's objectives and in particular from the identification of the main issues affecting agriculture in Gaza Strip.

As reported by several studies, main (and current) constraints of Palestinian and Gaza Strip agriculture can be summarised as follow:

- limited technical knowledge and a low level of technical support
- Limited mechanization (partly due to small size of holdings, poor road access)
- Lack of connectivity across value chain (e.g., food processors importing many of their key inputs, which could be produced locally)
- Highly fragmented productions
- Limited access to additional land and constraints on agricultural development (irrigation, rainwater harvesting, etc.)
- Limited access to high value inputs (e.g., restrictions on standard concentration nitrogenous fertilizers, high yield seed types)
- Limited availability of water for irrigation
- Cost and risk of delays at the commercial crossings
- Bureaucratic hurdles in PA administrative system for exports

The questionnaire was therefore built with the aim to receive from Gaza farmers, quantitative information about these constraints and transform a theoretical knowledge into economic and agronomic indicators.

The survey presents three main sectors

a) geographical sector, dealing with the identification of the farms within the project area.

Main objectives of this sector are the perfect acknowledgement on the farm borders ad of the relevant localisation and surface;

b) Farmers sector, dealing with collection from local farmers of agro-economic data and indicators;

c) Stakeholders sector, dealing with the collection from local stakeholders (producer associations, local Government and Administration) of agro-economic data and indicators.

Once the questionnaire will be approved and shared between all the project stakeholders, Almadina and Timesis will draft specific guidelines for the data collection in order to have homogeneous approach in the survey and in the collected data.

The draft version of the Farm Questionnaire is reported in the following pages.

Localisation of the Farm (address)	
Localisation within the project area	Known (please report the farm size on the map) Unknown

Figures of Agriculture	*North Gaza Governorate* ***project area*** ***Simplified Agriculture Survey – Single farm***								
	Citrus	Olives	Palm dates	Grapes	Guava	Mango	Fruits Almonds	Herbaceous crops	....
Total area (dunum)=>									

Costs											
	Unit	**Price per Unit NIS**	**Qty per dunum**								
tillage	n°										
fertilization											
labour	h										
machinery	h										
urea	kg										
phosphate	kg										
potassium	kg										
Plant protection											
labour	h										
machinery	h										
insecticide	kg										
polisolphur	kg										
pruning: each tree											
labour	h										
machinery	h										
irrigation	mc										
harvesting	h										

Simplified Agriculture Survey – Single farm										
Figures of Agriculture		Citrus	Olives	Palm dates	Grapes	Guava	Mango	Fruits Almonds	Herbaceous crops	……………….
Revenues										
Qty	kg									
Fresh consumption										
Unit price	**NIS**									
Food Industries (canned, juice etc.)s										
Unit price	**NIS**									
Total revenues	**NIS**									

Questions for a single farm **Owner**________________

Baseline (before the project):

- What is the size of your farm in dunums?
- Are you a private farmer or are you associated to a farmer association or *similia*?
- How do your farm collect water?
- Does your farm have private wells?
- Do you use a collective well?
- Do you pay for water?
- How much do you pay?
- What crops are you cultivating now, and on which percentage of the area?
- What percentage/crops of your farm is/are now irrigated?
- What percentage of your products/crops are you now sending to food industries (juice, canned etc.), and what percentage to fresh consumption?
- How many workers (hours per year) are you now employing, per crop, in your farm?
- Does your farm need technical assistance, now?
- What do you believe are the constraints for an intensification of your productions, more than irrigation scarcity?
- How much land (suitable for agriculture) are you now abandoning, due to irrigation scarcity?

Ex post (after the project): If you had enough water for irrigation:

- Which new crops would you grow with respect to the current situation?
- Do you think your farm would require in the future technical assistance for the irrigated crops?
- Which part of your presumable productions would you allocate, respectively, to fresh consumption (sale to retailers) and to the food industry?
- How much the employment would increase if the size of the irrigated area will increase?
- What type of investments would you do (machinery, irrigation structures, etc.)?
- How much do you suppose your farm income will increase?
- How much do you suppose your farm production costs will increase?

Questions for stakeholders **Stakeholder**____________________

The project area is approximately 1,500 ha (15,000 Dunum).

1) How many farms are there, and what is the average size:

Classes of farm size	*Number of farms*	*Number of irrigated farms*
- I°: 0 to 30 Dun		
- II°: from 30 to 100 Dun		
- III° from 100 to 300 Dun		
- IV°: >300 Dun		

2) Number and type of processing industries in the area, easily accessible by the local farmers.

For each significant "industry", we should know:

- Milled and processed product type (inputs of a raw material (fruit, vegetables, etc..) and output as a finished product (juice, can, etc.)
- Annual amount of raw material processed for each type
- Where the processed products are sold? Gaza Strip, West Bank, Israel, other countries?
- Prices of processed products
- Quality standards required for export
- How many and who are the traders (middle-men)?

State of Palestine

Palestinian Water Authority

دولـــــة فلسطيـن

سلطة الميـاه الفلسطينيـة

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 2b

Baseline Assessment Report

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

May 2017

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
du	dunum (1 dunum = 1000 m2)
NGEST	North Gaza Emergency Sewage Treatment
PWA	Palestinian Water Authority
ToR	Term of Reference
WB	World Bank
WWTP	Waste Water Treatment Plant

1 EXECUTIVE SUMMARY

1.1 Background

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project initiated in 2004 and being implemented in three phases, the latest of which, known as **supplementary phase,** was later added to the project to provide a mean to recover and reuse the treated effluent after completion of the new WWTP. This system, comprising of a water recovery scheme and a water reuse (irrigation) scheme, includes 27 recovery wells surrounding the infiltration basins, a network of 42 monitoring wells (10 of which will have to be newly built), 2 water tanks with the ability to store 4,000 m^3 each, 1 booster pumping station with 10 booster pumps and over 130 km of distribution network for the reuse of the water in irrigated agriculture.

The design of the system was completed in 2010. The original design foresaw a three-stage development of a full-scale irrigation system. The first two stages have been fully designed to make it possible to lunch tendering and construction procedures for both the recovery and the reuse schemes required to serve a gross agriculture area of 1,570 ha (15,700 du), subdivided in two sectors of approximately 500 ha (5,000 du) and 1,000 ha (10,000 du).

The construction of both the recovery and the reuse schemes has been delayed for several years, thus justifying the need for the review and updating of key design assumptions that were made in the original design.

This baseline assessment aims at providing the basic information necessary to understand the farming activities in the project area and the conditions needed for the agriculture sector to flourish, and to assess the economic justification of the project.

1.2 The Field Survey

Foundation of this baseline assessment, and primary tool for collecting first-hand and updated data, the field survey had the aim to **investigate the characteristics of the farming system** in the project area. A questionnaire was developed and tested in coordination with PWA; its questions were focused on the farm cropping system, the market channels, the selling prices, and incomes. Special emphasis was given to the water issue, by enquiring about the current use of water on crops, the irrigation methods and the source and cost of the water. Specific questions were dedicated to understanding the farmers' willingness to change/enlarge their cropping pattern and the role played by the farmers' associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017 by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 1.

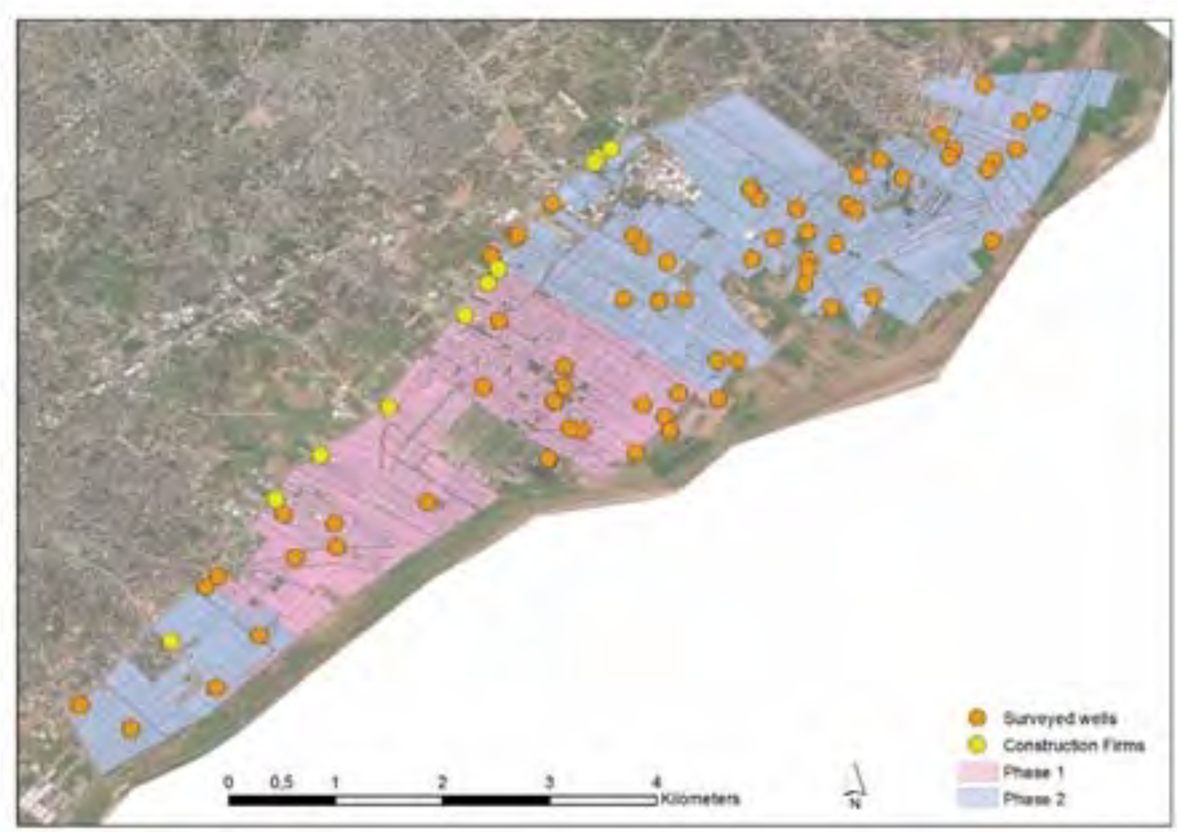


Figure 1: spatial location field survey

The survey resulted in the collection of **420 farm questionnaires**, **9 farm inputs questionnaires**, **11 industries questionnaires**. Next paragraphs summarize the results obtained from the analysis of the questionnaires.

1.3 Land Tenure and Cropping System

1.3.1 Farm size and land tenure

The Project area extends for 1,207 ha (12'068 du). As shown in Figure 2, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 donums are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

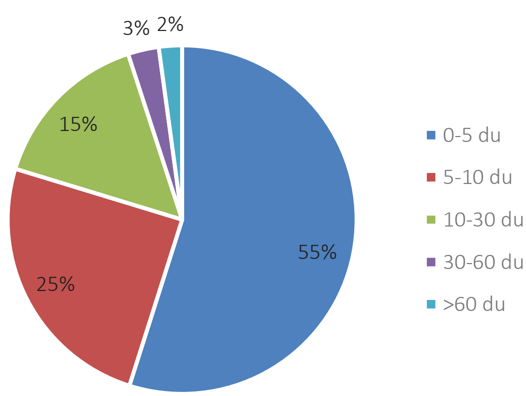


Figure 2. Distribution of farms by size.

1.3.2 Cropping System

The cropping pattern of the project area is resumed in Figure 3.

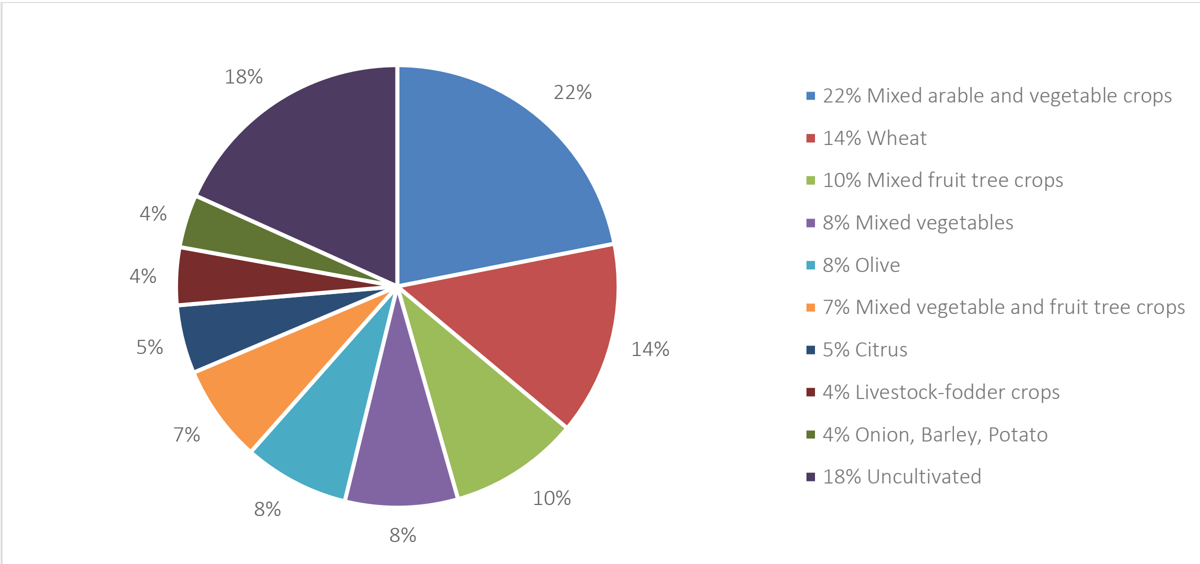


Figure 3. Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops; almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 5). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 5).

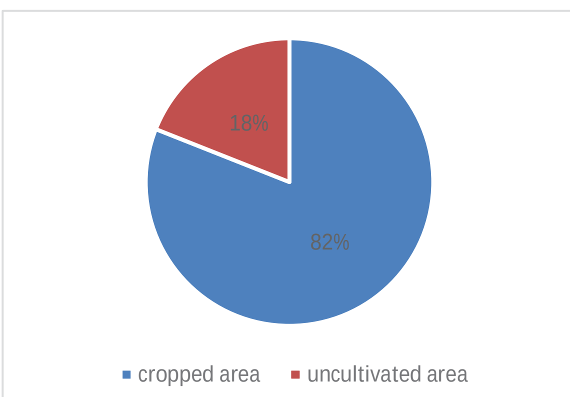


Figure 4. Cropped and uncultivated area.

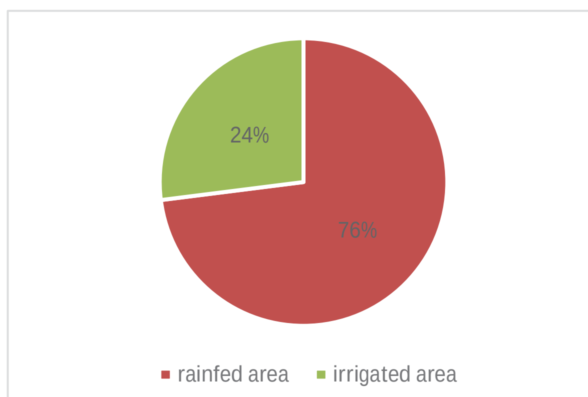


Figure 5. Irrigated and rainfed area.

1.4 Crop Water Requirements and Water Consumption in Agriculture

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well ("collective well") is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the "collective well" system owned by the remaining 8%.

Wells must be authorised by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also "non-legal" wells, estimated to be 5-6 times the number of the legal ones. The government does not close these wells but new unauthorised wells cannot be drilled.

The survey determined that water cost ranges from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

Figure 6 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

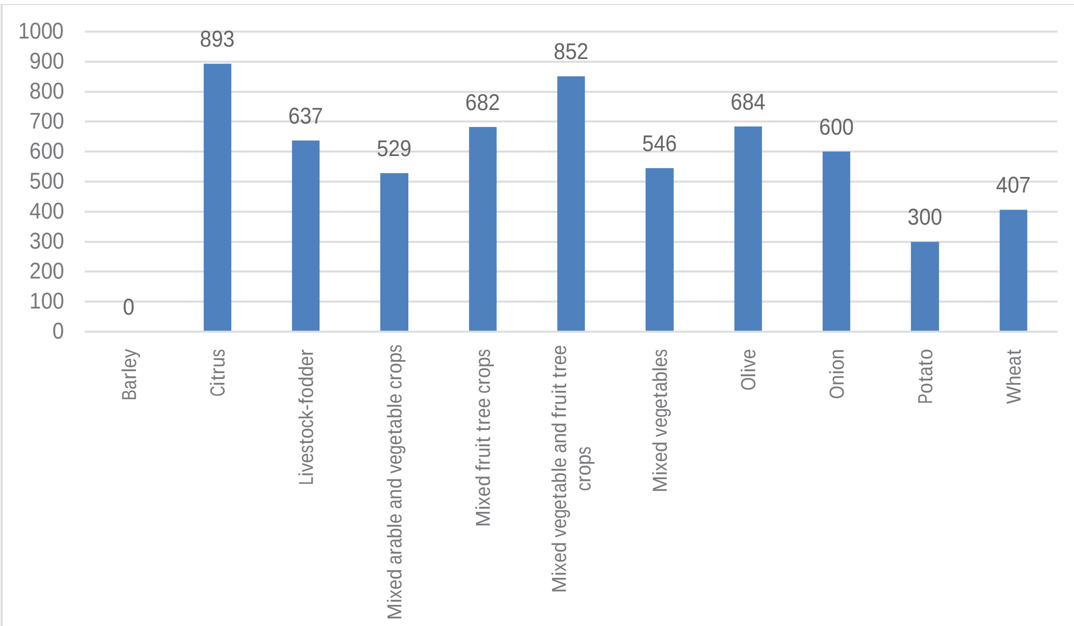


Figure 6. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m3/du); Barley is rainfed.

The **total crop water requirements** for the agriculture currently develloped across the whole 15,000 du is estimated to be **5.8 Mm^3/year** with an **average daily water requirement of 15,990 m^3/day**.

1.5 Causes of the Present Land Abandonment

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is represented by the frequent **land invasions from the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, and periodically sprays herbicides to keep the field clear, which kill the crops and make the farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out the cropping operations (23%); **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

1.6 Water Consumption in the Industries

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 1 their localisation): generally, most of them are small factories (less than 10 employees), operating only few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. The large majority (>80%) of them is using private wells for their water supply. Few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories gets their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

1.7 Value Chain

Interviews to the producers showed that the vast majority of the agricultural products is sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

Gaza Strip, for its high population density and urbanization connected to a production system reduced to a minimum because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

The market chain of horticultural and fruit products is as follows:

farmers → traders or intermediary (middle man) → retailers → consumers.

Next table summarises revenues, costs and margins for the different crops.

Table 1. Summary of the single accounts cultivation statements of agricultural products

Farm/Crops	Revenues	Cost	Margin	Net margin per kg	Net margin + LH[1] per kg
Apple	1,000	2,495	-1,495	-2.99	-2.81
Barley	655	1,630	-975	-2.02	-0.36
Citrus	3,494	3,172	322	0.19	0.52
Lemon	1,400	2,048	-648	-0.65	-0.33
Livestock	1,582	2,310	-728	-	-
Melon	2,400	2,401	-1	0	0.17
Mixed arable and vegetable crops	3,226	2,267	959	0.36	0.59
Mixed fruit tree crops	2,487	2,472	15	0.02	0.34
Mixed vegetables and tree crops	3,444	1,667	1,777	0.81	0.92
Mixed vegetables	3,407	3,061	346	0.11	0.33
Olive	806	2,376	-1,570	-2.92	-2.05
Onion	675	1,837	-1,162	-2.58	-0.58
Peach	1,000	1,055	-55	-0.11	0.07
Potato	2,500	1,656	844	0.34	0.50

[1] LH: Labour Harvesting

Farm/Crops	Revenues	Cost	Margin	Net margin per kg	Net margin + LH[1] per kg
Wheat	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

2 INTRODUCTION

2.1 Project's Background

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project initiated in 2004 and being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

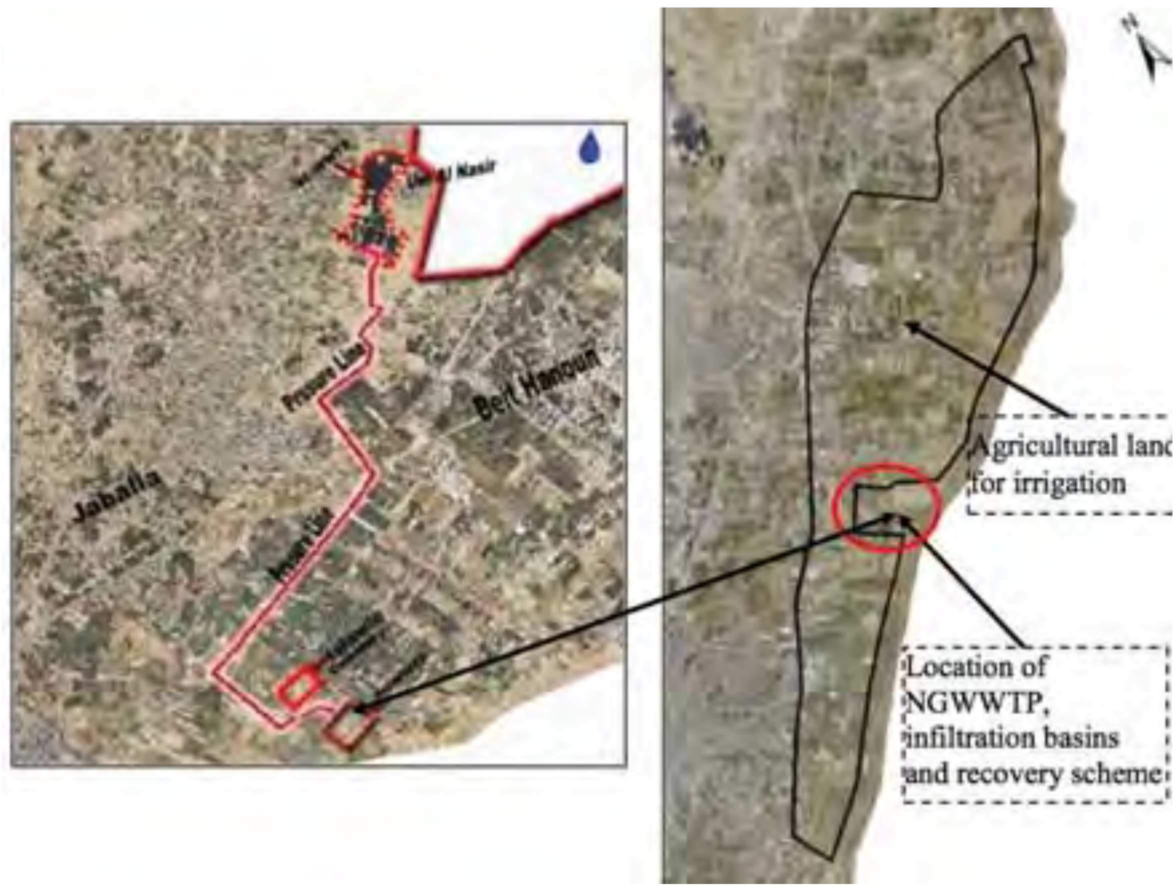


Figure 7: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the Plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

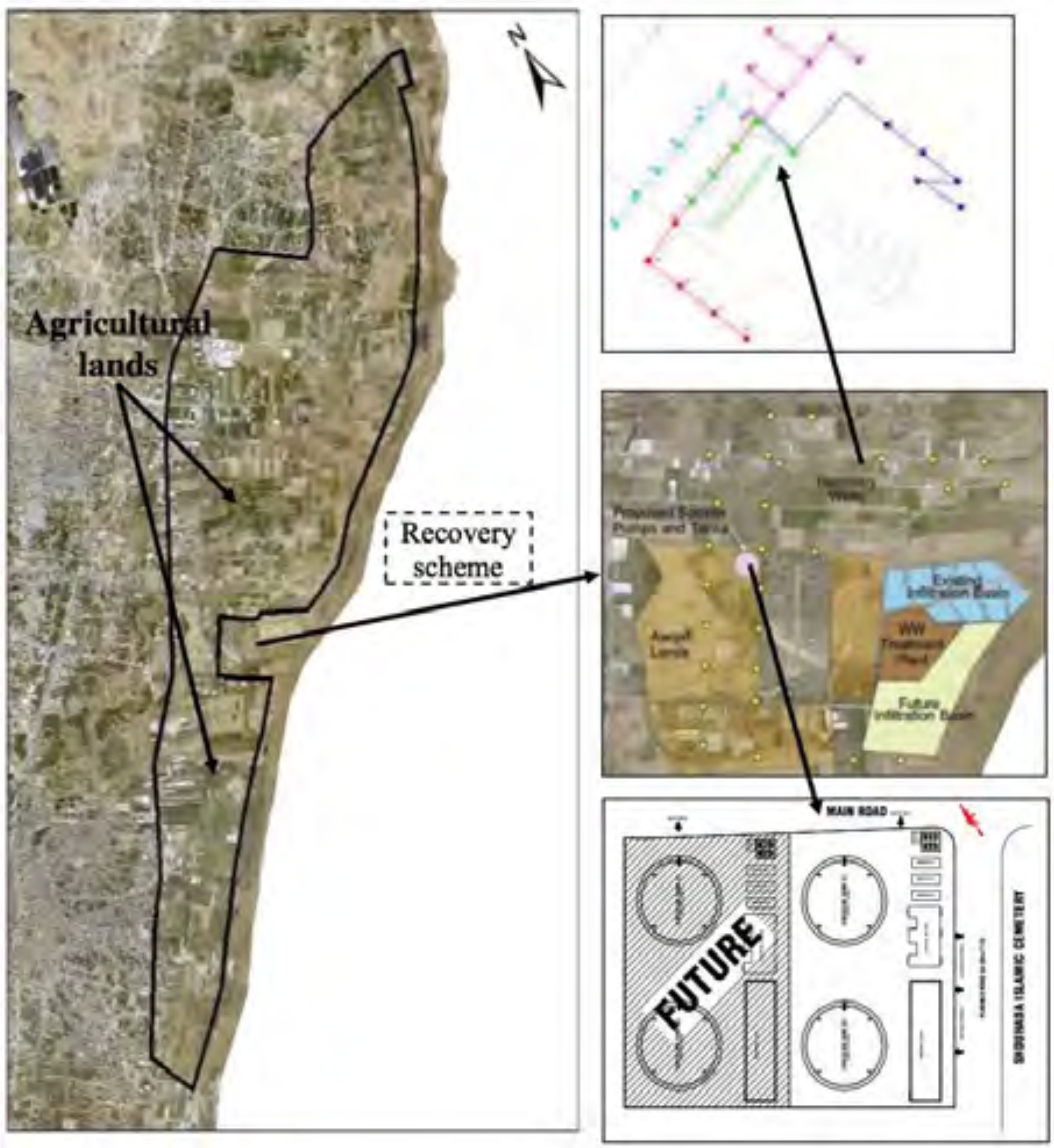


Figure 8: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, supplementary phase was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. This system is composed of a chain of 27 recovery wells surrounding the infiltration basins to capture the effluent after it passes through the effluent ponds, storage reservoirs and a distribution network for the reuse of the water in irrigated agriculture. The recovered effluent is expected to irrigate a gross area of 1,500 ha (15,000 du) of agricultural land located in the surroundings areas.

2.2 Project's Status

The original plan was to have all three phases of the NGEST project completed by the year 2015. Lack of funding and the political instability in the Region have delayed construction and the situation on the ground is, presently, as follows:

NGWWTP: The plant is 95% completed and construction is undergoing with the aim of starting operations by the end of 2017, and with the possibility to treat up to 35,600 m^3/day of waste water diverted from the Beit Lahia Wastewater Treatment Plant site.

Figure 9: Snapshot of a component of the NGWWTP as of March 2017

Water Recovery Scheme: Funding have been secured for the construction of 15 out of 27 recovery wells, 1 out of 2 storage tanks, none of the originally designed 5 recovery wells and all the collection pipes associated with the 10 recovery wells. Construction is presently undergoing and works are scheduled for completion by end of 2017.

Figure 10: Storage tank under construction in March 2017

Irrigation Scheme: The necessary funding has not been yet secured and the timing for the implementation of even a portion of the irrigation scheme is uncertain. Donors are awaiting the results of this 'Complementary Feasibility Study for Irrigation Project' to ascertain whether there exist the conditions for further financing the completion of the irrigation scheme.

3 PHYSICAL SETTINGS

3.1 Description of the Irrigation Project

A gross agriculture area, extending for approximately 1,570 ha (15,700 dunums[2]) in the immediate vicinity of the NGWWTP, has been proposed to benefit first from the recovered water and the treated sewage sludge. The component, known under the name of 'Supplementary Project' is subdivided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse (Irrigation) Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025.

3.1.1 Physical Components of the Recovery Scheme

The physical components of the recovery part of the scheme for the 35,600 m^3/day capacity included:

1. Recovery wells: a system of 27 groundwater recovery wells that will be able to capture the infiltrated water at the appropriate time and with the necessary quantity[3].
2. Collection pipes: Collection pipes are used to collect and transmit the recovered water from the recovery wells to water tanks.
3. Monitoring wells: 10 monitoring wells are used to observe the groundwater table and the groundwater quality status.

3.1.2 Physical Components of the Reuse (Irrigation) Scheme

The physical components of the reuse part of the scheme for the 35,600 m^3/day capacity include:

1. Water tanks: The recovered water from the wells is collected into two 4,000 m^3-water tanks that are in turn connected to a system of booster pumping station.
2. Booster pumping station and associated facilities: 2 booster pumping stations (5 pumps each) with a cumulative capacity of 6,000 m^3/hr are used to transmit the water from the tanks to the farms. The booster pumps will maintain a minimum pressure of 2.5 bars in the irrigation network at farm gates.
3. Irrigation distribution network: Water supply pipelines (trunk lines) are used for transmitting the water from the booster pumping station to the agricultural land. Water networks are used for irrigation the agricultural lands.

3.1.3 Agricultural Land and Irrigation Network

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 11. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire

[2] 1 dunum = 1000 m^2

[3] Indeed, to inverse the flow and artificially isolate the infiltrated wastewater underneath the infiltration basins from the aquifer, it is necessary to recover around 10% more than the quantity infiltrated, creating a depression, and then spread it in the area around through the irrigation scheme

project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 12.

In accordance with irrigation requirements, irrigation was to be carried out on a six-days rotation bases over six zones of almost equal sizes, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F as shown in the following Figure 12. According to the original design, each day only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water.

Figure 11: Location of agricultural land

Figure 12: Proposed Irrigation Zones

Ultimately, the original 2010 design evaluated three possible scenarios for project development (see Figure 13):

- Scenario I - the scenario was built on the assumption that, initially, no more than 16,500 m^3/day would have been recovered from the recovery wells and was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (15%) and grains (15%). The scenario assumed that the best location for planning orchards was the area located to the west of the project along Al Karama road and far away from the border with Israel. The profiles of the soils on the area are deep enough to cultivate tree crops. Based on crops water requirements, the available reclaimed water (16,500 m^3 daily) was barely sufficient to irrigate 5,375 du divided into citrus for 161.3 ha (1,613 du), olives for 1344.4 ha (1,344 du), fruit trees for 80.6 ha (806 du), alfalfa for 80.6 ha (806 du) and grains for 80.6 ha (806 du).

- **Scenario II** - like Scenario I, was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (15%) and grains (15%). This second scenario was built on the assumption that the NGWWT is operating more effectively than under Scenario I and more water (23,100 m^3/day) of better quality can be abstracted for irrigation. This reclaimed water will be used to irrigate addition land being 752.5 ha (7,525 du) in total. The citrus area will increase to 225.8 ha (2,258 du), whereas, olives to 188.1 ha (1,881 du), fruits to 112.9 ha (1,129 du), alfalfa to 112.9 ha (1,129 du) and grains to 112.9 ha (1,129 du).
- **Scenario III** - was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (10%), grains (10%) and vegetables (10%). This third scenario was built on the assumption that the NGWWT is operating at full capacity of 39,160 m^3/day (35,600 m^3/day plus 10% extra) and water can be produced for unrestricted use. The quantity of reclaimed water will be enough to irrigation about 12,577 du. The citrus area will increase to 377.3 ha (3,773 du), olives to 314.4 ha (3,144 du), fruit trees to 188.7 ha (1,887 du), and alfalfa and grains each will increase to 125.8 ha (1,258 du). At this scenario vegetable crops will be introduced with an area of 125.8 ha (1,258 du), as it might be difficult to convince the farmers to accept the use of the recovered water for cultivation of vegetables at the beginning of the project.

Planting tree crops adjacent to the political border should be avoided as much as possible due to the specific political issues in the region. By using the reclaimed water, more irrigation wells on the area will be closed and consequently the original groundwater will be increased and improved through yearly addition of rain water.

Figure 13: Proposed Scenarios for Irrigation Project Development according to the original design

Figure 14 shows the ultimate subdivision of the project into two construction Phases of 500 ha (Phase I) and 1,000 ha (Phase II) in size respectively. The layout of these two phases is different than the one originally sought under Part A and B as depicted in Figure 11 and yet, the idea behind the three scenarios for the project's development according to water availability and quality can be similarly applied to Phase I and II presently being considered.

Figure 14: Final subdivision of the project into Phase I (purple) and Phase II (blue)

3.1.4 Sites for Future Extensions

A future extension, designed to expand the use of the treated waste water to its full amount of 69,000 m^3/day, was originally projected to enter into operation by the year 2025 and would have included additional infiltration basins, water tanks, booster pumping stations and associated works, and agricultural land. Tentatively, the requirements for the future extensions were of the same order magnitude of those estimated for as for current phase effluent, since the increase in the effluent is almost equal to current design value of 35,600 m^3/day. The following are the proposed extensions.

3.1.4.1 Infiltration Basins

The original design completed in 2010 investigate infiltration basins and water recovery requirements that will allow 69,000 m^3/day overall infiltration of fully treated wastewater effluent by the design year 2025. The location of land for the new infiltration basins was identified considering prevailing soil conditions, relation with current facilities, e.g. infiltration basins and treatment plan, project components related to recovery scheme for the first phase, etc.

The proposed location for the extension of the infiltration basins for the 69,000 m^3/d effluent is positioned adjacent to the treatment plant in the south-eastern direction as shown in the following Figure 15. The identified location is also suitable for the recovery scheme where recovery wells will serve both existing and future infiltration basins. Also, the location is suitable from operational point of view since the operation team will be able to monitor and operate the whole facilities located in the area, i.e. infiltration basins, sewage treatment plant. The recovery wells, monitory wells and booster pumping station are also located near this location. Preliminary estimates show the need to allocated approximately 12 ha (120 dunums) for the future infiltration basins.

3.1.4.2 Water Tanks and Booster Pumping Station

Figure 15 shows the proposed location for water tanks, booster pumping stations and associated facilities. The proposed location, situated adjacent to the one currently under construction, presents many advantages.

3.1.4.3 Agricultural Land

The determination of the additional agricultural land of about 1,500 ha (15,000 du) is a difficult task considering the scarcity of land in the project area and in Gaza Strip in general. The only available land that can be used in the northern part of the Gaza Strip is located on the north-west side. Most of this land is being already used for agricultural purposes. This area also acts as a main source for groundwater recharge. Other possible agricultural lands may be in the southern part of Gaza Governorate and Middle Area Governorate as proposed for example in CAMP study[4]. However, a part of their far locations, these lands are reserved for other local reuse projects serving the concerned governorates.

Figure 15: Proposed plans for the full water re-use produced by the NGWWTP

[4] CAMP (2000) Integrated Aquifer Management Plan, Coastal Aquifer Management Program. Metcalf & Eddy in cooperation with the Palestinian Water Authority (PWA). United States Agency for International Development, May 2000

3.2 Climatic Conditions

The climate in the Occupied Palestinian Territory is predominantly of the eastern Mediterranean type with cool and rainy winters, hot dry summers and an annual rainfall in the range of 100-700 mm. The Territory is divided in five major zones based on several factors including climate, topography, soil types and farming systems. The one characterising the Gaza Strip is the "Coastal Plain". It has a rainfall of 200-400 mm/year. The soils are generally fertile and irrigated agriculture is substantially practiced using groundwater. However, overexploitation of the aquifer has led to extensive seawater intrusion and salinization of the water, especially in the southern part of the Strip.

The main rainfall season in the northern governorate, where the project area is localised, is from October to April. Average rainfall ranges from 0 mm in summer months to its maximum in December and January (Figure 16).

Table 2 shows rainfall, temperature, relative humidity, wind and sunshine hours for ten years (1997-2006), average values for the project area.

Figure 16: Average monthly temperature and rainfall for Gaza from 1900-2012. Source: The World Bank

Table 2: Climatic data of project area in average (1997-2006). Source: Meteorological Gaza Office

Month	Rainfall (mm)	Min Temp °C	Max Temp °C	Relative Humidity %	Wind (km/hr)	Sunshine (hours)
Jan	94.3	10.8	18.1	65	11.3	4.8
Feb	78.9	11	18.2	67	12.3	6.1
Mar	35.7	12.9	19.8	67	11.5	7.6
Apr	10.6	16.3	22.9	67	11.0	8.4
May	0.1	19	24.6	72	10.2	9.7
Jun	0	21.7	27.2	74	9.8	9.8
Jul	0	23.8	29.6	74	9.7	10.7
Aug	0	24.5	30.2	72	10.1	10.6
Sep	13.2	23	29	68	10.5	9.7
Oct	42.6	20.3	26.7	67	10.5	8.3
Nov	68.5	16.3	23.5	62	10.6	6.2
Dec	114.4	12.6	19.6	64	10.9	4.0
Average	38.2	17.7	24.1	68	10.7	8.0

3.3 Soil Conditions

3.3.1 Soil of the Project Area

Comprehensive study of the soils within the potential irrigation area is essential for economic and technical reasons. The high cost of development of irrigated agriculture requires justification by assessment of the risks and benefits, and the design of the irrigation scheme itself is dependent on detailed knowledge of the soils present within the irrigable area.

The following is a list of justifications for principal uses and reasons for soil study in irrigation investigations for this assignment:

1. Assure selecting productive soils for irrigation.
2. Assist with the irrigation networks location.
3. Determine irrigation needs of specific soil types.
4. Determine salinity leaching needs of specific soil types.
5. Assist with determining the farms sizes.
6. Assist in appraising land value to allocate the costs of development based on ability to pay;
7. Assist in determining the suitable crops for soils; as an aid in developing individual farm management needs, such as use of fertilizers, type of irrigation and/or leaching fraction, etc.
8. Identifying the non-suitable areas for food crops.

Besides reviewing the accessible published information on the soils of the northern area of Gaza Strip, a participatory and consultative approach was followed for executing this part of the assignment. A team of consultants visited the project area in March 2017. Meetings were also held during this survey with Ministry of Agriculture, Ministry of Health, Ministry of Environment, and local farmers, as part of public consultations.

3.3.2 Soil Textures

To characterize the soils in the project area, mapping was completed based on existing publicly available information. The information sources for the soil texture in the project area included the Ministry of Agriculture and national scale researches during the last couple of years, and based on soil texture classification adopted by the Soil Survey Staff of the United State Department of Agriculture USDA.

GPS location for samples used for this classification are presented in Figure 17.

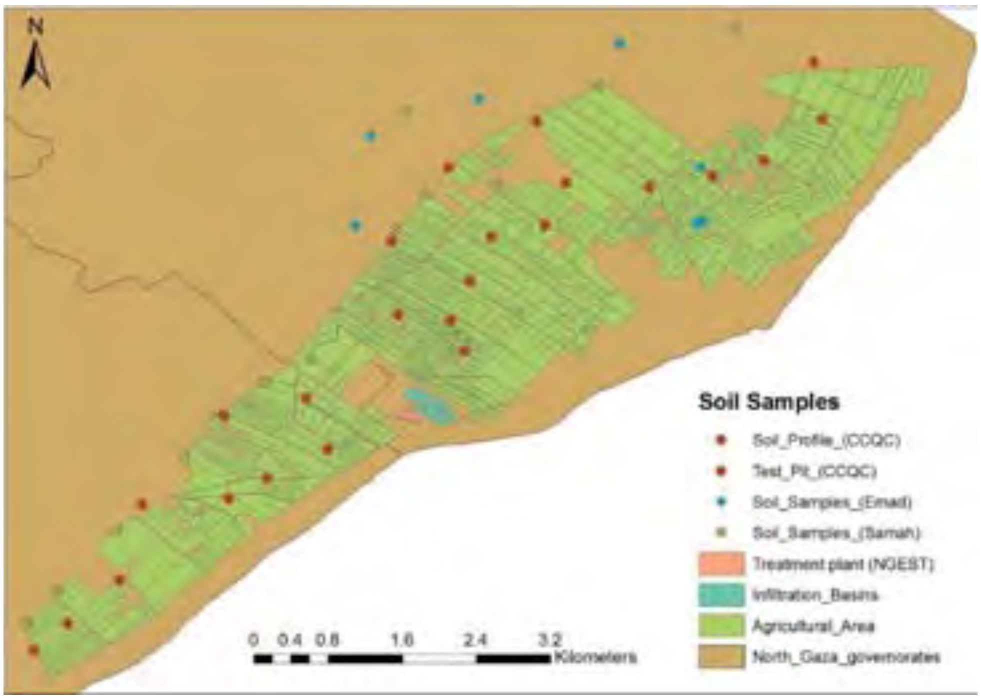


Figure 17: Locations of soil samples used for this study and the source for each sample.

The dominant soil type for the project area was found to be medium soil texture, as shown in Figure 18 .

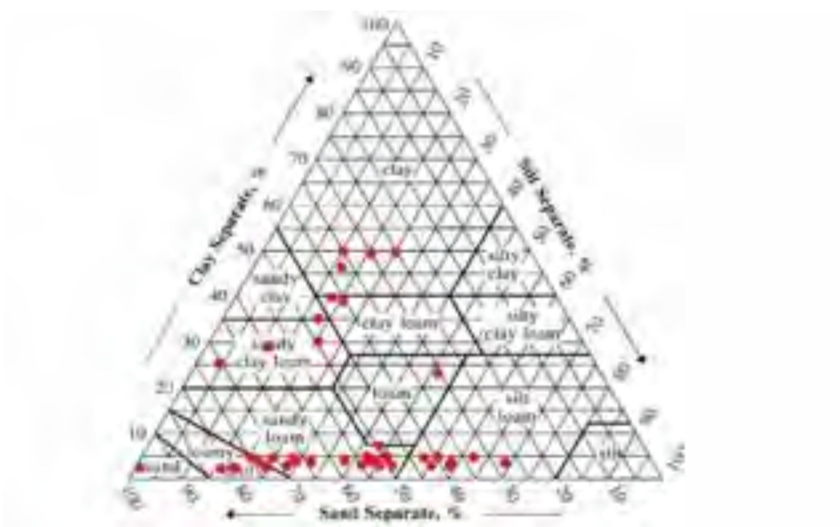


Figure 18: soil texture in the project area

Soil types that were observed in the Northern part of Gaza Strip generally have suitable characteristics for effluent irrigation. The dominated soils in the area are, in general, considered as soils with significant percentage of large sand particles and defined medium-textured soils (sandy loam, loam, sandy clay loam, clay loam, silt, silt loam, silty clay loam). They are characterized by moderate water infiltration and percolation, reasonable soil aeration, and sound water holding capacity, and lend to management practices designed to reduce soil salinity by leaching salts from the soil with applications of excess, low-salt irrigation water.

3.3.3 Soil Toxicity – Heavy Metals

During the last decade, Gaza strip was subjected to frequent escalation of hostilities and incursions. Accordingly, a significant environmental footprint has developed in Gaza strip. The last escalation of hostilities in Gaza (2014) is the most intense since the beginning of the Israeli occupation of 1967, surpassing the length and severity of the escalation of hostilities of 2008-2009. Israeli occupation forces used thousands of tons of ammunition (ARIJ 2014). According to the bomb disposal expert in the Palestinian Interior Ministry, about 20,000 ton of explosives were dropped on Gaza strip including 8,000 tons dropped by Israeli warplanes as well as 60,000 artillery shells of different sizes. As a result of using such massive amount of munitions, 7,473 craters were detected in agricultural and non-urbanized areas of Gaza strip. Taking into consideration the huge amount of ammunition was used, we can expect significant amount of toxic heavy metals will be introduced to the environment of Gaza including NGEST project area.

The heavy metal contamination of soil is one of the most pressing concerns in the debate about food security and food safety in Gaza Strip after these escalations. Recent research and investigation by Emad Abukrayem (2016)[5] summarizes the levels of heavy metals in 62 top soil samples including the NGEST project area as shown in Figure 17. The samples were collected in September 2014, immediately after the cease-fire of the last escalation of hostilities. The soil samples were collected from the targeted locations (targeted soil samples either by air force bombs or by artillery shells. Inside and surrounding the carters were considered during the sampling process. Table 3 summarizes the levels of heavy metals of the samples collected in NGEST project area during this study.

Unfortunately, Palestinian Authority has no approaches or thresholds to define risk levels associated with different concentrations of heavy metal in soil. The consultant chose the standards set in foreign and international legislation for contaminated soil.

Table 3: The levels of heavy metals in the project area compared to the threshold concentrations of heavy metals in contaminated soils by some countries.

Element	Emad (2016) [Average]	Germany	France	U. K	U.S.A.	Australia	Netherland
mg/kg dry soils							
Cd	0.91	3	20	3.5	2	-	12
Cu	15.635	100	100	140	45	60	190
Cr	19.973	100	150	600	212	50	380
Ni	11.32	50	50	35	31	60	210
Pb	7.761	100	100	550	68	-	580
Zn	25.854	300	300	280	50	200	720

[5] Emad Ali Mohammed Abukrayem, (2016), Soil and Rubble Pollution with Heavy Metals in the Gaza Strip. Ms.C Thesis, Al-Azhar University, Institute of Water and Environment.

Although military activities introduced metals to the targeted soils, the levels of metals in the targeted area in the project zone were found with concentrations lower than the threshold values of the contaminated soils in the international standards, as shown by Table 3.

1. **Zinc (Zn)**: Among the analyzed heavy metals, Zn had the highest average concentrations, up to 25 mg/kg in all the sampling sites. The natural background levels (the concentration of zinc in nature without the additional influence of human activities – anthropogenic emissions) in soil and rock vary over a wide range of concentrations. Background levels of zinc in soil and rock typically range between 10 and 300 mg/kg. Some characteristic features of Zinc include that the species typically considered to be the source of toxicity (bioavailable) is the uncomplex, free ion (Zn^{2+}). However, Zn commonly referred to worldwide as a "healthy metal," is the 27th most abundant, naturally occurring element in the Earth's crust. Agriculturally, Zn is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. Nevertheless, more important than the measured amount of zinc in the soil is the bioavailability of zinc to organisms. Bioavailability is known to be dependent on factors such as soil pH, organic matter content, and cation exchange capacity (CEC).
2. **Cadmium (Cd)**: Cd shows low concentration, up to 1 mg/kg; internationally, and in agricultural soils, concentrations of Cd from 0.005 to 2.4 mg/kg, with mean and median values of 0.27 and 0.20 mg/kg, have been reported. However, among anthropogenic input of Cd to soils are sewage sludge, manure and phosphate fertilizer application.
3. **Chromium (Cr):** The level of Cr in the project area is considered low as compared to the threshold values of a contaminated soil. It is the seventh most abundant available element in the earth's crust, with an average concentration of 100mg/kg. Although it has been well established that Cr(III) is essential to animal nutrition, the essentiality of chromium to plants has yet to be determined. Detectable concentrations of chromium are found in plants, and there is some evidence that Cr(III) has stimulatory effects on plant growth and yield. The concentrations vary considerably between different plant species, plant tissues, and soil types. Levels in shoots of plants grown on uncontaminated soil usually do not exceed 0.5 mg/kg. Whole plant concentrations mg/kg indicate possible contamination and/or increased accumulation. There are reported cases of plants growing on serpentine soils that accumulated tissue chromium concentrations as high as 100 mg/kg, but plants rarely exceed this value.
4. **Lead (Pb):** The data presented by Table 3 reveal insignificant amounts of Pb in the project area. In general, plants do not uptake or accumulate lead. However, in soils with high lead concentration, it is possible for some lead to be taken up. Studies have shown that lead does not readily accumulate in the fruiting parts of vegetable and fruit crops (e.g., corn, beans, squash, tomatoes, strawberries, and apples). Higher concentrations are more likely to be found in leafy vegetables (e.g., lettuce) and on the surface of root crops (e.g., carrots). Since plants do not take up large quantities of soil lead, the lead levels in soil considered safe for plants will be much higher than soil lead levels where eating of soil is a concern (pica). Commonly, it has been considered safe to use orchard produce grown in soils with total lead levels less than 300 mg/kg. The risk of lead poisoning through the food chain increases as the soil lead level rises above this concentration. Even at soil levels above 300 mg/kg, most of the risk is from lead contaminated soil or dust deposits on the plants rather than from uptake of lead by the plant.
5. **Nickel (Ni):** Ni content in soils varies widely and have been estimated to range from 3 to 1000 mg/kg; for the world soils, the average range is between 0.2 and 450 mg/kg, while the grand mean is calculated to be 22 mg/kg. It is reported an average concentration of 86 mg/kg for the natural nickel content in the earth's crust. Nickel Ni is not an important element for plant growth and development, but it is an essential micronutrient required for the growth of higher plants. Nickel is often uptake by

plants, and accumulates readily in plant leaves and seeds, thus, it is having a high potential to enter the food chain. Therefore, the uptake of nickel by plants is related to its toxicity, which may have possible implications with respect to humans and animals through the food chain. The benefits of Ni in soil includes its contribution to nitrogen fixation and the metabolism of urea (a nitrogen containing compound) and is important for seed germination. Nickel is also important for bacteria and fungi, which are both important for good plant growth. For healthy and productive soil the concentration of 1-20 mg/kg is considered ideal. Besides, excess nickel can impede the uptake of other essential nutrients, especially iron. It can also inhibit seed germination as well as shoot and root growth. Photosynthesis is impeded by excessive concentrations of nickel and flowers are often deformed under these conditions. Affected leaves may show signs of chlorosis and/or necrosis but this is not always the case.

6. **Copper (Cu):** The amount of Cu in the project area is considered uncountable comparing to the levels of contaminated soils. Besides, available Cu can vary from 1 to 200 mg/kg in both mineral and organic soils as a function of soil pH and soil texture. The finer-textured mineral soils generally contain the highest amounts of Cu. The lowest concentrations are associated with the organic or peat soils. Although soil rarely produces excessive amounts of copper on its own, copper toxicity can occur from the repeated use of fungicides that contain copper. Copper toxicity plants appear stunted, are usually bluish in color, and eventually turn yellow or brown. Toxic copper levels reduce seed germination, plant vigor, and iron intake. Neutralizing copper soil toxicity is extremely difficult once the problem occurs. Copper has low solubility, which enables it to persist in the soil for years. At the same time, Cu is considered as an essential element for plant growth. Most plants contain about 8 to 20 mg/kg dry matter. Without adequate copper, plants will fail to grow properly. Therefore, maintaining fair amounts of Cu for agriculture is important.

Generally, and based on published data, no countable levels of heavy metals are detected in the project area, that may cause soil toxicity. Besides, the most of pH values ranges from 7.2 to 7.8 in the project area top soil and have higher likelihood for plant nutrient availability. This is considered as a good and suitable for most common crops cultivated in the project area.

4 FIELD SURVEY AND QUESTIONNAIRE

4.1 Field Survey Framework and the Questionnaire

The field survey had the aim to investigate the characteristics of the farming system existing in the whole project area, namely the areas targeted by phase 1 and phase 2 of the project.

A questionnaire has been developed and submitted to the actors of the supply chain, such as farmers (individual and associated), wholesalers, food retailers, vendors of farm inputs and local and international institutions dealing with agricultural development.

The questionnaire (see Annex 1) enquired about the farm cropping system, i.e. crops grown and yields, area of the farm and plots, quality/quantity and costs of the agrochemicals applied in the farm, use and cost of machinery. Farmers were also asked about their market channels, the prices they fetch when they sell the agricultural products, whether the latter are sold as fresh or to processors, and what is their ultimate income. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

A special focus has been given to the water issue, through enquiring about the current use of water on the specific crops, the irrigation methods utilised and the source and cost of the water. The farmers' willingness to change/enlarge their cropping pattern, in case they would be provided with more water, has been also investigated. Specific questions were dedicated to understanding the technical/economic role played by the farmers' associations operating in the project area.

A team, comprising local technical surveyors and international experts, was set up to carry out the field survey following a methodology which, prior to full implementation, was tested in coordination with PWA.

4.2 Field Survey Methodology and Quality Control

The overall baseline assessment aims at providing the basic information necessary to understand:

- The farming activity in the project area and the conditions needed for the agriculture sector to flourish.
- The economic justification of the project.

Central to the preparation of the baseline assessment is a comprehensive field survey the implementation of which has been carried out in two phases namely Stage I, office studies, and Stage II, field reconnaissance.

4.2.1 Stage I: Office studies

Desk work was performed in parallel to the field activities by the following steps:

Problem Definition: First, the problem to be studied was defined precisely by statements indicating the nature of the problem.

Identifying Objectives: Objectives and purposes of the survey were outlined and in accordance to the term of reference for this assignment, suitable tools of acquisition of data and methods of analysis were chosen.

Scope of the field survey: The scope of survey was defined using ArcGIS software. The Consultant has performed an estimation for the spatial location of the surveyed parcels by making circles (shape file with no regard to circular area) to highlight the spatial distribution of surveyed samples depending on the location of agricultural wells. This shape file contains in the attribute table statistics about parcels number and total area around each surveyed agricultural well. These estimates make it possible to determine where new samples are needed to be representative and to cover all the study area,

Identifying tools and techniques for data collection: The consultant adopted the following tools and techniques in order to collect the required data (see following Figure 19)

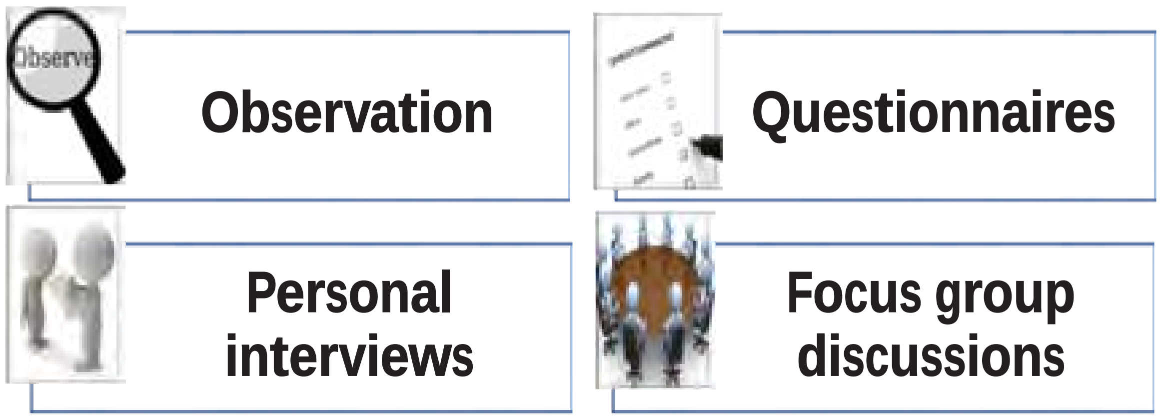


Figure 19: Tools and techniques for field survey

- **Observation:** the consultant conducted a pilot visit for a random sample of farmers to observe the study area characteristics and the existing situation of their practices.
- **Questionnaires:** the consultant designed a questionnaire to meet the required output of the study and reflect the main changes after 2014 war. The designed questionnaire was simple and depend on multiple choice questions which will be used easily for socio-economic statistical analysis.
- **Personal interviews:** Question and Answer (Q&A) sessions was conducted to receive a specific information related to the socio-economic situation and the value chain analysis, these interviews are integrated between structured and unstructured interviews.
- **Focus group discussions:** The groups consisted of 12-15 persons. The evidence resulting from the focus group discussion is characterized by the deep understanding of the perspective of the farmers about the project especially for farmers who are sharing the same well.

Compilation and Computation: Information collected was organized further meaningful interpretation and analysis to achieve the set objectives. Similarly, questionnaire and schedule based information area tabulated on the spreadsheet.

Bridging gaps approach: The consultant adopted bridging gaps approach by dividing the collection period into three separate stages, at the end of each stage a spatial allocation of the covered areas. For example; surveyed samples were performed to ensure that these samples are representative and cover all the study area. By the end of the second stage, the estimation for the spatial location of the surveyed parcels was as shown in Figure 20.

Figure 20: the spatial location of the surveyed parcels by the end of Stage (2)

Comprehensive check: by performing comprehensive check, the consultant noticed that phase (1) of the project area, marked by blue colour, was not duly covered so he decided to conduct additional survey (stage 3) to fill the gaps. The final distribution of farmers interviewed around each well is shown in Figure 21.

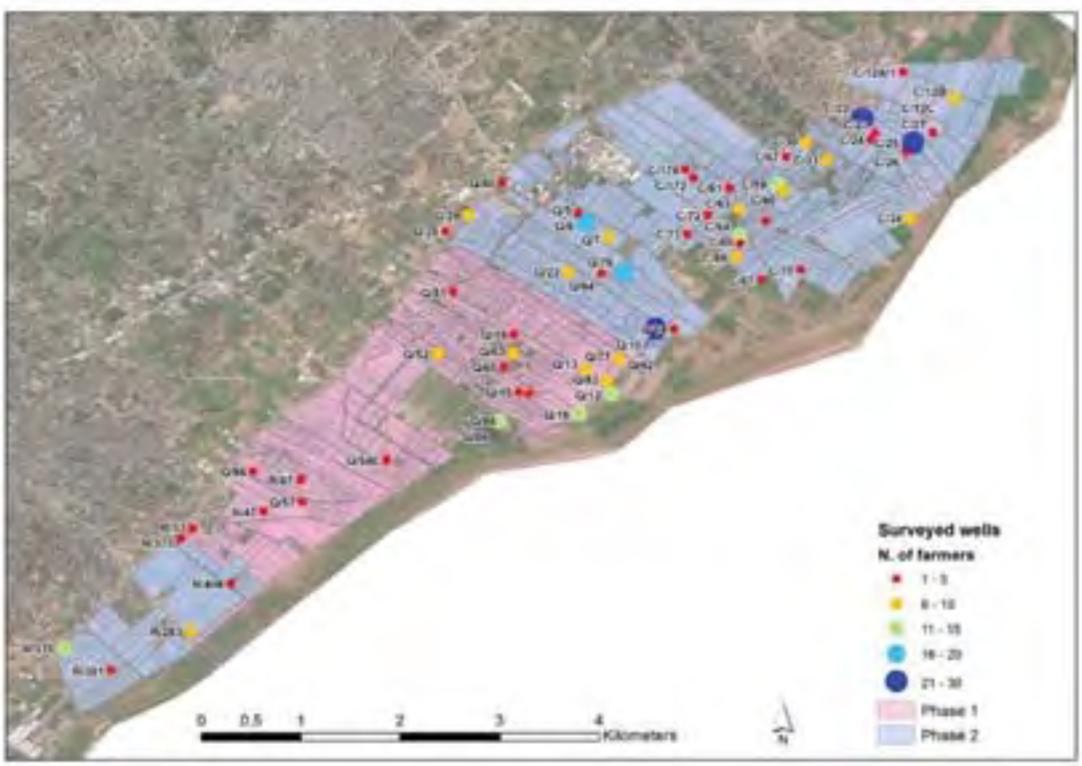


Figure 21: the spatial location of the additional survey (stage 3)

4.2.2 Stage II: Field Reconnaissance

The field survey started in 18 February 2017 and ended in the 28 March 2017. It aimed to investigate four different target groups: farms, industrial firms, seeds and nursery shops, the local market available within the project area.

Figure 22: Survey target groups

The consultant depended on the agricultural wells database provided by the Ministry of Agriculture (MoA) as a starting point for the field survey.

4.2.3 Farms Visits

The field survey recalled the help of the ministry of agriculture facilitator to organize their visits along the task period, as he is familiar with the study area and well-known in the northern governorate's farmers. The surveyors adopted various data collection and questionnaires filling methods to assure high quality input, using:

- Face- to-face interviews for farmers who are using private wells.
- Focus groups interviews for farmers who are sharing collective well.
- Group discussions with farmers regarding changing crops, water quality used for irrigation, etc.
- Taking notes for the farm's boundaries using GPS and locate them on the GIS map to check the changes of lands ownership (the results were satisfactory; there are almost no changes in the ownership after 2014).

The field survey team initiated their task through filling pilot questionnaires in 25 January 2017 with the farmers in order to update the questionnaire tools to be suitable with the study area context. The piloting phase led to number of changes and additions for the original questionnaire version to be more suitable for the study area characteristics as follows:

- Number of the famer works varies along the whole year based on the harvesting times/cultivation period, not based on the season.

- Ownership changes since 2014 and Waqf ownership were added to the types of the ownership.
- The water wells details section was added (legal/illegal, XY coordinates).
- Water sources fees section was added.
- Details for the soil texture of the land (type, %).
- Soil Improvements section was added.

The team started to cover the collective wells as it able the surveyor to meet and discuss wide range of farmers in the same time, give more flexibility and accreditation to expand and investigate the general situation of the farmers in the study area. The total number of the farmers collected data was around 420. The team assured the selection of farms with different characteristics (small /large farm, farm with/without livestock, rainfall/irrigated crops, etc.)

In advanced stages of the surveying task, after filling around 200 questionnaires, it was noticed that some important issues required more clarifications, like the following:

- The cost of olive milling, the percentage of oil delivers from olive.
- Adding separate cultivation details for each crop as each crop has its own requirements.
- The soil texture was omitted, as data received from farmers regarding it were inaccurate. Besides, the solid texture of Gaza Strip lands does not make significant difference regarding water quantities consumption.

Limitations

The surveying team faced many obstacles while filling the questionnaires that can be summarized as follows:

- The beginning of data collection phase was during the rainy season that led to difficulties in gathering farmers and talking to them.
- Surveyors had to visit each farmer in his land or house to get his farm data: it was particularly difficult to reach remote and off-road farms.
- Many of the land owners were located close to the Israeli border where movements are restricted.

4.2.4 Industrial Firms Visits

On 4 March 2017, the field surveyors made exploratory visit for the industrial zone, within the project area, in order to locate the relevant target industrial firms (construction firms). The total number of construction firms located in the study area was identified as 14, and the surveyors managed to evaluate 11 firms in the agreed timeframe and upon the availability of the construction firms' administrative employee. The construction firms were block and/or concrete factories. The location of each firm was registered using GPS for further analysis related to the firm's site.

4.2.5 Seeds and Nursery Shops Visits

On 5 March 2017, a number of interviews was conducted with seeds and nursery shops to evaluate prices, types, quality of their products. The total number of interviews was: 5 seed, pesticides and fertilizers shops and 4 nursery shops located in different governorates in Gaza Strip to assure more accurate and representative data. The collected data showed a mass variation in prices which was processed later by the analysis team. It was noticeable that most of the visited shops' owners were with a scientific background (agronomist/pharmacists, etc.), which eased the collection process.

4.2.6 Local Market Visits

On 1 March 2017, the agricultural economists accompanied by the field surveyors interviewed local market shops owners (Souq ALZawia), to investigate the agricultural products' prices for the direct customer, the cost of buying these goods from its source (local farmers/ imported). Also, the team interviewed wholesale trader to understand the exporting and importing patterns of Gaza Strip. The process was smooth and very informative regarding the type of products exported and imported in Gaza Strip, the consumption of the local market and the restrictions and policies over the exporting and importing process.

4.2.7 Quality Control Process

Qualitative and quantitative answers provided by the respondents to the topics raised by the questionnaire have been carefully analysed by the consultant in order to identify and discard inconsistencies and unreliable figures. In particular, the collected economic data have been checked against the statistics of the region as provided in agricultural studies carried out by UN Organisations and the World Bank.

5 INDUSTRIAL ZONES

5.1 Present Conditions

5.1.1 Description of Existing Infrastructures

Nowadays there are no large industrial facilities (chemical plants, cement factories, etc.) consuming high volumes of water in Gaza and in the Project areas. Generally, most industries are just small factories and they use the urban water supply network as their sole source of water. Within the project's area, the few existing cement and block factories are using groundwater. Many of these industries are billed as conventional customers (as are many shops). The water operators in Ramallah and Nablus estimate that these small industries use 3% of the total urban water supply[6].

At country level, 3% of urban water equates to 3.1 Mm^3/year in the West Bank and 3.0 Mm^3/year in Gaza (source: PWA's Water Strategy for the year 2013). In the Project area, there are currently 14 industries extending over a total area of approximately 5 ha (50 du) and using, on average, around 2,000 m^3 of water per year. The large majority (>80%) of the existing farms are using private wells for their water supply. Few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories gets their water solely from the municipal water system. With few exception, most of the exiting factories are small and have less than 10 employees.

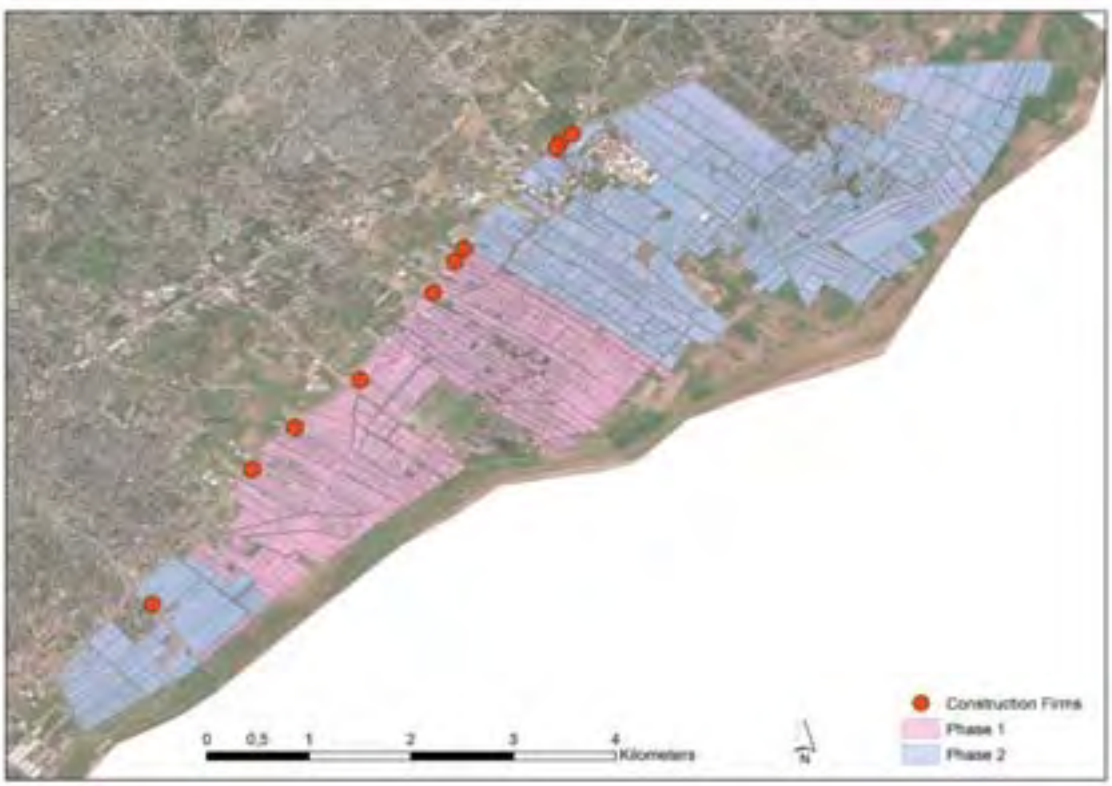


Figure 23: Location of the existing factories within the Project's area

[6] This figure seems rather low, but it is like what is observed in similar countries: Jordan (3%), Israel (5.7%) and Lebanon (11%).

5.1.2 Water Rights

Almost all of the privately-owned wells used in the industrial sector are registered as irrigation wells, as PWA has not issued abstraction rights for industry wells. According to PWA estimations, this industrial consumption is very low, as farmers already struggle to find sufficient water to irrigate their land and are thus unwilling to resell this water to industry.

The average cost of water in the project area is 1.35 ILS/m^3 with some factories paying as low as 0,4 ILS/m^3 and some other paying as high as 4 ILS/m^3.

5.1.3 Water Utilization

The 14 existing factories located within the project area consume less than 30,000 m^3 of water per year. Most of the factories operate only few days a week whereas a few works few days per month. Furthermore, most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

5.2 Future Conditions

5.2.1 Future Development Plans

The fact that Gaza uses only 3% of the municipal water in the industry can be explained by the constraints that industry itself has been facing over the past 40 years (difficulties in accessing the land, markets, suppliers, etc.).

Once the political constraints have been removed, the market opportunities for Palestinian industries will increase and more investors will venture to develop small factories. Nevertheless, heavy industry requiring huge amounts of water (paper, chemical, mining, etc.) will still be constrained by the limited water resources available in the Middle East.

According to PWA' 2013 Water Strategy, the long-term plan is based on the following hypotheses:

- the demand for water for industry will rise from 3% of urban water supply to 7%. Future conditions assume that industries need to be provided an opportunity for development. The plan is based on a significant increase in industrial water supply (10% of domestic water demand). The idea is that if water can be accessed more easily, the Government will be able to promote larger investments in the sector and favor jobs creation;
- most of these industrial plants will be supplied water provided by Regional Water Utilities;
- Wherever possible, the treated waste water will be a source to meet the demand for water in some industries or PWA may authorize the use of private wells for industry, on a case-to-case basis, in accordance with the National Water Policy[7].

[7] Policy statement: "*It is the National Policy of Palestine to allocate water rights for economic benefit (agriculture, industry, tourism...) between different users according to economic benefits to Palestine (in terms of revenue, job creation and food security) and in agreement with national development plans. in order to preserve the limited resources available for agriculture*".

Table 4: Baseline and Future Demand for both Domestic and Industrial needs in Gaza (source: PWA's 2013 Water Strategy)

	Industry Share	Production for Domestic [Mm^3/year]	Industry Share
Present Conditions	3%	104	3,1
Long-Term Conditions	7%	131,5	9,2

Table 5: Production/Import needs in the Gaza Strip (Source: PWA's 2013 Water Strategy)

Gaza Strip Water Supply		Baseline	Short-Term Action Plan	Long-Term Strategy		
		2012	2012-2017	2017-2022	2022-2027	2027-2032
Production Needs	UFW (%)	42,0%	36,5%	31,0%	25,5%	20,0%
	Production Needs [Mm^3/year	102	113	134	151	176
	Groundwater Abstraction (Mm^3/year)	93	48	50	37	33
	From Springs (Mm^3/year)	0	0	0	0	0
	From Wells (Mm^3/year)	93	48	50	37	33
	Desalination (Mm^3/year)	4,0	55	70	100	129
	Import (Mm^3/year)	5	10	14	14	14

6 The Structure of the Agricultural System

6.1 Farm Types and Cropping Patterns

6.1.1 Farm size and land tenure

The survey carried out during the months of March 2017 shows that nearly 55% of the farms are smaller than 5 du (see following Table 6). The project area extends for 1'207 ha (12'068 du).

Table 6: distribution of farms by size

Size of farms (du) %	No.of farms	%
0-5	230	55%
5.1-10	104	25%
10.1-30	64	15%
30.1-60	12	3%
>60	9	2%
Area of the smallest farm	0.5	
Area of the largest farm	400	

About land tenure, the survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

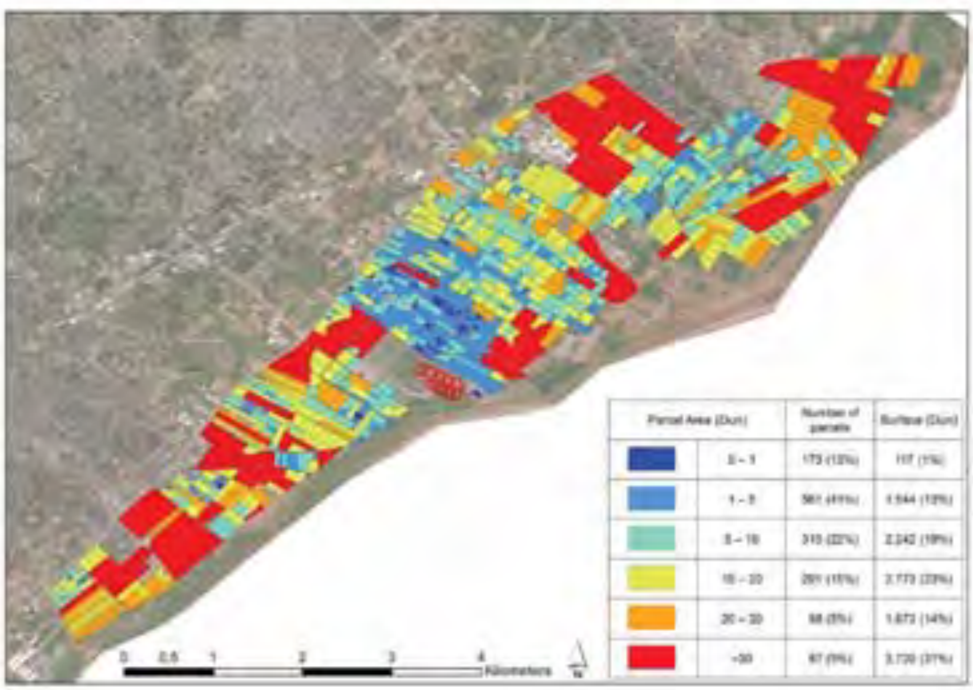


Figure 24: Land distribution and ownership within the project's area

6.1.2 Cropping System

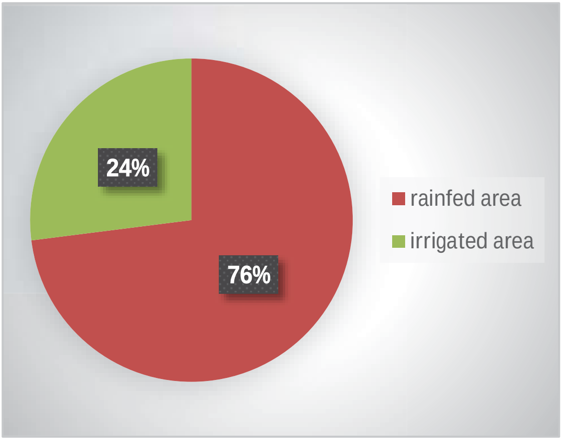
The identified cropping pattern in the project area is shown in Table 7.

Table 7: Indicative cropping pattern of the project area

Crops and crop groups	%
Mixed arable and vegetable crops	21.91
Wheat	14.16
Mixed fruit tree crops	9.50
Olive	7.71
Mixed vegetable and fruit tree crops	7.10
Mixed vegetables	8.25
Livestock-fodder crops	4.22
Citrus	5.00
Onion	2.30
Barley	1.03
Potato	0.55
Uncultivated	18.27
Total	100

Furthermore, some of the key results of the survey are:

- Around 24% of total cultivable land is rain fed, while the reminder 76% is being irrigated through private wells (see Figure 25);
- Around 18% of total cultivable land was not cropped at the time of the survey, due to several reasons which are explained in chapter 4.3 (see Figure 25);
- Almost half of total farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops (perennials). Among the latter, citrus and olive play the most important role. Arable crops, such as wheat and barley, are also quite important as staple food for the household and can – for a certain extent – offer acceptable yields under rain fed conditions too (although wheat is also irrigated);
- The vast majority of the agricultural products is sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. A minor part of products can be also exported in the West Bank and Israel, depending on the market demand. However, the government allows export of fresh products only when domestic needs are satisfied, namely only production in excess (as reflected by low market price) can leave the Gaza Strip;
- At present, the few food industries operating in the area do not usually purchase the farmers' products;
- Sheep and dairy cows represent the main livestock in project area. Rearing structures and fodder crops (mostly clover Berseem) takes about 4% of the area. However, sheep are often left grazing on uncultivated land;



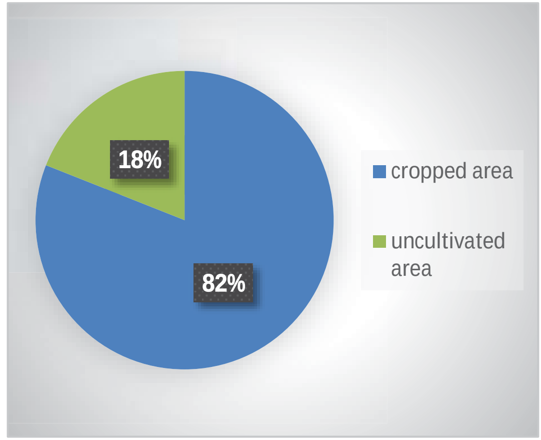


Figure 25: Rain fed and irrigated shares out of total cultivable land (L) and cropped and uncultivated land within the project area (R)

- The interviewed farmers stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.


Figure 26: Harvest of lemons (L) and mixed arable and fruit tree crops (R)

Figure 27: Typical mixed cropping system including trees and vegetables

Figure 28: Sheep in the project area bordering with Gaza City. Besides growing Berseem as fodder, farmers leave livestock grazing on uncultivated land

Figure 29: Uncultivated plot, left abandoned between agricultural fields

6.2 Water Use in Agriculture

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – from which the definition of “collective well”. Namely, a farmer owns one well and other neighbouring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The survey shows that 92% of the farmers depend on the “collective well” system owned by the remaining 8%.

Interestingly, the farmers using a collective well do not sign any formal agreement, neither they are linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmer do not pay his share in due time, thus undermining the efficient operation of the well.

According to the MoA, in the project area there is no water shortage, the water quality is satisfactory for irrigation but water extraction is expensive because of the high fuel cost (to feed the diesel pumps). The survey found that water cost ranges from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

Wells must be authorised by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However there are also “non-legal” wells, estimated to be 5-6 times the number of the legal ones. These wells are generally tolerated by the authorities. Namely, the government does not close these wells but new unauthorised wells cannot be drilled. Furthermore, the owners of “illegal” wells do not receive funds to rehabilitate their wells in case of damage/total destruction by the Israelis army (in 2014 Israel destroyed about 800 wells).

Table 8 shows the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers. These figures are compared with the theoretical ones estimated by the "Special Report Concerning Irrigation Scheme" (June 2010), carried out by the Joint Venture Association of the Center for Engineering and Planning (CEP) and the FCG International Ltd. It is noted that the figures for fruit trees and olive are not so different, but vegetables and citrus show to be quite under watered in the actual farming system with respect to the estimated crop requirements.

Table 8: Water use for the current cropping pattern

		Water amount supplied to crops as provided by the survey	Gross irrigation water demand as calculated by previous study[8]
Crops and crop groups	%	m^3/du	m^3/du
Mixed arable and vegetable crops	21.91	529	N/A
Wheat	14.16	407	803
Mixed fruit tree crops	9.50	682	768
Olive	7.71	684	628
Mixed vegetable and fruit tree crops	7.10	852	N/A
Mixed vegetables	8.25	546	1,353
Livestock-fodder	4.22	637	
Citrus	5.00	893	1,140
Onion	2.30	600	N/A
Barley	1.03	0	N/A
Potato	0.55	300	N/A
Uncultivated	18.27	N/A	
Total	100		

Finally, the crop water requirements for the entire project area, 15'000 du, is estimated to be 5.8 Mm^3/year with an average daily water requirement of 15'990 m^3/day.

6.3 Causes of the Present Land Abandonment

As indicated in Figure 25, 18% of total project area is currently not cultivated.

The main reason for land abandonment is represented by the frequent land invasions from the Israeli army, which destroys agricultural structures and plantations, as reported by more than 45% of the respondents. The proximity of the fields to the border with Israel is also a concern for 14% of the interviewed farmers. It should be also noted that the Israeli army periodically sprays herbicides by airplane along the border, to keep clear the fields. However, the herbicides are transported on the closest cultivated fields of the Gaza farmers, which kills the crops and makes the farming conditions unhealthy. This is an additional reason for concern for the farmers.

[8] Leaching requirements are included in the figures.

Thus, for most the farmers in the project area Israel's aggressive behaviour is the principal cause of non-cultivation of part of their land.

The second reason in order of importance is the lack of financial resources needed to carry out the cropping operations (23%), while water scarcity is the third reason (17% of respondents). When the high cost of water extraction is considered, it appears that the two causes are strongly linked in determining land abandonment.

7 FARMS ECONOMY

7.1 Economic Analysis of the Present Condition

In order to realise the study on costs and revenues for the individual crops, the consultant has prepared the Questionnaire number 1 (see annex), that collects the costs and revenues elements per single culture. 420 questionnaires were administered in three consecutive steps between February and March 2017.

As already specified in the quality control process explanation, careful examination of Questionnaire 1 results has led not to take into account some data due to misspelling or because the figures were statistically too different from those indicated in economic studies conducted in the area.

The questionnaires are subdivided into 15 groups, characterized by production sector, respectively:

(1) Mixed Vegetables; (2) Citrus; (3) Olive; (4) Mixed arable and vegetables crops; (5) Mixed fruit tree crops; (6) Mixed vegetable and fruit tree crops; (7) Lemon; (8) Wheat; (9) Barley; (10) Melon; (11) Apple; (12) Potato; (13) Onion; (14) Peach; (15) Livestock and mixed crops.

By referring to Gaza market information, the economic margin of these activities was completed. According to farming accounting rules, revenues include only the market-oriented products, as cereals, etc. The crops used for the feeding of sheep and cows have been processed as the meat production costs. After the aggregating phase, every production sector group has been analysed, carrying out a subsequent screening.

For each crop, two values were calculated:

i. the margin, that is the difference between gross revenues and direct costs, and represents the enterprise margin

ii. Labor & enterprise, which is the sum of the margin and the harvesting labor, which is a good economic indicator of the crop social impact: this value takes into account the work done by the entrepreneur and the labor required for the harvest.

7.1.1 Mixed Vegetables

This group includes all farms producing various types of vegetables. Vegetables normally have a high-water consumption because the root system is close to the surface of the soil. The high-water consumption also comports a high cost of water, the highest in all tested crops. Despite this, the vegetables can produce a positive margin.

Table 9: Balance sheet for Mixed Vegetables

ILS/du					
Mixed Vegetables	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	3,094.44	1.10	3,407.75		
Tillage				90.00	
Fertilization				756.78	
Soil disinfection				0.56	
Plant Protection				526.44	
Irrigation				1,020.69	
Labour Harvesting				666,67	
Harvesting Machinery				-	

ILS/du					
Mixed Vegetables	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
TOTAL			*3,407.75*	*3,061.14*	*346.61*
Labour & Enterprise					1,013.28

7.1.2 Citrus

This tree crop shows the highest Production Value, among all the examined sectors. However, the crop production cost, calculated on the ten examined citrus farms, is the highest among all the farm typologies, leading to a positive margin, however lower than other similar sectors.

Table 10: Balance sheet for Citrus

ILS/du					
Citrus	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	1,709.43	2.04	3,494.34		
Tillage				147.20	
Fertilization				977.45	
Soil Disinfection				-	
Plant Protection				562.94	
irrigation				920.00	
Harvesting - Labour				565.20	
Harvesting - Machineries					
TOTAL			*3,494.34*	*3,172.79*	*321.55*
Labour & Enterprise					886.75

7.1.3 Olive

The Olive's grove sector has the highest examined farms number (27); this sector also has the second highest irrigation cost (being vegetables the first); however, fertilization and plant protection costs are lower if compared to other tree crop sectors.

Table 11: Balance sheet for Olives

Olive	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	537.43	1.50	806.15		
Tillage				107.78	
Fertilization				492.87	
Soil Disinfection				111.11	
Plant Protection				205.11	
irrigation				972.97	
Harvesting - Labour				466.67	
Harvesting - Machineries				20.37	
TOTAL			*806.15*	*2,376.88*	*-1,570.73*

Olive	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
Labour & Enterprise					-1,104.06

7.1.4 Mixed arable and Vegetable Crops

The sector gathers the farms (10) where farmers are cropping different herbaceous species together, as potato, watermelon, wheat, squash, garlic, etc., and which production was not possible to disaggregate otherwise. Tough not so frequent into the Gaza farming system, this solution may be interesting for familiar farms characterized by land scarcity and plenty of labor resources.

Table 12: Balance sheet for Mixed Arable and Vegetable Crops

mixed arable and vegetable crops	*ILS/dunum*				
	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	2,677.41	1.20	3,226.02		
Tillage				211.41	
Fertilization				483.14	
Soil Disinfection				15.63	
Plant Protection				490.26	
irrigation				455.10	
Harvesting - Labour				610.74	
Harvesting - Machineries				1.56	
TOTAL			*3,226.02*	*2,267.83*	*958.18*
Labour & Enterprise					1,568.93

7.1.5 Mixed Fruit Tree Crops

This category includes 16 analysed farms, which pattern is made by some olive grove with other areas planted with apricot, citrus, barbary figs, lemon, peach, etc. As for Mixed herbaceous crops, it has not been possible to disaggregate otherwise the farms included in this sector.

To even out the strong difference among some prices and values, standard prices for production and for some production means were adopted. Tough the Margin be feeble, the result including Harvesting Labour became satisfactory.

Table 13: Balance sheet for Mixed Fruit Tree Crops

mixed fruit tree crops	*ILS/dunum*				
	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	746.48	3.33	2,487.38		
Tillage				148.60	
Fertilization				826.08	
Soil Disinfection				-	
Plant Protection				463.63	
irrigation				792.70	
Harvesting - Labour				238.81	
Harvesting - Machineries				2.22	

mixed fruit tree crops	*ILS/dunum*				
	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
TOTAL			*2,487.38*	*2,472.05*	*15.33*
Labour & Enterprise					254.14

7.1.6 Mixed Vegetable and Fruit Tree Crops

This is a very particular sector, including four analysed farms, which is typical of farmers who prefer to distribute labour potentialities among the different seasons. This typology is comprehensive of vegetables as cabbage, potato, melon, wheat, etc., side by side with tree crops as olive, peach, etc.

Both the Margin and Labour & Enterprise are the highest in respect of all other farms.

Table 14: Balance sheet for Mixed Vegetables and Fruit Tree Crops

mixed vegetable and fruit tree crops	*ILS/dunum*				
	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	2,195.96	1.57	3,444.70		
Tillage				96.67	
Fertilization				426.81	
Soil Disinfection				1.67	
Plant Protection				180.63	
irrigation				675.00	
Harvesting - Labour				252.50	
Harvesting - Machineries				34.67	
TOTAL			*3,444.70*	*1,667.94*	*1,776.76*
Labour & Enterprise				169.11	2,029.26

7.1.7 Lemon

Lemon crop is only represented in 6 farms; even if it can be grouped as part of the citrus fruits, details on this group may be useful.

Table 15: Balance sheet for Lemon

lemon	*ILS/dunum*				
	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	1,000.00	1.40	1,400.00		
Tillage				106.67	
Fertilization				341.67	
Soil Disinfection				-	
Plant Protection				146.67	
irrigation				1,133.33	
Harvesting - Labour				320.00	
Harvesting - Machineries				-	
TOTAL			*1,400.00*	*2,048.33*	*-648.33*
Labour & Enterprise					-328.33

7.1.8 Wheat

The cereal crop has rarely a good profitability, if done in little familiar farms not capable to exploit labour and irrigation potentialities: this is testified by the results of the six analysed farms. Notwithstanding the price was been fixed at the top, both margin and Labour & Enterprise margin remain negative.

Table 16: Balance sheet for Wheat

ILS/du					
wheat	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	400.00	1.23	492.00		
Tillage				91.67	
Fertilization				311.83	
Soil Disinfection				-	
Plant Protection				65.00	
irrigation				583.33	
Harvesting - Labour				386.67	
Harvesting - Machineries				-	
TOTAL			*492.00*	*1,438.50*	*-946.50*
Labour & Enterprise					-559.83

7.1.9 Barley

This cereal, being rougher than wheat, is adaptable to the not easy Gaza conditions; as for wheat, barley doesn't look as a profitable crop, due to the low production value and its irrigation needs.

Table 17: Balance sheet for Barley

ILS/du					
barley	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	481.84	1.36	655.55		
Tillage				90.00	
Fertilization				243.00	
Soil Disinfection				-	
Plant Protection				97.20	
irrigation				400.00	
Harvesting - Labour				800.00	
Harvesting - Machineries				-	
TOTAL			*655.55*	*1,630.20*	*-974.65*
Labour & Enterprise					-174.65

7.1.10 Melon

This intensive crop, typical of Mediterranean areas, requests high labour inputs, that bring the crop results to a feeble economic margin, but a considerable Labour & Enterprise one.

Table 18: Balance sheet for Melon

ILS/du					
melon	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	4,000.00	0.6	2,400.00		
Tillage				170.00	
Fertilization				274.00	
Soil Disinfection				160.00	
Plant Protection				197.50	
irrigation				900.00	
Harvesting - Labour				700.00	
Harvesting - Machineries				-	
TOTAL			*2,400.00*	*2,401.50*	*-1.50*
Labour & Enterprise					698.50

7.1.11 Apple

Even if it's not a typical Mediterranean crop, in other southern countries the apple has a decent appeal, due to interesting prices. In the Gaza environment, the very expensive irrigation doesn't allow to reach positive margins.

Table 19: Balance sheet for Apple

ILS/du					
apple	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	500	2	1,000.00		
Tillage				300.00	
Fertilization				600.00	
Soil Disinfection				-	
Plant Protection				305.00	
irrigation				1,200.00	
Harvesting - Labour				90.00	
Harvesting - Machineries					
TOTAL			*1,000.00*	*2,495.00*	*-1,495.00*
Labour & Enterprise					-1,405.00

7.1.12 Potato

At the survey results, potato can become a very rentable crop, demonstrating good revenues and low production costs. Overall the Labour & Enterprise result seems one of the highest of all sectors.

Table 20: Balance sheet for Potato

ILS/du					
potato	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	2,500.00	1	2,500.00		
Tillage				-	

Fertilization				655.00	
Soil Disinfection				-	
Plant Protection				151.00	
irrigation				450.00	
Harvesting - Labour				400.00	
Harvesting - Machineries				-	
TOTAL			*2,500.00*	*1,656.00*	*844.00*
Labour & Enterprise					1,244.00

7.1.13 Onion

Due to high needs in technical inputs, resulting in significant production costs, this crop doesn't demonstrate good performances, so in terms of economic margin, as in the Labour & Enterprise one.

Table 21: Balance sheet for Onion

ILS/du					
onion	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	450.00	1.50	675.00		
Tillage				50.00	
Fertilization				15.70	
Soil Disinfection				20.00	
Plant Protection				252.00	
irrigation				600.00	
Harvesting - Labour				900.00	
Harvesting - Machineries				-	
TOTAL			*675.00*	*1,837.70*	*-1,162.70*
Labour & Enterprise				34.36	-262.70

7.1.14 Peach

It appears hard to evaluate the peach crop performance, because of the low number of farms and dunums involved. Furthermore, profitability of the crop looks very poor, in respect to other comparable tree crops.

Table 22: Balance sheet for Peach

ILS/du					
peach	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	500.00	2.00	1,000.00		
Tillage				100.00	
Fertilization				525.00	
Soil Disinfection				-	
Plant Protection				340.00	
irrigation				-	
Harvesting - Labour				90.00	
Harvesting - Machineries				-	

TOTAL			*1,000.00*	*1,055.00*	*-55.00*
Labour & Enterprise					35.00

7.1.15 Livestock and market crops

The more traditional animal rearing in the country is the sheep and goat one; lamb's meat is an important component of local food. The cropping and rearing combination is supposed to give farmer better earnings, but it's not demonstrated by the present survey.

Table 23: Balance sheet for Livestock and Market Crops

livestock and market crops	*ILS/du*				
	Q.ty kg/du	ILS/kg	Revenues	Costs	*Margin*
	agriculture		682.27		
	animal rearing		900.00		
Tillage				81.82	
Fertilization				478.03	
Soil Disinfection				-	
Plant Protection				1,196.97	
irrigation				509.09	
Harvesting - Labour				17.50	
Harvesting - Machineries				27.27	
TOTAL			*1,582.27*	*2,310.68*	*-728.41*
Labour & Enterprise					-710.91

Table 24: Summary table of the single accounts cultivation statements of agricultural products[9]

Farm/Crops	Q.ty kg/d.	ILS/kg	Revenue	Net Margin	NM + LH	Net Margin per kg	NM + LH per kg
Mixed Vegetables	3,094.44	1.10	3,407.75	346.61	1,013.28	0.11	0.33
citrus	1,709.43	2.04	3,494.34	321.55	886.75	0.19	0.52
olive	537.43	1.50	806.15	-1,570.73	-1,104.06	-2.92	-2.05
lemon	1,000.00	1.40	1,400.00	-648.33	-328.33	-0.65	-0.33
mixed arable and vegetable crops	2,677.41	1.20	3,226.02	958.18	1,568.93	0.36	0.59
mixed fruit tree crops	746.48	3.33	2,487.38	15.33	254.14	0.02	0.34
mixed vegetable and fruit tree crops	2,195.96	1.57	3,444.70	1,776.76	2,029.26	0.81	0.92
onion	450.00	1.50	675.00	-1,162.70	-262.70	-2.58	-0.58
wheat	400.00	1.23	492.00	-946.50	-559.83	-2.37	-1.40
peach	500.00	2.00	1,000.00	-55.00	35.00	-0.11	0.07
barley	481.84	1.36	655.55	-974.65	-174.65	-2.02	-0.36
melon	4,000.00	0.60	2,400.00	-1.50	698.50	-0.00	0.17

[9] NM: Net Margin – LH: Labour Harvesting

potato	2,500.00	1.00	2,500.00	844.00	1,244.00	0.34	0.50
apple	500.00	2.00	1,000.00	-1,495.00	-1,405.00	-2.99	-2.81
animal rearing - sheep			1,582.27	-728.41	-710.91		

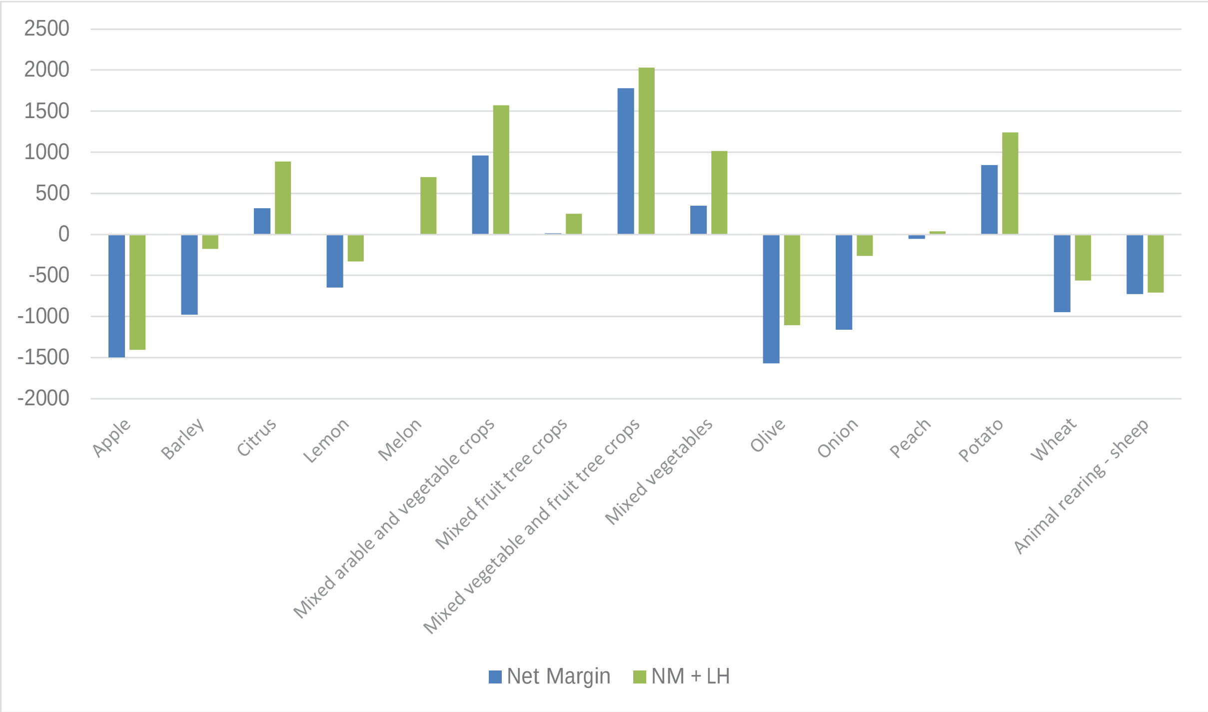


Figure 30. Net margin and Net Margin + Labour Harvesting, in ILS

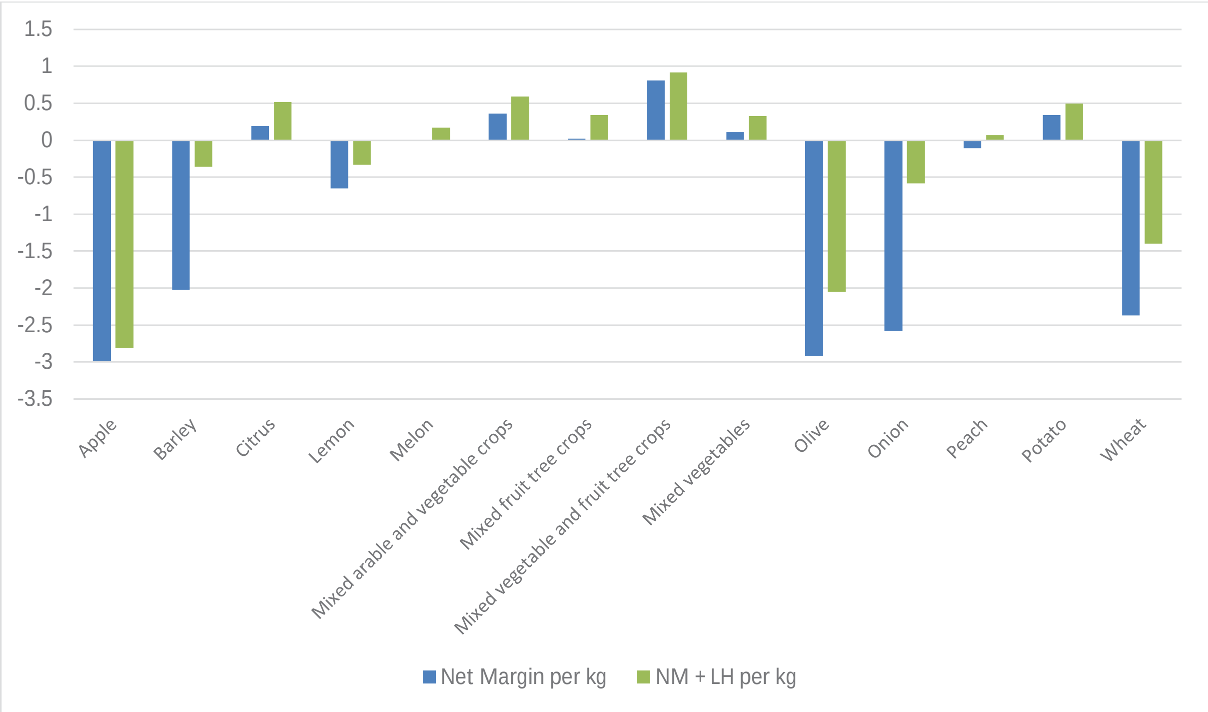


Figure 31. Net Margin and Net Margin + Labour Harvesting per kilogram of agricultural product, in ILS

Under the present conditions, antiquated cultivation techniques and the marketing system are heavily penalizing the profitability of many of the crops been farmed in the project's area. This situation is noticeable even though only direct costs were accounted for. If overheads costs such as the costs of administrative, technique and logistic nature, which cannot be attributed directly to a culture but which are incurred for the performance of activities of the entire farm (infrastructure costs, costs for utilities, for technical personnel expenses / administrative, postage, indirect taxes ...), and depreciations were to be included in the analysis, profitability would decrease even further.

8 VALUE CHAIN IN AGRICULTURE

8.1 Review of Available Information

DOCUMENT TITLE	CONTENT	NOTES	KEYWORDS
Gaza and West Bank - a country fact sheet on youth employment	The situation of youth employment in Palestine 2011 Government Council	English language	Youth employment
Value Chain upgrading in Palestine – past experience and outlook	Document submitted to the second international conference of SME's Development 2008	English language	Value chain
Potato Value Chain Analysis Report	description of the value chain of the potato - OXFAM 2015	English language	Value chain
Vegetable Value Chain Report	description of the value chain of the vegetables – Confédération Swisse – Ruaf Foundation - Oxfam	English language	Value chain

8.2 Present Farmers' Organisations

The Union of Agricultural Work Committees (UAWC) is the main organisation[10]active in the project area, already working with a few farmers. UAWC is a non-profit organisation founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union also aims to help Palestinian farmers to market their produce and provides agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions. Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors; in the West Bank and in Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in the different Palestinian rural areas of the West Bank and Gaza. UAWC receives funding from numerous western governments and aid organisations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organisations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like the Ministry of Agriculture. Cooperation is also established with international development agencies, like the Food and Agriculture Organisation of the United Nations.

Based on discussion with UAWC the following outcomes can be drawn:

[10] other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

a) The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, that is: land reclamation; building greenhouses; products quality enhancement and new crops introduction;

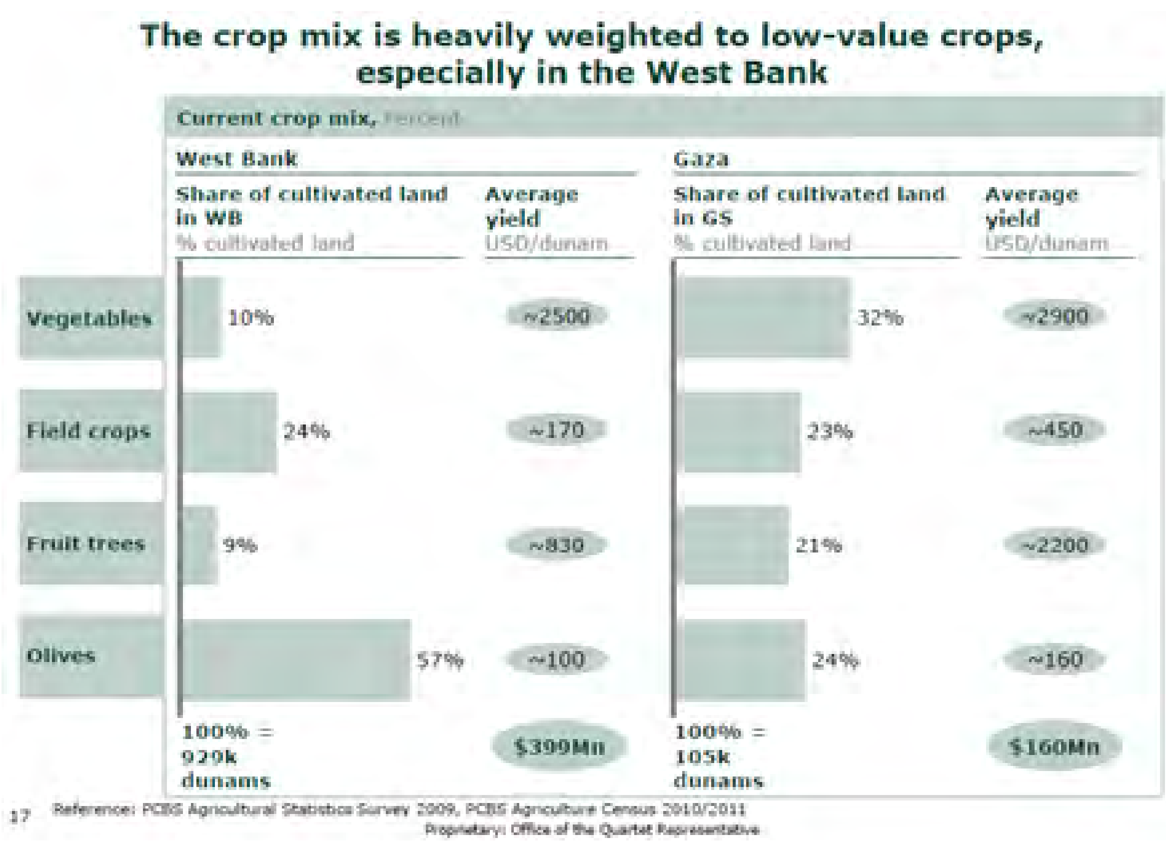
b) Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistic and financial support for exporting good such as strawberries and medical herbs, which usually ensure a good revenue.

8.3 Present Market's Condition

The Gaza Strip, for its high population density and urbanization connected to a production system reduced to a minimum because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

The trade in the Gaza Strip is the second most important productive sector and contributes to 15.9% of Gaza's GDP and 18.3% of employment. Between 2012 and 2015, trade has contributed to the reduction of the deficit of 182 million dollars. There remains a large trade gap with Israel, which is the first country to supply goods to Gaza. This situation is further complicated by the actions of Israel, which reduces the movement of people and goods from Gaza and severely restricting the development and the necessary reconstruction.

Table 25: PCBS Agriculture Census for the year 2010/2011



As far as the internal barriers, we can observe the lack of infrastructure, constant interruptions of electricity, weak regulation of markets, and obstacles that producers and farmers face, including lack of raw materials, non-potable water, poor electricity supply, as well as the complex procedures relating to trading houses and high credit costs. Some solutions are proposed by actors of economy, namely: creating a fund to support Gaza's exports; encouraging business sector participation in workshops and sharing information with other markets; upgrading the infrastructure of the Karem Abu Salem Crossing; controlling quality; making the Department of Standards and Specifications functional in Gaza.

Given the existing market situation it is possible to identify, in the agricultural sector, the value chain of agricultural products whether they are produced directly inside the Gaza strip. The food-processing sector is part of a large informal economy in Gaza, and is mainly dominated by women living in poverty selling agricultural products, such as pickles and herbs, in subsistence marketplaces. But in these market places buyers and sellers generally buy and sell little more than what is necessary for survival and are therefore not currently able to supply vegetables to the local market in sufficient quantities.

8.3.1 Value Chain of Agricultural Products

Value chain analysis is a powerful tool (Schmitz, 2005), as it provides important information for decision making in value chain development and support (UNIDO, 2009). It allows to identify bottlenecks and opportunities, to pinpoint and make sector-specific recommendations. Its goal is to recognize which activities are the most valuable (i.e. the source of cost or segment advantage) to the firm and identify the ones to improve so to increase the competitive advantage.

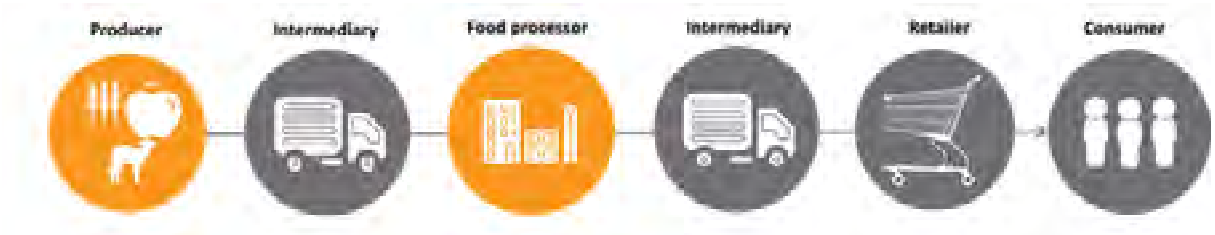


Figure 32: Value Chain in Agriculture

To efficiently describe the agricultural products value chains, the following key aspects must be considered:

- The main actors participating in the production, distribution, marketing, and sales of the agricultural products (Figure 34);
- The distribution of prices and profits between the various stages of the value chain (Table 31 and Table 32) in Strategy Planning and identify where the profit is created to plan the necessary development strategies.

The types of marketing channels in the northern Gaza strip has a simple scheme since there are no large intermediary structures between the producer and the consumer. Normally, agricultural products can be classified as arising from four main types of business that is:

1. Olive farms: In the first case the olives for oil producers can sell to mills or turn the olives into oil and sell it directly usually not bottled;
2. Orchardists;
3. Horticultural Farms;
4. Mixed Farms.

In many reports, the chain of vegetables, fruit and olive oil, is described as a very important industry in the Gaza Strip because it ensures food security of the fresh product for the local population.

Despite the growing problems in the presence of water scarcity and salinity of soils we see that they grow most of the vegetables such as citrus, olive, fruits, onion, melon, okra, zucchini, cowpea, tomatoes, etc.

Figure 33: Method of transport and sale of products in Gaza Strip

In the project area there are no greenhouses and the productions are not for export but in most cases for domestic consumption. In fact, the consumption per capita is quite high and is about 110 kg of vegetables per year (DAI Europe Ltd, 2011).

These products are sold directly by the farmer to middle-men or directly to Gaza city Souq fruit market or in some cases directly from his cart pulled by a donkey. The fruit and vegetable shops or groceries generally do not buy from farmers, they receive supplies directly from middle-men or traders. It must be said that consumers are wary of local products because there are rumours of a high use of pesticides for production, preferring imported products.

8.3.2 Structure of the Farm Prices (Questionnaire1)

The important work of preparing and administering the questionnaire 1 (farms) has revealed the prices at the origin of sales by farmers for many products ranging from fruits to vegetables and citrus.

Table 26: Average prices at farm level reported by questionnaire 1

Farm/crops	ILS/kg
Mixed Vegetables	1,10
citrus	2,04
olive	1,50
lemon	1,40
mixed arable and vegetable crops	1,20
mixed fruit tree crops	3,33
mixed vegetable and fruit tree crops	1,57
onion	1,50
wheat	1,23
peach	2,00
barley	1,36
melon	0,60
potato	1,00
apple	2,00

8.3.3 Distribution and Commercialisation of Agricultural Products

The market chain of horticultural and fruit products is as follows:

- farmers - traders or intermediary (middle man) -- retailers - consumers.

According to some traders, there are over-production tips that often cannot be handled due to lack of marketing facilities. In fact, there are very few refrigerator storage infrastructures in Gaza, and if the goods are not sold quickly, they can rot, making them unmarketable. Often farmers, to reduce this risk, collect the products and market them little by little.

This certainly can't be considered a proper strategy: in some seasons and for certain products there may be a simultaneous maturation of the product, for example. At a first glance, it does not seem there are authorities that regulate or orient production towards effective solutions for farmers. Only the Ministry of Agriculture tries to support farmers, but a knowledge gap remains on new market trends and modern cultivation techniques.

The extension service should strengthen its role of assisting farmers. The following is an attempt to reconstruct the value chain in the project area.

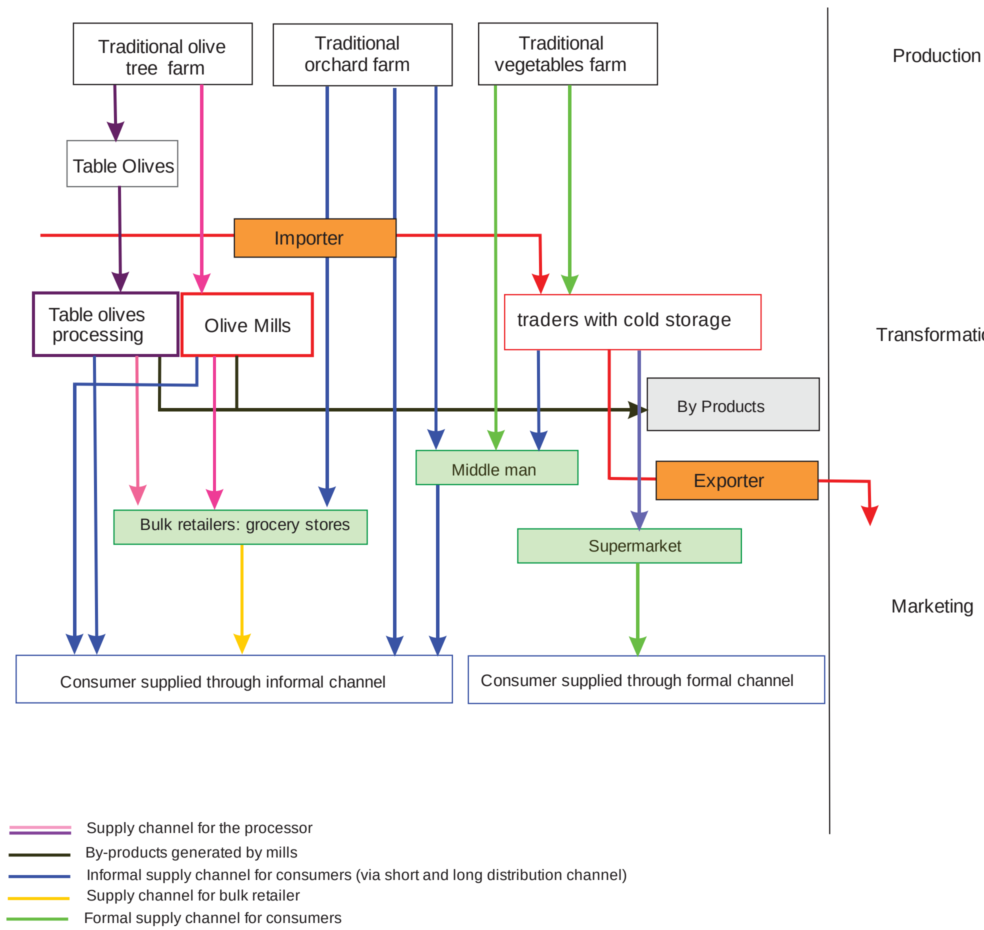


Figure 34: Value Chain Map for Agricultural products in the North of Gaza Strip

The prices charged to consumers in the various types of market in Gaza city were detected by face-to-face interviews with middle-men and retailers.

8.3.4 Pricing Structure of Retailers

8.3.4.1 Gaza City Souq

Table 27: Gaza Souq market price ILS/kg

tomato	2.5
lemon	2.0
eggplant	4.0
zucchini	4.0
pepperoni	8.0
potato	2.0
onion	2.0
average prices vegetables	**3.5**

Figure 35: the Souq in Gaza City

8.3.4.2 Fruits and Vegetables Store

Table 28: Fruits and vegetables store price ILS/kg

zucchini	5.0
eggplants	5.0
cucumbers	3.0
tomato	2.5
fresh peas	9.0
pepperoni	9.0
fava beans	8.0
average prices vegetables	**5.9**
lettuce pz	2.0
cabbage pz	4.0

Figure 36: Fruits and Vegetable stores in Gaza City

8.3.4.3 Supermarkets

Table 29: Gaza supermarket (meat city) price ILS/kg

	product packed	product unpacked
little tomato	5.0	
tomato for sauce	2.5	
green beans	8.5	6.5
sweet pepper		9.0
eggplant		6.0
zucchini dark green	4.0	
zucchini		4.9
fava beans		6.0
thin pepper		3.0
regular thin pepper selected	12.0	9.9

	product packed	product unpacked
peas, peeled, selected	17.0	
peas		8.0
potato		2.0
onion		2.0
carrots	1.0	
cabbage pz	1.9	
white turnip		1.6
Average prices vegetables		**5.4**
lemon		2.3
orange		1.8
tangerine		3.0
grapefruit		2.5

Figure 37: fruits and vegetables sold at the local supermarkets in Gaza City

8.3.5 Evolution of Prices in the Value Chain

In not all components of the value chain has been possible to raise the prices of products - it shows that the main products are representatives of vegetables, lemons and olive trees. As can be seen the price grows with the evolution of the business model, this fact is quite normal and in fact the profit lies always commercial ring more evolved revenues by subtracting the portion of the primary production.

Table 30: Prices in the various stages of the value chain

products	Farm	middle man	Souq	store	super
vegetables	1.10	1.60	3.50	5.90	5.40
citrus	2.04	2.54	2.84	3.00	3.00
olive	1.50				
lemon	1.40	1.90	2.50	2.30	2.30
mix. herb. crops	1.20	1.70	2.30	4.00	
orchard mix	3.33	3.73	4.03	4.00	
mix herb-orch	1.57	1.97	2.37	3.00	
onion	1.50	1.70	2.00	2.00	
wheat	1.23				
peach	2.00	2.50	3.10	9.00	

products	Farm	middle man	Souq	store	super
barley	1.36				
melon	0.60	1.10	1.70		
tomato	1.50	2.00	2.50	2.50	2.50
apple	2.00				
melon	0.60				
potato	1.00	1.50	2.00	2.00	2.00
apple	2.00				

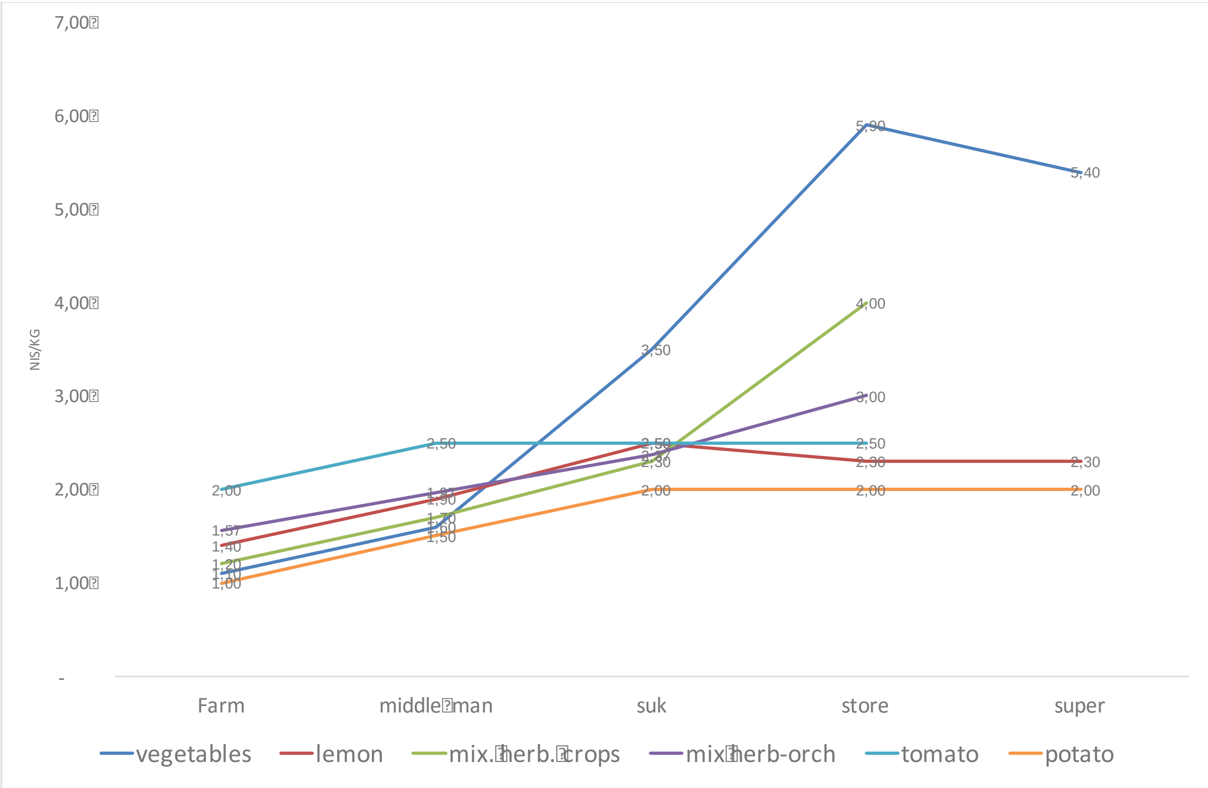


Figure 38: Price evolution in the value chain

8.3.6 Evolution of Profit in the Value Chain

The analysis of the distribution of profit within the value chain has been performed for Vegetables which represent a large portion of the agricultural food market in Gaza that moves 198 million t each year; other important crops for the local economy are citrus fruits, of which is the lemon is produced in the Gaza Strip while the orange for the most part is imported from Israel.

Table 31: Profit distribution through Vegetables Value Chain

	Vegetables [ILS per kg]				
	farmer	**middle man**	**Souq**	**store**	**super**
price	1.10	1.60	3.50	5.90	5.40
net profit	0.33	0.48	1.75	3.74	3.42

Table 32: Profit distribution through Lemon Value Chain

	Lemon [ILS per kg]				
	farmer	**middle man**	**Souq**	**store**	**super**
price	1.40	1.90	2.50	2.30	2.30
net profit	-0.33	0.48	0.55	0.35	0.36

The olives are processed in mills which apply a cost of 0.5NIS / kg of pressed olives. The average yields are 13% then the farmer for every 100 kg of olives produces 13 kg of extra-virgin or virgin olive oil which is sold in the informal market with a price that goes from 10 to 20 ILS per liter.

If the farmer can reach the final consumer directly then the profit can reach ILS 600 per ton of olive.

The value rises in the process of milling and production of olive oil and in the bottling phase where the highest increase is reached. Further profit is expected in retailing.

8.3.7 Distribution and Commercialisation of Agricultural Products Outside Gaza Strip

The distribution and commercialisation of agricultural products outside Gaza is made difficult because of the complicate relationship with Israel:

- Israel tends to complicate the export of products from the Gaza Strip, for careful control involving the systematic opening of all the crates, boxes and containers, a procedure that often involves long waits in the sun with perishable goods.
- The MoA authorizes the export of some products only if the domestic price is reduced a lot compared to the price in Israel, this is to ensure domestic demand.
- Taxes for export are around 0.2 ILS per kg of product.

The World Bank estimates the times of trading faced by Israeli and Palestinian businesses to import and export. For exporting goods, part of the costs is related to documents preparation - customs clearance and technical control - ports and terminal handling - inland transportation and handling. The duration of procedures is related to the typology like:

- document preparation (10-15 days),
- customs clearance and technical control (6-10 days)-
- ports and terminal handling (3 - 7days)-
- inland transportation and handling (3 -4 days)

for a total of 22 to 36 days.

The length of the process makes it difficult to promote the export of goods from Gaza strip.

An example of cost analysis to export a guava trucks in Jordan are provided below, the costs are calculated for a dry cargo, 10 ton, full container load for exporting goods, procedures range from packing the goods at the warehouse to their departure from the port of exit.

Table 33: Example of cost analysis for the export of guava to Jordan

Operations	ILS
Transportations to Jordan 1 truck guava 10 ton	6,000.00
export tax	2,000.00
Packing 10 ton	16,000.00
Local price (guava 20 kg) 10 ILS	5,000.00
handling	2,000.00
Total cost	**31,000.00**
Total revenues in Jordan (1.35 JOD Kg)	**99,323.23**
net margin of traders	68,323.23
net margin per kg	6.83
export costs per kg	2.60
local price per kg	0.50

8.3.7.1 Processing Unit

The food-processing sector is part of a large informal economy in Gaza, and is mainly dominated by women living in poverty selling agricultural products, such as pickles and herbs, in subsistence marketplaces. But in these market places buyers and sellers generally buy and sell little more than what is necessary for survival and are therefore not currently able to supply vegetables to the local market in sufficient quantities.

Only a limited part of the products go to processing units for production of pickled vegetables. In Gaza, there are 11 processing units for the production of pickled vegetables (cucumber, pepper, eggplant and other types of vegetables), all led by men. Five small processing units were recently established in the Gaza Strip. These units are led by women and located across the different governorates of the Gaza Strip. Four of these processing units – Khayrat al-Shamal, Sabaya, Al-Amal and Khayrat Al-Sham - were established under the DANIDA project funded by Oxfam GB in cooperation with UAWC. The units-officially registered with governmental ministries- employ in total 16 women. They process pickled cucumbers and peppers with a capacity of 0.5 TN per year."

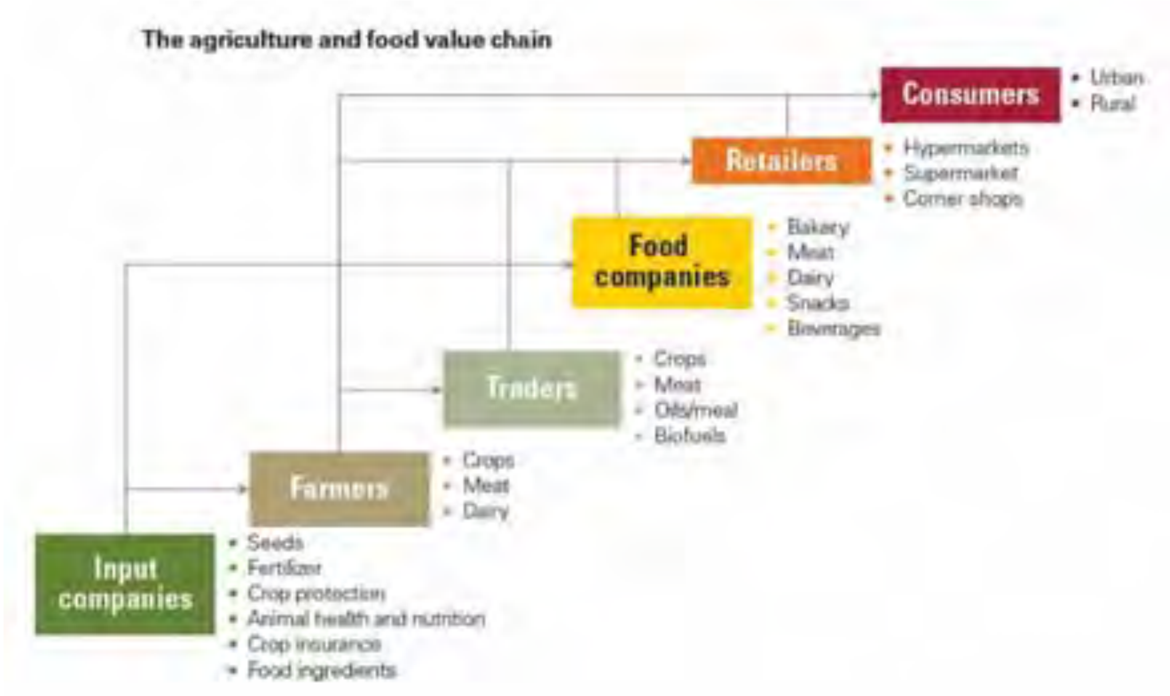


Figure 39: Value Chain Integration and actors.

8.3.8 Actors of Value Chain and Logical Integration Process

- Input companies
- Farmer
- Traders
- Food Companies
- Retailers
- Integration of the actors

9 ANNEX 1: FIELD SURVEY QUESTIONNAIRES

9.1 Questionnaire 1: Farm Survey

North Gaza Governorate project area *Simplified Agriculture Survey – Single farm* *Survey code ID* Figures of Agriculture	
Crop Type	
Total area (dunum)=>	

Costs			
	Unit	Price per Unit ILS	Qty per Dunum
tillage	n°		
fertilization			
Chemical	kg or L		
Organic	kg or L		
Soil Disinfiction			
Chemical	kg or L		
Solar	m		
Plant protection			
insecticide	kg or L		
fungicide	kg or L		
Herbicide	kg or L		
Nematicide	kg or L		
irrigation	m³		
harvesting	h		
labour	day		
machinery	h		
Simplified Agriculture Survey – Single farm			
Figures of Agriculture			

Revenues		
Qty	kg	
Fresh consumption		
Unit price	ILS	
Food Industries (canned, juice etc.)		
Unit price	ILS	
Total revenues	ILS	

Animal rearing	Unit	Price for unit	Annual total
Sheep-goat			
Water Source			
Consumption	CM		
Price	ILS/yr.		
Facilities			
Sheep fold	sq m.		
milk process.	sq m.		
Costs			
hay	ton		
silage	ton		
barley grain	ton		
corn grain	ton		
proteic supplement	ton		
veterinary service	ILS/		
drugs	ILS/		
vaccins	ILS/		
grazing area	dunum		
natural pastures	dunum		
Revenues			
milk	kg		
cheese	kg		
lambs	kg		
wool	kg		
other products	kg		
Livestock-Dairy			
Water Source			
Consumption	CM		
Price	ILS/yr.		
Facilities			
shed	sq m.		
milk process.	sq m.		
Costs			
hay	ton		
silage	ton		
burley grain	ton		

corn grain	ton		
proteic supplement	ton		
veterinary service	ILS/yr.		
drugs	ILS/yr.		
vaccins	ILS/yr.		
grazing area	dunum		
natural pastures	dunum		
Revenues			
milk	kg		
cheese	kg		
beef	kg		
cows	kg		
other products	kg		

9.2 Questionnaire 2: Land and Farm Survey

Questionnaire to be submitted to single farms.

Farm Location (address)	
Location within the project area	Known (please report the farm size on the map) Unknown
Name Owner/Tenant	
ID	
Mob. Number	
Is there any change in ownership in your farm after 2014?	

Land survey (baseline)

1) What is the ownership type of your farm?	**Owner**	**Tenant**	**Sharecropper**	Waqf
Area (Dunum)				
2) What is the average price of one dunum of agricultural land, in your area?				
3) What is the average cost of leasing the land				
4) Are Farmers selling/buying Land in your area?	yes	no		
5) What is your current farm income, per month?				
6) If you have left farming (completely or partially), what type of work are you currently doing?				
7) What is the income you deem acceptable per year to justify your return to farming?				

Farm survey (baseline)

8) Are you an individual farmer or are you associated to a farmer association/cooperative?	Individual			Associated
9) From where do you get the water to irrigate your crops?	Private Well:		Collective Well:	Other sources (specify):
10) Details of your well	Legal	Illegal	Code/No.: Coordinates: X= Y=	
11) Do you pay a fee to get the water per hour?	Labor	Fuel	Electricity	Direct water cost
12) What percentage of your farm is irrigated, in season?	%		Which crops are irrigated?	
13) What is the percentage of your crops that you sell to food industries for processing?	more 50%	less 50%	Types:	
14) If you send your olives to the mill, what is the % of oil you return back out of the total amount of olives delivered?	%			
15) How much do you pay the mill to process 100 kg of olives?	ILS			
16) What is the percentage of your crops that you sell for fresh consumption?	more 50%	less 50%	Types:	
17) How many workers do you employ over one year in your farm?	Permanent:		Temporary:	

18) Do you need technical assistance for your farm activities?	yes	no	Explain what:
Area Percentage %			
19) Types of Soil improvement	Fertilization		Other:

Current Uncultivated / Non-crop farms

20) Are there fields in your farm which are not cultivated, or which you used to cultivate in the past and then stopped?	yes	no	If yes, what percentage of the total farm area?
If there is land that you do not cultivate in your farm, indicate the reasons:			
a) Fields are too close to the border	yes	no	
b) Israeli are destroying the land/crops/wells	yes	no	
c) I do not have enough water for irrigation	yes	no	If yes, what solution do you envisage? Explain:
d) Soil productivity is too poor	yes	no	If yes, what is the reason of the low productivity? Explain:
e) Lack of financial resources to expand my activity	yes	no	If yes, would you be willing to get a loan and what type (short, medium, long term; leasing)
H) Water quality	yes	no	If yes, what is the problem of water quality?

If you had enough and additional cheap water source for irrigation:

21) Which new crops would you grow with respect to the current situation?	Indicate the crops:		
22) Do you think your farm would require in the future technical assistance for the irrigated crops? Explain what services would you like to receive	yes	no	Indicate required support:
23) Which part of your presumable productions would you allocate, respectively, to fresh consumption	Fresh consumption: 30% - 50% - 70% - 0%		

(sale to local retailers), to export and to the food industry (%)?	Export: 30% - 50% - 70% - 0% Food industry: 70% - 50% - 30% - 0%
24) How much the employment would increase in your farm with respect to present if the size of the irrigated area will increase	+ 10%; 30%; 50%; 80%; 100%
25) What type of investments would you do (machinery, irrigation structures, greenhouse, etc.)?	Description:
26) How much do you suppose your farm income will increase?	+ 10%; 30%; 50%; 80%; 100%
27) How much do you suppose your farm production costs will increase?	+ 10%; 30%; 50%; 80%; 100%

9.3 Questionnaire 3: Farm Inputs

Item	Unit	Cost	Comments
Urea	kg		
Ammonium nitrate	kg		
Phosphate fertiliser	kg		
Potassium fertiliser	kg		
Pesticide (avg.)	l or kg		
Fungicide (avg.)	l or kg		
Seedling tomato	each		
Seedling cucumber	each		
Seedling aubergine	each		
Seeds tomato	kg		
Seeds cucumber	kg		
Seeds aubergine	kg		
Sapling olive	each		
Sapling grape	each		
Sapling citrus	each		Specify if lemon, clementine, orange, etc.:
Sapling almond	each		
Sapling guava	each		
Sapling mango	each		
Construction costs of greenhouse	m2		

9.4 Questionnaire 4: Industries

Questions for a single construction firm (industry)

Owner________________

Baseline (before the project):

1. What is the size of your factory as turnover?	0 – 50,000 $	50,000 – 100,000 $	101,000 – 200,000 $	More than 20
2. How many people are now employed?	0 – 5 workers	6 – 10 workers	11 – 20 workers	More than 20
3. Source of water	- private well	- municipal water system	- other (specify)	
4. How much water is your factory consuming at the moment? CM/Year	0 – 50,000	50,001 – 100,000	101,000 – 200,000	More than 20
5. What is the cost of the water? ILS/CM				
6. Do you know the quality of your water?	- Yes	- No		
7. If yes, what are the quality parameters?				

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State of Palestine

Palestinian Water Authority

دولـــــة فلسطيـن

س-لطة المي- اه الفلسطيني-ة

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 3

Review of the Irrigation Project

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

May 2017

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CP	Cropping Pattern
ILS	Israeli New Shekel
MoAg	Ministry of Agriculture
NGEST	North Gaza Emergency Sewage Treatment
PWA	Palestinian Water Authority
ToR	Term of Reference
WB	World Bank
WWTP	Waste Water Treatment Plant

1 SUMMARY

1.1 Background

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project initiated in 2004 and being implemented in three phases the latest of which, known as **supplementary phase,** was later added to the project to provide a mean to recover and reuse the treated effluent after the new WWTP is completed. This system, comprising of a water recovery scheme and a water reuse (irrigation) scheme includes 27 recovery wells surrounding the infiltration basins, a network of 42 monitoring wells (10 of which will have to be newly built), 2 water tanks with the ability to store 4,000 m^3 each, 1 booster pumping station with 10 booster pumps and over 130 km of distribution network for the reuse of the water in irrigated agriculture.

The design of the system was completed in 2010. The original design foresaw a three-stages development of a full-scale irrigation system. The first two stages have been fully designed to make it possible to lunch tendering and construction procedures for both the recovery and the reuse schemes required to serve a gross agriculture area of 1,570 ha (15,700 du) subdivided in two sectors of approximately 500 ha (5,000 du) and 1,000 ha (10,000 du).

The construction of both the recovery and the reuse schemes has been delayed for several years thus justifying the need for the review and updating of key design assumptions that were made in the original design.

1.2 The Present Report

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare a Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and make the project feasible. To carry out its task, this project has drawn upon massive data collection, expansive field visits, and state-of-the-art computer modeling in order to best understand the country's hydrology and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

1.3 Key Achievements

Some of the key achievements obtained while reviewing the original design of the Irrigation Project include:

- The introduction of a new Cropping Patter (CP) that vastly draws from the results of a baseline assessment and survey that reached nearly 70% of all farmers. More specifically, the newly proposed CP encapsulate the desires and technical abilities of the existing farmers, follows the directives of the Ministry of Agriculture and maintains key features of the original design (i.e. irrigation layout and pumping system) unchanged.

- A review and update of the irrigation water demand in the Project Area based on the newly proposed cropping pattern. The results lead to a saving of nearly 3.2 Million of Cubic Meter of Water per year (MCM/year) or 21.5% less water of what required by the original design. Less water requirements also leads to reduced energy needs for the recovery and the reuse of the water extracted from the aquifer. More precisely, the proposed changes will allow saving 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation scheduling that largely differs from the original one by providing water to the entire irrigation project at all times (instead of on a 6 days' rotation with 12 lots irrigated 2 at a time once a week). The newly proposed irrigation schedule hinges on the idea of delivering a constant amount of water to the farms gate for 12 hours per day (10 hours per day during the least warm months of the year). Farms with different sizes will receive the necessary amount of water thanks to flow reducers that now comes standards with many commercially available type of manholes. Furthermore, the possibility to pump water into the system on a constant rate through the day drastically reduces the complexity of managing the irrigation scheduling and eliminate the risk of overdrawing water from the storage tanks and stalling the system.
- A review of the original irrigation project layout that allowed to resolve some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gates (the original design failed to do so for a sizable number of farms).
- A review of the original design for the recovery scheme. Our review confirms the validity of the original design;
- A review of the original design for the reuse (irrigation) scheme. The review confirms that the selection of materials, the general layout and the selection of the pumping system is still applicable today.

1.4 Key Recommendations

Some of the key recommendations that can be provided after reviewing the original design of the Irrigation Project are:

- The original detailed design is based on a low quality topographic and cadastral survey thus leading to detailed layout drawings that are often confusing. Farms boundaries are not precisely delineated on a map and the layout of main and sub-mains pipe lines is not clearly mapped as it should for a detailed design. We therefore recommend performing a detailed topographic survey of the entire area and, based on that, to adjust the original design considering some of the layout adjustment proposed in this report.
- The overall cost for the construction of the water reuse (irrigation) scheme has significantly increased (nearly 40% increase) from its original estimation. Although this might be justifiable in the contest of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%.

2 Project's Background Information

2.1 Project's History

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, it is being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

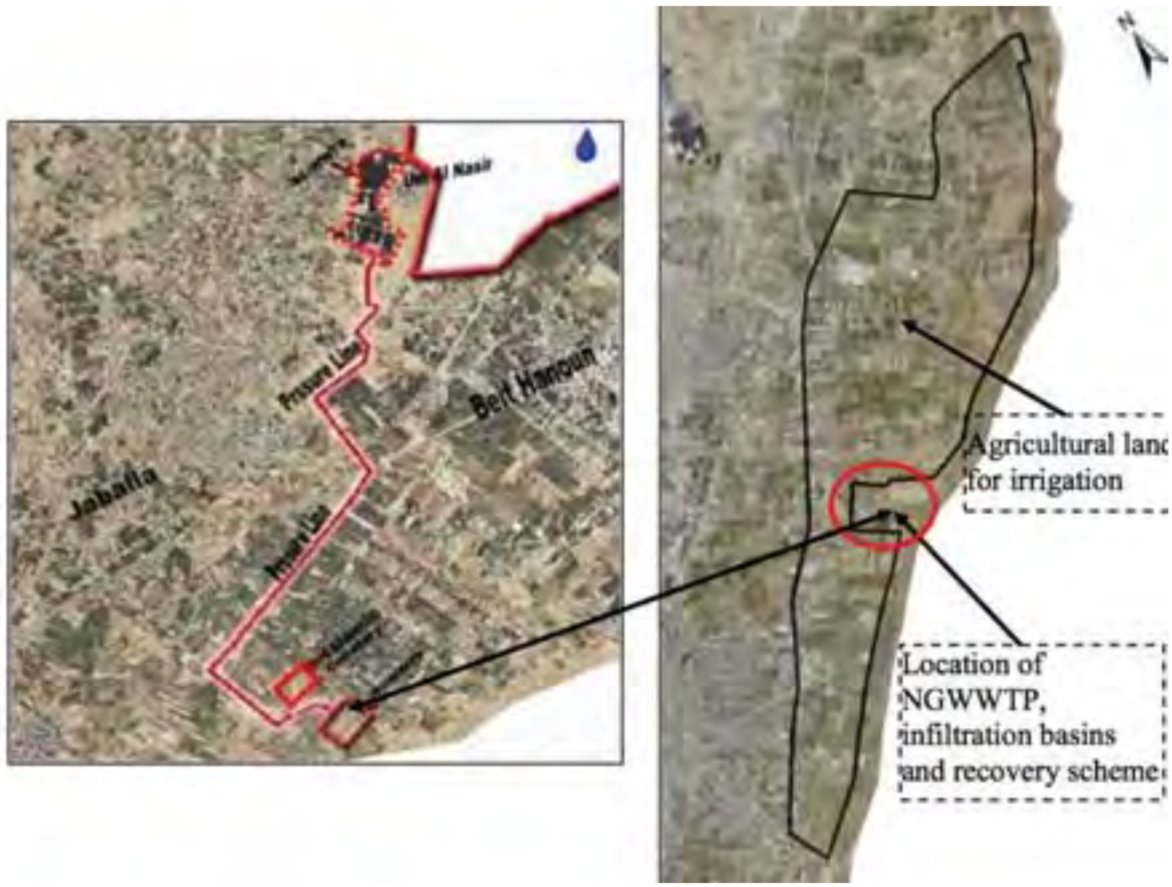

Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the Plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

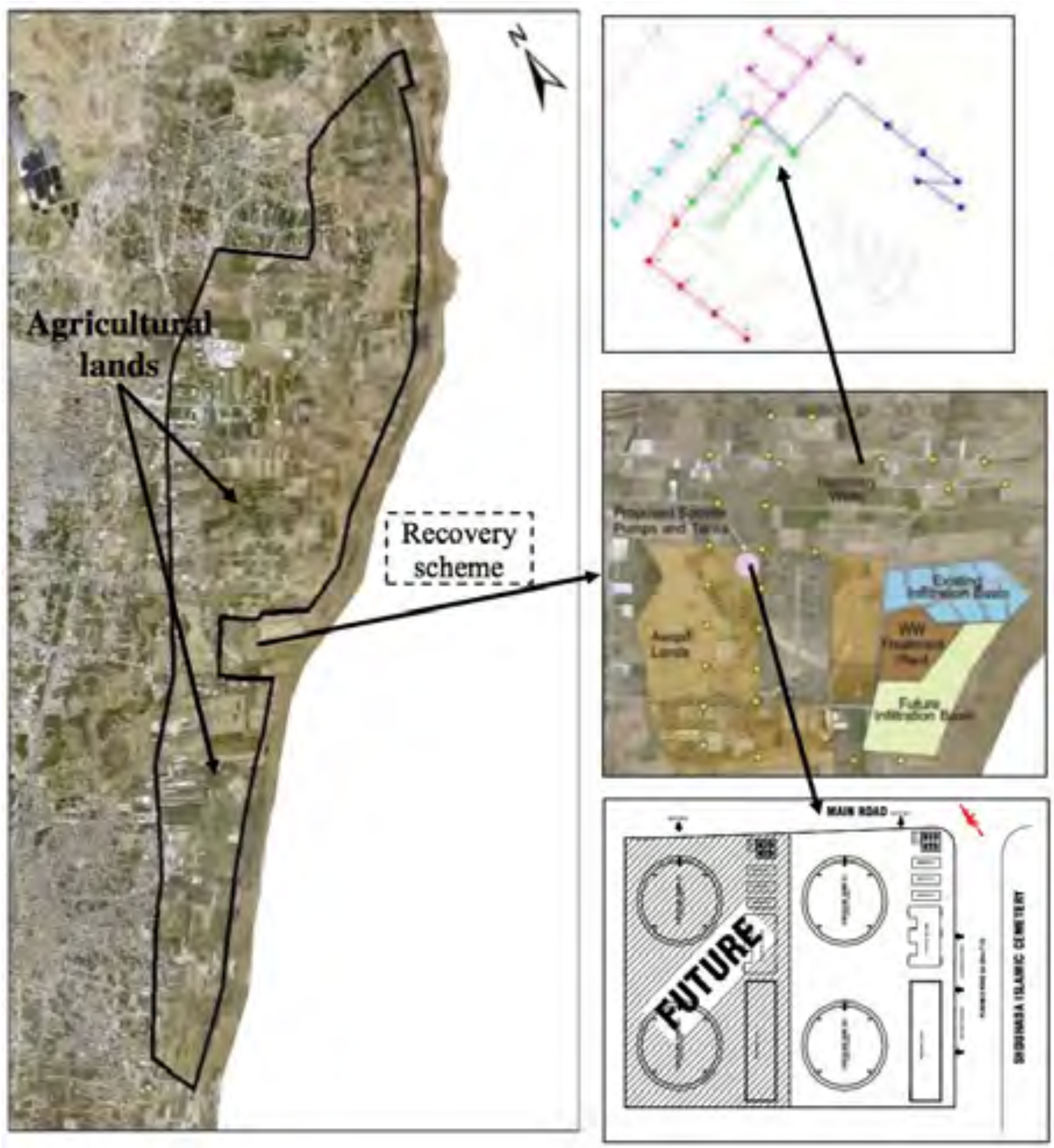

Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, supplementary phase was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. This system is composed of a chain of 27 recovery wells surrounding the infiltration basins to capture the effluent after it passes through the effluent ponds, storage reservoirs and a distribution network for the reuse of the water in irrigated agriculture.

A gross agriculture area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit first from the recovered water and the treated sewage sludge. The component, known under the name of 'Supplementary Project' is subdivided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse (Irrigation) Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000

m^3/day by the design year 2025. The overall implementation of the supplementary phase has been subdivided into three stages.

The **first stage,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 15 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells - and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume to reach agricultural and municipal wells located beyond the recovery wells.

The **second stage,** now scheduled for completion by the year 2018, would extend the recovery systems by a second row of 12 recovery wells (along with the previous 15 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated waste water infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank, booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **third stage**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

This report focus on the evaluation of the original design of the first two stages. Key design aspects of both the recovery scheme and the irrigation scheme are summarized in the following sections.

2.2 Physical Components of the Recovery Scheme

The recovery scheme comprises a system of 27 recovery wells and all related connection pipes as well as 10 monitoring wells. The following three sections provide a more detailed description of each component.

2.2.1 Recovery Wells

There are 27 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 zones (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 3. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

The 27 groundwater recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the 27 wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October which is equal to 50,885 m^3/day. The total number of wells is 27 where each should have a capacity of pumping between 150 m^3/hr to 200 m^3/hr. 25 out of the 27 wells are assumed to be operational always with a capacity of 170 m^3/hr. The two additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure of one of the other wells.

According to the numerical modelling results, the exact location of the 27 wells was defined to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 3 shows the locations of the recovery wells.

Figure 3: Location of the 27 Recovery Wells

2.2.2 Collection Pipes

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 4. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

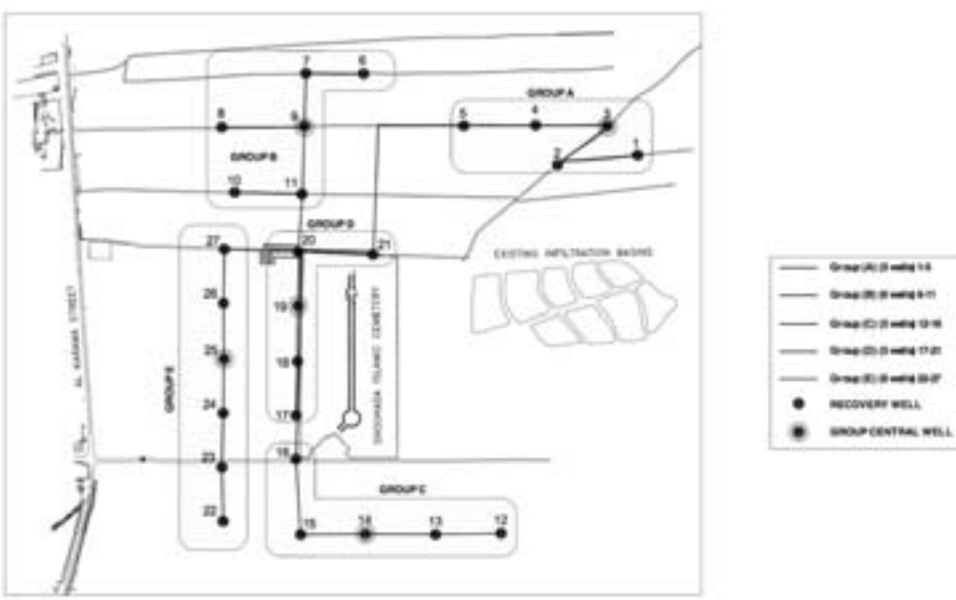

Figure 4: Wells grouping and Piping System

2.2.3 Monitoring Wells

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore taken and analysed randomly at farms level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extend, a system of 42 monitoring wells will be implemented by using the 5 existing monitoring wells, the 27 newly built recovery wells and 10 new monitoring wells.

The location of the 42 monitoring wells is provided in the following Figure 5.

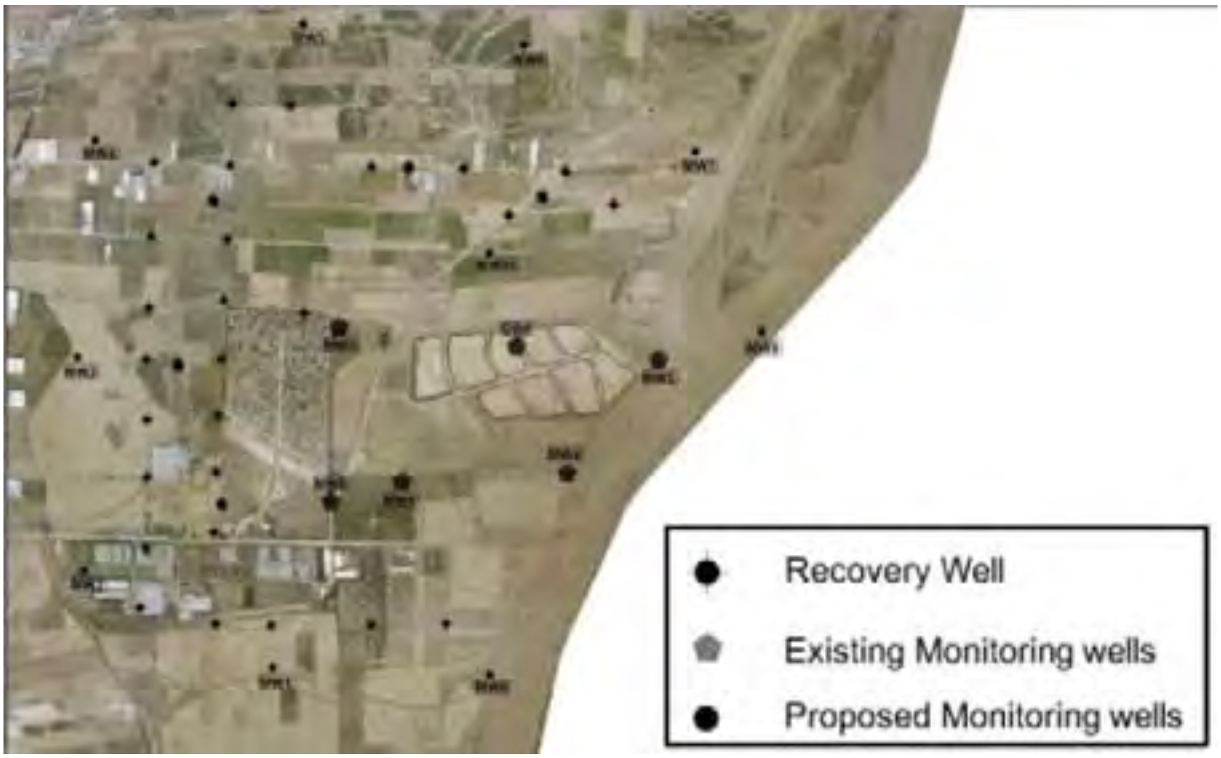

Figure 5: Location of the existing and newly proposed monitoring wells

2.3 Physical Components of the Reuse (Irrigation) Scheme

The physical components of the reuse part of the scheme for the 35,600 m^3/day capacity is described in the following sections and includes: i) Water Storage Tanks, ii) Booster Pumping Station and related piping and iii) the Irrigation network serving 1,570 ha (15,700 du) of gross agriculture land.

2.3.1 Water Storage Tanks

The recovered water from the wells is collected into two 4,000 m^3-water tanks that are in turn connected to a booster pumping station housing 10 irrigation booster pumps.

The two tanks of 4,000 m^3 each are shown in Figure 6. There are two inlet pipelines from well groups C and D with a diameter of 450 mm to Tank 1 and three inlet pipes with diameter equal to 450 mm from well groups A, B, and E to Tank 2. The two tanks are connected by a balancing pipe of 900 mm diameter. Washout pipes of 200 mm diameter are located in two places in the bottom of each tank. Overflow of 200 mm is to be connected with washout pipes out of the tank with a gate valve on the washout pipe. The overflow and washout pipes from the two tanks are connected to each other with a pipe of 300 mm diameter. The feeder from each tank to the booster pump stations is 800 mm in diameter with main gate valve.

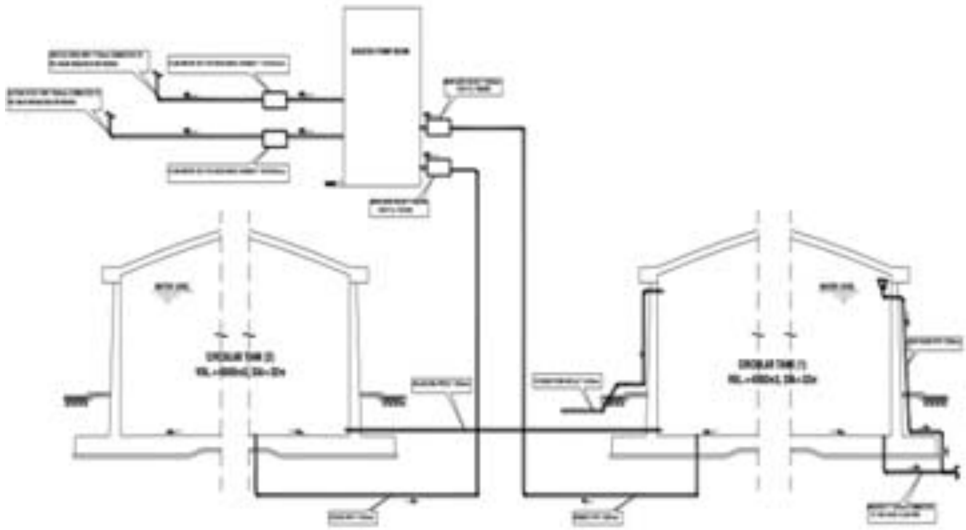

Figure 6: Water Storage Tanks

2.3.2 Booster Pumping Station and Associated Facilities

A booster pumping stations housing 10 pump (8 + 2 stand-by pumps) with a cumulative capacity of 6,000 m^3/hr are used to transfer the water from the tanks to the farms. The booster pumps are designed to maintain a minimum pressure of 2.5 bars in the irrigation network at farm gates.

According to the 2010 design, Cropping Pattern and Irrigation Scheduling, the 27 recovery wells - even if operated concurrently - cannot re-file the storage tanks if farmers, for some reason, decides to start irrigation outside the proposed hours of operation during the days of peak water demand. The result would create a drop below threshold minimum operation water levels of the storage tank and a consequential blockage of the polders.

Accordingly, and to mitigate the risk described above, the operation of the booster pumps should be based on fuzzy control rules in which the number of operating boosters along with their speed is dependent on the following control variables:

- Planned irrigation schedule.
- Water pressure at the distribution pipe.
- Water flow at the distribution pipe.
- Water level in the reservoir.

The controller will be responsible to automatically change order and speed of the pumps based on the demand.

A detailed layout of the booster pumping station and the 10 booster pumps is provided in the following Figure 7.

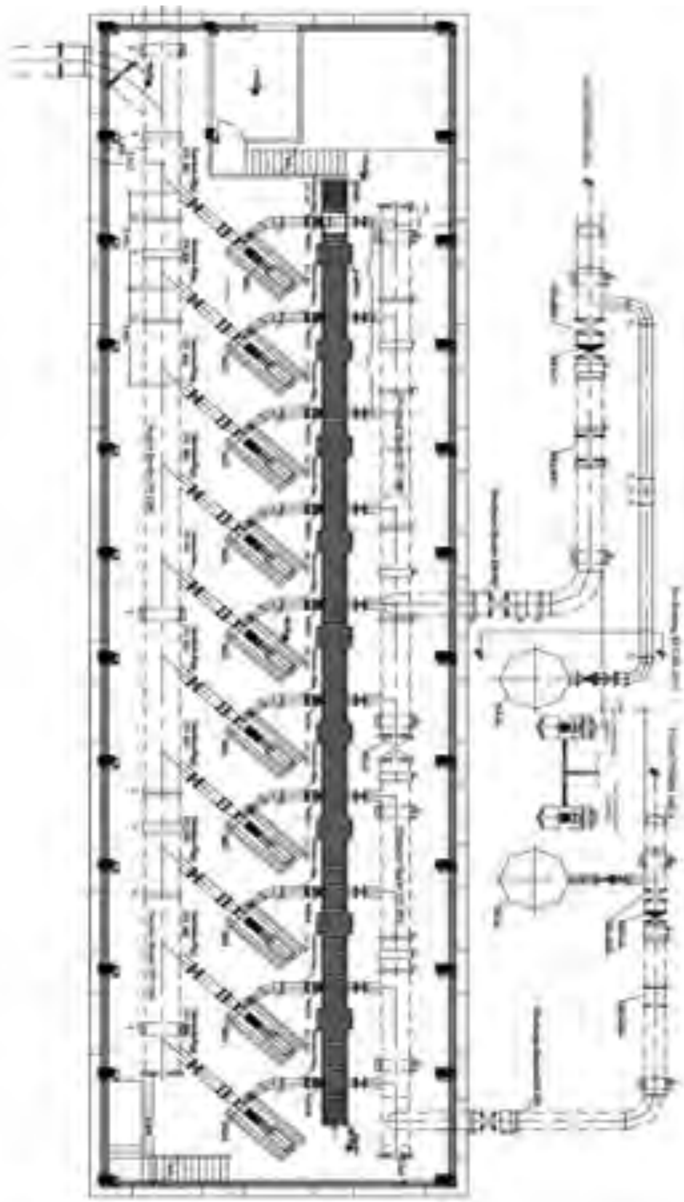

Figure 7: General Layout of the Booster Pumping Station

2.3.3 Irrigation Distribution Network

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 8. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 9.

In accordance with irrigation requirements, irrigation was to be carried out on a six-days rotation bases over six zones of almost equal sizes, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F as shown in the following Figure 9. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 10.

Figure 8: Location of agricultural land

Figure 9: Proposed Irrigation Zones

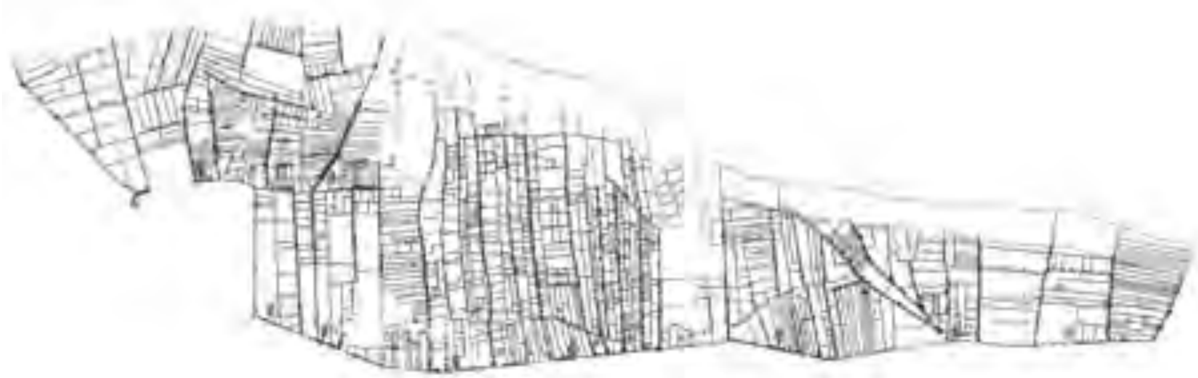

Figure 10: General Layout of the Originally Proposed Irrigation Network

2.4 Cropping Pattern and Water Requirements for Irrigation

2.4.1 Original Irrigation Project's Development Scenarios

Ultimately, the original 2010 design evaluated three possible scenarios for project development (see Figure 11).

Figure 11: Proposed Scenarios for Irrigation Project Development according to the original design

1. **Scenario I -** the scenario was built on the assumption that, initially, no more than 16,500 m^3/day would have been recovered from the recovery wells and was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (15%) and grains (15%). The scenario assumed that the best location for planning orchards was the area located to the west of the project along Al Karama road and far away from the border with Israel. The profiles of the soils on the area are deep enough to cultivate tree crops. Based on crops water requirements, the available reclaimed water (16,500 m^3 daily) was barely sufficient to irrigate 537 ha (5,375 du) divided into citrus for 161.3 ha (1,613 du), olives for 134.4 ha (1,344 du), fruit trees for 80.6 ha (806 du), alfalfa for 80.6 ha (806 du) and grains for 80.6 ha (806 du).

2. **Scenario II** - like Scenario I, was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (15%) and grains (15%). This second scenario was built on the assumption that the NGWWT is operating more effectively than under Scenario I and more water (23,100 m^3/day) of better quality can be abstracted for

irrigation. This reclaimed water will be used to irrigate addition land being 752.5 ha (7,525 du) in total. The citrus area will increase to 225.8 ha (2,258 du), whereas, olives to 188.1 ha (1,881 du), fruits to 112.9 ha (1,129 du), alfalfa to 112.9 ha (1,129 du) and grains to 112.9 ha (1,129 du).

3. Scenario III - was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (10%), grains (10%) and vegetables (10%). This third scenario was built on the assumption that the NGWWT is operating at full capacity of 39,160 m^3/day (35,600 m^3/day plus 10% extra) and water can be produced for unrestricted use. The quantity of reclaimed water will be enough to irrigation about 12,577 du. The citrus area will increase to 377.3 ha (3,773 du), olives to 314.4 ha (3,144 du), fruit trees to 188.7 ha (1,887 du), and alfalfa and grains each will increase to 125.8 ha (1,258 du). At this scenario vegetable crops will be introduced with an area of 125.8 ha (1,258 du), as it might be difficult to convince the farmers to accept the use of the recovered water for cultivation of vegetables at the beginning of the project.

Planting tree crops adjacent to the political border should be avoided as much as possible due to the specific political issues in the region. By using the reclaimed water, more irrigation wells on the area will be closed and consequently the original groundwater will be increased and improved through yearly addition of rain water.

Figure 12 shows the ultimate subdivision of the project into two construction Phases of 500 ha (Phase I) and 1,000 ha (Phase II) in size respectively. The layout of these two phases is different than the one originally sought under Part A and B as depicted in Figure 8 and yet, the idea behind the three scenarios for the project's development according to water availability and quality can be similarly applied to Phase I and II presently being considered.

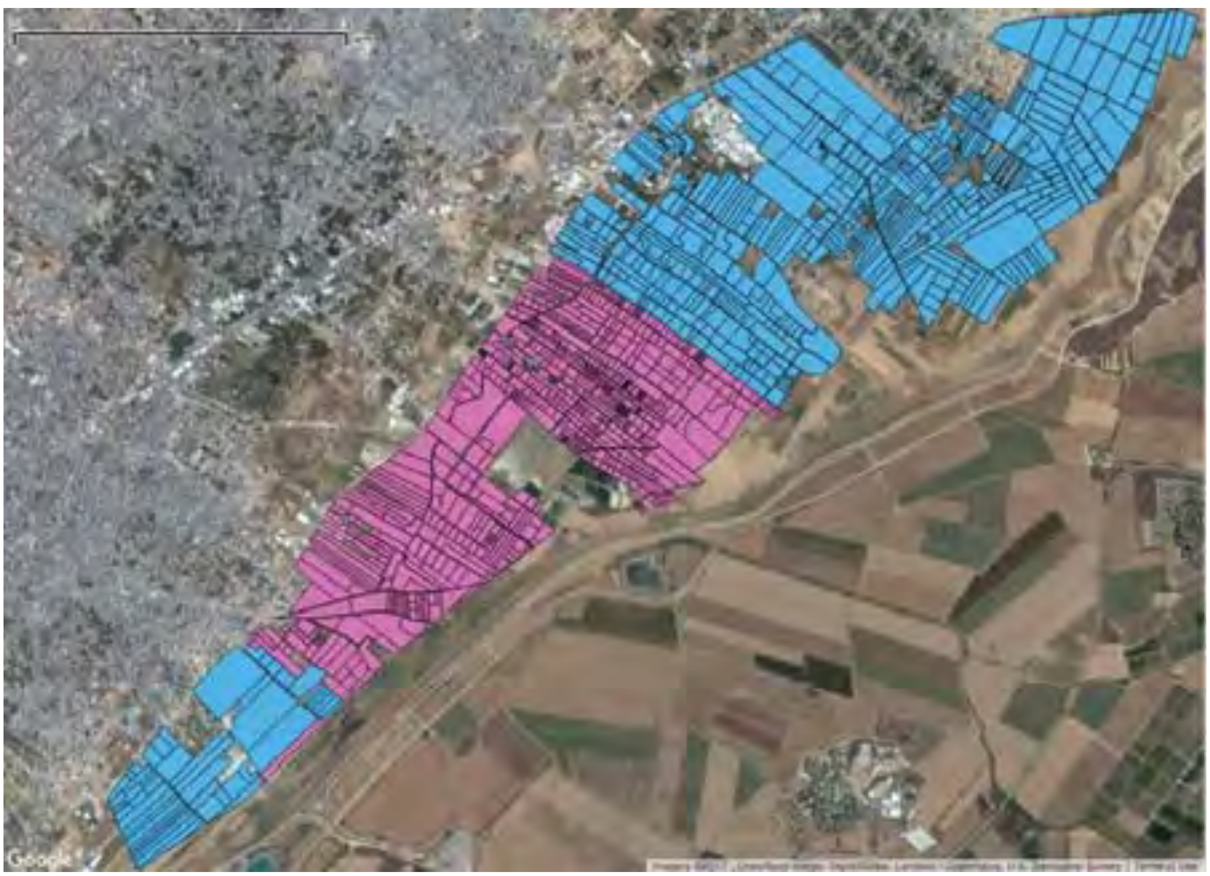

Figure 12: Final subdivision of the project into Phase I (purple) and Phase II (blue)

2.4.2 Cropping Pattern and Crops Water Requirement

The original 2010 cropping pattern was defined according to monthly crops requirement in millimeters as presented in the Table 1 and Figure 13 below.

Table 1: Monthly Crop Water Requirements (mm) (Cropwat V.8, 2009)

Month	Citrus	Olives	Fruit	Alfalfa	Vegetables	Grains
January	12,1	1,3	0,6	40,7	8,2	48,5
February	17,2	4,8	1,4	11,0	16,8	19,4
March	35,0	8,5	12,8	29,8	56,1	10,1
April	67,0	35,5	40,5	60,7	111,2	108,2
May	89,8	53,3	60,9	87,9	140,0	166,3
June	98,8	60,5	71,6	115,0	145,1	123,0
July	115,6	72,9	88,6	154,8	132,3	6,1
August	117,6	74,6	91,8	180,8	77,1	0,0
September	92,2	54,8	69,8	157,1	67,4	0,0
October	68,2	37,2	49,6	122,3	80,8	0,0
November	38,8	15,2	24,2	80,8	57,1	13,6
December	7,7	0,0	0,2	43,4	9,9	40,0
TOTAL	**760,0**	**418,6**	**512,0**	**1084,3**	**902,0**	**535,2**

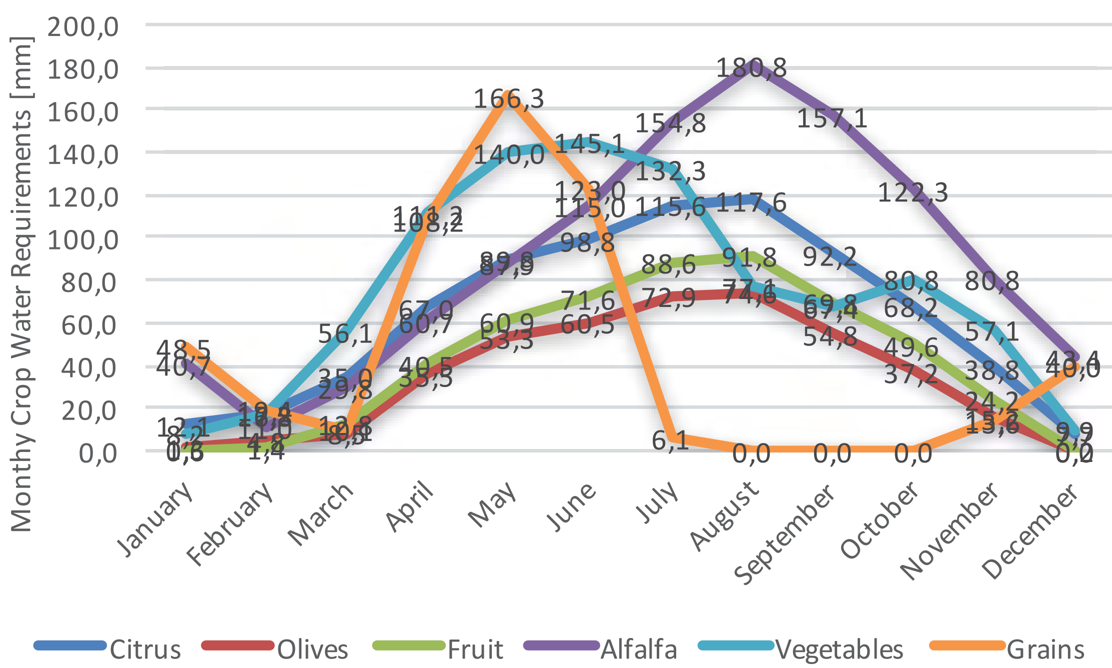

Figure 13: Monthly Crop Water Requirements [mm/month]

Figure 14: Mean monthly crop water demand (mm) for citrus, olives, fruit trees, alfalfa, vegetables and grains crops.

Total irrigated area for each crop and water balance for all three development scenarios is presented in the following Table 2.

Table 2: Irrigated area and Total Water balance for the three development scenarios

Crop	Scenario I (16,500 m^3/day)		Scenario II (23,100 m^3/day)		Scenario III (39,160 m^3/day)	
	%	Area (du)	%	Area (du)	%	Area (du)
Citrus	30	1,613	30	2,258	30	3,773
Olives	25	1,344	25	1,881	25	3,144
Fruits	15	806	15	1,129	15	1,887
Alfalfa	15	806	15	1,129	10	1,258
Grains	15	806	15	1,129	10	1,258
Vegetables	0	0	0	0	10	1,258
Total area	100	5375	100	7,525	100	12,577
Total infiltrated	**5,460,000 m^3**		**7,644,000 m^3**		**12,958,400 m^3**	
Total Recovered	**6,006,000 m^3**		**8,408,400 m^3**		**14,254,240 m^3**	
Balance	**-546,000 m^3**		**-764,400 m^3**		**-1,295,840 m^3**	

As can be noted, the total amount of water recovered per year is always greater that the amount of water infiltrated per year for each scenario. It means that the yearly water balance is negative and must be compensate by rain water directly.

Scenario III has been considered as the basis for the design of the irrigation network whereas the total water requirements have been generically increased of an additional 15% to account for extra water needed for non-irrigation needs (such as industries and other farm-related water needs) as well as to account for possible climate changes. Finally, the total gross irrigation demand (plus 15%) is presented in the following Table 3.

Table 3: Gross Water Requirement for Scenario III

Crop	% of Area	Area (du)	Gross Irrigation (m^3/du)	Total Irrigation demand (m^3/year)	Total Gross Water Requirement (m^3/year)
Citrus	30%	3,773	1,140	4,301,334	4,946,534
Olives	25%	3,144	627.9	1,974,275	2,270,416
Fruits	15%	1,887	768	1,448,870	1,666,201
Alfalfa	10%	1,258	1,626.5	2,045,649	2,352,496
Grains	10%	1,258	802.8	1,009,682	1,161,134
Vegetables	10%	1,258	1,353	1,701,668	1,956,918
Total Area	**100%**	**12,577**	**6,318.2**	**12,481,478**	**14,353,700**

The average daily and hourly irrigation water requirements for each month are given below which consider an efficiency of the system equal to 80%. The irrigation demand during the summer months (June, July and August) accounts for about one third of the yearly crops water requirements.

Table 4: Net Daily Water Requirement for Scenario III

Net daily water requirement for irrigation (m^3/day)	
month	**m^3/day**
January	28,766
February	31,144
March	30,431
April	29,743
May	40,541
June	44,248
July	43,597
August	42,673
September	35,034
October	26,250
November	27,377
December	28,823
Average	34,052

Table 5: Net Hourly Water Requirement for Scenario III[1]

Net hourly water requirement (m^3/h)	
month	(m^3/h)
January	2,877
February	3,114
March	3,043
April	2,974
May	3,378
June	3,687
July	3,633
August	3,556
September	2,920
October	2,625
November	2,738
December	2,882
Average	**3,119**

[1] number in white cells are calculated based on 10 hours pumping daily in low water demand months while numbers in brown-shaded cells are calculated based on 12 hours pumping daily in high water demand months

2.4.3 *Water Recovery Needs*

The following table shows the daily water needs which should be extracted by the recovery wells and pumped through the irrigation networks. The values consider a further amount of water of 15% to account for non-farming activities and potential climatic change.

Table 6: Daily Water Recovery Needs [m^3/day] for Scenario III

Water Recovery Needs (m^3/day)	
month	m^3/day
January	33,081
February	35,816
March	34,996
April	34,204
May	46,622
June	50,885
July	50,137
August	49,074
September	40,289
October	30,188
November	31,484
December	33,146
Average	**39,160**

Table 7 Hourly Water Recovery Needs [m^3/hr] for Scenario III[2]

Water Recovery Needs (m^3/h)	
month	m^3/h
January	3,308
February	3,582
March	3,500
April	3,420
May	3,885
June	4,240
July	4,178
August	4,089
September	3,357
October	3,019
November	3,148
December	3,315
Average	**3,587**

[2] number in white cells are calculated based on 10 hours pumping daily in low water demand months while numbers in brown-shaded cells are calculated based on 12 hours pumping daily in high water demand months

2.4.4 *Irrigation Schedule*

The total area is divided into 6 equal main lots (A1+A2, B1+B2, C1+C2, D, E, and F) as depicted in Figure 15

In order to balance the pumping load, two lots (the farthest and the closest to the booster station) can be irrigated at each single day of the week (example: A1 + A2). The following Table 8 presents the proposed pumping schedule on a seven weeks' rotation.

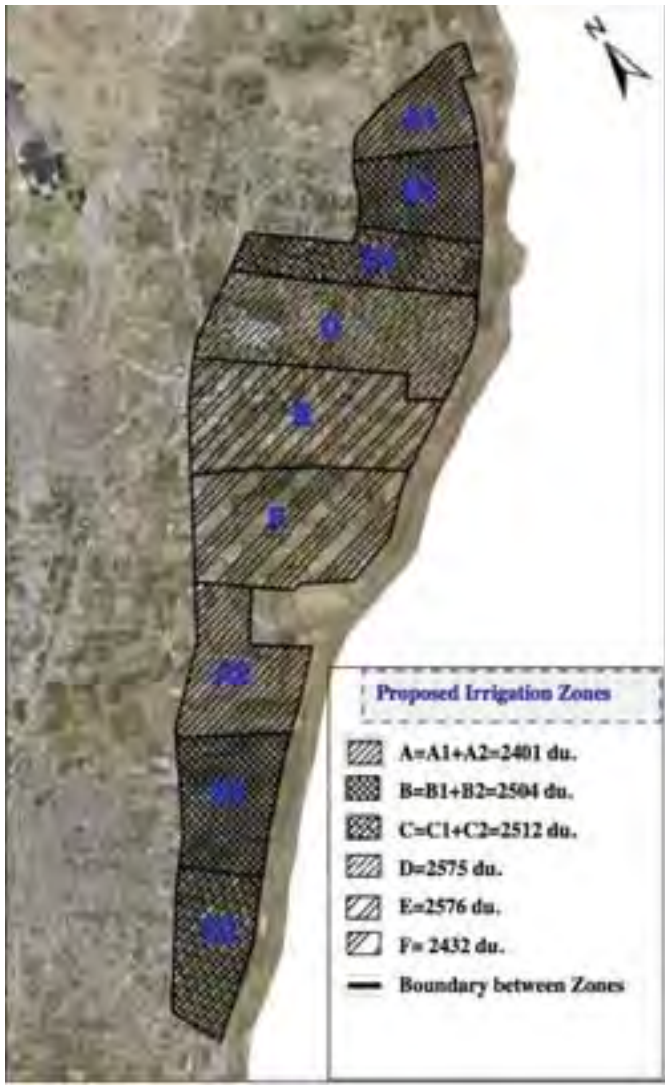

Figure 15: Proposed Irrigation Zones

Table 8: Pumping Schedule

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Saturday	A1+A2	B1+B2	C1+C2	D	E	F	A1+A2
Sunday	B1+B2	C1+C2	D	E	F	A1+A2	B1+B2
Monday	C1+C2	D	E	F	A1+A2	B1+B2	C1+C2
Tuesday	D	E	F	A1+A2	B1+B2	C1+C2	D
Wednesday	E	F	A1+A2	B1+B2	C1+C2	D	E
Thursday	F	A1+A2	B1+B2	C1+C2	D	E	F
Friday	A1+A2	B1+B2	C1+C2	D	E	F	A1+A2

3 Criteria for Crop Selection

3.1 Background

The recovery and reuse component of NGEST is relevant and will be efficient only if all the infiltrated wastewater is recovered and reused, to preserve further deterioration of the quality of the aquifer used for drinking by an additional contamination of the infiltrated treated wastewater. The irrigation network has thus been sized to match with the total quantity of water infiltrated and recovered by the recovery wells and based on the cropping pattern around the project and water requirements per crops. To do so, two assumptions were made.

i. the availability of water provided by the implementation of the recovery and reuse scheme will increase number of farmers returning to their uncultivated lands;

ii. the owners and users of private irrigation wells will stop the operation of their wells to switch to the reused water.

3.1.1.1 Status of agriculture in the project area: water use, rain fed agriculture and land abandonment.

As emphasised by the survey carried out by the consultant, three quarters of the project area mainly depend on irrigation by private wells while rain fed agriculture takes around 24% of the total 12,068 du. It has been also clarified that about 18% of total cultivable land is in fact not cropped. This happens mostly because of the frequent land invasions from the Israeli army and the periodical spraying of herbicides by Israeli airplanes to keep clear the fields along the border. But the herbicides are in fact air borne on the close cultivated fields of the Gaza farmers, which kills the crops and makes farming conditions unhealthy. Furthermore, lack of financial resources to carry out cropping operations and water scarcity are other causes of land abandonment.

The survey showed that half of total farms has a mixed crop pattern (see Table 9), composed by arable, vegetable and fruit tree crops (perennials). Among the latter, citrus and olive play the most important role. Arable crops, such as wheat and barley, are also quite important as staple food for the household and can – for a certain extent – offer acceptable yields under rain fed conditions too (although wheat is also irrigated).

Table 9: Indicative cropping pattern of the project area

Crops and crop groups	%
Mixed arable and vegetable crops	21.91
Wheat	14.16
Mixed fruit tree crops	9.50
Olive	7.71
Mixed vegetable and fruit tree crops	7.10
Mixed vegetables	8.25
Livestock-fodder crops	4.22
Citrus	5.00
Onion	2.30
Barley	1.03

Crops and crop groups	%
Potato	0.55
Uncultivated	18.27
Total	100

The vast majority of the agricultural products is sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. A minor part of products can be also exported in the West Bank and Israel, depending on the market demand. However, the government allows exporting fresh products only when domestic needs are satisfied, namely only production in excess (as reflected by low market price) can leave the Gaza Strip. In general, the value chains are very simple, no local food industries process local products, and wholesalers take the highest part of the crop value. Farmers' organisations are scarcely present in the project area, hence farmers work on individual basis without post-harvest facilities, so having a weak contractual power with respect to the wholesalers. Sheep and dairy cows represent the main livestock. Rearing structures and fodder crops (mostly alfalfa) takes about 4% of the area, but most the necessary feed is currently imported from Israel, so making the north Gaza livestock sector highly dependent from the neighbour.

With the foreseen availability of large quantities of water for irrigation, it is assumed that the removal of water constraint will reinvigorate agriculture in the target area. However, a more comprehensive strategy is needed to cope with the other current shortcomings. The institutional environment should be strengthened to provide effective advisory support to the farmers, who in the survey asked for specific technical assistance. Collective post-harvest services should be created by helping the farmers to establish associations, which will also foster their contractual power toward the wholesalers. Permanent crops and field structures should be systematically placed far from the border area with Israel. Fodder crops production should be enhanced.

3.2 Proposed Cropping Pattern

The cropping pattern showed in Table 10 is proposed to be implemented through the new irrigation scheme, in the entire target area (12,068 dun). It is highlighted that 65% of the cropping pattern is represented by tree crops.

Table 10: Proposed Crops and Crop Groups

Crops and crop groups	%
Citrus	22
Olive	23
Almond	10
Peach	7
Other fruit tree crops	3
Grains	12
Winter vegetables	4

Crops and crop groups	%
Winter vegetables (GH)	3
Summer vegetables	6
Alfalfa (green fodder)	10
Total	100

The criteria followed by the consultant for the selection of the crops/crop groups and their relative share within the pattern are described below:

1. Farmers' preference and crop economic profitability.

The chosen crops are all already extensively grown in the target area, especially Citrus and Olive which are highly appreciated. Citrus has usually good market demand and Olive is important both for the traditional diet of the households and for the good market of the olive oil. The survey showed that about 39% and 16% of the interviewed farmers would introduce respectively olive and citrus trees in their farms, in case proper water supply will be ensured by the project.

Stone fruits are also well appreciated and farmers are familiar with the required cropping techniques. As emerged in the survey, 12% of the respondents declared they would grow stone fruits (or would increate their share) in case of irrigation supplied by the project.

Grains (Wheat and Barley) are traditional staple crops, quite crucial for food security.

Winter and summer vegetables are important cash crops for the local farmers but their cultivation is however affected by water availability in summer and by climatic conditions in winter. The survey showed that the majority of the interviewed farmers (54%) would grow more vegetables when water supply will be ensured in the right period. In order to intensify the cultivation of vegetables, the proposed cropping pattern includes a small share of tomato grown under greenhouse in winter, which is intended to satisfy the off-season tomato demand by consumers, allowing the farmers to fetch higher prices in the market.

Alfalfa (fodder crop). One tenth of the cropping pattern will be taken by alfalfa, a soil-improving fodder crop which is usually supplied green to the animals. If properly irrigated, alfalfa may produce plenty of fodder through three/four cuts per season. This crop, which typically remains over three years in the field, has high nutritional value. It can be grown either in pure stand either among fruit trees, being capable to fix nitrogen and make it available to the trees.

2. Water availability. The water requirements of the designed cropping pattern are compatible with the estimated amount of water made available by the aquifer together with the water deriving from the new WWTP.
3. Climate and soil suitability. Crops have been selected and crop cycles planned based on the eco-physiology of the crops, in terms of required soil characteristics and suitable temperature interval.

4 WATER RESOURCES REQUIREMENTS

4.1 Water Demand

Based on the newly proposed cropping pattern, a net daily water requirement for irrigation has been calculated as shown in the following table. Minimum demands occur during winter season, maximum demands occur in the summer season in the month of May.

Table 11: Net daily water requirement for proposed Cropping Pattern

Net daily water requirement for irrigation (m^3/day)	
month	m^3/day
Jan	39
Feb	43
Mar	19,698
Apr	36,807
May	45,781
Jun	43,405
Jul	42,238
Aug	35,893
Sep	19,309
Oct	10,433
Nov	2,333
Dec	0
Average	21,332

The water requirements presented in the previous table defines the net irrigation water requirements but do not consider the additional water that might be required by the local industries as well as the one needed for uses not directly connected to irrigation practices (such as the one required for washing, the one required for sanitary uses, etc.). Finally, Table 11 does not consider the impact of climate change to the irrigation water requirements.

The previous study has generally addressed this additional water needs by increasing the net irrigation water demand by a flat 15% during each month. Such practice is not correct since water needs for the industries and for non-irrigation practices do not vary in the same way that irrigation does. Furthermore, climate change in this part of the World does not necessarily means that more water will be needed but will, more likely, means that the distribution of the rain patter might change. A more appropriate approach is to explicit the additional water needs.

Finally, a 70,000 m^3/year has been proposed for the industrial activities (with a progressive increase from the current water use of 30,000 m^3/year to the project 70,000 m^3/year over a period of 25 years, 830,375 m^3/year has been considered for other uses (assuming 500 liters per habitants/day consider about 650 families with 7 people per family). This amount of water can be considering to be provided constantly during the year. To be note that this amount of water corresponds in a year to about 10% of the total irrigation demand. This means that summarizing 5% of climate change, 15% of yearly irrigation demand has been considered for other uses obtaining the same value of the original project but such volume will be distributing differently during the months of the year.

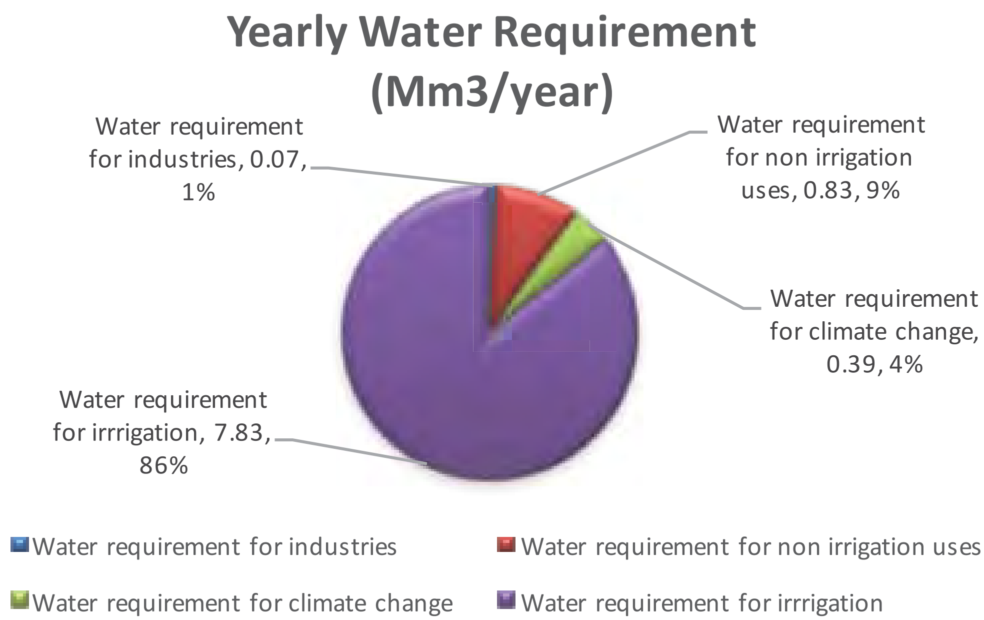

Figure 16 – Pipe chart with Yearly Net Water Demand for different uses

4.2 Irrigation Scheduling

Based on effective water requirement and the necessity of daily irrigation for the crops, the consultant wants to propose an irrigation pattern in which all sectors are evenly irrigated at the same time for 10 hours during low demand months (from October to February) and 12 hours during high demand months (from March to September).

Table 12: Irrigation scheduling

Daily irrigation schedule for all irrigation area	
month	Pumping hours
Jan	10
Feb	10
Mar	12
Apr	12
May	12
Jun	12
Jul	12
Aug	12
Sep	12
Oct	10
Nov	10
Dec	10

4.2.1.1 Water Savings

Differently from the existing project, the efficiency of the network has been divided into two terms: the efficiency of the pipelines equal to 5% (i.e. to consider lacks water during the transmission pipelines, for example in the joints, valves, etc.) and the efficiency of irrigation method equal to 80% (i.e. the lack of water from the gate farm to the roots of crops.

The gross water requirement i.e. the recovered water has been calculated and shown in the following tables.

Table 13: Water recovered for proposed Cropping Pattern

Water recovered (m^3/day)			Water recovered (Mm^3/month)	
month	m^3/day		month	Mm^3/month
Jan	4,060		Jan	0.13
Feb	4,065		Feb	0.11
Mar	29,927		Mar	0.93
Apr	52,439		Apr	1.57
May	64,246		May	1.99
Jun	61,120		Jun	1.83
Jul	59,585		Jul	1.85
Aug	51,236		Aug	1.59
Sep	29,415		Sep	0.88
Oct	17,736		Oct	0.55
Nov	7,078		Nov	0.21
Dec	4,009		Dec	0.12
Average	28,068		Total (Mm^3/year)	11.77

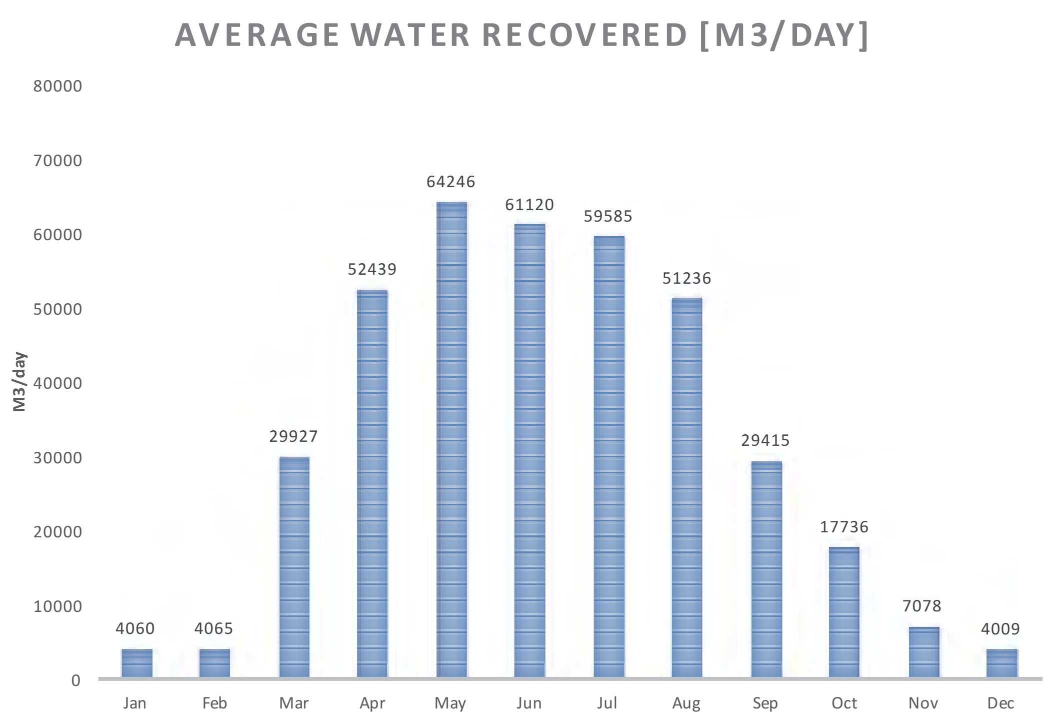

Figure 17: Histogram of water recovered (m^3/day)

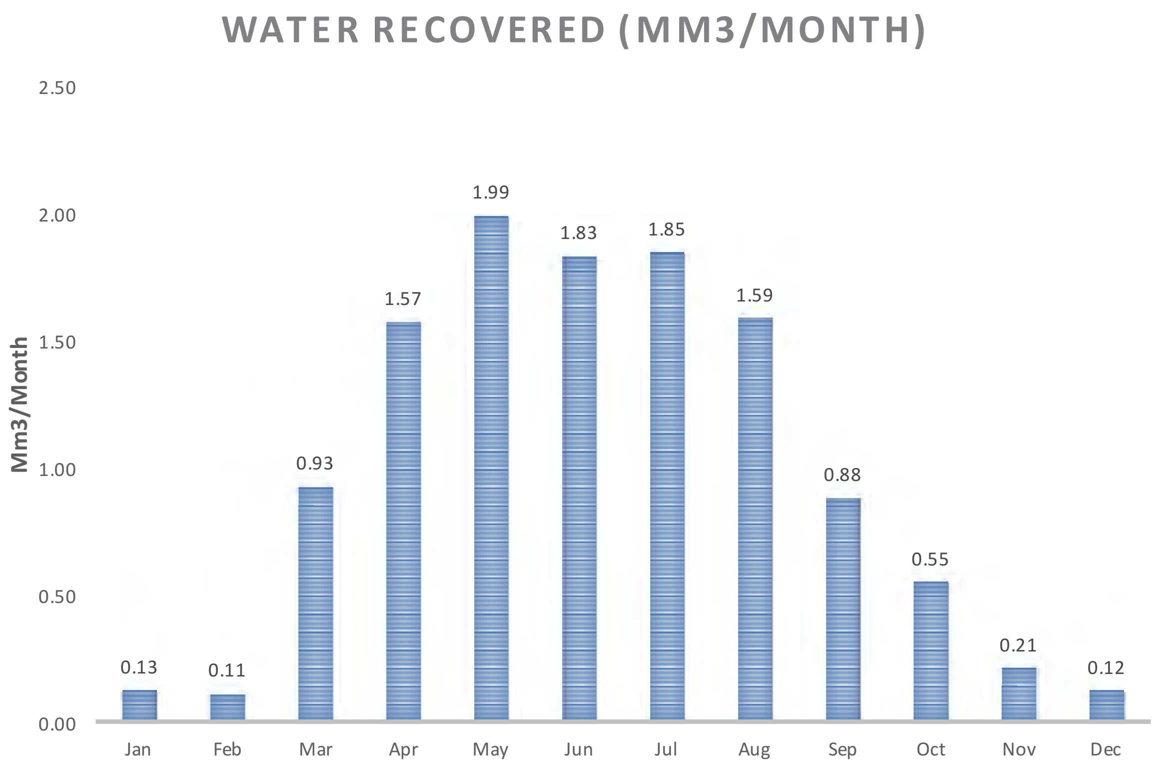

Figure 18 – Histogram of water recovered (Mm^3/Month)

As can be seen, the total water recovered per year is lower than total infiltrated waste water so the yearly water balance is positive.

The table below shows the hourly water recovered for each hour according the selected cropping pattern and irrigation scheduling.

Table 14: Hourly Water recovered for proposed Cropping Pattern according the proposed irrigation scheduling[3]

Water Recovered (m^3/h)	
month	m^3/h
Jan	406
Feb	407
Mar	2494
Apr	4370
May	5354
Jun	5093
Jul	4965
Aug	4270

[3] white cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

Sep	2451
Oct	1774
Nov	708
Dec	401
Average	2724

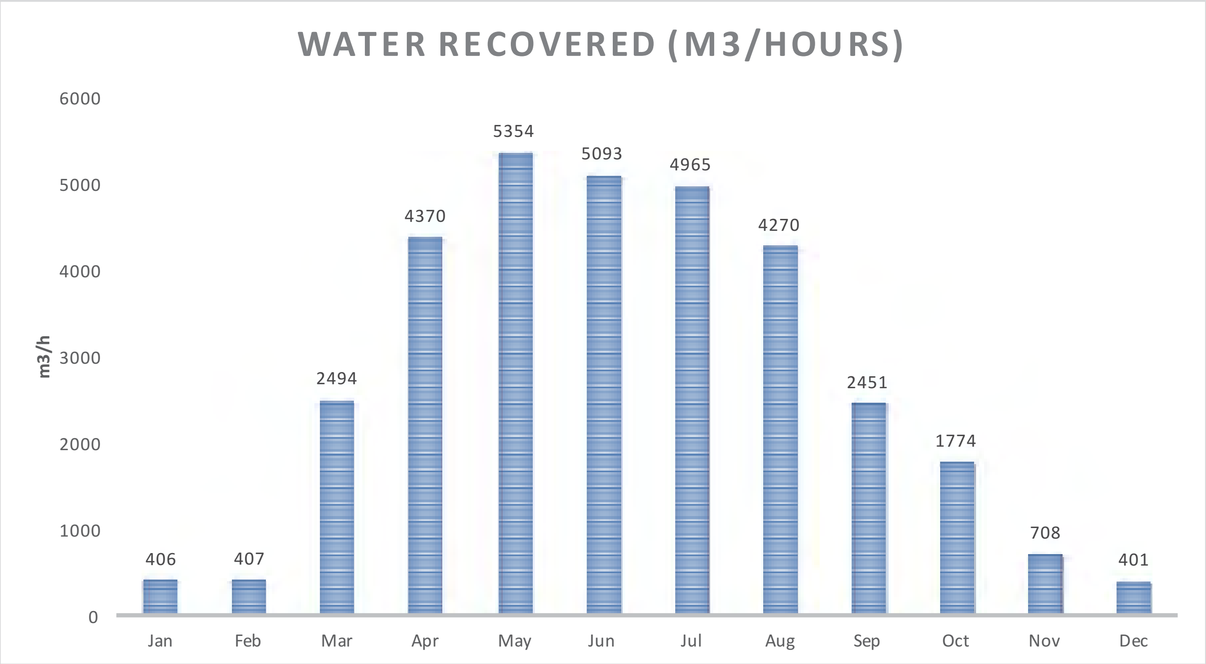

Figure 19: Histogram of the water (overaged over the day) recovered (m^3/hrs)

4.3 Irrigation Methods

The selection of the most appropriate irrigation method inside the farms depends on:

- Crop type,
- Soil characteristics,
- Investment costs of system.
- Ability of farmers to manage the system.

The common method of irrigation used by farmers in the Gaza Strip is surface irrigation which involves complete coverage of soil surface around the tree (small basin) with water. In the recent years using of more efficient irrigation method, like drip irrigation which is relatively expensive, has increased particularly for high price vegetables. The most appropriate efficient methods to be recommended under our conditions are sprinkler and localized irrigation system, which includes bubbler and drippers.

- *Sprinkler systems:* Applying of irrigation water in the form of a spray reaching the soil as rain. There are a variety of sprinkler systems including mini-sprinkler (30-80 l per hr.) which is used for irrigation of most citrus, olive and fruit trees. Macro-sprinklers can be used to irrigate cereals, fodder crops and industrial crops. Efficiency ranges from 70 to 80%.
- *Localized systems:* Water is applied more efficiently near the plant root zone, so that only the root zone gets wet and avoiding overlapping problems. These systems have low energy requirements (1-

3 bar) but require high quality of irrigation water to prevent clogging problems. Thus, good filtration (90- 120 mesh screen or disc filter) unit is required.

- ***Drip (Trickle) irrigation**:* Applying water (4-8 l per hr.) continuously through drippers to each individual plant at limited rates. Its efficiency is high (up to 90%) and used for high value crops (vegetables and citrus). Drip irrigation requires clean water without any particles or algae on it. Hazard categories include sand grains, precipitation of carbonates and algae.
- ***Bubbler irrigation**:* This system is more recommended as irrigation method for reclaimed water because exit openings are wider than of a dripper and thus less clogging problems. It can be used to irrigate citrus trees under our conditions. The irrigation efficiency is slightly lower than drip irrigation.
- ***Sub-surface drip irrigation (SDI): This system is still not enough evaluated through trials under Gaza conditions.***

Appropriate irrigation systems for proposed crops:

- *Citrus and fruit trees:* bubblers, drippers and mini-sprinklers.
- *Fodder and grains:* macro-sprinklers
- *Vegetables and row crops:* In-line drippers

The rate of irrigation can be controlled accurately and nutrients can be also added with irrigation water (fertigation).

5 Irrigation System Review and Recommendations

5.1 Review of Original Detailed Design of the Irrigation Network

Based on existing (and more recent version) of the available documents, the consultant reviewed the irrigation network design prepared in 2010. The review process was somehow limited by the following factors:

- The original detailed design lack in clearly explanation of some of the design choices that were made in 2010. This is particularly evident while trying to understand the proposed functioning and management of the irrigation system as well as in relation to some of the choices that the designers made while selecting some components of the irrigation network. Further to that, tables providing calculation of the main hydraulic parameters (pressure, length, connection, etc.) cannot be linked to the layout drawings of the network itself making it very difficult to follow some of the logics adopted by the original designer and impossible to verify the design without having to recreate and recalculate all parameters independently.
- The material that was provided for the review is incomplete. Two important pieces of information were not provided: i) the final bill of quantities for both Phase I and Phase II of the Irrigation Network component, and ii) the detailed calculation on the operation and maintenance cost for both the recovery and the reuse schemes.
- Furthermore, multiple different version of the same irrigation network was provided thus making unclear to which version of the final design we should refer to. Lacking better guidance, the review process was conducted on the latest version received.
- Finally, all digital files lack a clear georeferencing making it impossible to correctly overlay the irrigation network on satellite image or aerial photography.

To overcome some of the limitation listed above it was necessary to create a computer model of the proposed network layout and, ultimately, re-calculate all the design parameters.

5.1.1 Consistency of the Irrigation Network Design

5.1.1.1 Parcel Incongruences

Several incongruences about parcels layout can be found in the detailed design. A detailed topographic and cadastral survey of the project's area appears to be a necessary requirement to better locate the pipelines layout. Few example are provided in Figure 20 and Figure 21.

Furthermore, It should be note that the geographical reference system was not provided with the original design and cannot be inferred by the available material. The layout of the drawing is not based on a common Geographic Reference System thus making the review process particularly difficult and, more importantly, proving a set of drawings that are often confusing and that will likely confuse the contractors that will need to use them as a base for construction. Our suggestion is that all available drawings (for both Phase I and Phase II) should be incorporated into a common geographical reference system (local topographic system or UTM-WGS84 projection) avoiding incongruences when a is necessary to produce a unique map for the entire project's area.

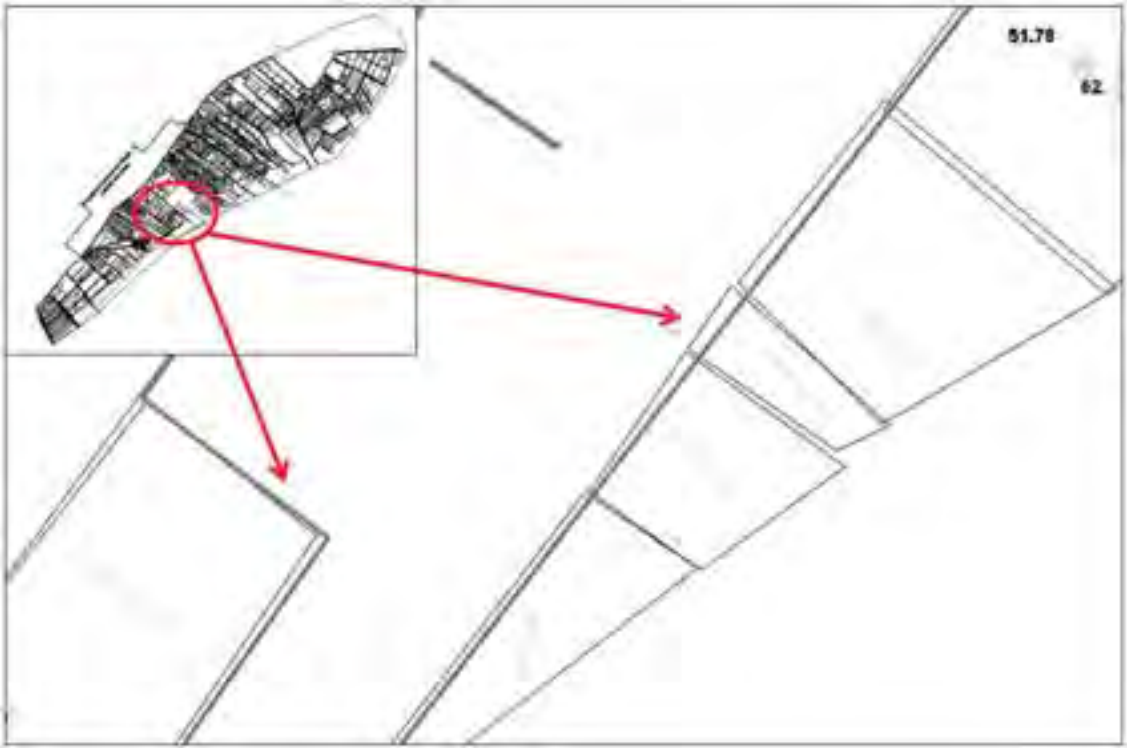

Figure 20: Arrows indicate incongruences between parcels

Figure 21: Arrows indicate incongruences between parcels

5.1.1.2 Pipeline functioning

Although general concept of functioning and network design results to be acceptable, some minor inconsistencies were found. Practically speaking it is not always possible to understand how the proposed distribution network might work once built as proposed by the original design.

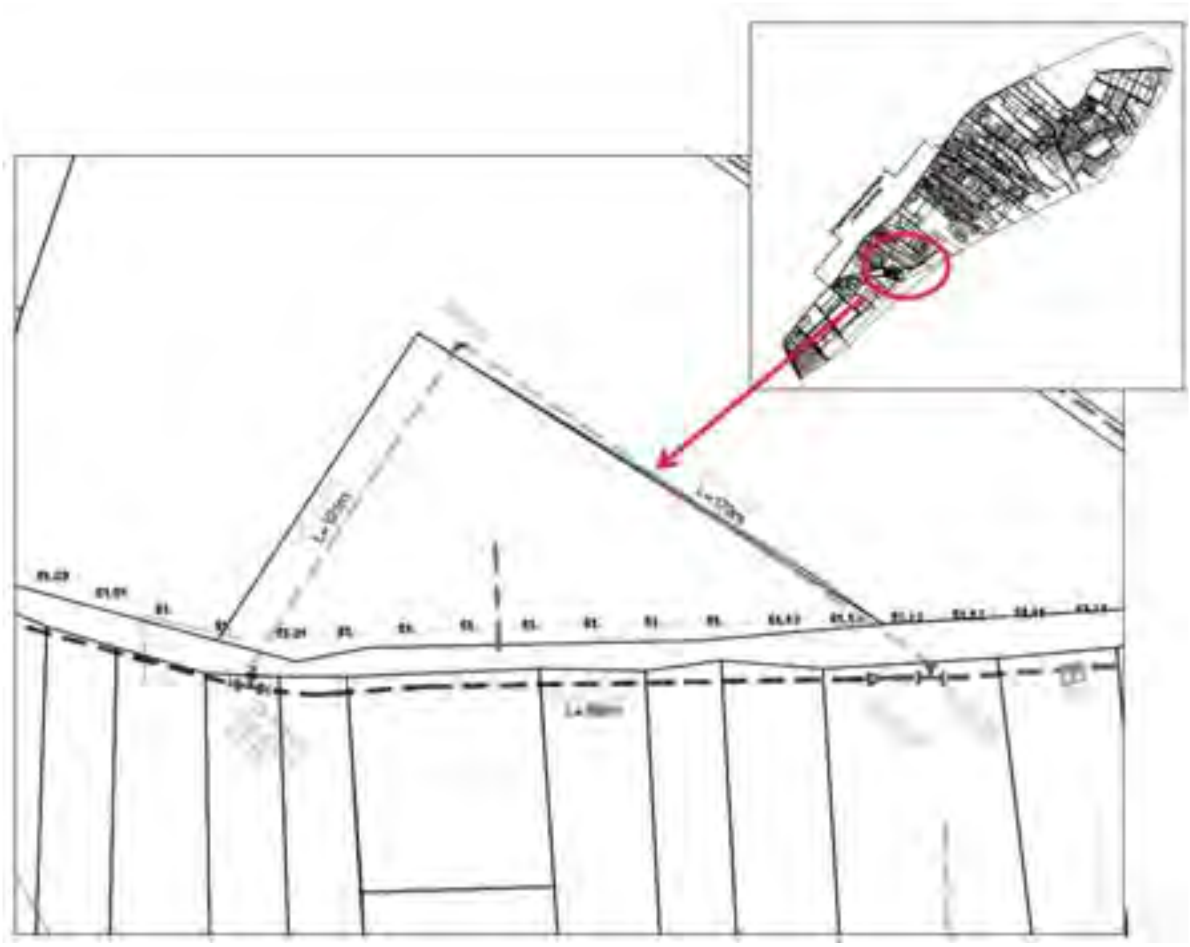

Figure 22: Arrow indicates a pipeline without any Farm connection and apparently without a sense to exist

Figure 23 : Arrow indicates a pipeline very long extending about 200m further the last Farm Connection

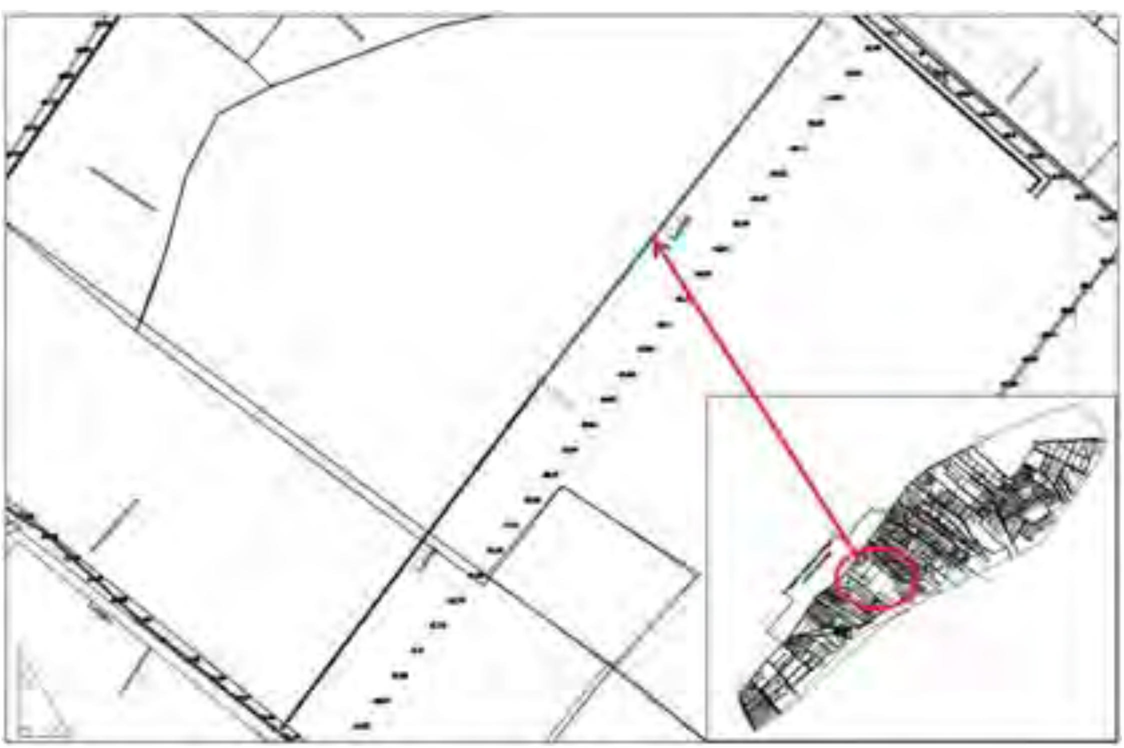

Figure 24: Arrow indicates a pipeline without any Farm connection and apparently without a sense to exist

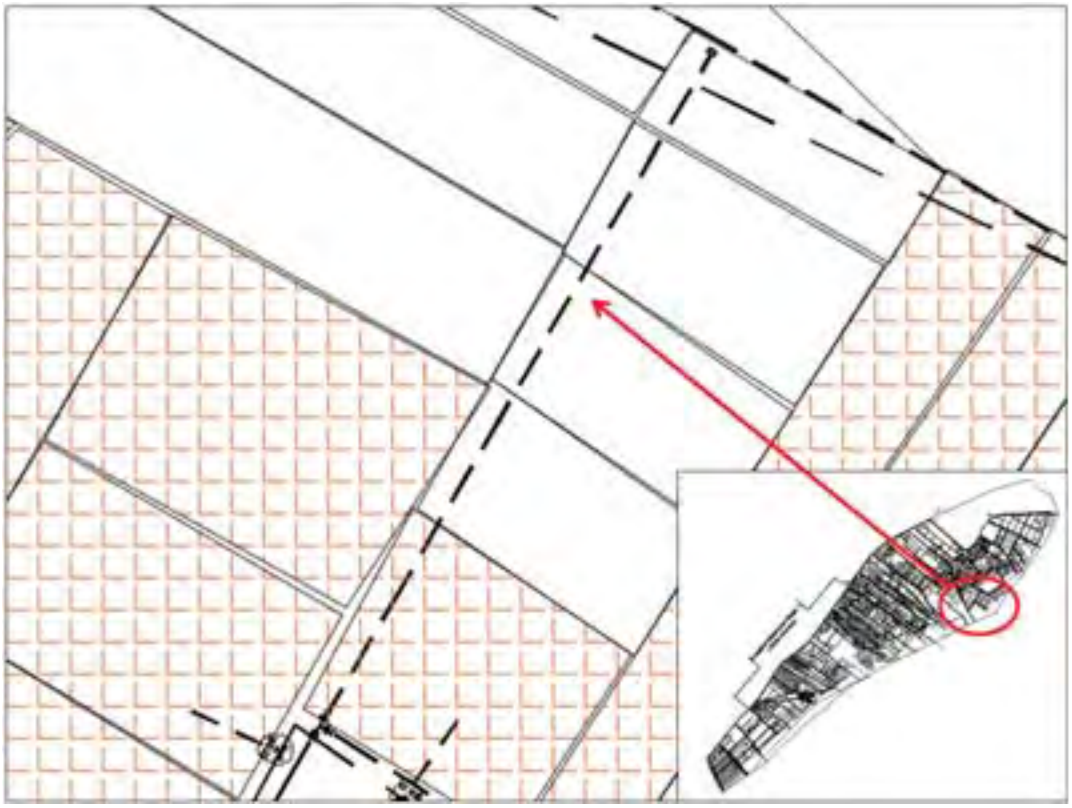

Figure 25 : Arrow indicates a pipeline without any Farm connection and apparently without a sense to exist

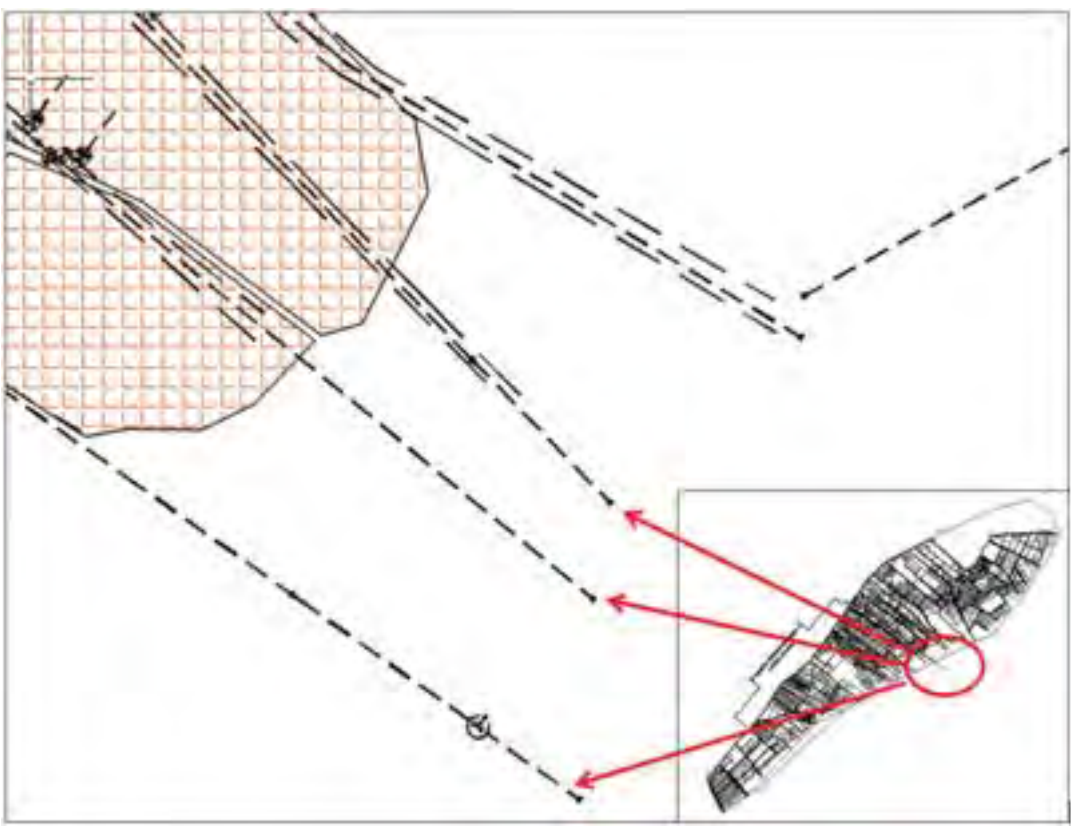

Figure 26: Arrows indicate some pipelines without any Farm connection and apparently without a sense to exist

Figure 27: Arrow indicates two pipelines: ones with Farm connections and the other closed and apparently without a sense to exist

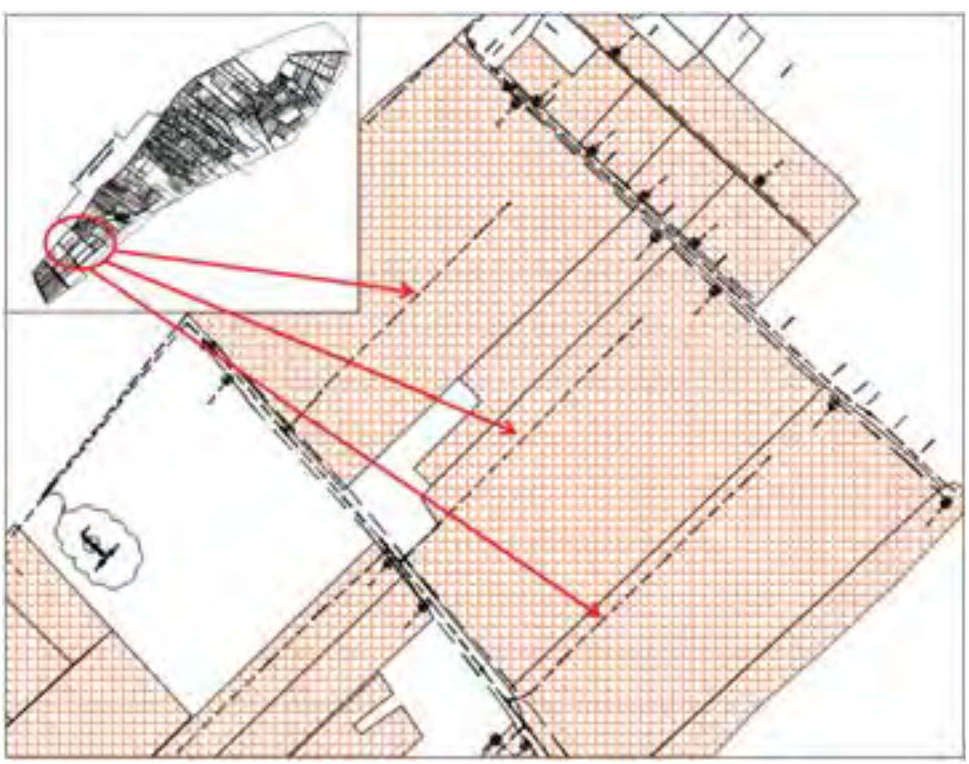

Figure 28 – Arrows indicate some pipelines without any Farm connection and apparently without a sense to exist

5.1.2 *Evaluation of Key Hydraulic Parameters*

One of the key design requirements for the irrigation system is the ability to deliver water at a pressure of at least 2.5 bar at each farm's gate. As previously mentioned, considering that the level of details provided by the original design is scarce, the verification of such hydraulic parameter over the existing detailed design has been particularly difficult and an Epanet model of the proposed network (the model encompasses the network from the downstream connection with the water tanks to the farm gates) has been developed according and following the available existing design documents. In particular:

- topography has been taken from available digital survey maps;
- hydraulic parameters and geometric characterization of the network have been taken as per the existing network design;
- Water Demand at the various networks' nodes was assigned to be congruent with the areas of the parcels and the proposed Cropping Pattern.

The functioning of irrigation network has been verified in the case of maximum demands from the system. It occurs during the months of June in scenario III as highlighted in the available documents.

Friction losses through pressure piping are based on Hazen-Williams formula:

$$V = 0.849\ C\ R^{0.63} S^{0.54}$$

Where:

V=velocity (m/s)

C=roughness coefficient

R=hydraulic radius (m)

S=friction head loss per unit length

Pipe roughness coefficient has been chosen according the following table:

Table 15: Roughness Coefficient

Pipe Material	New Pipe	Old Pipe
PVC, UPVC	150	130
PE	150	130
Steel (cement lined)	150	120
Asbestos, Cement	140	130

5.1.3 *Pipe Material*

Different pipe material can be used for water pipelines network and can be divided mainly into three categories:

- Metallic pipes: includes steel pipes, galvanized iron pies and cast iron pipes)
- Cement: pipes include concrete cement pipes and asbestos
- Plastic pipes: include plasticized polyvinyl chloride (PVC) pipes

Recently, the choice for irrigation network is usually made considering three materials: UPVC (for smaller diameter), Steel and Ductile Iron (for grater diameter), as explained in the original project.

The comparison between different pipe materials in terms of advantage or disadvantage in their use are well explained in the table below, extracted from the original project:

Table 16: Comparison between UPVC, Steel and Ductile Iron

Criteria	UPVC	Steel	Ductile Iron
Capital Cost	Low	High	Moderate
Operation and Maintenance Cost	Low	High	Moderate
Corrosion control	NA	Difficult	Easier
Chemical characteristics of the conveyed fluid	Not influenced	Not influenced	Not influenced
The source of pipes	Not local	Not local	Not local
Environment of the project area where the transmitted water is partially treated waste water	Can be used	Can be used	Can be used
Available experience	High	High	High
Pressure of pipeline	Moderate resistant	High resistant	High resistant
Field condition	Low adapted	Moderate adapted	High resistant

The consultants approved and recommend the use of UPVC pipes for diameter less that 600mm and Ductile Iron pipes for diameter greater than 600mm as per the original project.

Below a synthetic table summarizing the advantage in the use of PVC and Ductile Iron pipe well explained in the available documents.

Table 17: Advantages in using UPVC and Ductile Iron pipes.

PVC	Ductile Iron
1. Favorable initial and maintenance cost compared with other pipes of traditional materials for smaller sizes. 2. Longer length, depending on type and ease of joining reduce jointing costs. It is easy to bend. 3. Light weights resulting in lower handling and transporting costs and make it easier and faster to install. 4. Lower coefficient of friction permitting greater	1. It is easier and less expensive to control corrosion on ductile iron pipe than it is on steel pipe, where Ductile Iron Pipe Corrosion Control is accomplished with Polyethylene Encasement 2. The largest practical advantage of Ductile Iron pipe compared with steel pipe is that Ductile Iron pipe is much easier to install properly. Handling, assembling, backfilling, and adapting to field conditions all are areas in which Ductile Iron pipe offers distinct benefits

flows through a particular size. 5. Resistance to corrosion and built-up of deposits. 6. Good chemical resistance with non-absorbent walls. 7. Lower modulus of elasticity giving an advantage where there is soil movement or vibration. 8. Good tensile strength. 9. Thermal and electrical insulator. 10. No danger to health (non-toxic) and internationally approved for potable water use and for stormwater and wastewater	3. Ductile Iron Pipelines Adapt to Field Conditions in Installation more than steel pipes. 4. Since Ductile Iron pipe design results in a thicker wall for a given set of parameters, Ductile 5. In all normally specified pipe sizes, cement-mortar lined Ductile Iron pipe has an inside diameter that is larger than the nominal pipe size. 6. Pumping costs are lower for Ductile Iron pipelines, this reduction in pumping costs will save the system owner significantly over the life of the pipeline 7. Protection systems, often a requirement for steel pipelines, involve higher design and installation costs. They require monitoring and maintenance over the lifetime of the pipeline. There are also costs associated with pumping water through a pipeline and these costs are directly related to pipe inside diameters.

The distribution system fixed points in the model are the ground tanks. The entire model has been divided into the 6 sectors A1, A2, B1, B2, C1, C2, D, E, F.

The demands of each farm connection have been calculated according the proposed Cropping Pattern and the proposed pumping schedule.

The number and size of pumps has been fixed according the following table as per the available design documents

Table 18: Pumping flow rate and pressure for each sector

Irrigation zone	**Output pressure in booster station (bar) when output flow is (m^3/h)**											**Max flow of the zone**
	1,000	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**5,500**	**6,000**	
North A1	5.90	6.30	6.80	7.50								2,382
South A2	4.60	4.70	4.90	5.00								2,539
North B1	7.30	7.70	8.30	8.90								2,571
South B2	4.80	4.90	5.10	5.30								2,482
North C1	6.70	7.10	7.60	8.30								2,269
South C2	5.20	5.50	6.00	6.40								2,301
North D	6.90	7.00	7.20	7.40	7.60	7.80	8.10	8.50	8.90	9.20	9.70	5,444
North E	6.40	6.50	6.70	6.90	7.20	7.50	7.90	8.40	8.90	9.40	10.10	5,175
North F	5.90	6.00	6.20	6.30	6.50	6.70	6.80	7.10	7.40	7.60	7.90	5,159

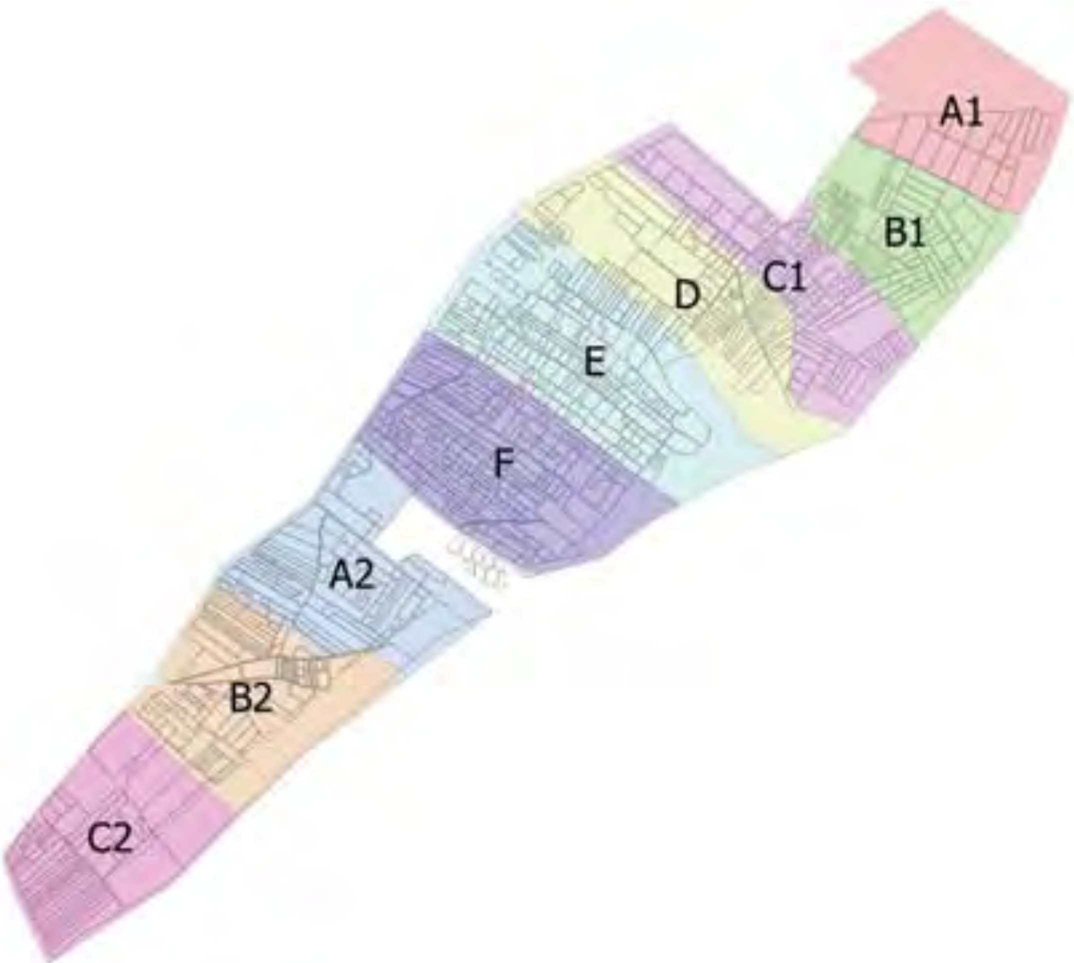

Figure 29: Project area divided into 6 main sectors

5.1.4 Results of Hydraulic Model for the Original Design

The hydraulic model highlights that most of the farm gates reach the desired head of 2.5 bar.

However, some nodes present pressure lower than this target values, usually located in the farthest point from water tank.

The following figure provides a snapshot(see red dots) of the network nodes where the desired head of 2.5 bar is not met at some point in time during the year.

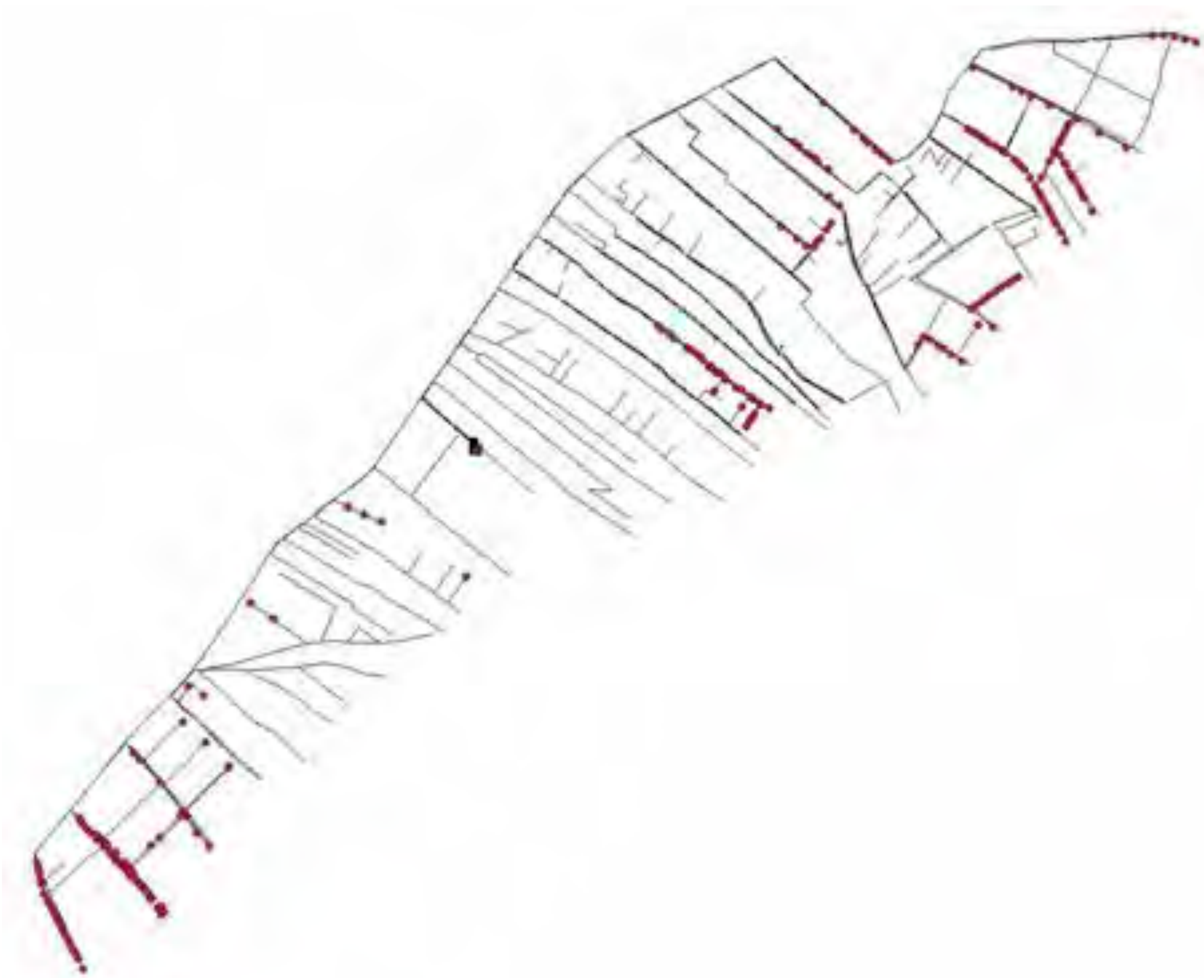

Figure 30: Gate farm with pressure below 2.5bar during the irrigation period (6 days)

This problem can be solved by increasing total pump head or by substituting some pipelines with others of greater diameter, so reducing the head losses and increasing pressure head at the farm gate. The second solution is the optimum one because in front of a limited increase of capital cost for the entire project (about 105,000 US$, 0.47% of the total investment cost for the irrigation network), it's possible to have the required pressure saving energy consumption and limiting in the same time excessive velocity of water flow through the pipelines.

5.1.4.1 Proposal for Network Improvements

A new Epanet model has been prepared to verify the pressure at the farm gate after the substitution of some pipelines with others of the same material but with greater diameter, to allow for reduced head losses through them.

A comparison between modified diameter in terms of total length for different pipe diameter from original irrigation network and the proposed ones can be seen in the following table.

Table 19: comparison between modified diameter in terms of total length for different pipe diameter from original irrigation network and the proposed ones

DN	Total length difference
	- sign indicates minor total length for selected diameter respect the original project + sign indicates greater total length for selected diameter respect the original project
90	-2528
110	574
140	-13707
160	4817
180	2962
200	3182
225	-604
250	3357
280	-363
300	716
355	708
400	886
500	-138
600	138

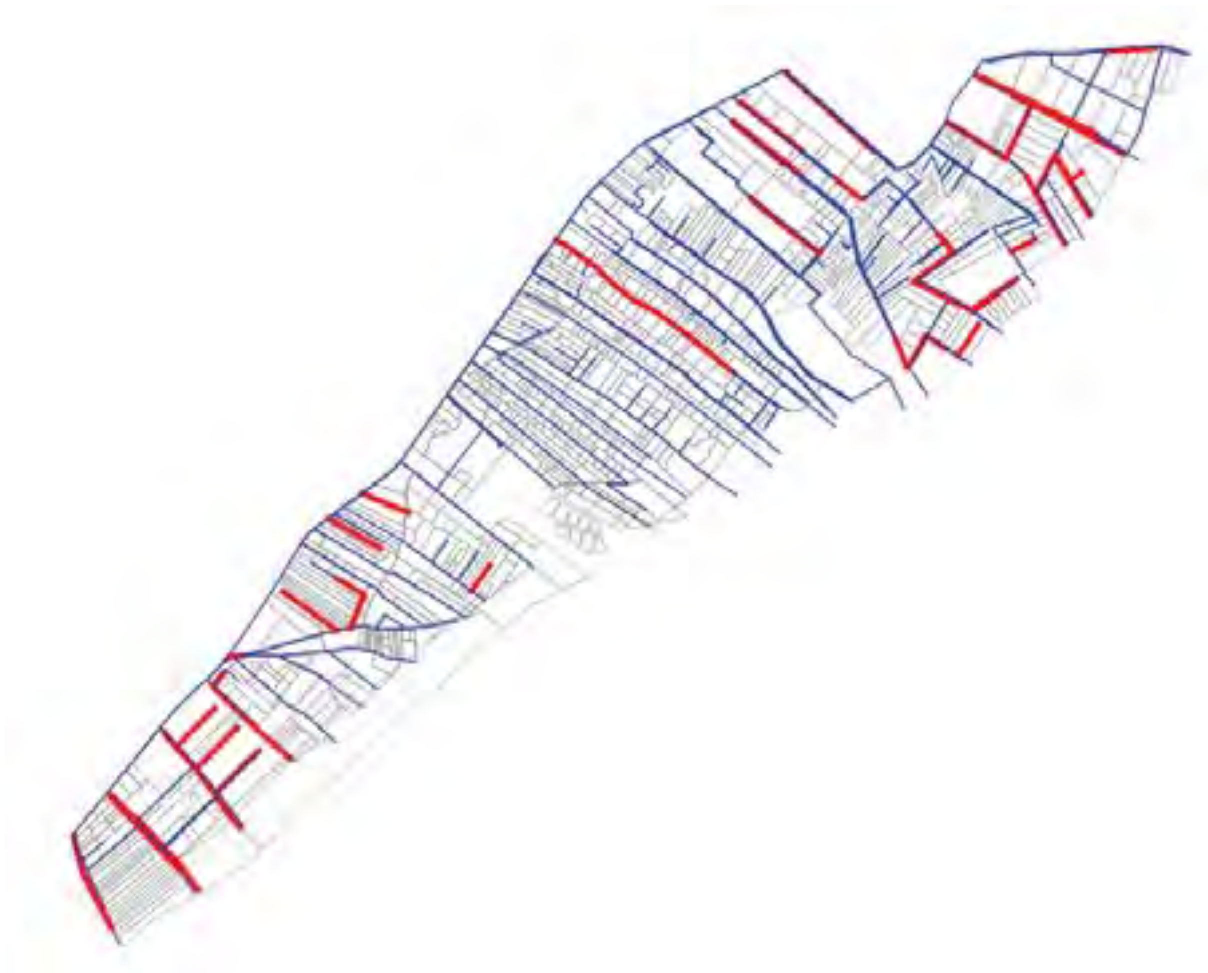

Figure 31: Irrigation network with highlight in red the pipes with proposed greater diameter

Annex 1 to this report provides a detailed set of drawings representing the modified irrigation network with the pressure estimated by the hydraulic model applying the proposed pipe diameter increase (highlighted in red color)

5.2 Irrigation Network Design Applying the New Cropping Pattern

5.2.1 Design Criteria and Parameters for a Peak Summer Day in May

The following design criteria and parameters are determined based on the analysis results for critical design requirements for the considered peak summer month.

Being the amount of water recovered during the peak water requirement in summer months greater that maximum capacity of wells, water storage is essential to guarantee the continuity of supplying during irrigation hours.

The month of May is the critical one for the design of tanks. Considering a maximum constant water supply from wells equal to 175 m^3/hour each (it varies from about 150 m^3/hour to about 200 m^3/hour per well) and the maximum water required per hour in the month of May during irrigation hours, it’s possible to calculate the volume of water in the tanks that permits to guarantee the total volume required during the day. Obviously the pumps of the wells have to work for a longer period than booster pumping station to recharge the tanks at the end of irrigation period.

Below a table showing the calculation to estimate the minimum volume of the tanks, which results to be 8,000 m^3.

Time [Hours of the Day]	Max Q demand in May [m^3/h]	Q supply [m^3/h]	Cumulative demand [m^3]	Cumulative supply [m^3]	Difference [m^3]	Hours per day to recharge the tanks at the end of irrigation period [hours]
7-8	5,354	4,725	5,354	4,725	629	1.60
8-9	5,354	4,725	10,708	9,450	1,258	
9-10	5,354	4,725	16,062	14,175	1,887	
10-11	5,354	4,725	21,415	18,900	2,515	
11-12	5,354	4,725	26,769	23,625	3,144	
12-13	5,354	4,725	32,123	28,350	3,773	
13-14	5,354	4,725	37,477	33,075	4,402	
14-15	5,354	4,725	42,831	37,800	5,031	
15-16	5,354	4,725	48,185	42,525	5,660	
16-17	5,354	4,725	53,538	47,250	6,288	
17-18	5,354	4,725	58,892	51,975	6,917	
18-19	5,354	4,725	64,246	56,700	7,546	

Summarizing:

- Two water storage tanks of 4,000 m^3 each (8,000 m^3 altogether) are used where the slight increase compared to maximum required volume (7,546 m^3) in the size is to allow for proper connections, etc. For other months, this increased storage capacity will provide additional flexibility in the operation of the system. The capacities of water tanks satisfy the hydraulic and mechanical operational requirements.
- Maximum hourly pumping rate is about 6,000 m^3/hr. where the slight increase in the rate (9%) compared to maximum required (5,354 m^3/hr) is taken as a factor of safety and to allow for more flexibility in the operation.
- The 6,000 m^3/hr maximum and the 410 m^3/hr minimum hourly pumping rates are considered in the design of pumping station, trunk lines, irrigation networks and associated facilities.

5.2.2 Validation of the Existing Hydraulic Network with Proposed Cropping Pattern and Irrigation schedule

The maximum flow in the pipeline network during the peak month is comparable with that in the existing project, so the pipeline network is the same.

Also the proposed pipe material are suitable as said before.

As done before, an Epanet model has been performed to verify the hydraulic network considering a minimum head pressure at the farm gate of 2.5 bar.

Assuming the geometric and hydraulic characteristics of the network pipeline as per the previous project and assuming the proposed irrigation pattern (based on uniform irrigation across the entire agricultural area on 10 or 12 hours per day), it's possible to satisfy the required head at the nodes, in particular during the maximum flow rate, with lower pumping heads than those assigned in the original project.

Dividing the entire area into two sectors for simplicity, named North and South sectors, comprising respectively previous sectors A1+B1+C1+D+E+F for an area of 8,402.50 du and previous sectors A2+B2+C2 for an area of 3665.50 donum, the pumping flow rate and pressure for each of them is shown in the following table.

Table 20: Pumping flow rate and pressure for north and south sectors

Irrigation zone	Output pressure in booster station (bar) when flow is (m^3/h)				Max flow of the zone (m^3/h)
	1,000	2,000	3,000	4,000	
North	5.8	6.1	6.3	6.5	3,728
South	4.8	5.0			1,626

Table 21: Flow through the irrigation network for north and south sectors during the year[4]

Flow (l/s)		
month	**north sector**	**south sector**
Jan	76	33
Feb	76	33
Mar	483	211
Apr	837	365
May	1,036	452
Jun	991	432
Jul	969	423
Aug	814	355
Sep	483	211
Oct	341	149
Nov	128	56
Dec	75	33
Average	526	229

Supposing to use analogue type of pumps as per the original project (duty point: 750 m^3/h – total head 6.5 bar), 5 pumps serve the north sector, 3 pumps serve the south sector while 2 pumps are in stand-by.

As per the original project, the booster pumps are located in a pumping hall together with the suction and pressure manifolds and with all necessary pipe works. The pumping station will serve both irrigation network, the south area with three irrigation zones and north area with six irrigation zones. The pumps are installed parallel and pumping from a common suction manifold into a common pressure manifold.

Table 22: Number of operating pumps and irrigation zones

Irrigation zone	Number of pumps	
North	5	Simultaneous pumping
South	3	

[4] white cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

Drawings provided in annex 2 represent the proposed irrigation network with the results of hydraulic model applying the proposed Cropping Pattern.

5.2.3 Consideration about the implementation of irrigation network with the consultant's Cropping Pattern

As described before, respect to the original ones, the proposed Cropping Pattern allow to have some advantages, which the most important are:

- Less amount of water per year for irrigation purposes. Other activities (industrial, farming, etc) can be developed in the area exploiting saving water
- Lower pumping head especially during the peak demands i.e. lower energy consumption and then lower operation costs.
- Lower total hours per year of pumps functioning i.e. lower pumps wear.
- Lower velocity of water inside pipes for most of the year i.e. lower pipes wear and lower surge pressure in case of rapid velocity change in the network

5.2.4 Energy Consumption

Based on the proposed Cropping Pattern and the assumptions made for the functioning of the entire irrigation system, a preliminary estimation of the power absorption and energy consumption is presented in Table 23 and Table 24.

Table 23: Power absorption for the booster pumping station[5]

Power Absorption (kW)		
Month	**North Sector**	**South Sector**
Jan	45	34
Feb	45	34
Mar	406	332
Apr	739	574
May	943	726
Jun	903	695
Jul	883	666
Aug	719	559
Sep	406	325
Oct	277	229
Nov	90	72
Dec	0	0
Average	**455**	**354**

[5] White cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

Table 24: Energy consumption for the booster pumping station

Energy consumption (kWh)		
Month	**North Sector**	**South sector**
Jan	13,904	10,594
Feb	12,576	9,582
Mar	151,020	123,333
Apr	265,905	206,815
May	350,928	269,945
Jun	325,105	250,081
Jul	328,449	247,600
Aug	267,507	208,061
Sep	146,148	116,919
Oct	85,812	71,017
Nov	26,966	21,573
Dec	0	0
Average	164,527	127,960
Total (MWh/year)	**1,974**	**1,536**

Based on the above results, the total energy consumption for both the North and the South sectors is therefore:

TOTAL Energy consumption per year [MWh]	**3,510**

Referring to the original 2010 design, power absorption and energy consumption can be estimated based on the power head and flow corresponding to the water requirement from the system during the year as defined by the Cropping Pattern proposed in the original design. Corresponding values are presented in the table below:

TOTAL Energy consumption per year [MWh]	4,147

As can be seen, the new proposed Cropping Pattern allows for a saving of approximately 637 MWh per year. This is essentially due to a lower flow rate during most of the months of the year and a lower pumping head which, in turn, leads to a lower total energy consumption.

5.3 Capital Investments

Capital investments, as provided[6] by PWA for both the recovery and the irrigation schemes, are presented in the following Table 25.

[6] At the time this evaluation was prepared not all the documentation related to the original design was made available to the consultant. The bill of quantities for the irrigation scheme was not provided and the consultant had to rely on costing adjustments provided by PWA.

Overall, Table 25 identifies a 28% increase in construction costs if compared with the original estimates presented in 2010. The major difference is due to the over 40% increase in construction costs associated to the implementation of the irrigation network which now is projected to cost US$ 22,000,000 instead of the original estimated US$ 15,649,730.

Table 25: Capital Investments for the Recovery and Irrigation Schemes

Implementation Stage			Phase I	Phase II
Item No.	**Description**	**Total (US$)**	**US$**	**US$**
1	General Items	$262,400	$131,200	$131,200
2	Circular Tank 4,000 m^3 (2 Tanks)	$1,061,300	$530,650	$530,650
3	Booster Site (Civil)	$511,000	$511,000	$-
4	Mechanical Building	$2,285,150	$340,000	$1'945,150
5	Electrical Building	$1,060,000	$1,060,000	$-
6	Guard Room	$15,500	$15,500	$-
7	Recovery Wells (27 Wells)	$3,270,000	$1,816,667	$1,453,333
8	Monitoring Wells (10 Wells)	$260,000	$130,000	$130,000
9	Well Networks (approximately 6.7 km)	$707,000	$707,000	$-
10	SCADA System	$1,961,250	$1,321,250	$640,000
11	Electric Works	$2,885,897	$1,885,897	$1,000,000
12	Irrigation Network (approximately 128 km)	$22,000,000	$6,015,625	$15,984,375
Grand total		**$36,279,497**	**$14,464,789**	**$21,814,708**

5.4 Operation and Maintenance Costs

The following Table 26 summarizes the Operation and Maintenance cost for both the recovery and the irrigation system broken down per construction phase. The same items of the original project have been considered (Manpower, power consumption, maintenance and repair works, consumables) but these values could not be verified (except for the power consumption) as the original Operation and Maintenance 'Annex 7' O&M calculation sheet was not available.

Table 26: Yearly O&M Costs associated to the recovery and irrigation schemes

Operation and Maintenance Cost		Phase I	Phase II
Description	**US$/year**	**US$/year**	**US$/year**
Manpower	$150,000	$90,000	$60,000
Power consumption	$933,660	$311,220	$622,440
Maintenance and repair works	$83,345	$27,782	$55,563
Consumables & Miscellaneous	$76,960	$25,653	$51,307
Total O&M cost USD/year	**$1,243,965**	**$454,655**	**$789,310**

The only difference in O&M costs between the original design and the proposed alternative is due to the reduction in power consumption and cost of energy per MWh (which we have assumed to be in the range of 133 US$/MWh) and – in turn – in power costs.

5.5 Construction Stages

In agreement with the original design, four tender packages are recommended for the implementation as defined in the following Table 27:

Table 27: Recommended tender packages

ID	Phase	Package	Description	Cost [US$]
A	I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$8'449'163,67
B		2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)	$6'015'625,00
C	II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$5'830'333,33
D		2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)	$15'984'375,00
			TOTAL	**$36'279'497,00**

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REVIEW OF THE IRRIGATION PROJECT

Selection of Consulting Service for Complementary Feasibility Study for Irrigation Scheme

ANNEX 1

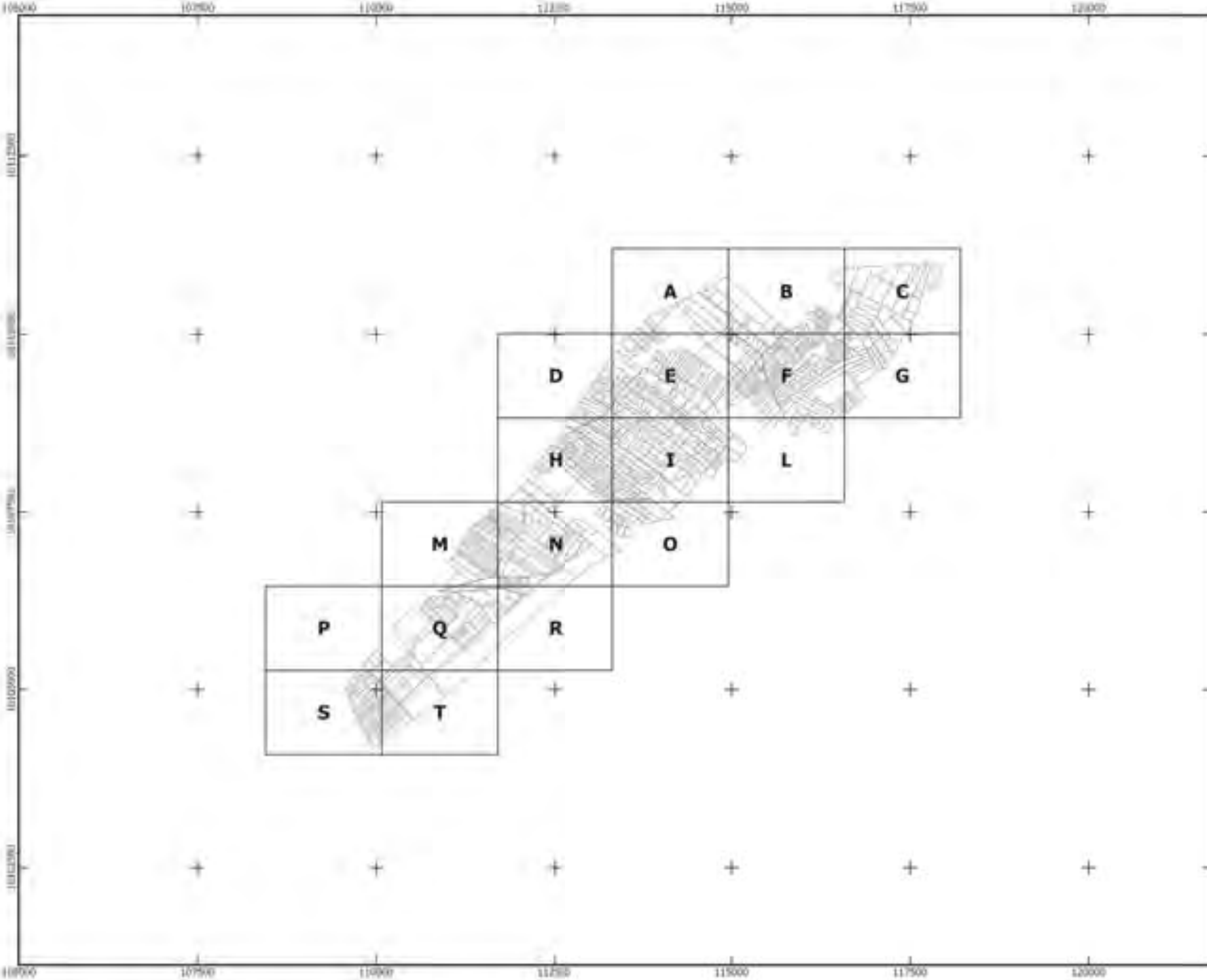
LAYOUTS OF EXISTING IRRIGATION NETWORK AND PRESSURE AT FARM GATE WITH PROPOSED PIPELINES MODIFICATION

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

May 2017



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Irrigation Area General view

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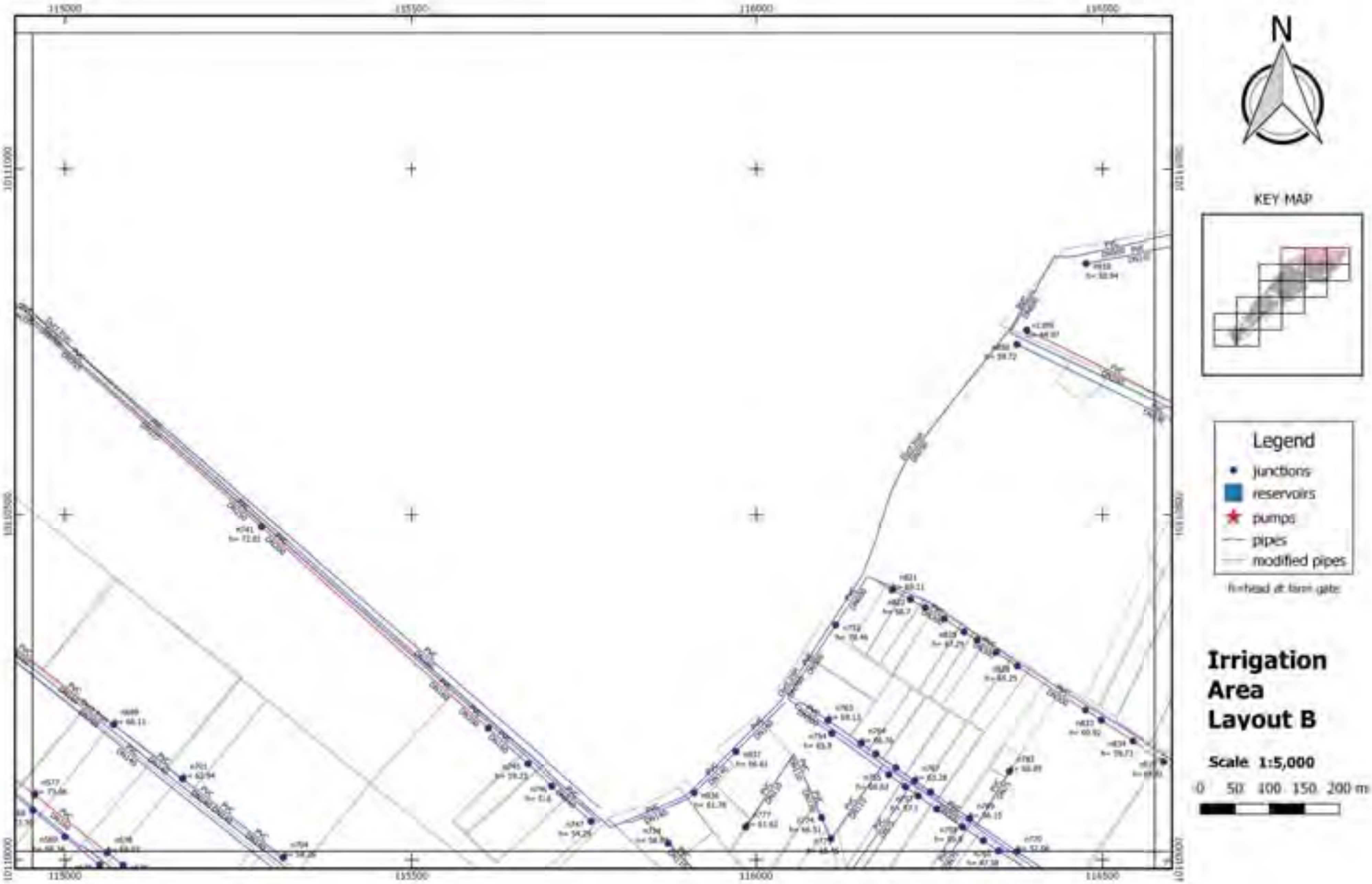
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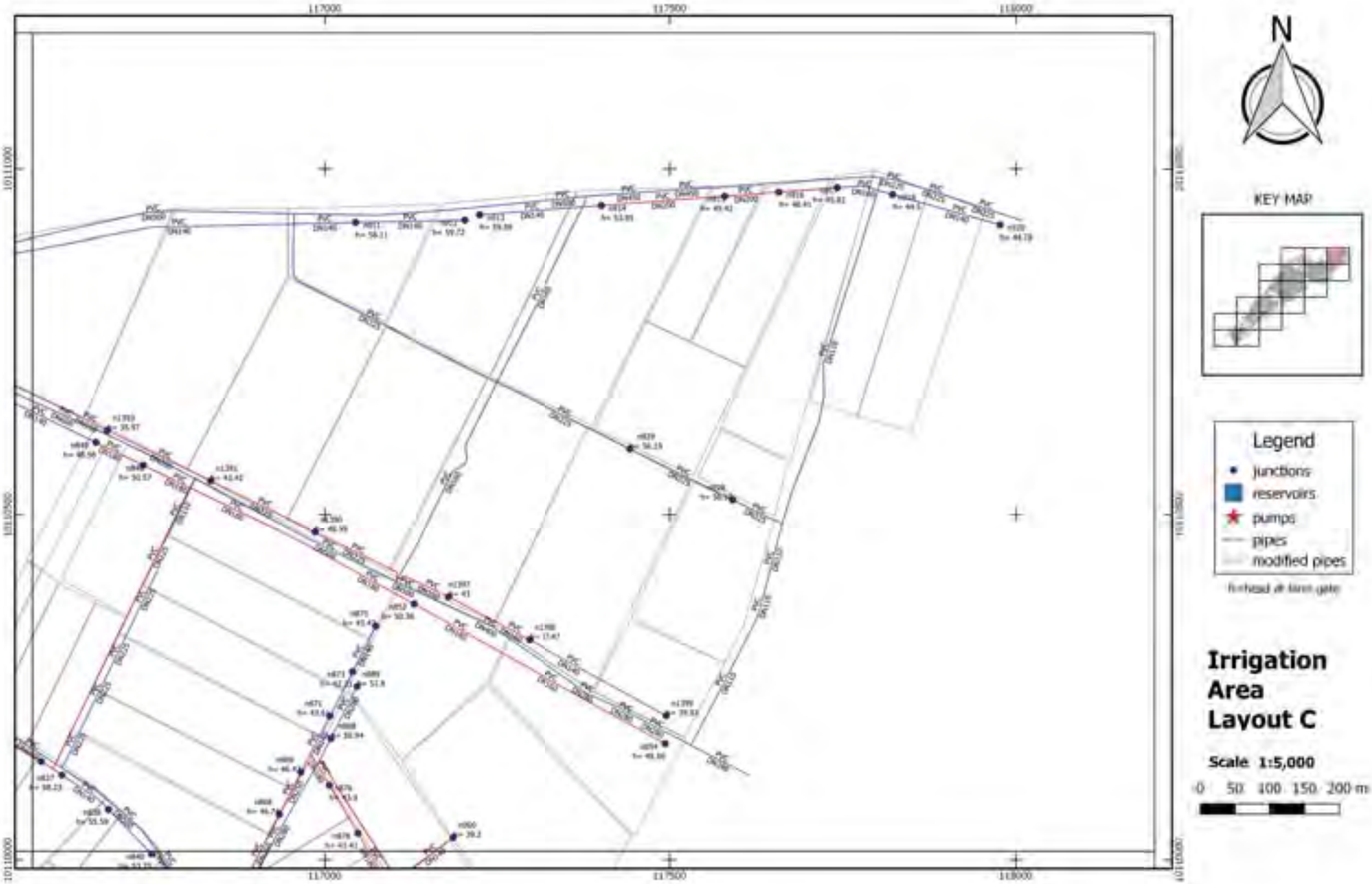
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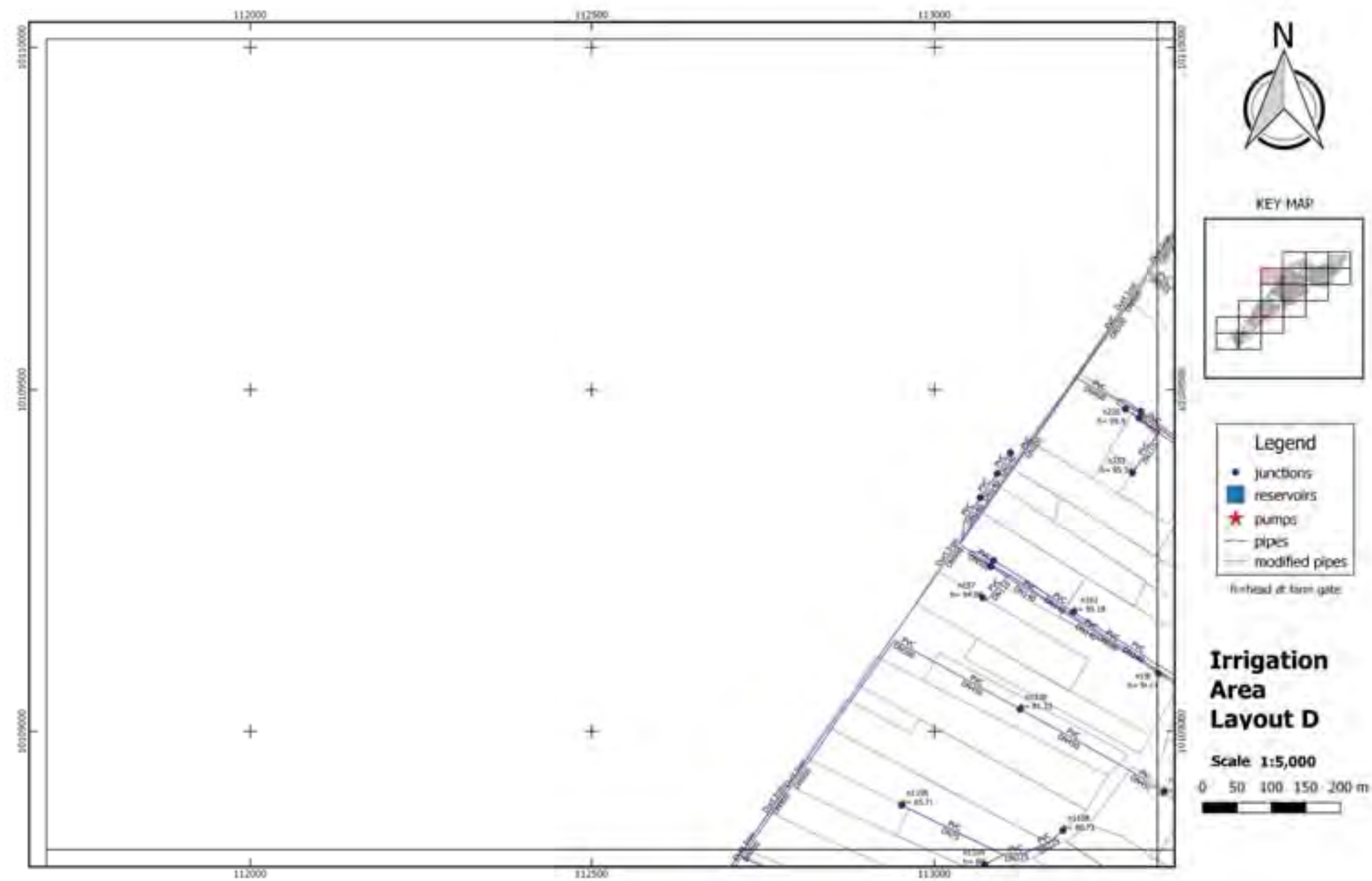

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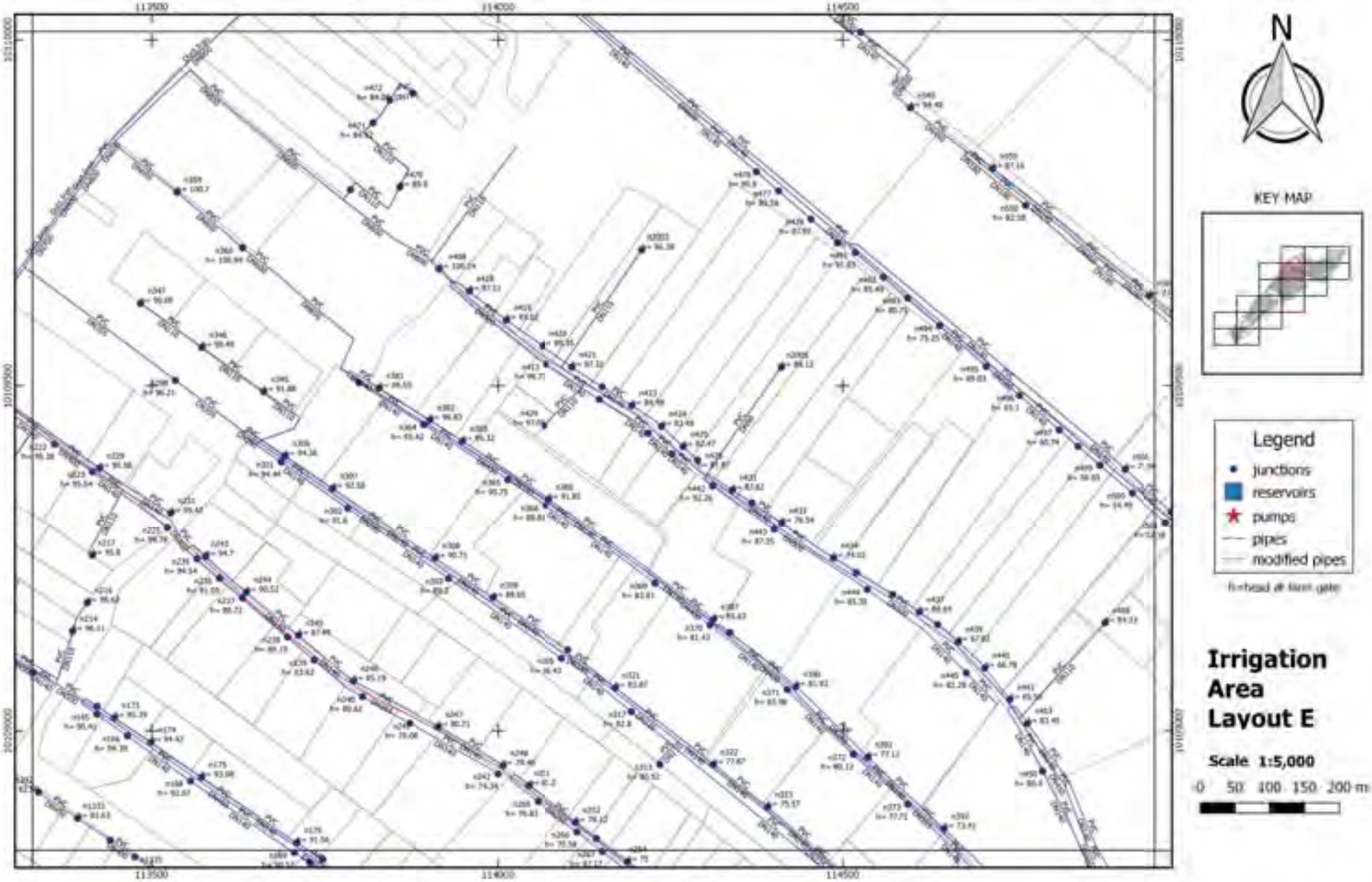
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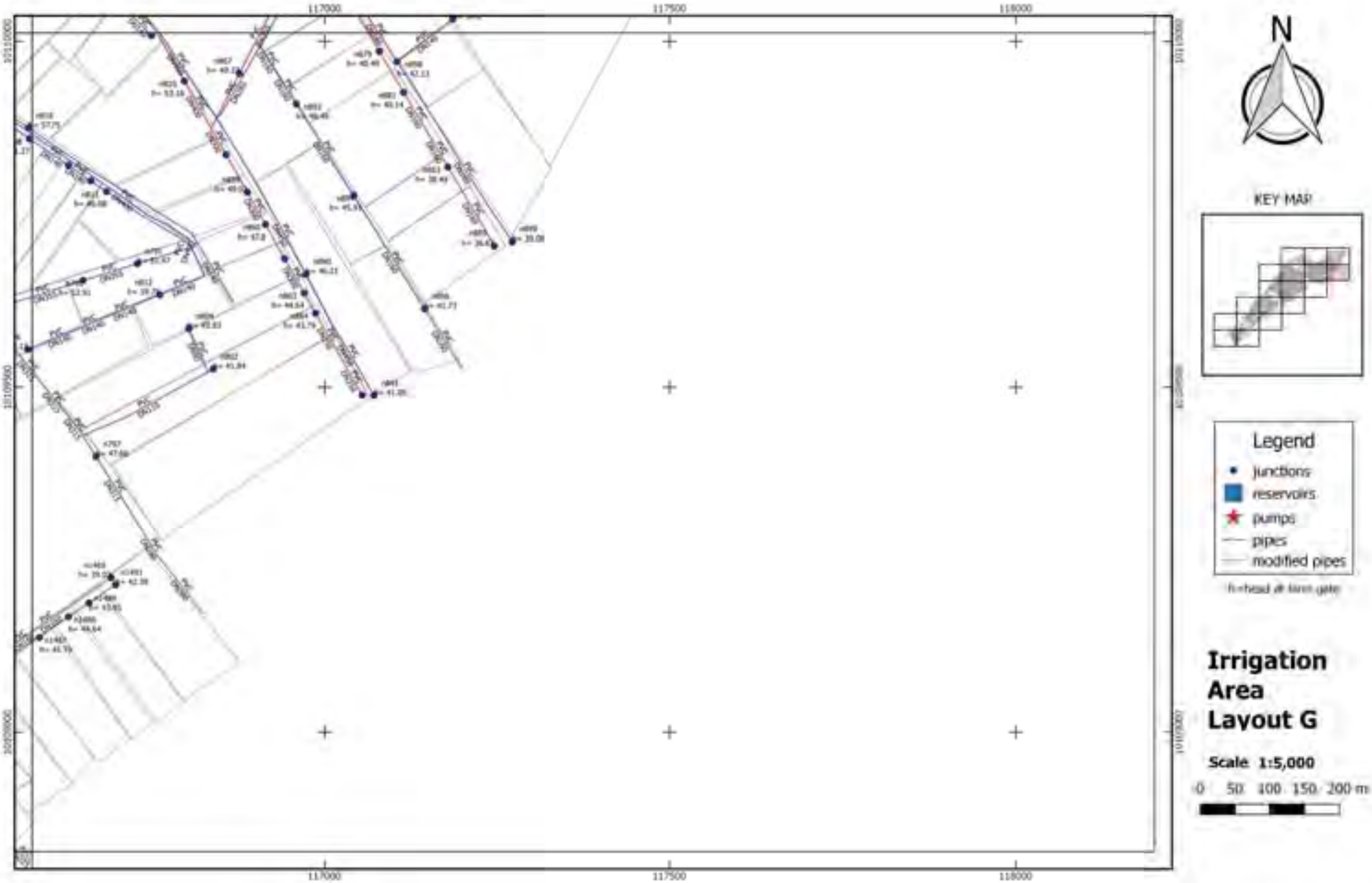

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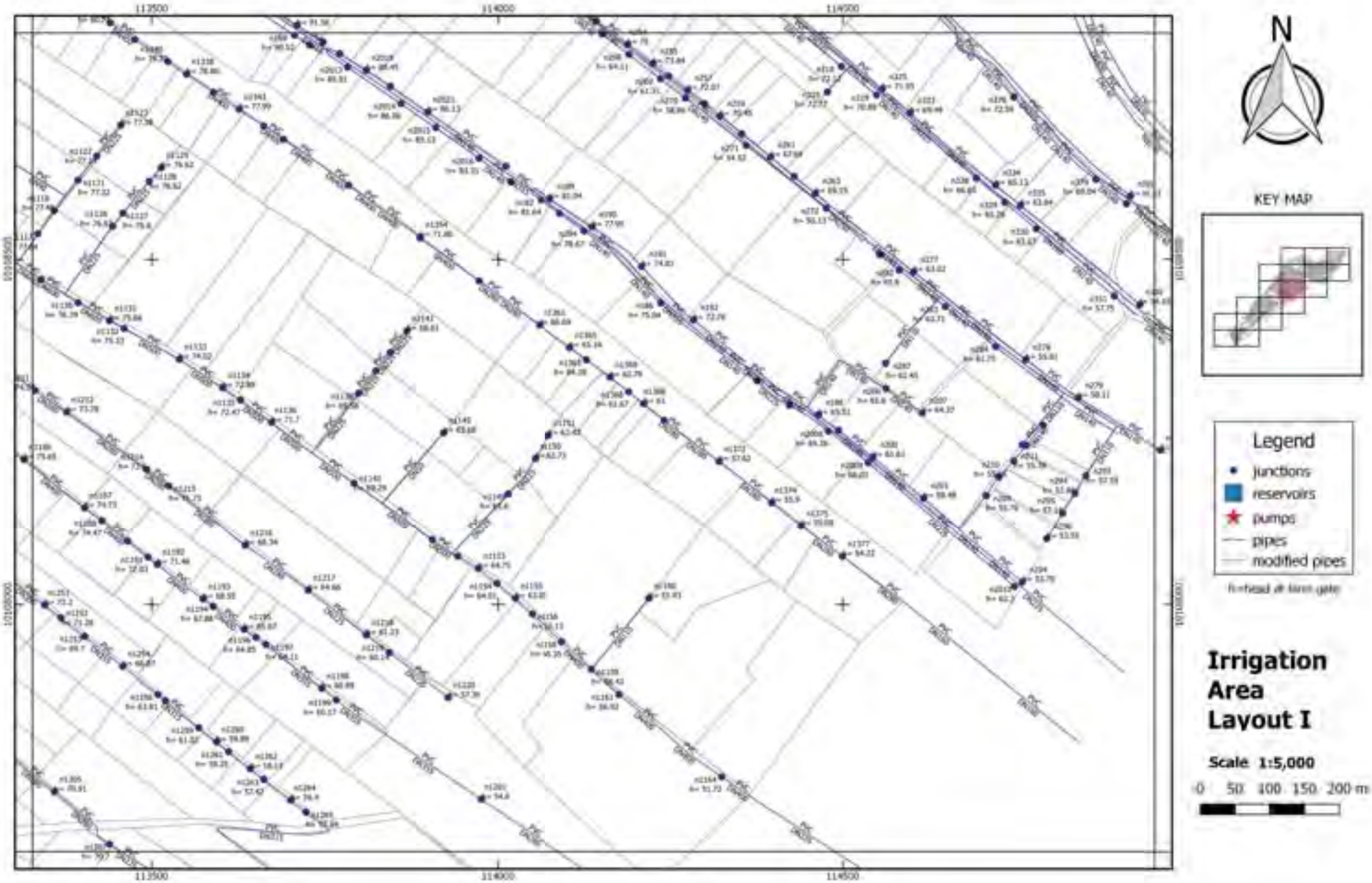
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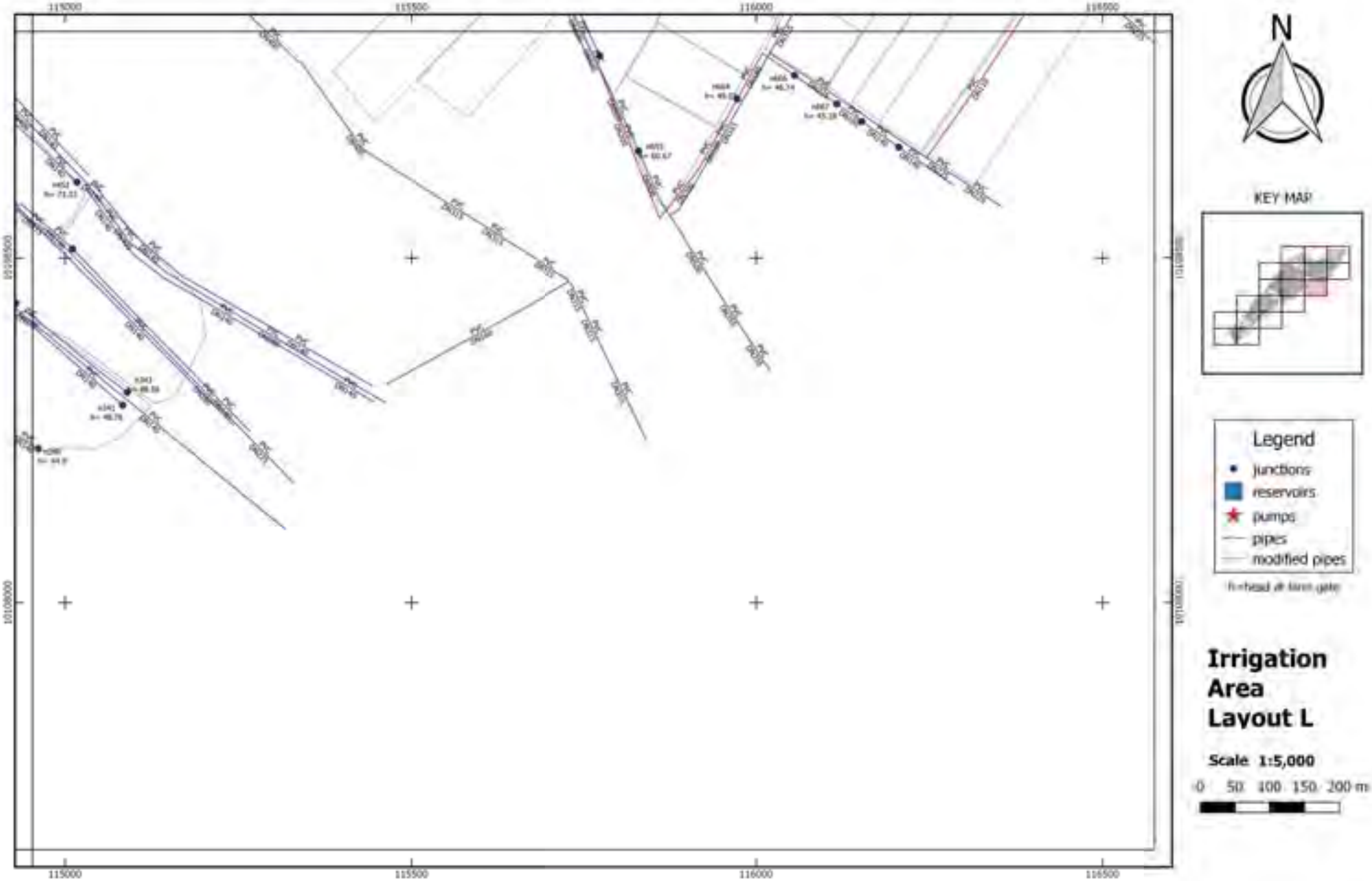
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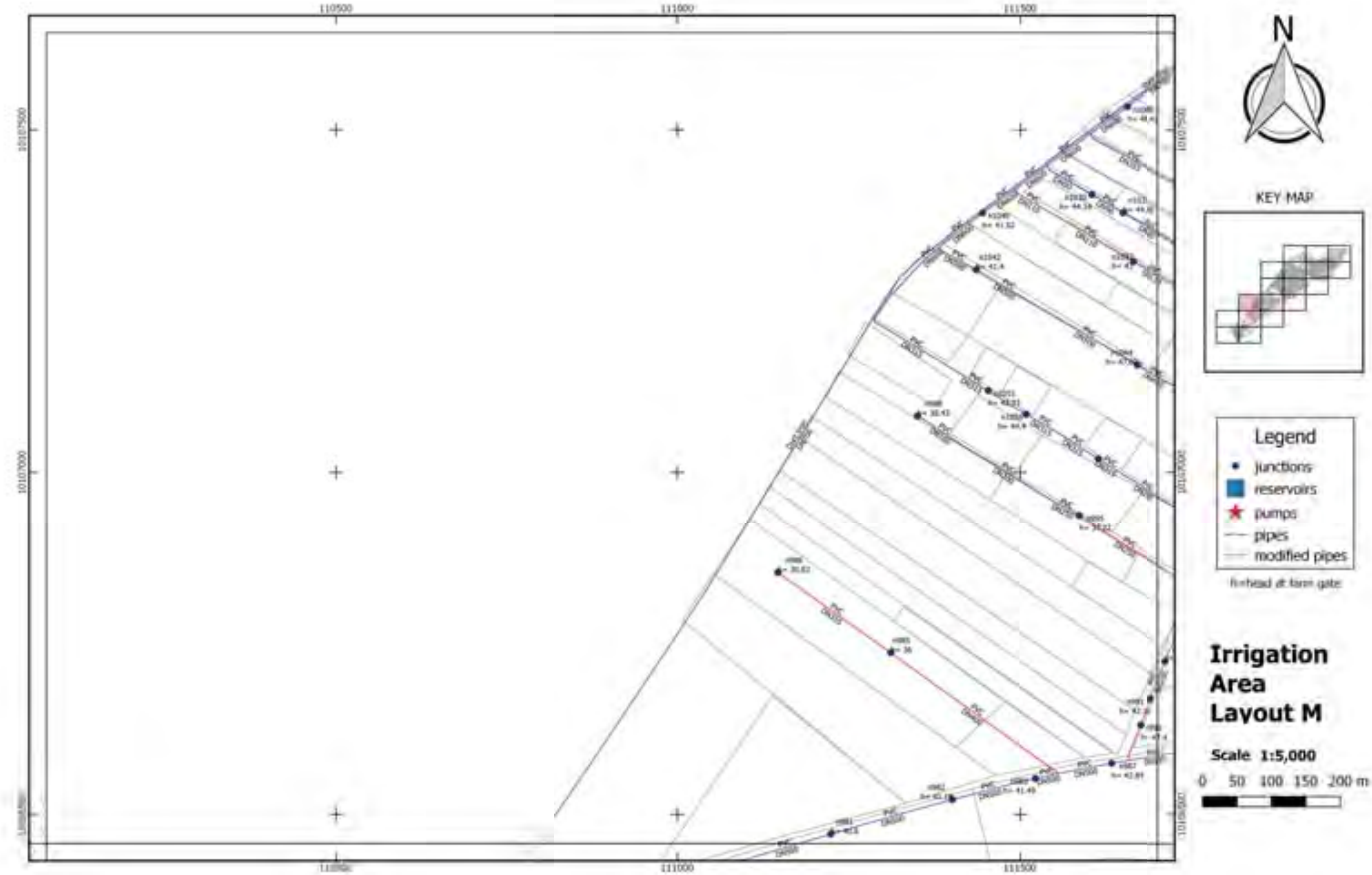
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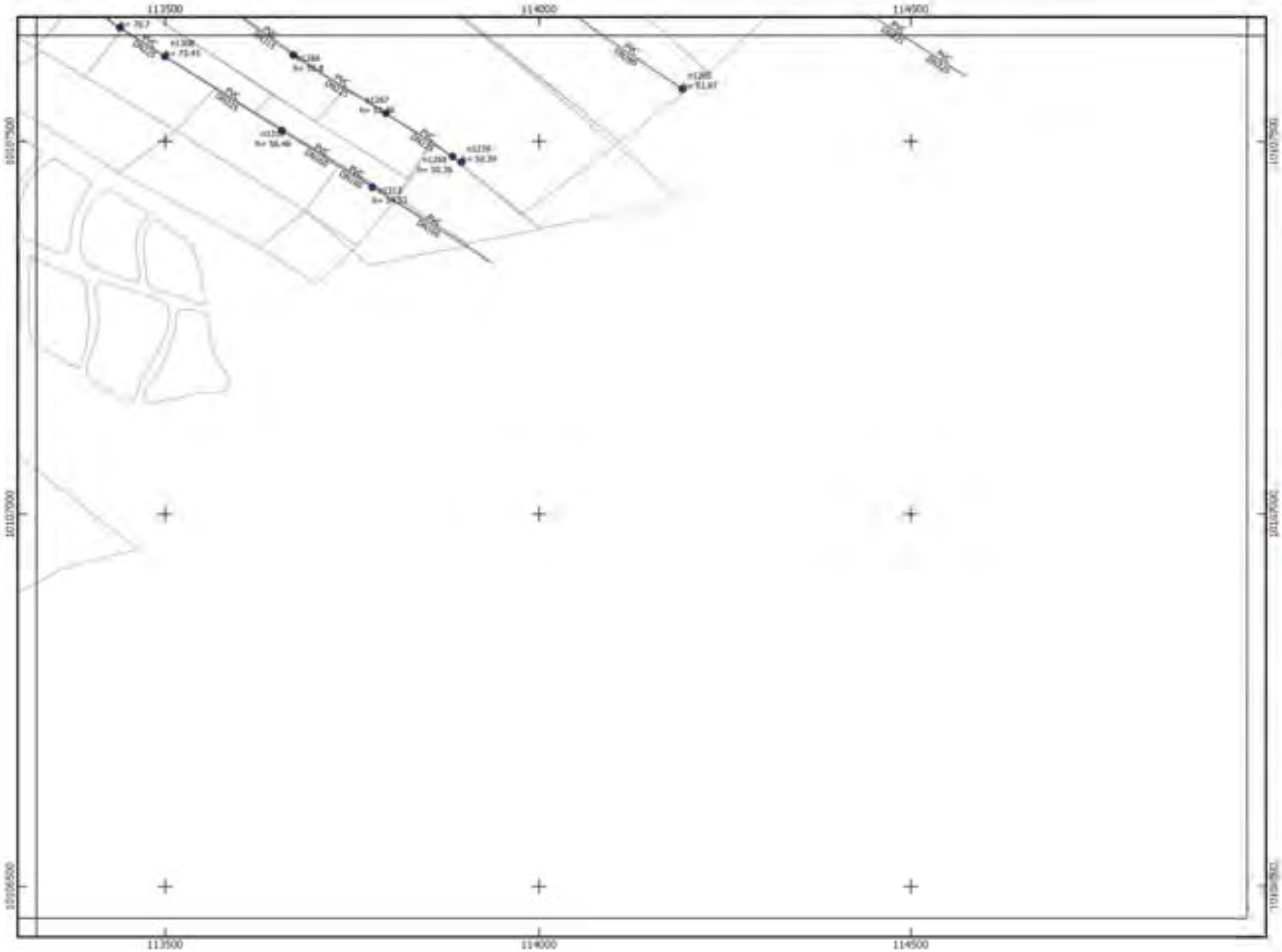

Irrigation Area Layout O

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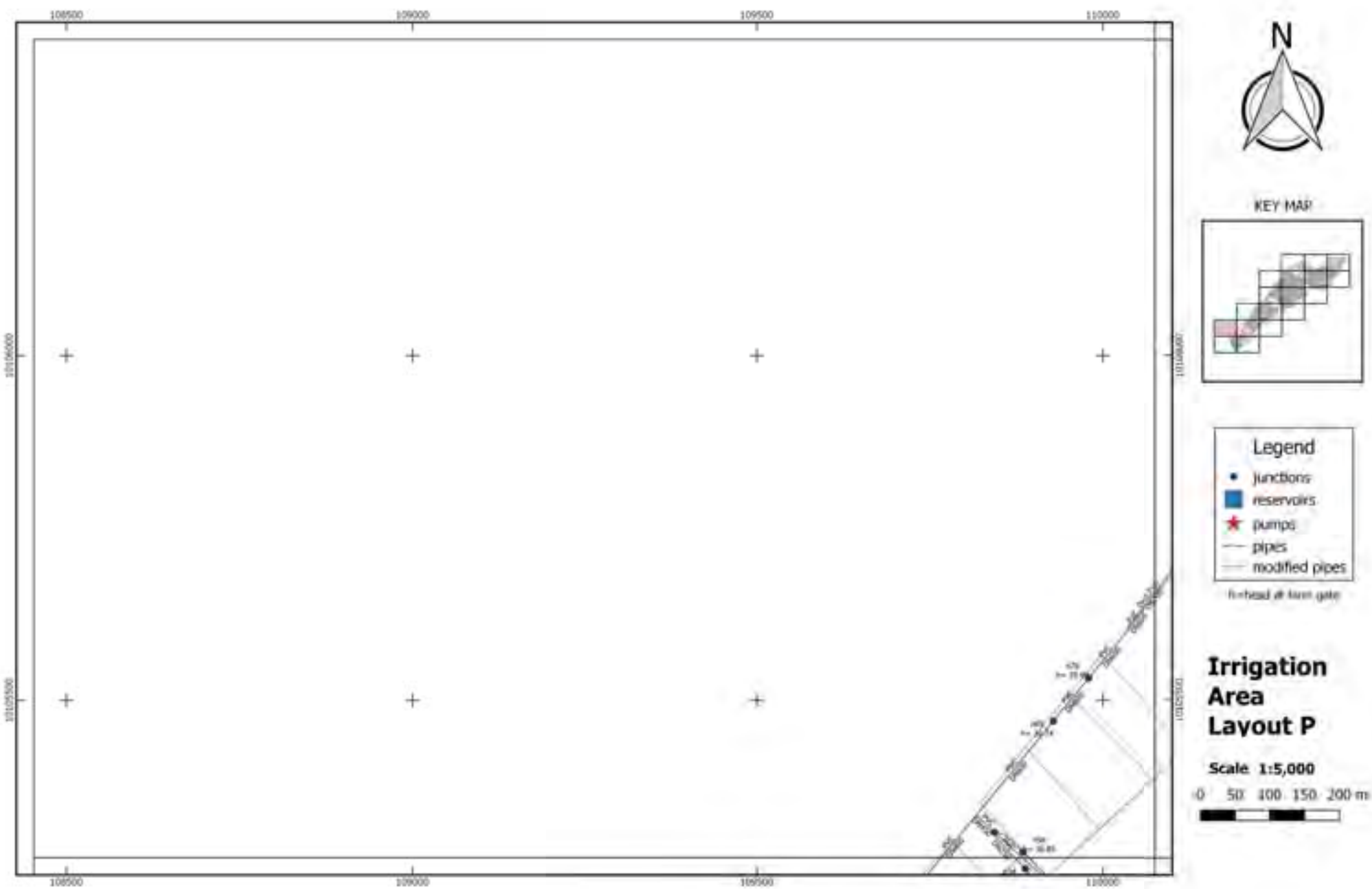
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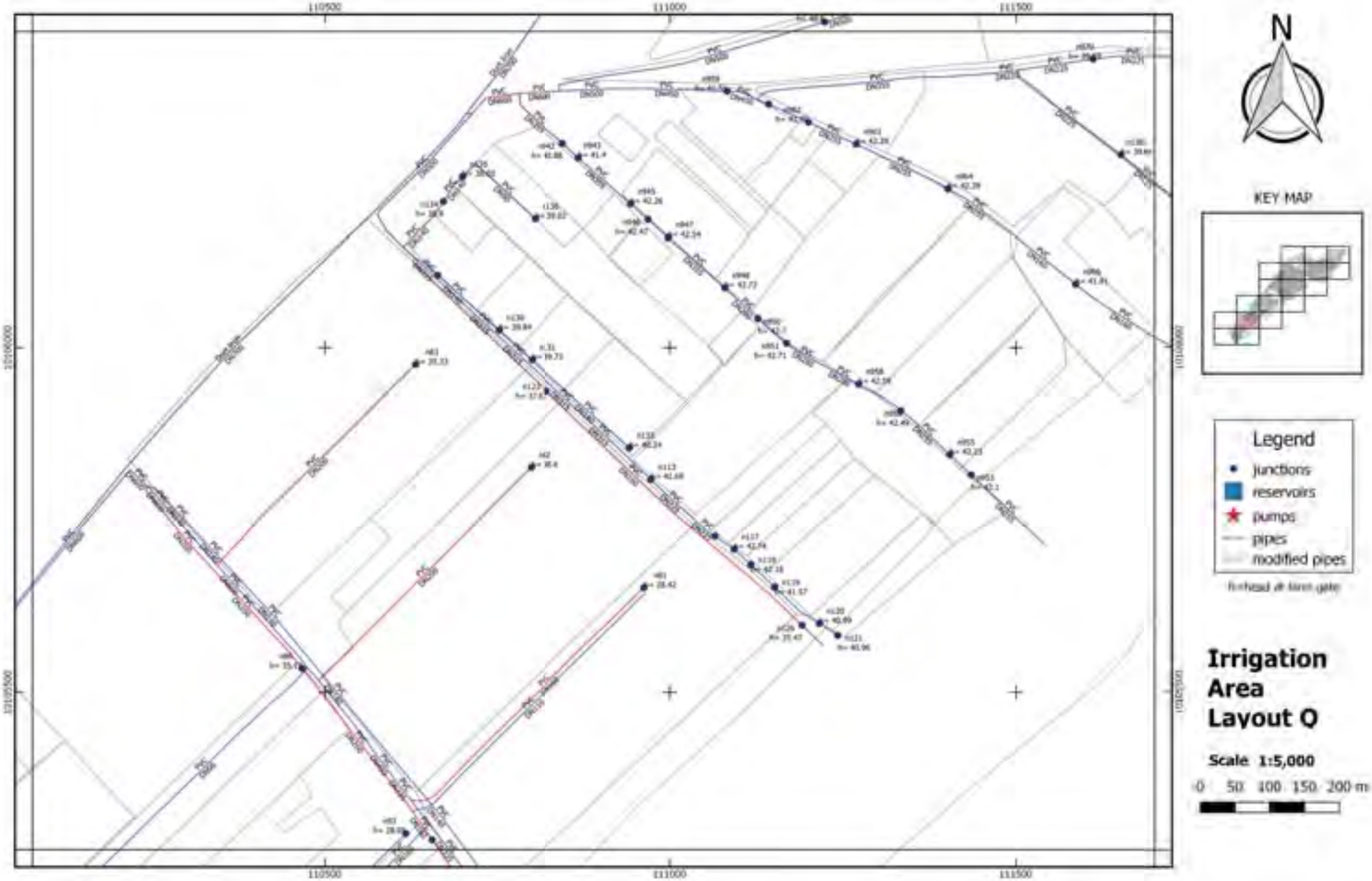
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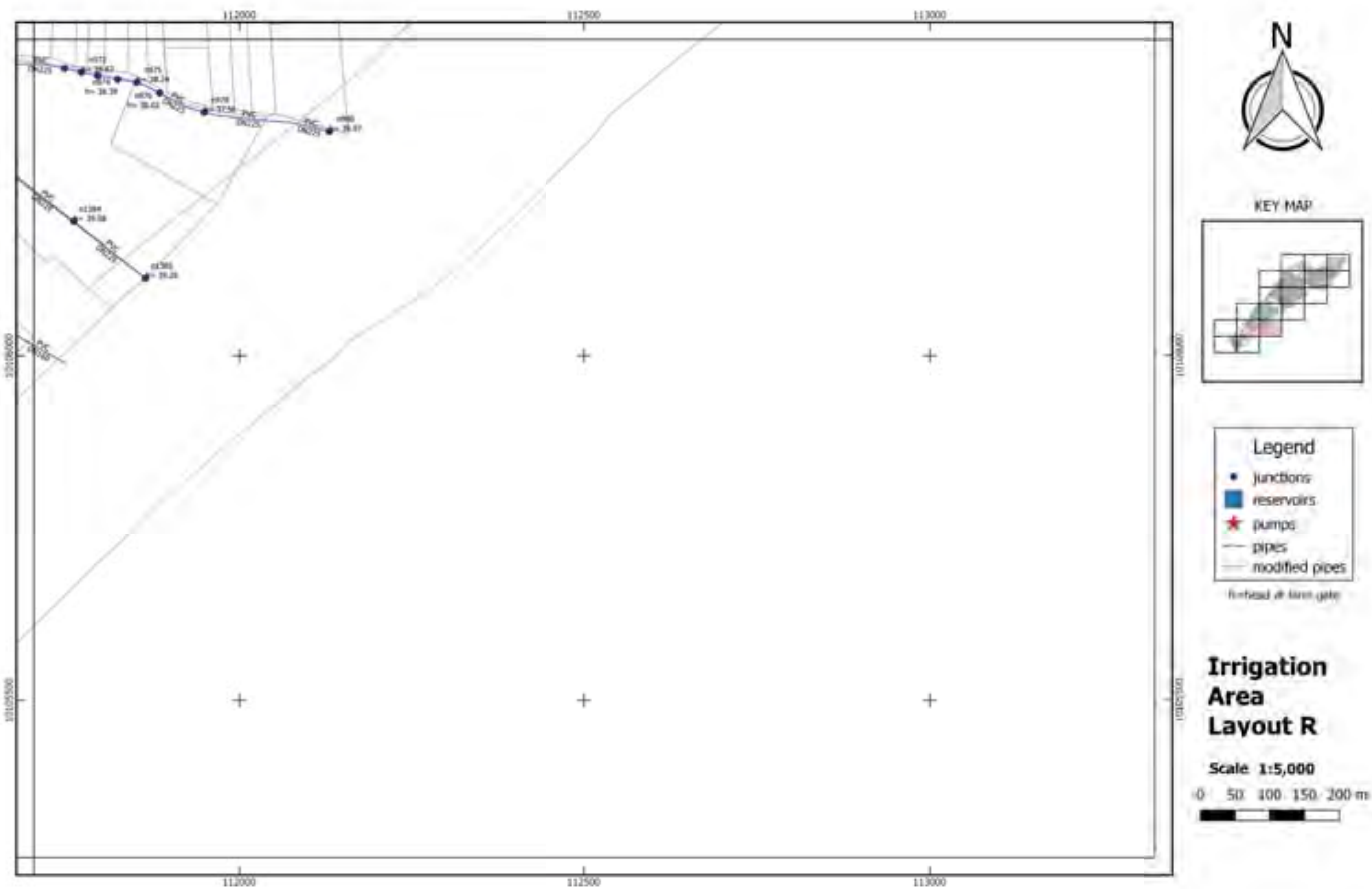
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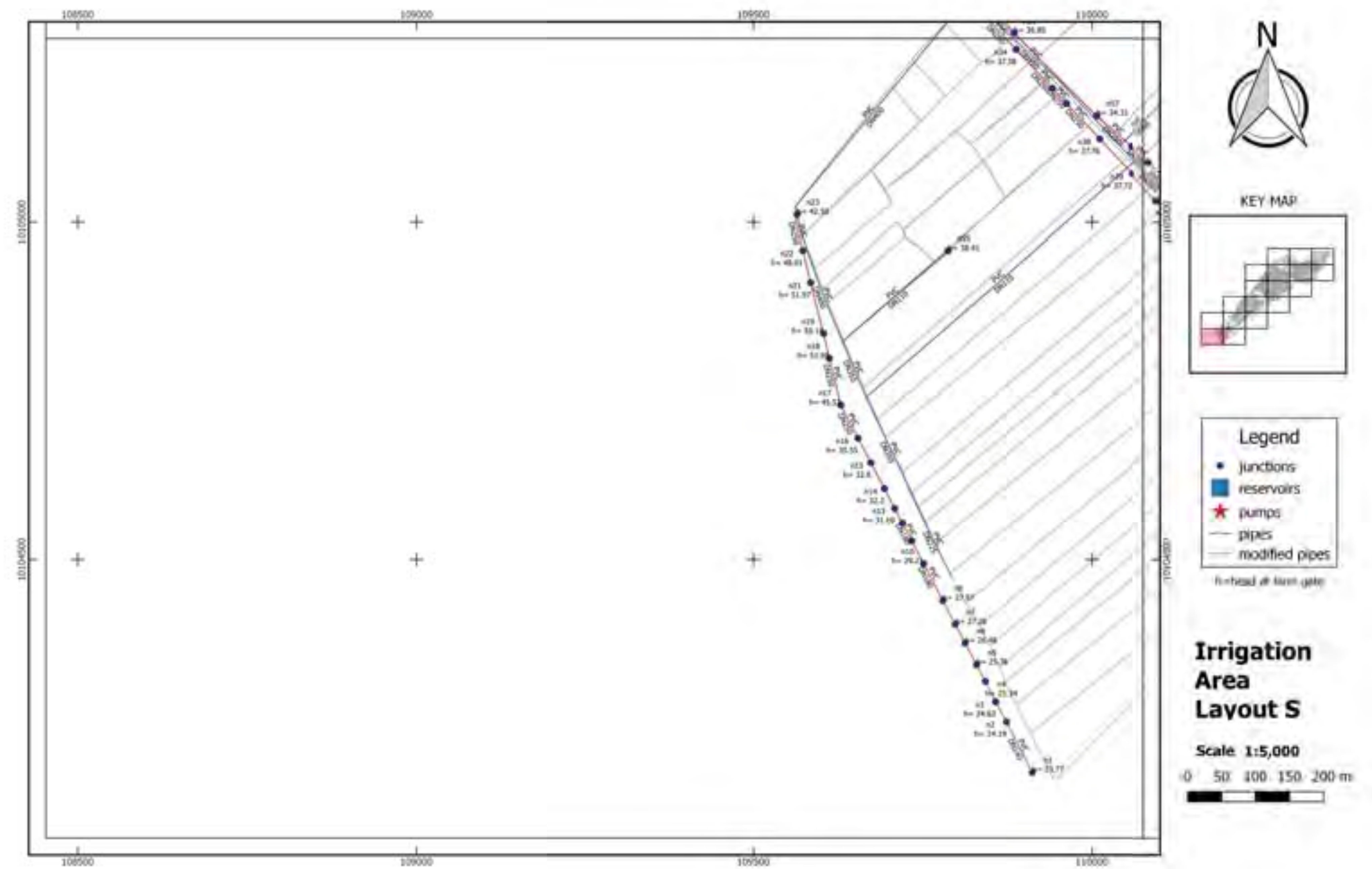
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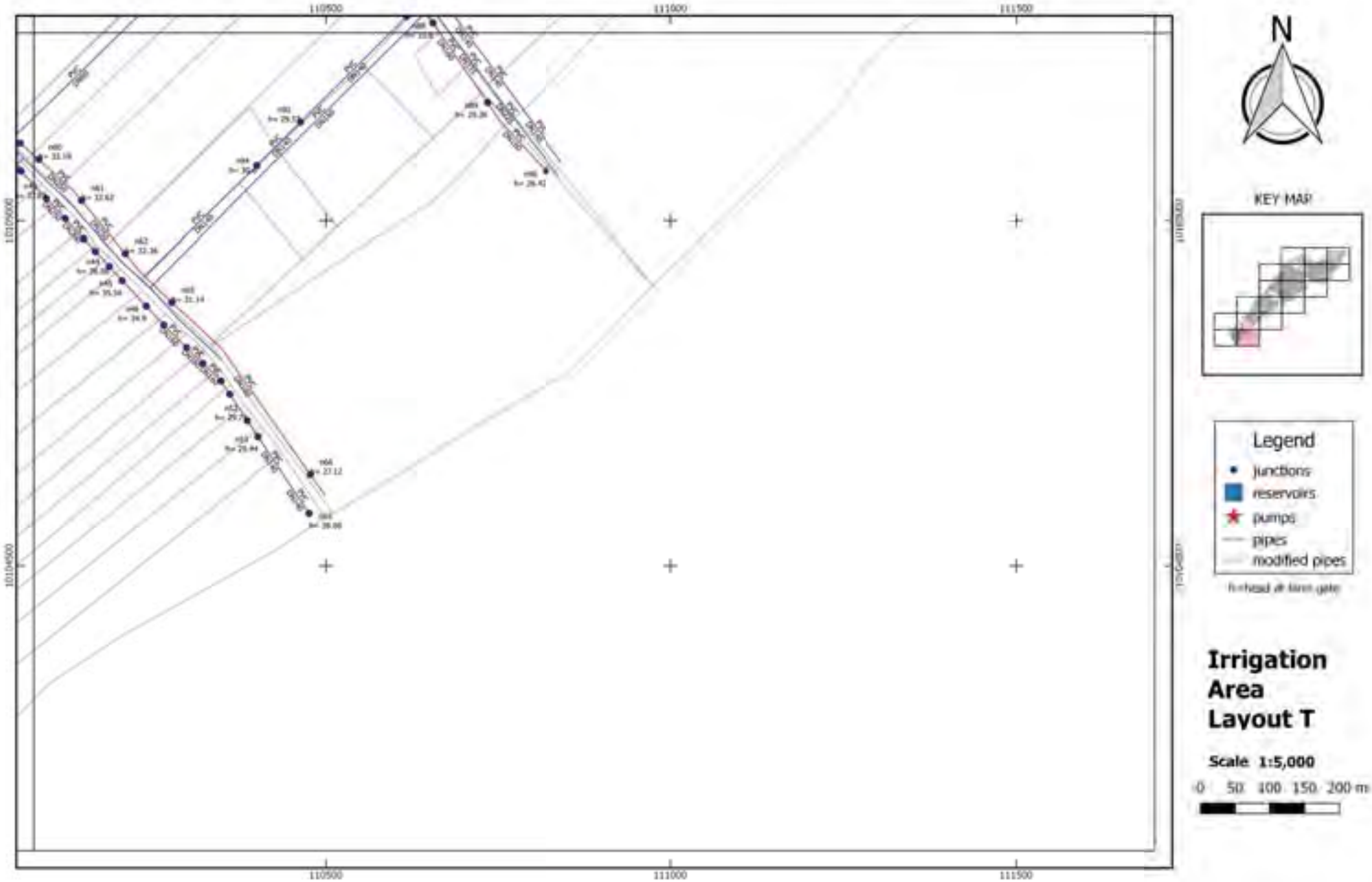
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REVIEW OF THE IRRIGATION PROJECT

Selection of Consulting Service for Complementary Feasibility Study for Irrigation Scheme

ANNEX 2

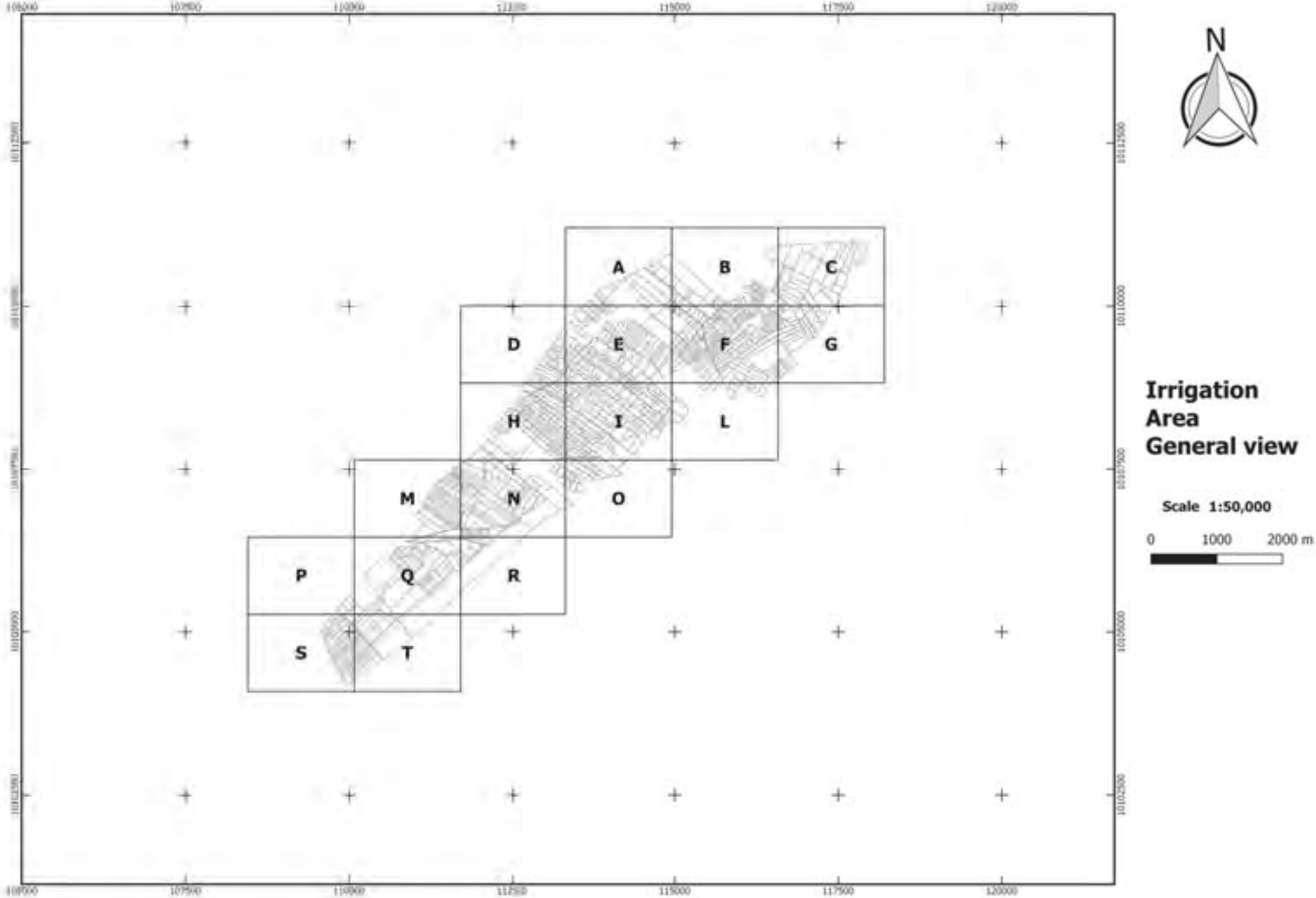
LAYOUTS OF IRRIGATION NETWORK AND PRESSURE HEAD AT FARM GATE WITH PROPOSED WATER REQUIREMENTS AND IRRIGATION SCHEDULING

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

May 2017



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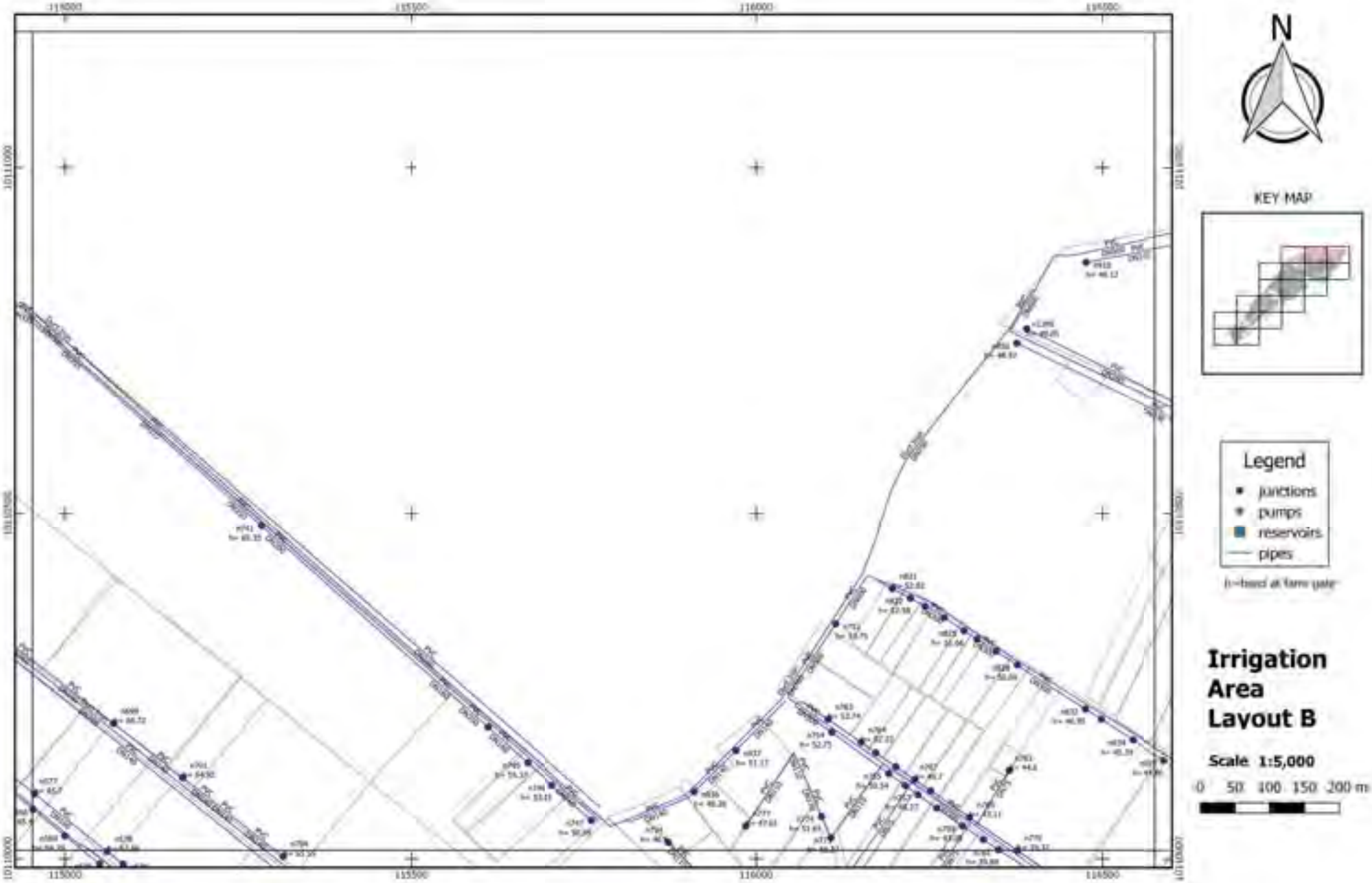
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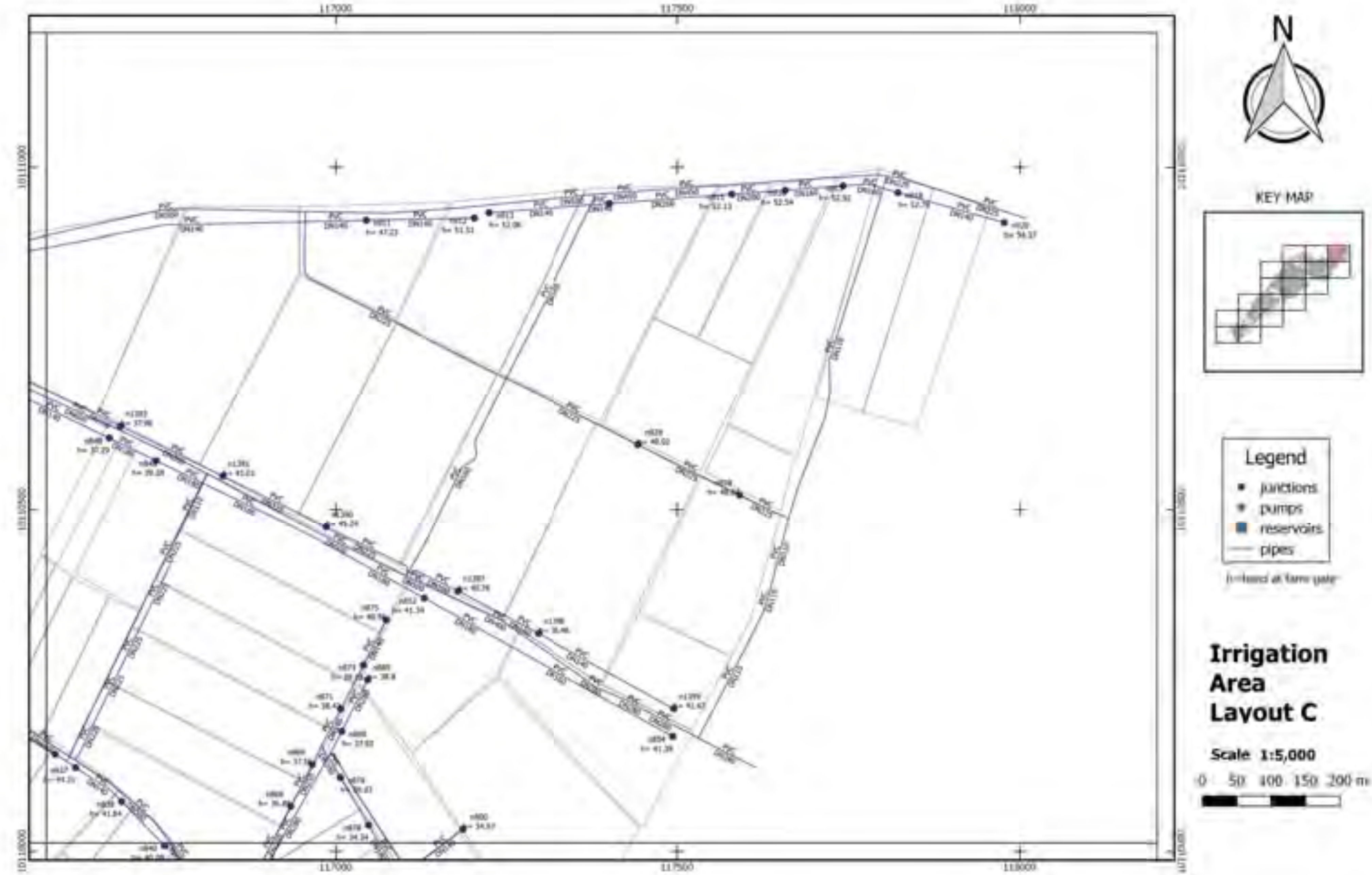

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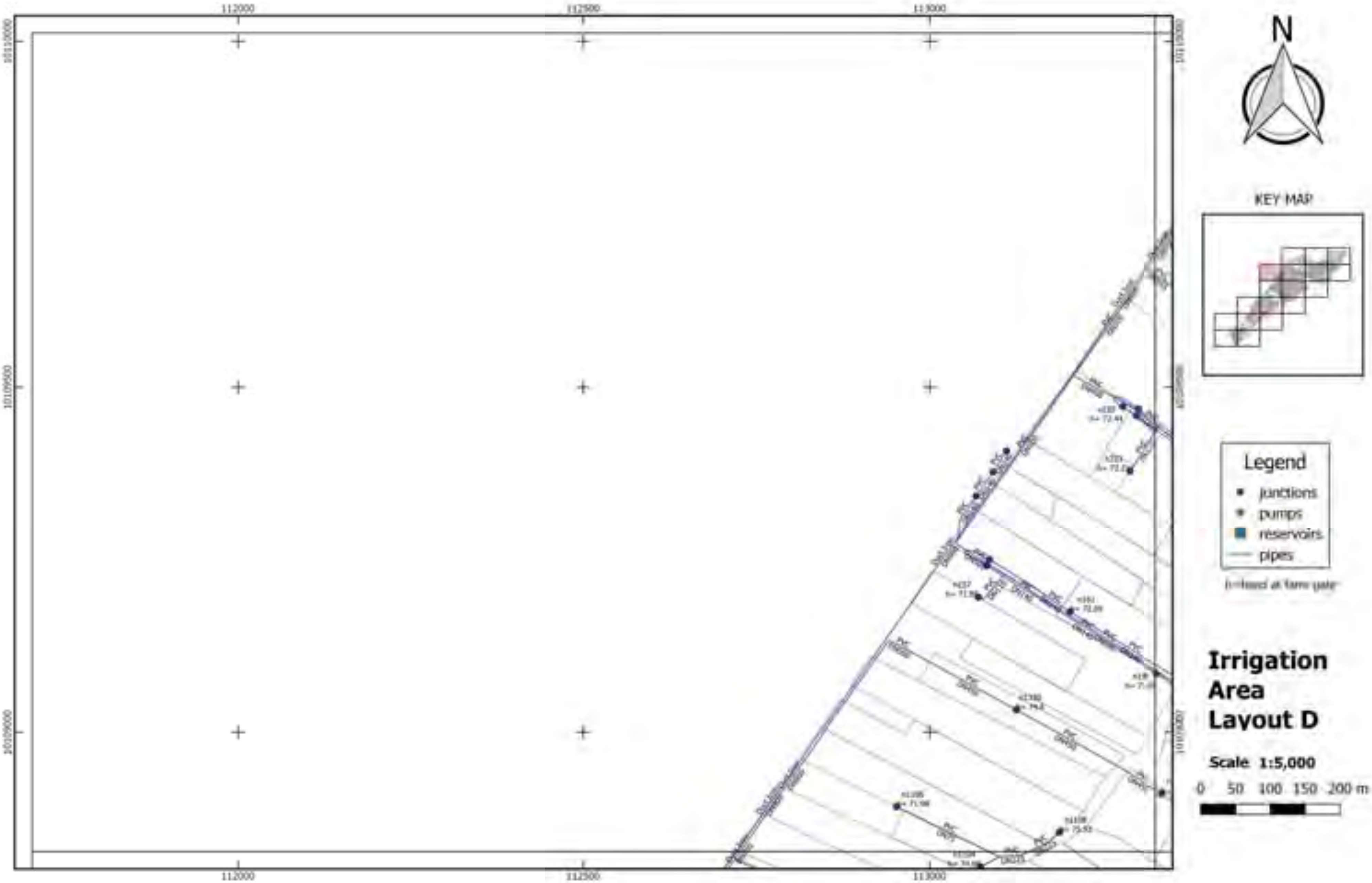
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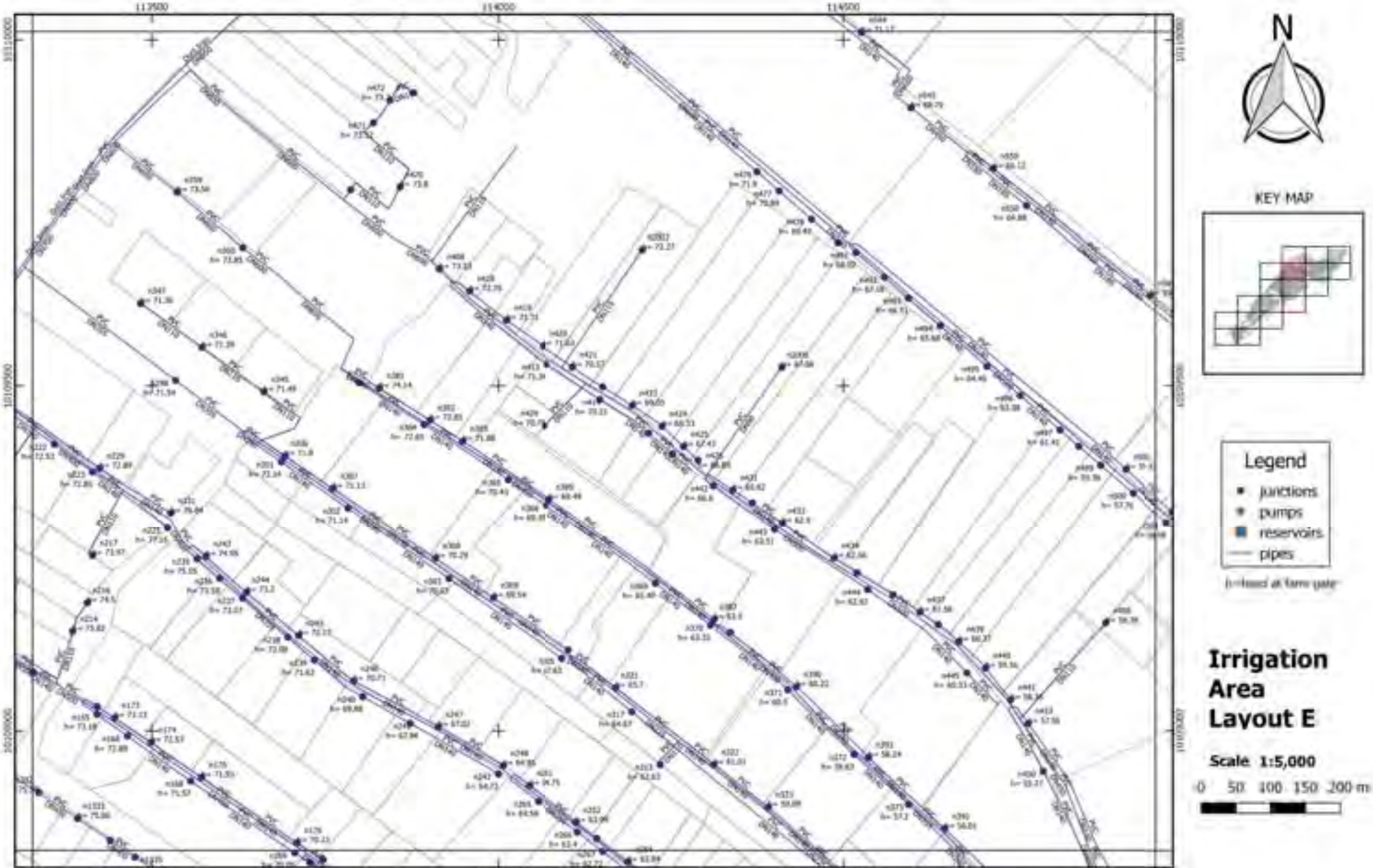
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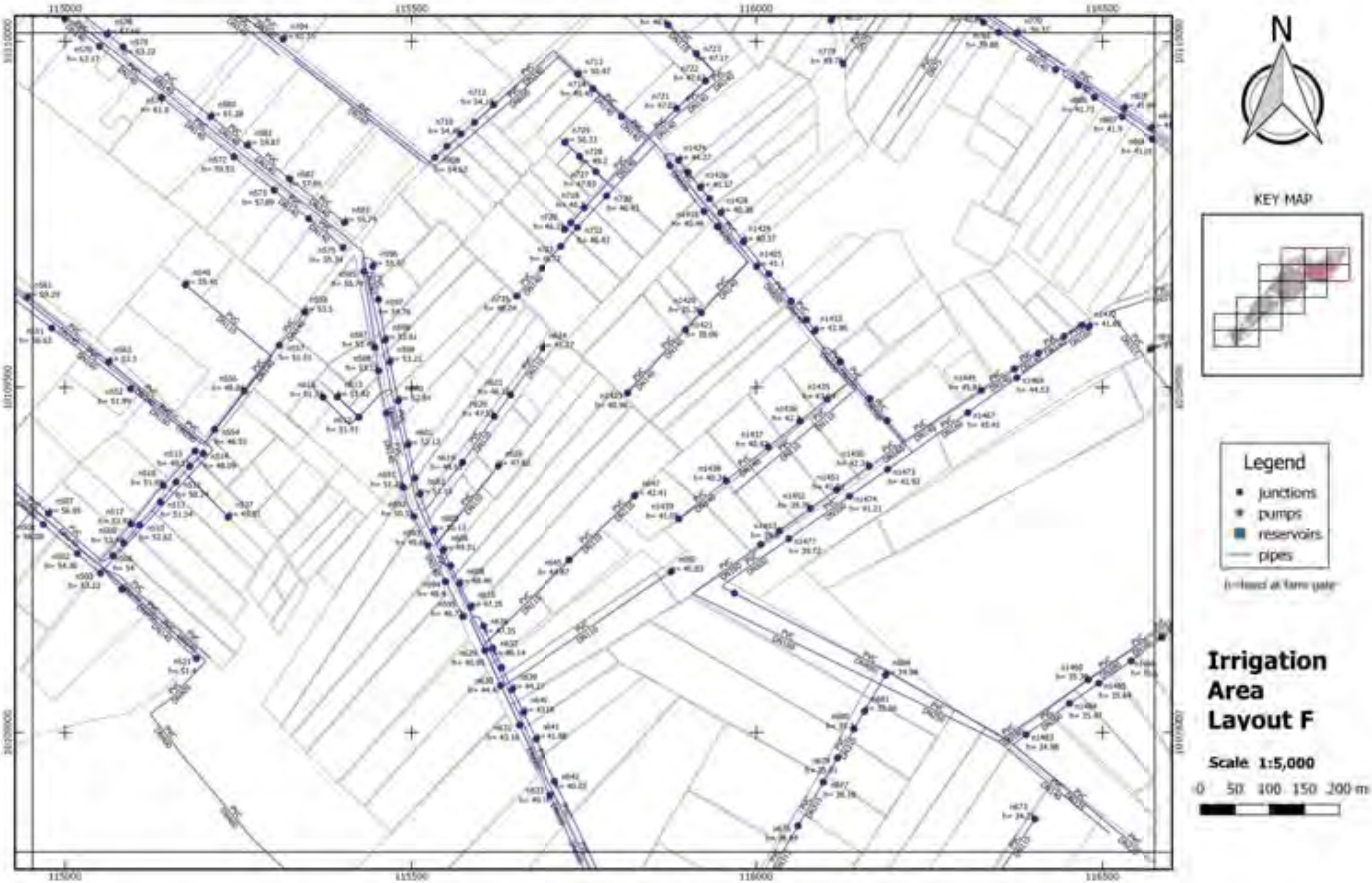

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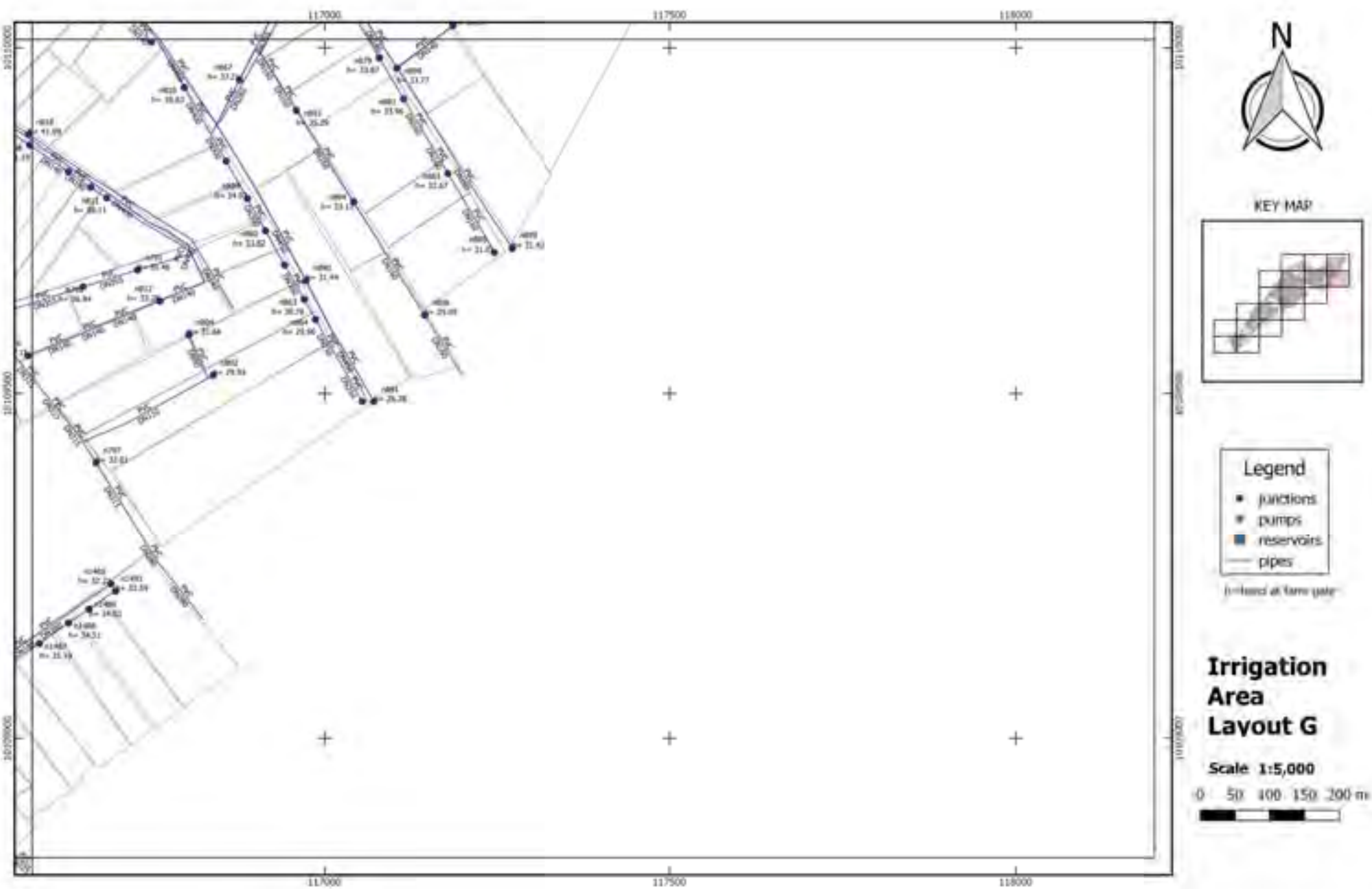
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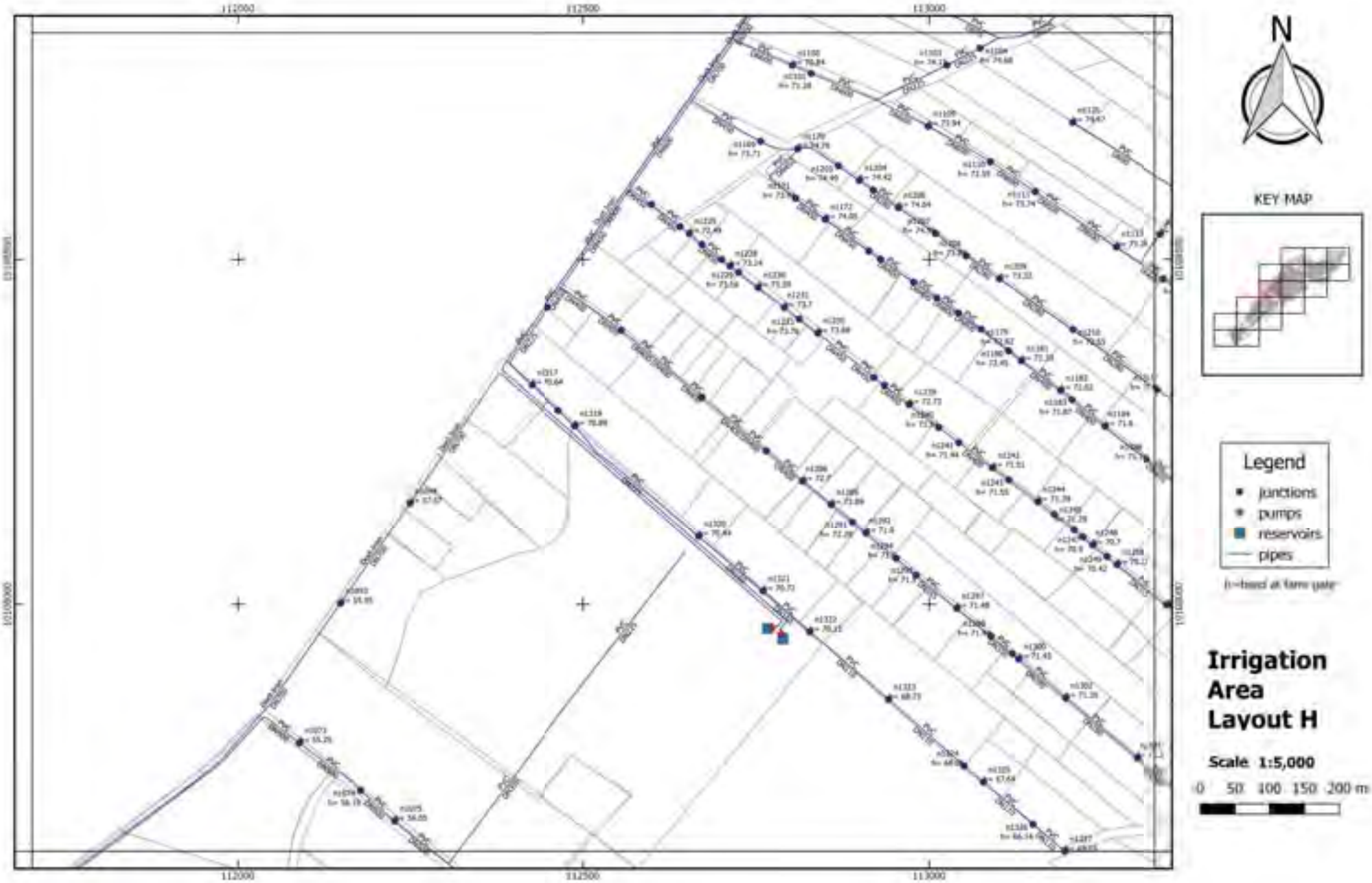
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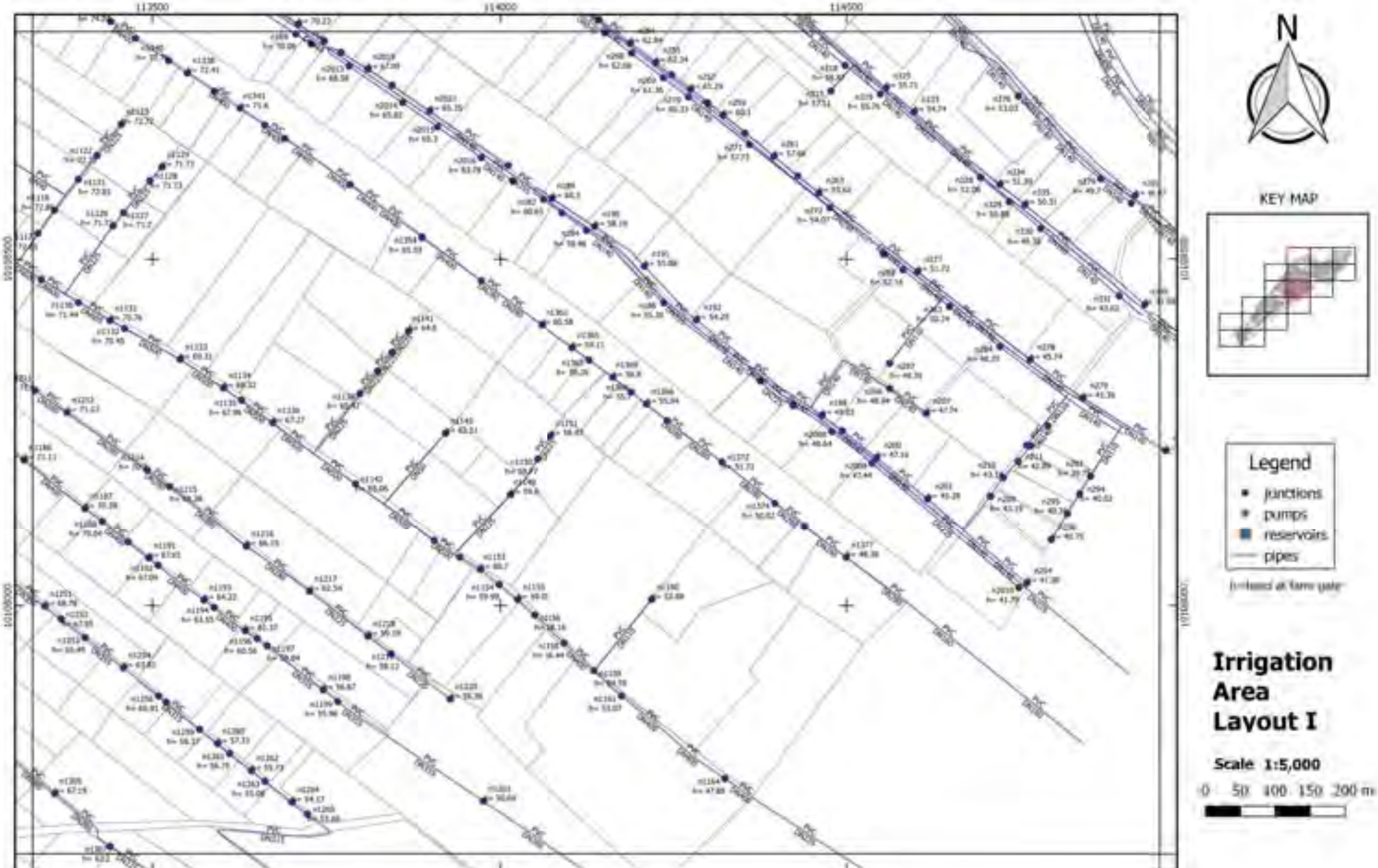

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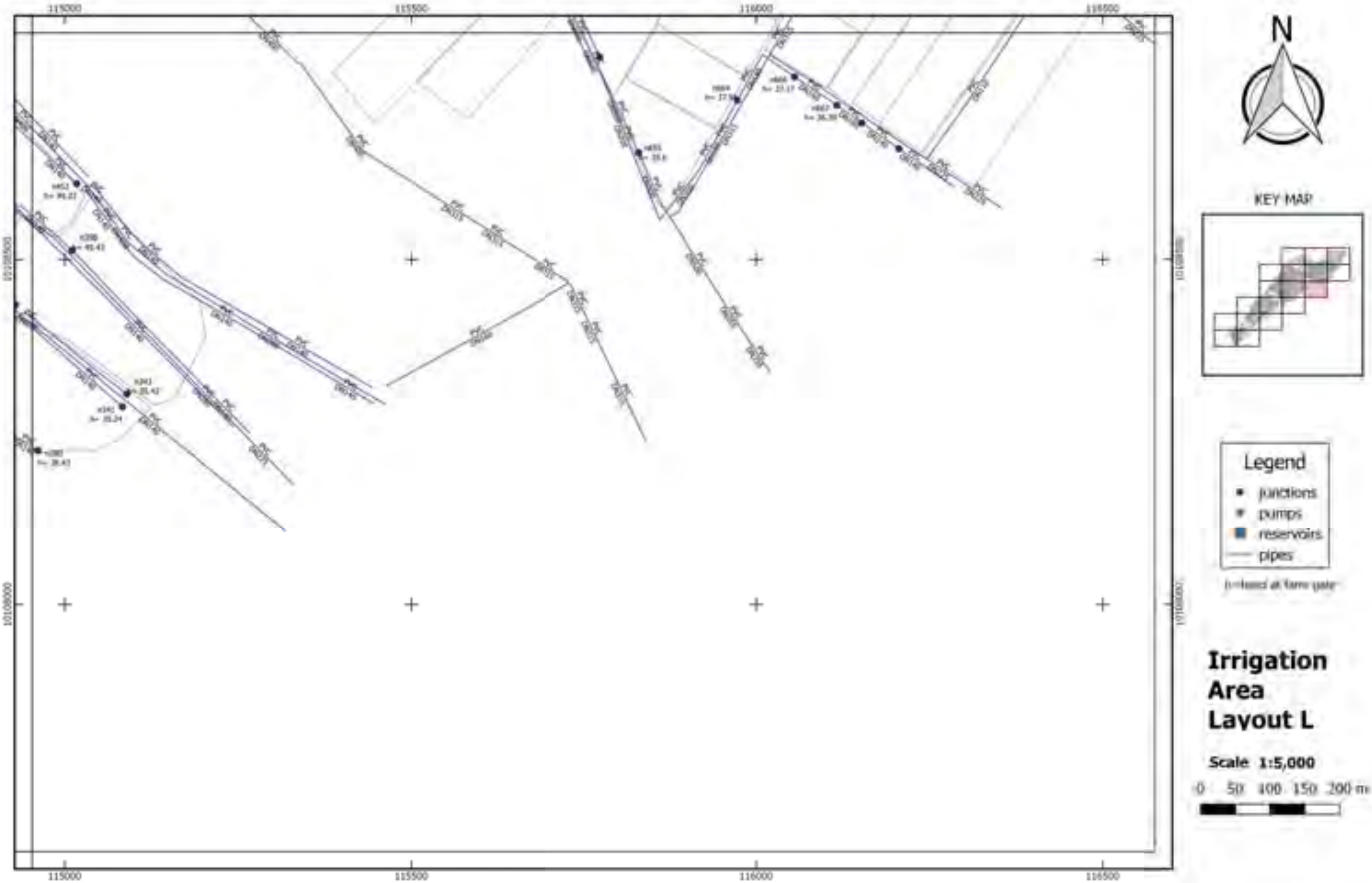

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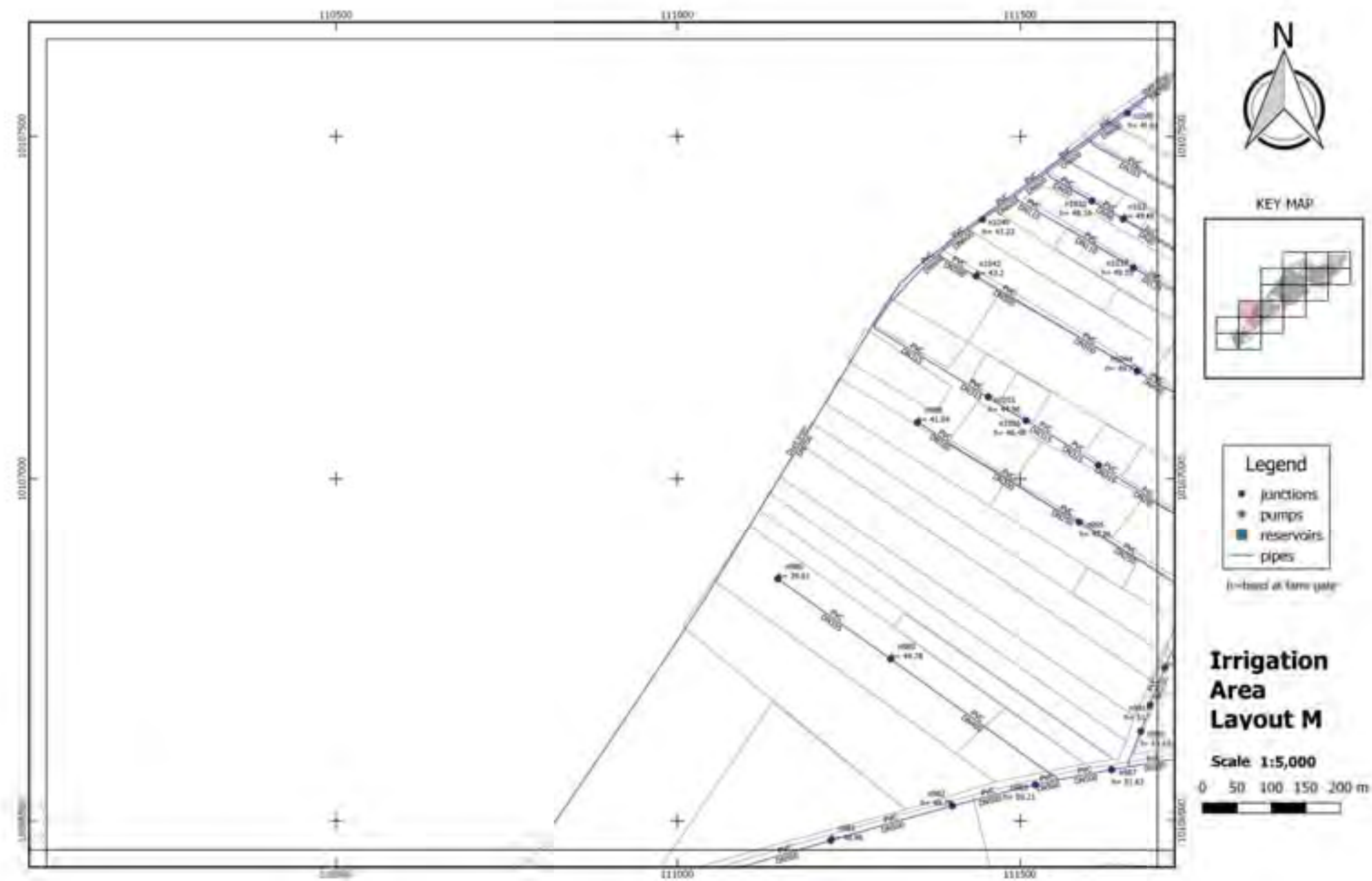

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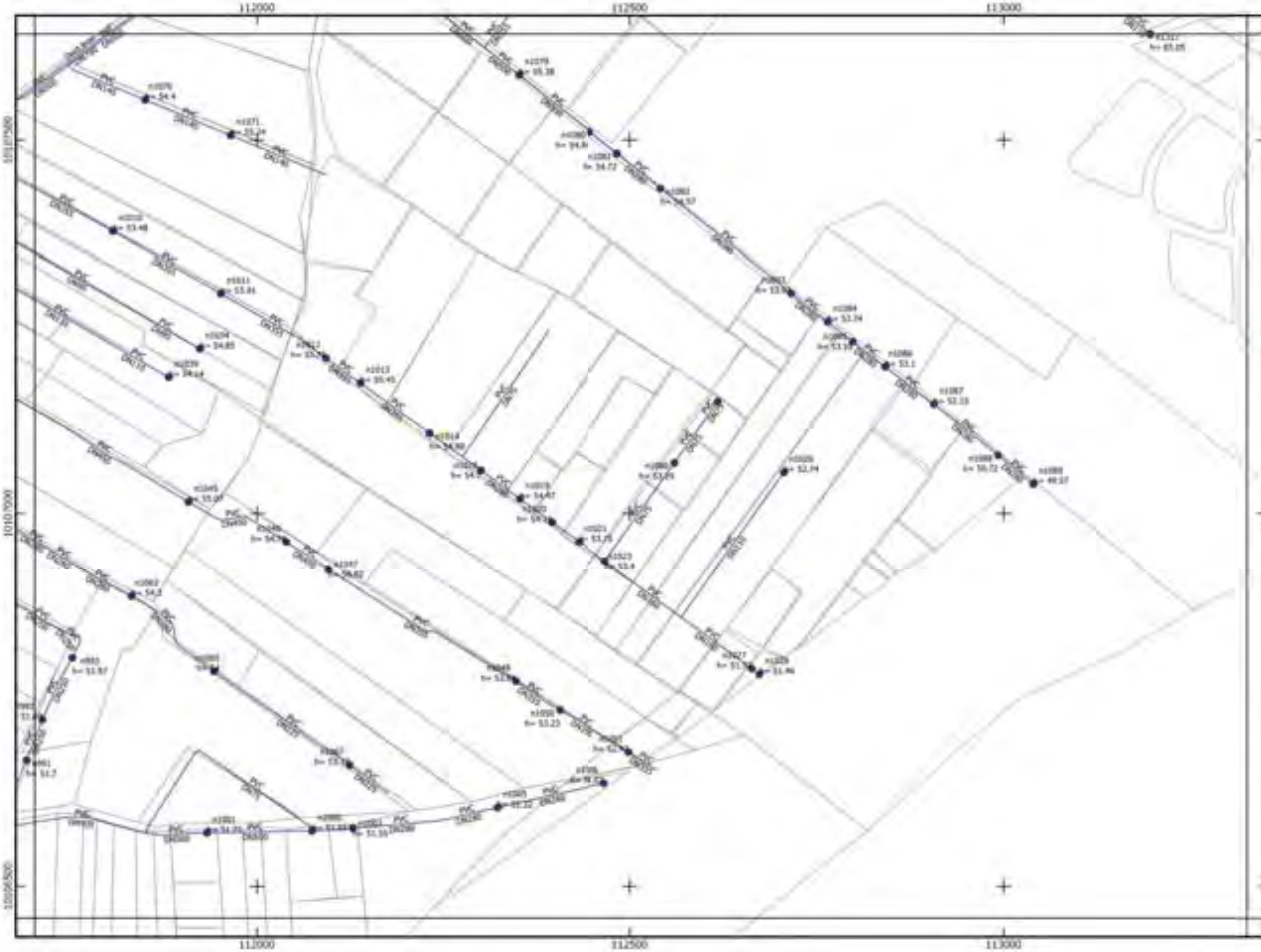

KEY MAP

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- junctions
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(i=hand at farm gate)

Irrigation Area Layout N

Scale 1:5,000

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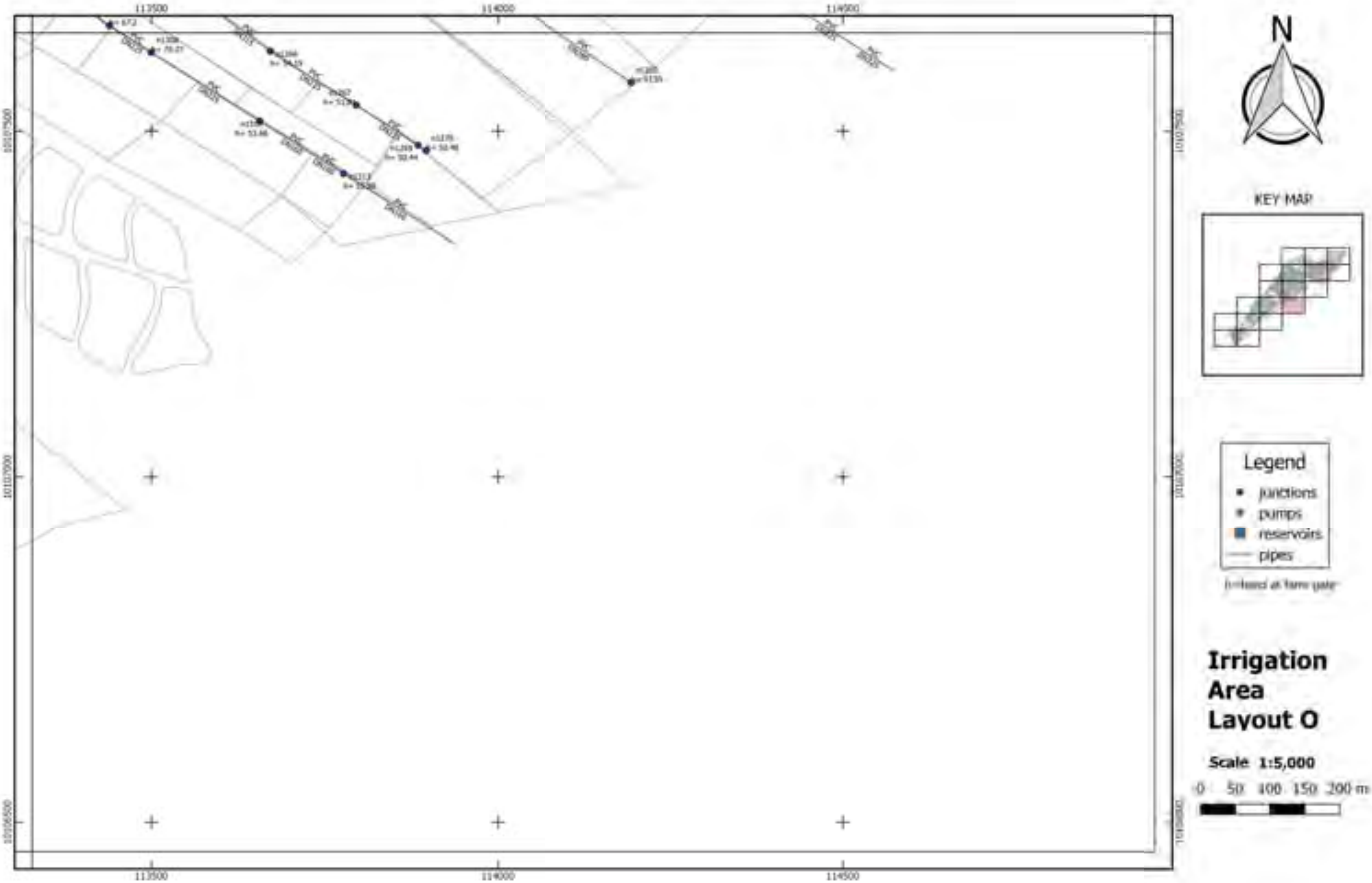

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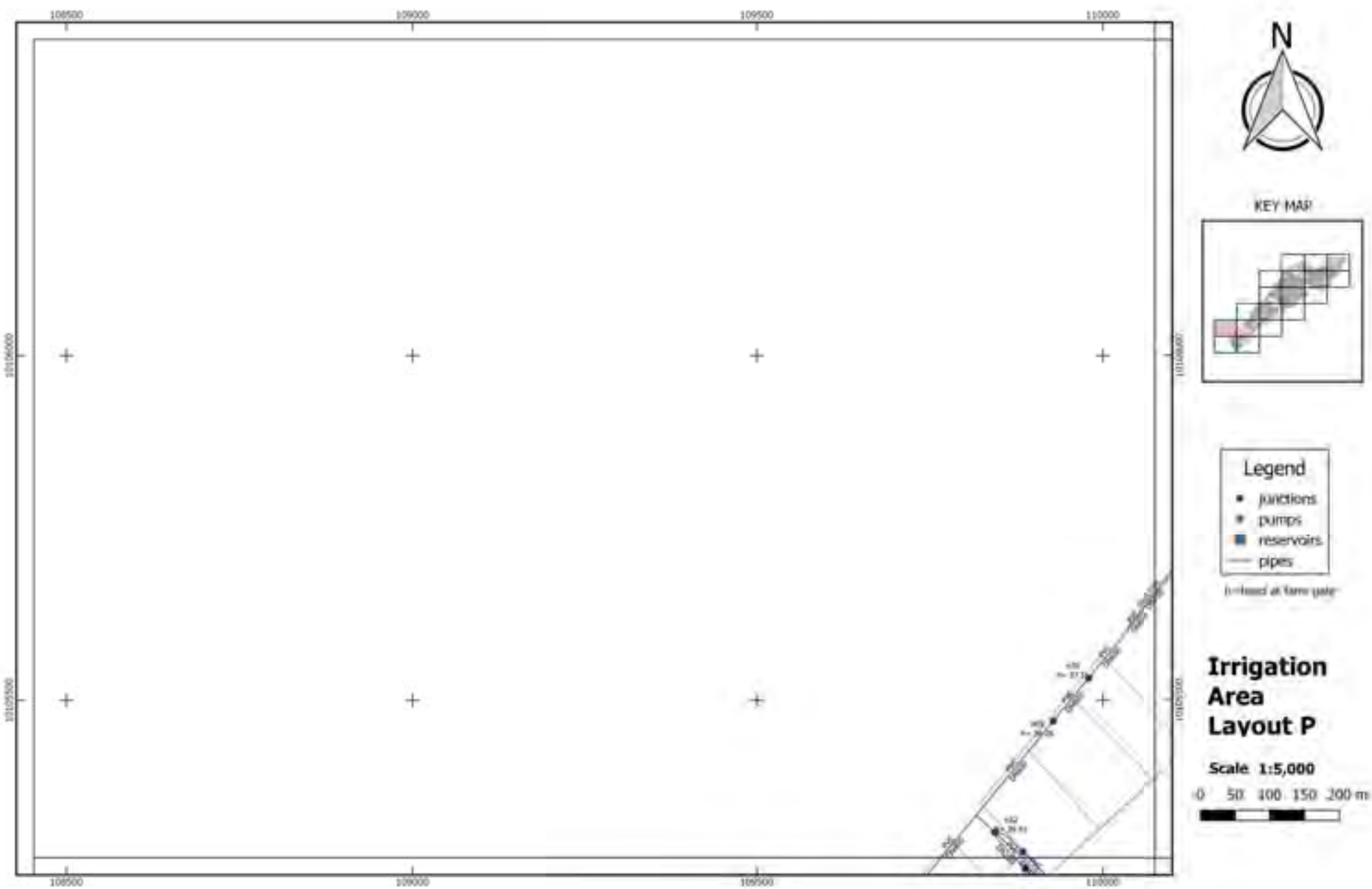

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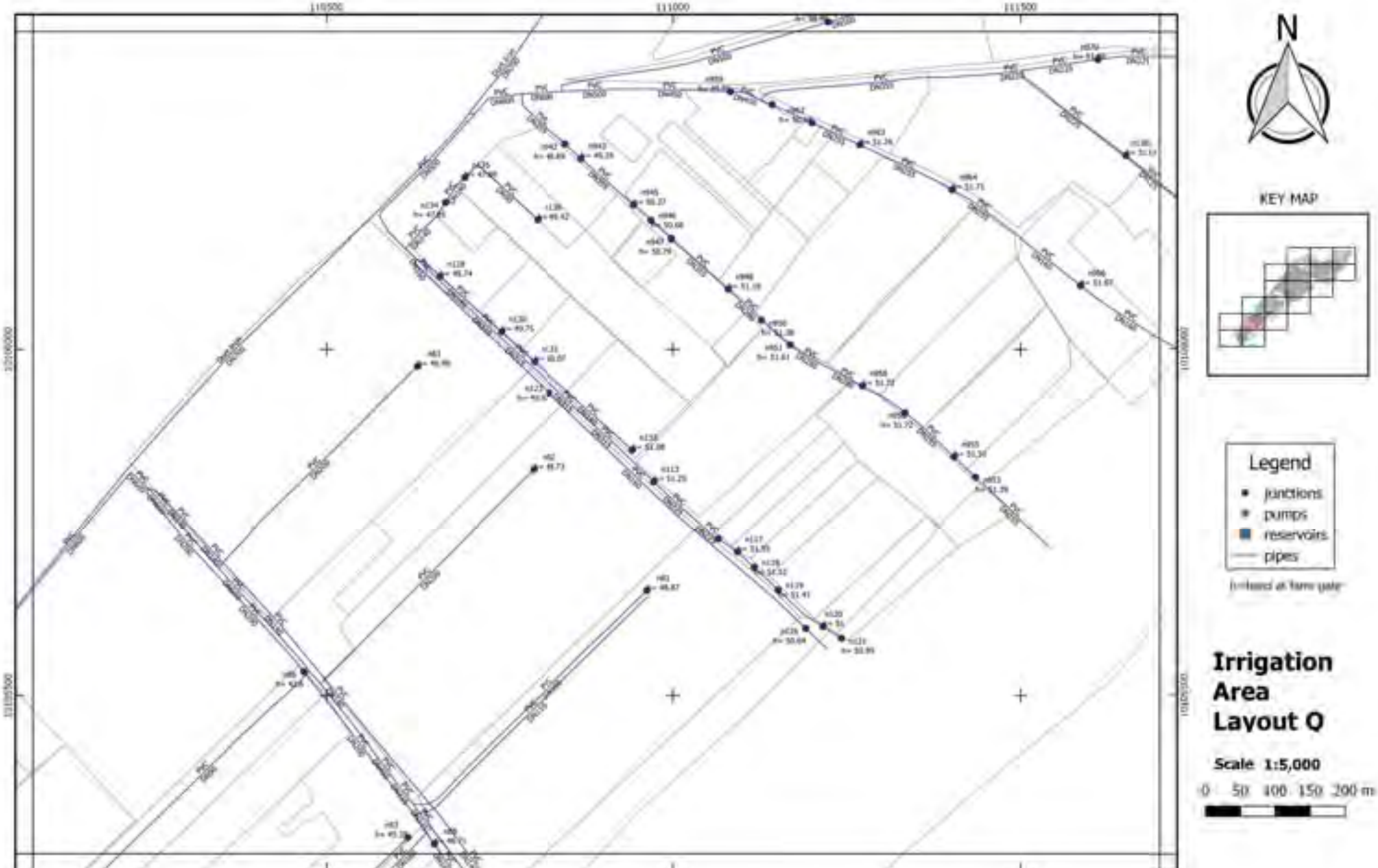
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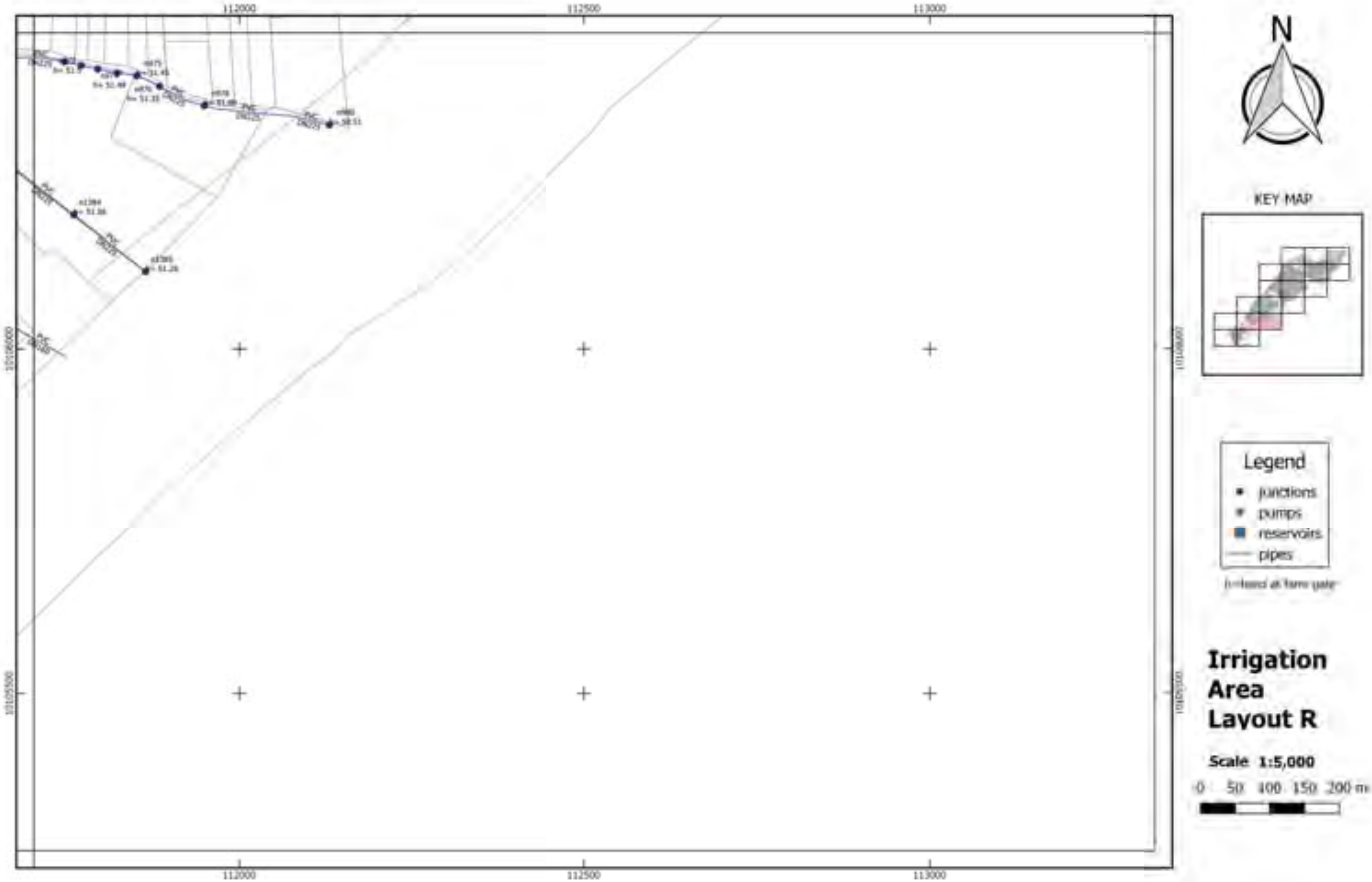
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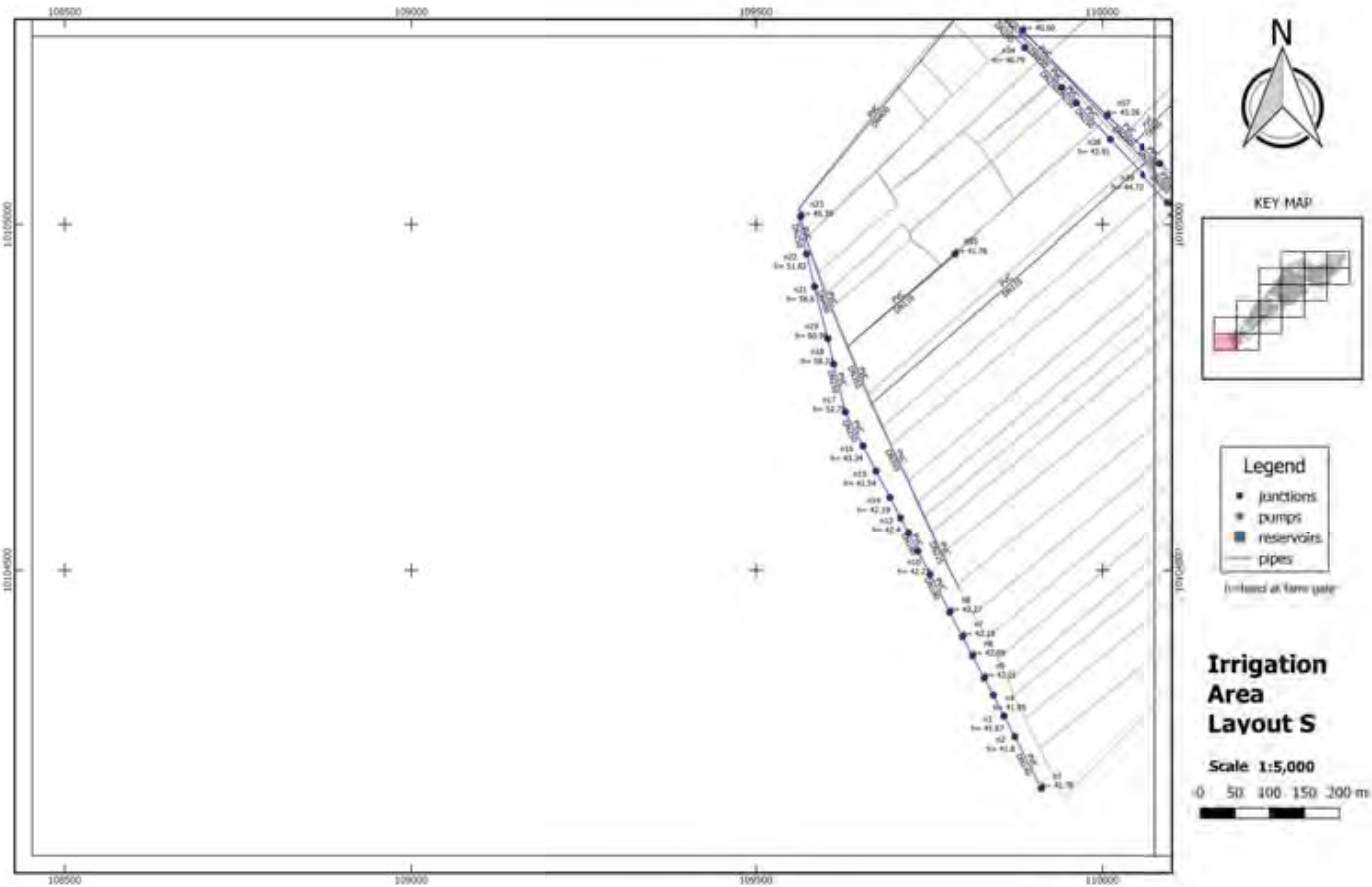
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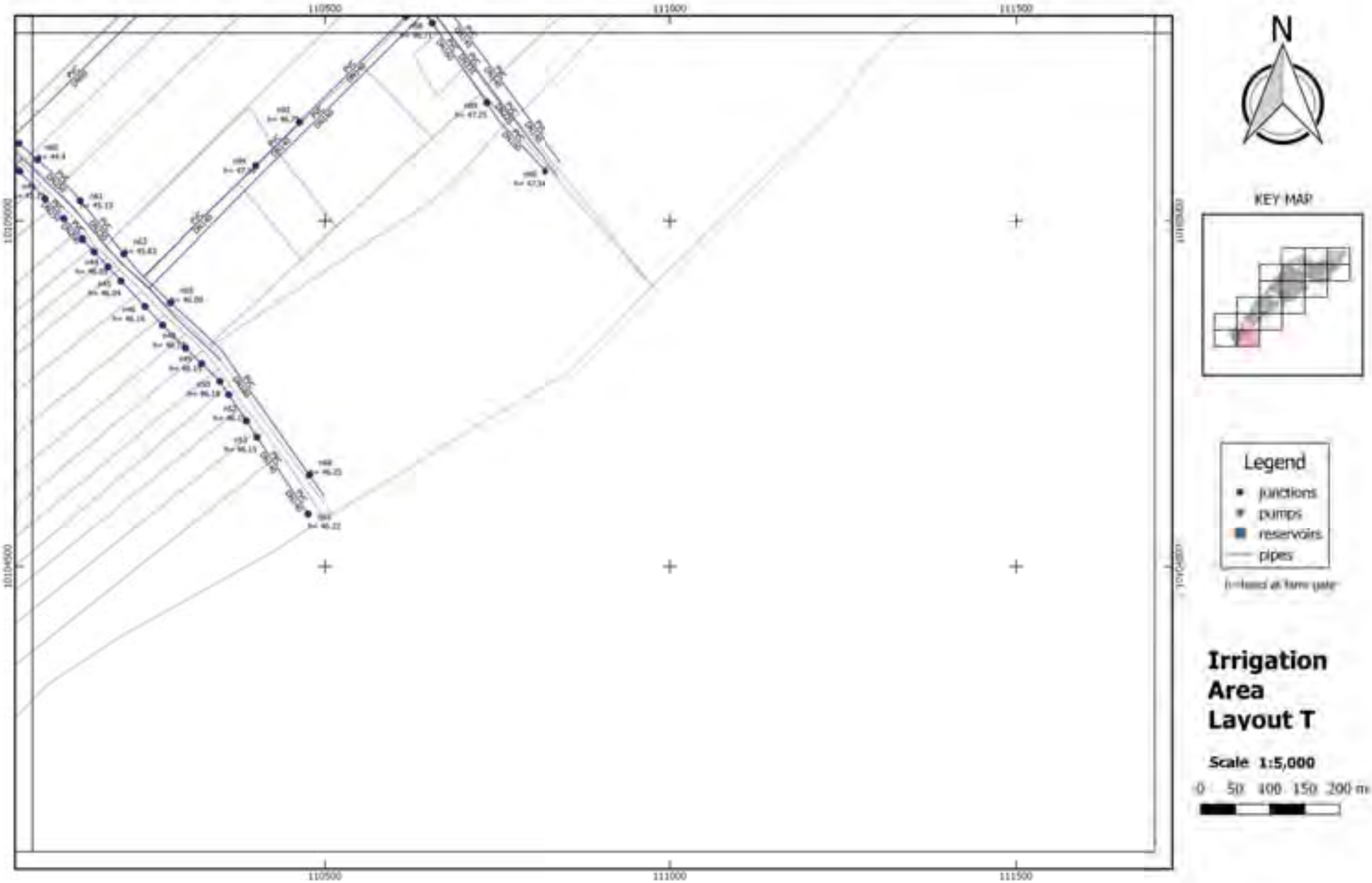

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State of Palestine

Palestinian Water Authority

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SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 3
Review of the Irrigation Project

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

May 2017

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CP	Cropping Pattern
ILS	Israeli New Shekel
MoAg	Ministry of Agriculture
NGEST	North Gaza Emergency Sewage Treatment
PWA	Palestinian Water Authority
ToR	Term of Reference
WB	World Bank
WWTP	Waste Water Treatment Plant

1 SUMMARY

1.1 Background

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project initiated in 2004 and being implemented in three phases the latest of which, known as **supplementary phase**, was later added to the project to provide a mean to recover and reuse the treated effluent after the new WWTP is completed. This system, comprising of a water recovery scheme and a water reuse (irrigation) scheme includes 27 recovery wells surrounding the infiltration basins, a network of 42 monitoring wells (10 of which will have to be newly built), 2 water tanks with the ability to store 4,000 m^3 each, 2 booster pumping station with 10 booster pumps and over 130 km of distribution network for the reuse of the water in irrigated agriculture.

The design of the system was completed in 2010. The original design foresaw a three-stages development of a full-scale irrigation system. The first two stages have been fully designed to make it possible to launch tendering and construction procedures for both the recovery and the reuse schemes required to serve a gross agriculture area of 1,570 ha (15,700 du) subdivided in two sectors of approximately 500 ha (5,000 du) and 1,000 ha (10,000 du).

The construction of both the recovery and the reuse schemes has been delayed for several years thus justifying the need for the review and updating of key design assumptions that were made in the original design.

1.2 The Present Report

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare a Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and make the project feasible. To carry out its task, this project has drawn upon massive data collection, expansive field visits, and state-of-the-art computer modeling in order to best understand the country's hydrology and strategic options. Equally important, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, other irrigation projects and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

1.3 Key Achievements

Some of the key achievements obtained while reviewing the original design of the Irrigation Project include:

- The introduction of a new Cropping Patter (CP) that vastly draws from the results of a baseline assessment and survey that reached nearly 70% of all farmers. More specifically, the newly proposed CP encapsulate the desires and technical abilities of the existing farmers, follows the directives of the Ministry of Agriculture and maintains key features of the original design (i.e. irrigation layout and pumping system) unchanged.

- A review and update of the irrigation water demand in the Project Area based on the newly proposed cropping pattern. The results lead to a saving of nearly 3.2 Million of Cubic Meter of Water per year (MCM/year) or 21.5% less water of what required by the original design. Less water requirements also leads to reduced energy needs for the recovery and the reuse of the water extracted from the aquifer. More precisely, the proposed changes will allow saving 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation scheduling that largely differs from the original one by providing water to the entire irrigation project at all times (instead of on a 6 days' rotation with 12 lots irrigated 2 at a time once a week). The newly proposed irrigation schedule hinges on the idea of delivering a constant amount of water to the farms gate for 12 hours per day (10 hours per day during the least warm months of the year). Farms with different sizes will receive the necessary amount of water thanks to flow reducers that now comes standards with many commercially available type of manholes. Furthermore, the possibility to pump water into the system on a constant rate through the day drastically reduces the complexity of managing the irrigation scheduling and eliminate the risk of overdrawing water from the storage tanks and stalling the system.
- A review of the original irrigation project layout that allowed to resolve some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gates (the original design failed to do so for a sizable number of farms).
- A review of the original design for the recovery scheme. Our review confirms the validity of the original design;
- A review of the original design for the reuse (irrigation) scheme. The review confirms that the selection of materials, the general layout and the selection of the pumping system is still applicable today.

1.4 Key Recommendations

Some of the key recommendations that can be provided after reviewing the original design of the Irrigation Project are:

- The original detailed design is based on a low quality topographic and cadastral survey thus leading to detailed layout drawings that are often confusing. Farms boundaries are not precisely delineated on a map and the layout of main and sub-mains pipe lines is not clearly mapped as it should for a detailed design. We therefore recommend performing a detailed topographic survey of the entire area and, based on that, to adjust the original design considering some of the layout adjustment proposed in this report.
- The overall cost for the construction of the water reuse (irrigation) scheme has significantly increased (nearly 40% increase) from its original estimation. Although this might be justifiable in the contest of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%.

2 Project's Background Information

2.1 Project's History

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, it is being implemented in three phases. Phase A of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

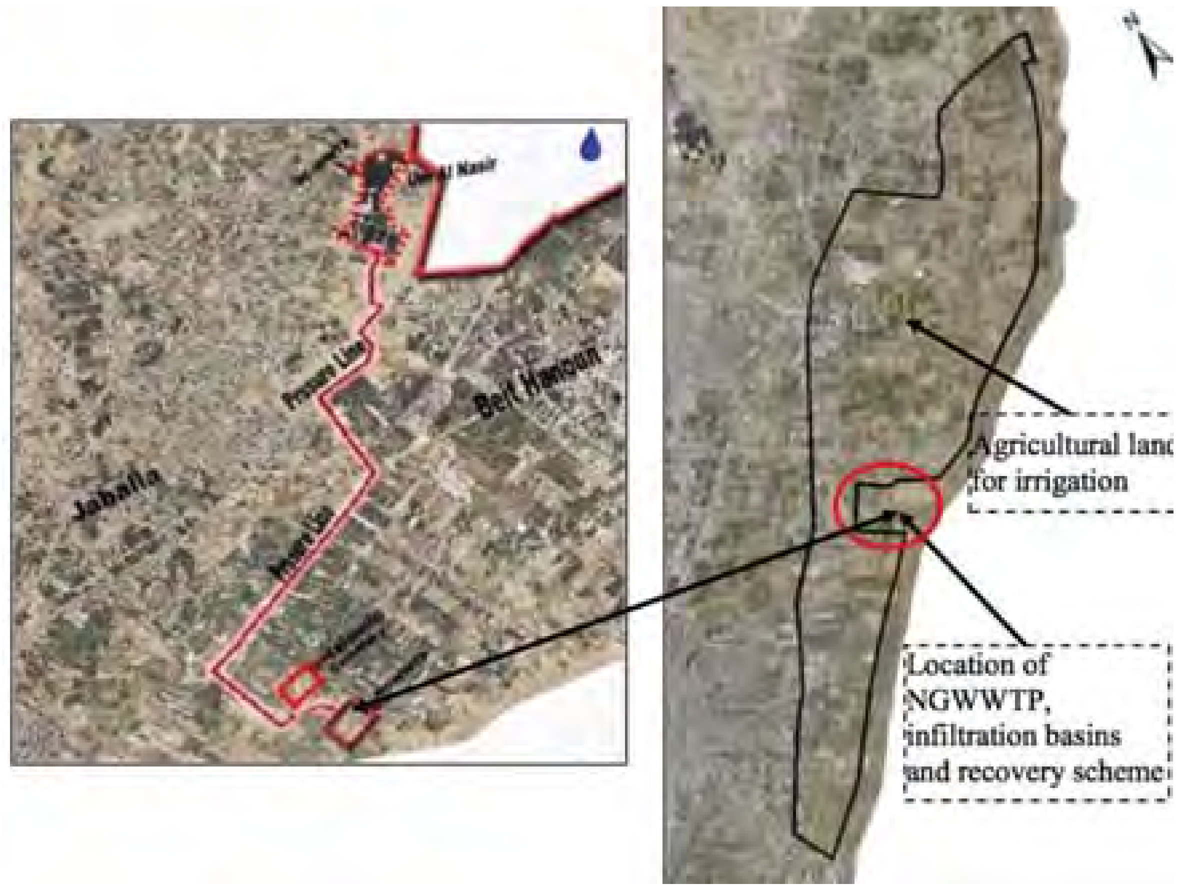

Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the Plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

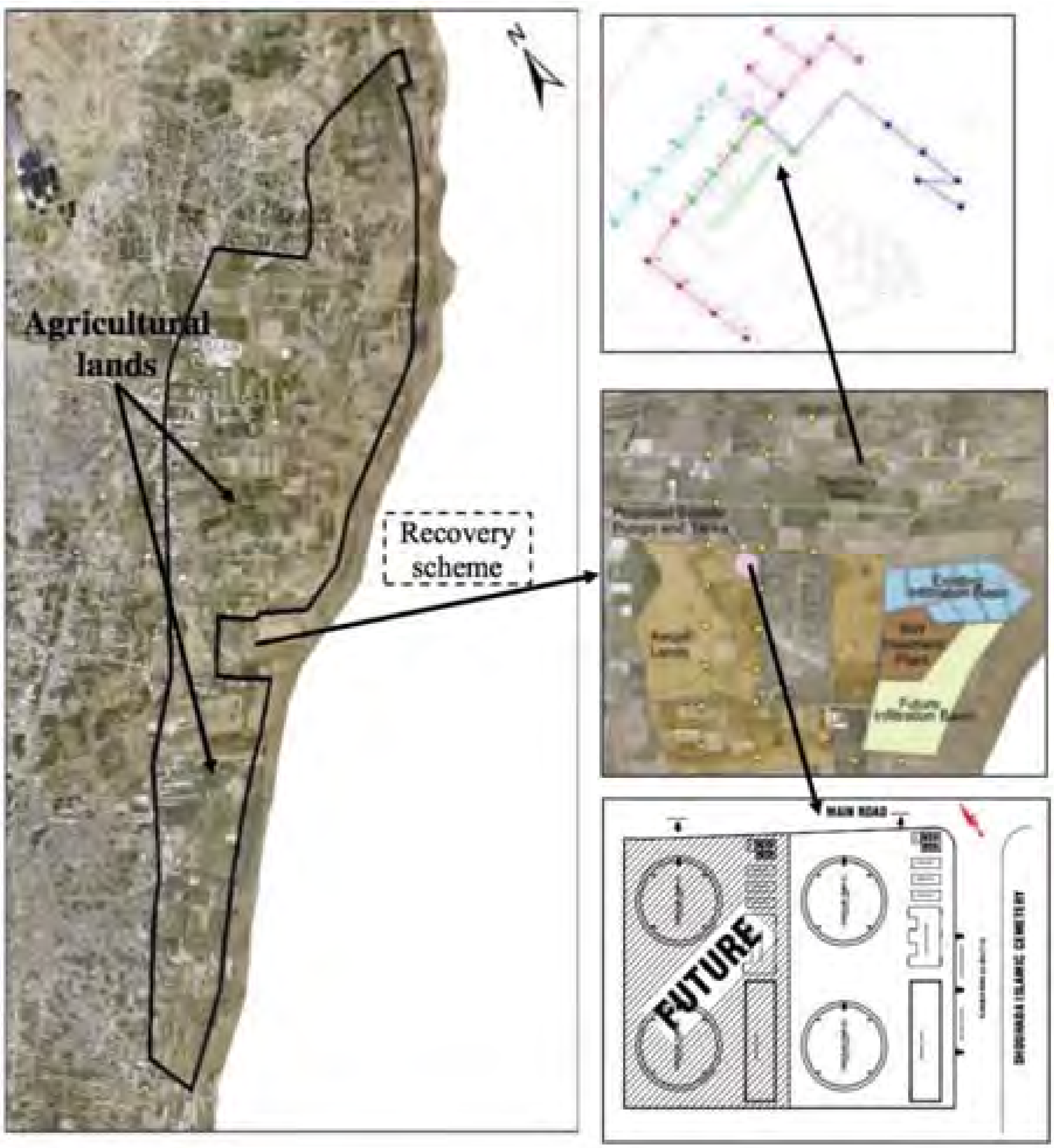

Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, supplementary phase was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. This system is composed of a chain of 27 recovery wells surrounding the infiltration basins to capture the effluent after it passes through the effluent ponds, storage reservoirs and a distribution network for the reuse of the water in irrigated agriculture.

A gross agriculture area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit first from the recovered water and the treated sewage sludge. The component, known under the name of 'Supplementary Project' is subdivided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse (Irrigation) Scheme. The original design, concluded in 2010, foresaw the possibility to use

35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary phase has been subdivided into three stages.

The **first stage,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 15 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells - and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume to reach agricultural and municipal wells located beyond the recovery wells.

The **second stage,** now scheduled for completion by the year 2018, would extend the recovery systems by a second row of 12 recovery wells (along with the previous 15 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated waste water infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank, booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **third stage**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

This report focus on the evaluation of the original design of the first two stages. Key design aspects of both the recovery scheme and the irrigation scheme are summarized in the following sections.

2.2 Physical Components of the Recovery Scheme

The recovery scheme comprises a system of 27 recovery wells and all related connection pipes as well as 10 monitoring wells. The following three sections provide a more detailed description of each component.

2.2.1 Recovery Wells

There are 27 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 zones (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 3. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

The 27 groundwater recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the 27 wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October which is equal to 50,885 m^3/day. The total number of wells is 27 where each should have a capacity of pumping between 150 m^3/hr to 200 m^3/hr. 25 out of the 27 wells are assumed to be operational always with a capacity of 170 m^3/hr. The two additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure of one of the other wells.

According to the numerical modelling results, the exact location of the 27 wells was defined to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 3 shows the locations of the recovery wells.

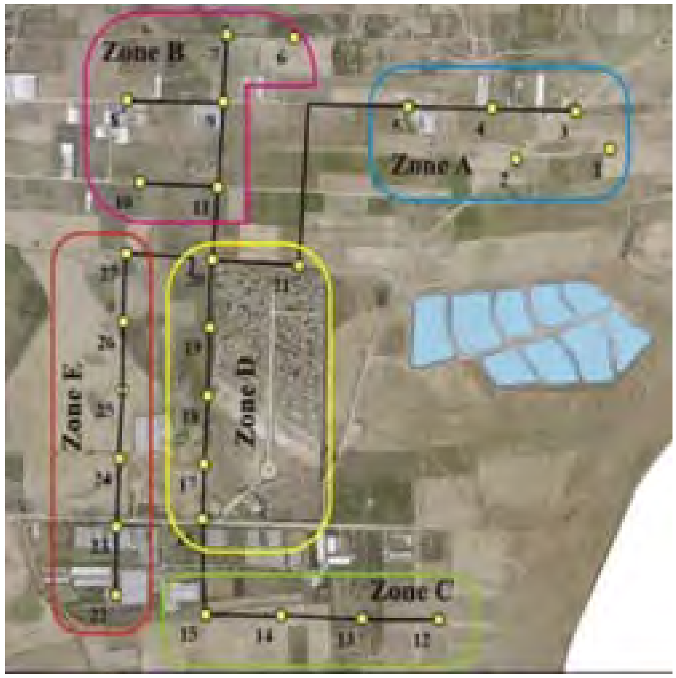

Figure 3: Location of the 27 Recovery Wells

2.2.2 Collection Pipes

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 4. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

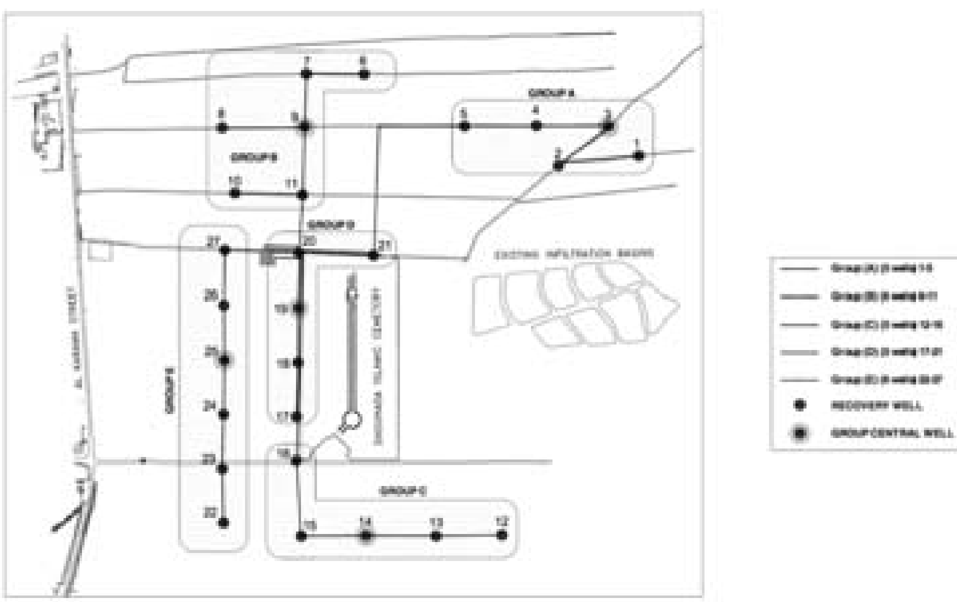

Figure 4: Wells grouping and Piping System

2.2.3 Monitoring Wells

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore taken and analysed randomly at farms level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 42 monitoring wells will be implemented by using 5 existing monitoring wells, 27 newly built recovery wells and 10 new monitoring wells.

The location of the 42 monitoring wells is provided in the following Figure 5.

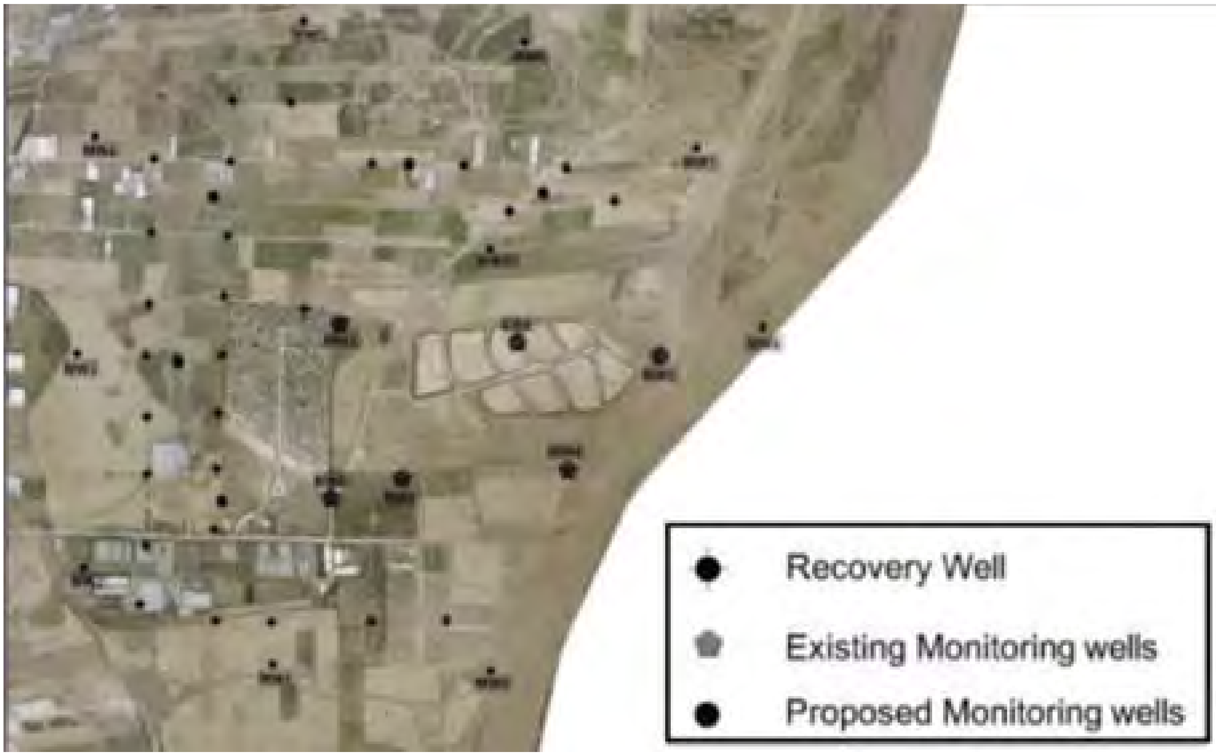

Figure 5: Location of the existing and newly proposed monitoring wells

2.3 Physical Components of the Reuse (Irrigation) Scheme

The physical components of the reuse part of the scheme for the 35,600 m^3/day capacity is described in the following sections and includes: i) Water Storage Tanks, ii) Booster Pumping Station and related piping and iii) the Irrigation network serving 1,570 ha (15,700 du) of gross agriculture land.

2.3.1 Water Storage Tanks

The recovered water from the wells is collected into two 4,000 m^3-water tanks that are in turn connected to a booster pumping station housing 10 irrigation booster pumps.

The two tanks of 4,000 m^3 each are shown in Figure 6. There are two inlet pipelines from well groups C and D with a diameter of 450 mm to Tank 1 and three inlet pipes with diameter equal to 450 mm from well groups A, B, and E to Tank 2. The two tanks are connected by a balancing pipe of 900 mm diameter. Washout pipes of 200 mm diameter are located in two places in the bottom of each tank. Overflow of 200 mm is to be connected with washout pipes out of the tank with a gate valve on the washout pipe. The overflow and washout pipes from the two tanks are connected to each other with a pipe of 300 mm diameter. The feeder from each tank to the booster pump stations is 800 mm in diameter with main gate valve.

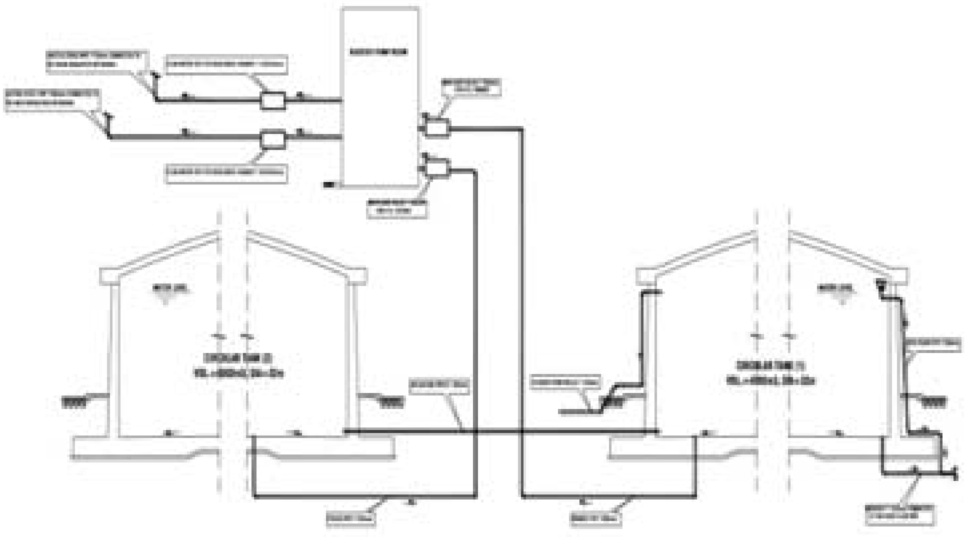

Figure 6: Water Storage Tanks

2.3.2 Booster Pumping Station and Associated Facilities

A booster pumping stations housing 10 pumps (8 + 2 stand-by pumps) with a cumulative capacity of 6,000 m^3/hr are used to transfer the water from the tanks to the farms. The booster pumps are designed to maintain a minimum pressure of 2.5 bars in the irrigation network at farm gates.

According to the 2010 design, Cropping Pattern and Irrigation Scheduling, the 27 recovery wells - even if operated concurrently - cannot re-file the storage tanks if farmers, for some reason, decides to start irrigation outside the proposed hours of operation during the days of peak water demand. The result would create a drop below threshold minimum operation water levels of the storage tank and a consequential blockage of the polders.

Accordingly, and to mitigate the risk described above, the operation of the booster pumps should be based on fuzzy control rules in which the number of operating boosters along with their speed is dependent on the following control variables:

- Planned irrigation schedule.
- Water pressure at the distribution pipe.
- Water flow at the distribution pipe.
- Water level in the reservoir.

The controller will be responsible to automatically change order and speed of the pumps based on the demand.

A detailed layout of the booster pumping station and the 10 booster pumps is provided in the following Figure 7.

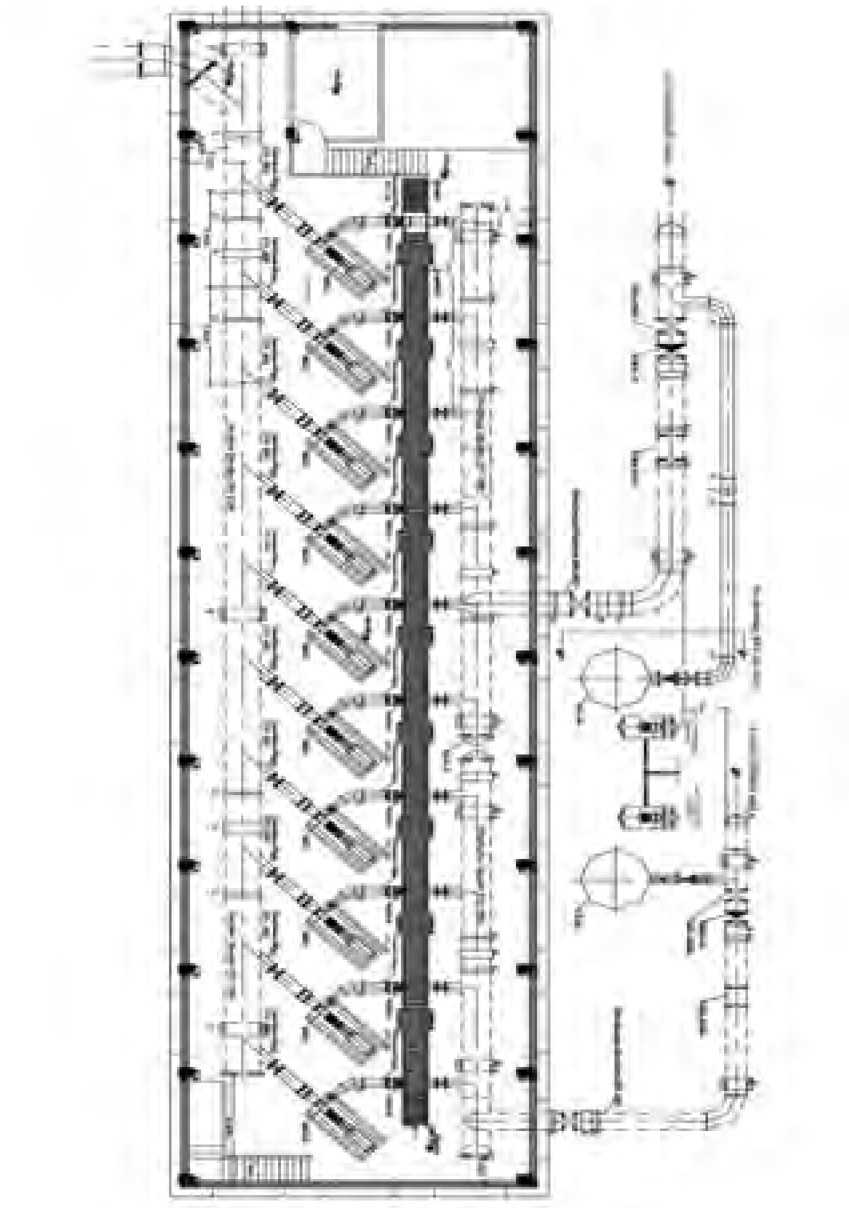

Figure 7: General Layout of the Booster Pumping Station

2.3.3 Irrigation Distribution Network

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 8. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 9.

In accordance with irrigation requirements, irrigation was to be carried out on a six-days rotation bases over six zones of almost equal sizes, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F as shown in the following Figure 9. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 10.

Figure 8: Location of agricultural land

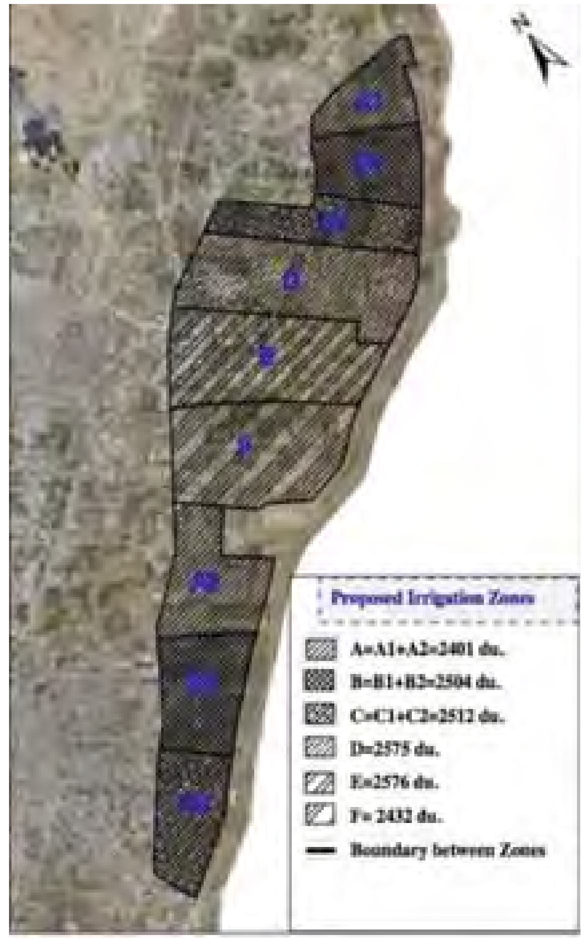

Figure 9: Proposed Irrigation Zones

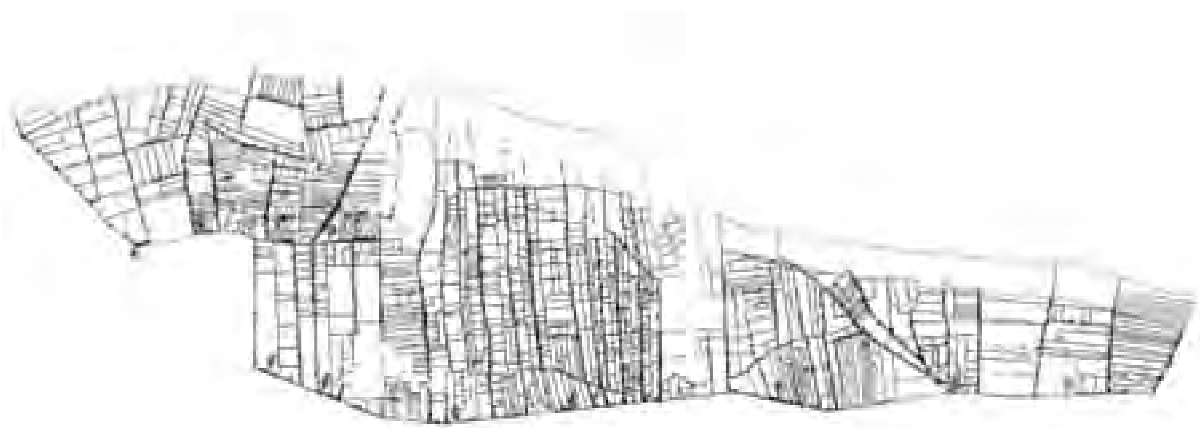

Figure 10: General Layout of the Originally Proposed Irrigation Network

2.4 Cropping Pattern and Water Requirements for Irrigation

2.4.1 Original Irrigation Project's Development Scenarios

Ultimately, the original 2010 design evaluated three possible scenarios for project development (see Figure 11).

Scenario	Area
I	A
II	A+B
III	A+B+C

Figure 11: Proposed Scenarios for Irrigation Project Development according to the original design

1. **Scenario I -** the scenario was built on the assumption that, initially, no more than 16,500 m^3/day would have been recovered from the recovery wells and was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (15%) and grains (15%). The scenario assumed that the best location for planning orchards was the area located to the west of the project along Al Karama road and far away from the border with Israel. The profiles of the soils on the area are deep enough to cultivate tree crops. Based on crops water requirements, the available reclaimed water (16,500 m^3 daily) was barely sufficient to irrigate 537 ha (5,375 du) divided into citrus for 161.3 ha (1,613 du), olives for 134.4 ha (1,344 du), fruit trees for 80.6 ha (806 du), alfalfa for 80.6 ha (806 du) and grains for 80.6 ha (806 du).

2. **Scenario II** - like Scenario I, was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (15%) and grains (15%). This second scenario was built on the assumption that the NGWWT is operating more effectively than under Scenario I and more water (23,100 m^3/day) of better quality can be abstracted for irrigation. This reclaimed water will be used to irrigate addition land being 752.5 ha (7,525 du) in total. The citrus area will increase to 225.8 ha

(2,258 du), whereas, olives to 188.1 ha (1,881 du), fruits to 112.9 ha (1,129 du), alfalfa to 112.9 ha (1,129 du) and grains to 112.9 ha (1,129 du).

3. **Scenario III** - was based on a crop mix that included citrus (30%), olives (25%), fruit trees (15%), alfalfa (10%), grains (10%) and vegetables (10%). This third scenario was built on the assumption that the NGWWT is operating at full capacity of 39,160 m^3/day (35,600 m^3/day plus 10% extra) and water can be produced for unrestricted use. The quantity of reclaimed water will be enough to irrigation about 12,577 du. The citrus area will increase to 377.3 ha (3,773 du), olives to 314.4 ha (3,144 du), fruit trees to 188.7 ha (1,887 du), and alfalfa and grains each will increase to 125.8 ha (1,258 du). At this scenario vegetable crops will be introduced with an area of 125.8 ha (1,258 du), as it might be difficult to convince the farmers to accept the use of the recovered water for cultivation of vegetables at the beginning of the project.

Planting tree crops adjacent to the political border should be avoided as much as possible due to the specific political issues in the region. By using the reclaimed water, more irrigation wells on the area will be closed and consequently the original groundwater will be increased and improved through yearly addition of rain water.

Figure 12 shows the ultimate subdivision of the project into two construction Phases of 500 ha (Phase I) and 1,000 ha (Phase II) in size respectively. The layout of these two phases is different than the one originally sought under Part A and B as depicted in Figure 8 and yet, the idea behind the three scenarios for the project's development according to water availability and quality can be similarly applied to Phase I and II presently being considered.

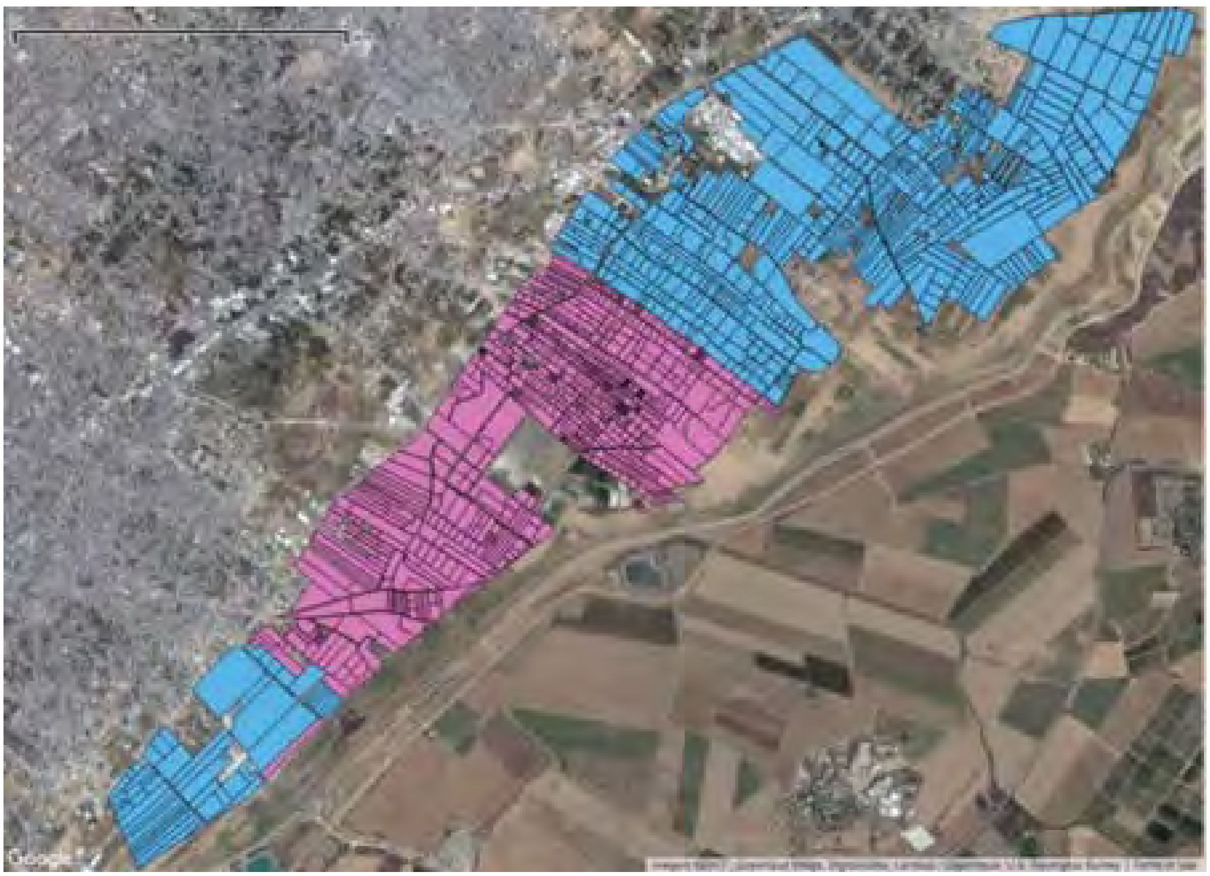

Figure 12: Final subdivision of the project into Phase I (purple) and Phase II (blue)

2.4.2 Cropping Pattern and Crops Water Requirement

The original 2010 cropping pattern was defined according to monthly crops requirement in millimeters as presented in the Table 1 and Figure 13 below.

Table 1: Monthly Crop Water Requirements (mm) (Cropwat V.8, 2009)

Month	Citrus	Olives	Fruit	Alfalfa	Vegetables	Grains

January	12,1	1,3	0,6	40,7	8,2	48,5
February	17,2	4,8	1,4	11,0	16,8	19,4
March	35,0	8,5	12,8	29,8	56,1	10,1
April	67,0	35,5	40,5	60,7	111,2	108,2
May	89,8	53,3	60,9	87,9	140,0	166,3
June	98,8	60,5	71,6	115,0	145,1	123,0
July	115,6	72,9	88,6	154,8	132,3	6,1
August	117,6	74,6	91,8	180,8	77,1	0,0
September	92,2	54,8	69,8	157,1	67,4	0,0
October	68,2	37,2	49,6	122,3	80,8	0,0
November	38,8	15,2	24,2	80,8	57,1	13,6
December	7,7	0,0	0,2	43,4	9,9	40,0
TOTAL	**760,0**	**418,6**	**512,0**	**1084,3**	**902,0**	**535,2**

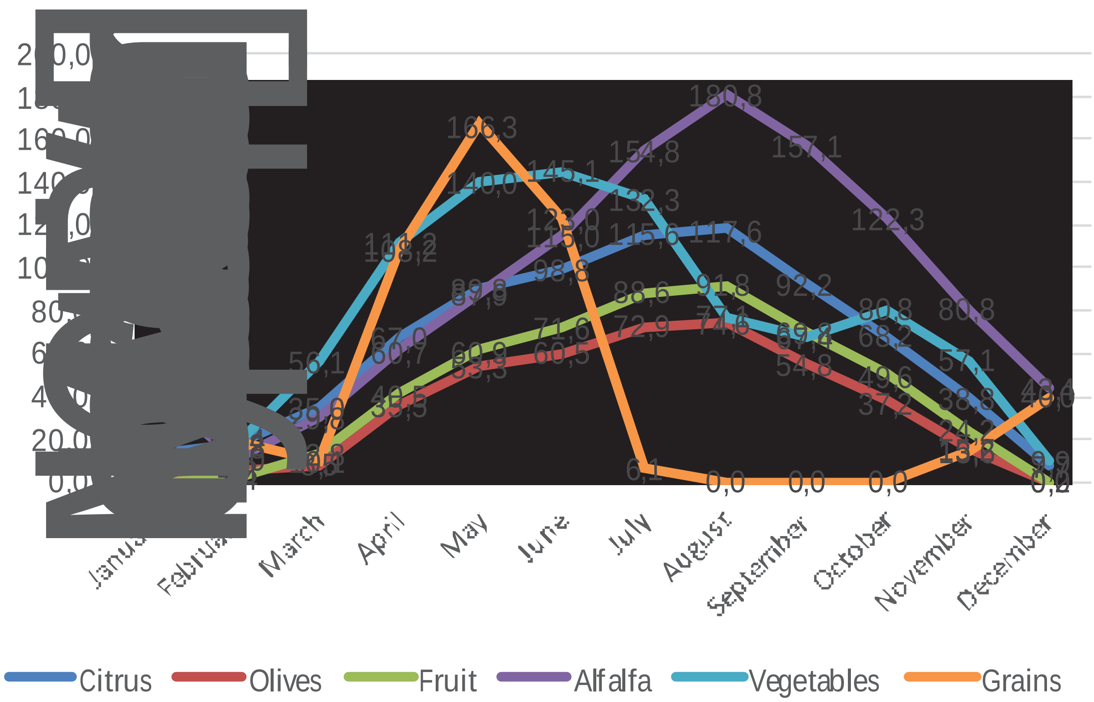

Figure 13: Monthly Crop Water Requirements [mm/month]

Figure 14: Mean monthly crop water demand (mm) for citrus, olives, fruit trees, alfalfa, vegetables and grains crops.

Total irrigated area for each crop and water balance for all three development scenarios is presented in the following Table 2.

Table 2: Irrigated area and Total Water balance for the three development scenarios

Crop	**Scenario I** (16,500 m^3/day)		**Scenario II** (23,100 m^3/day)		**Scenario III** (39,160 m^3/day)	
	%	**Area (du)**	**%**	**Area (du)**	**%**	**Area (du)**
Citrus	30	1,613	30	2,258	30	3,773

Olives	25	1,344	25	1,881	25	3,144
Fruits	15	806	15	1,129	15	1,887
Alfalfa	15	806	15	1,129	10	1,258
Grains	15	806	15	1,129	10	1,258
Vegetables	0	0	0	0	10	1,258
Total area	100	5375	100	7,525	100	12,577
Total infiltrated	**5,460,000 m^3**		**7,644,000 m^3**		**12,958,400 m^3**	
Total Recovered	**6,006,000 m^3**		**8,408,400 m^3**		**14,254,240 m^3**	
Balance	**-546,000 m^3**		**-764,400 m^3**		**-1,295,840 m^3**	

As can be noted, the total amount of water recovered per year is always greater that the amount of water infiltrated per year for each scenario. It means that the yearly water balance is negative and must be compensated by rain water directly.

Scenario III has been considered as the basis for the design of the irrigation network whereas the total water requirements have been generically increased of an additional 15% to account for extra water needed for non-irrigation needs (such as industries and other farm-related water needs) as well as to account for possible climate changes. Finally, the total gross irrigation demand (plus 15%) is presented in the following Table 3.

Table 3: Gross Water Requirement for Scenario III

Crop	% of Area	Area (du)	Gross Irrigation (m^3/du)	Total Irrigation demand (m^3/year)	Total Gross Water Requirement (m^3/year)
Citrus	30%	3,773	1,140	4,301,334	4,946,534
Olives	25%	3,144	627.9	1,974,275	2,270,416
Fruits	15%	1,887	768	1,448,870	1,666,201
Alfalfa	10%	1,258	1,626.5	2,045,649	2,352,496
Grains	10%	1,258	802.8	1,009,682	1,161,134
Vegetables	10%	1,258	1,353	1,701,668	1,956,918
Total Area	**100%**	**12,577**	**6,318.2**	**12,481,478**	**14,353,700**

The average daily and hourly irrigation water requirements for each month are given below which consider an efficiency of the system equal to 80%. The irrigation demand during the summer months (June, July and August) accounts for about one third of the yearly crops water requirements.

Table 4: Net Daily Water Requirement for Scenario III

Net daily water requirement for irrigation (m^3/day)	
month	m^3/day
January	28,766
February	31,144
March	30,431
April	29,743
May	40,541
June	44,248

July	43,597
August	42,673
September	35,034
October	26,250
November	27,377
December	28,823
Average	34,052

Table 5: Net Hourly Water Requirement for Scenario III[1]

Net hourly water requirement (m^3/h)	
month	(m^3/h)
January	2,877
February	3,114
March	3,043
April	2,974
May	3,378
June	3,687
July	3,633
August	3,556
September	2,920
October	2,625
November	2,738
December	2,882
Average	**3,119**

2.4.3 Water Recovery Needs

The following table shows the daily water needs which should be extracted by the recovery wells and pumped through the irrigation networks. The values consider a further amount of water of 15% to account for non-farming activities and potential climatic change.

Table 6: Daily Water Recovery Needs [m^3/day] for Scenario III

Water Recovery Needs (m^3/day)	
month	m^3/day
January	33,081
February	35,816
March	34,996
April	34,204
May	46,622
June	50,885
July	50,137
August	49,074

[1] number in white cells are calculated based on 10 hours pumping daily in low water demand months while numbers in brown-shaded cells are calculated based on 12 hours pumping daily in high water demand months

September	40,289
October	30,188
November	31,484
December	33,146
Average	**39,160**

Table 7 Hourly Water Recovery Needs [m^3/hr] for Scenario III[2]

Water Recovery Needs (m^3/h)	
month	m^3/h
January	3,308
February	3,582
March	3,500
April	3,420
May	3,885
June	4,240
July	4,178
August	4,089
September	3,357
October	3,019
November	3,148
December	3,315
Average	**3,587**

2.4.4 Irrigation Schedule

The total area is divided into 6 equal main lots (A1+A2, B1+B2, C1+C2, D, E, and F) as depicted in Figure 15

In order to balance the pumping load, two lots (the farthest and the closest to the booster station) can be irrigated at each single day of the week (example: A1 + A2). The following Table 8 presents the proposed pumping schedule on a seven weeks' rotation.

[2] number in white cells are calculated based on 10 hours pumping daily in low water demand months while numbers in brown-shaded cells are calculated based on 12 hours pumping daily in high water demand months

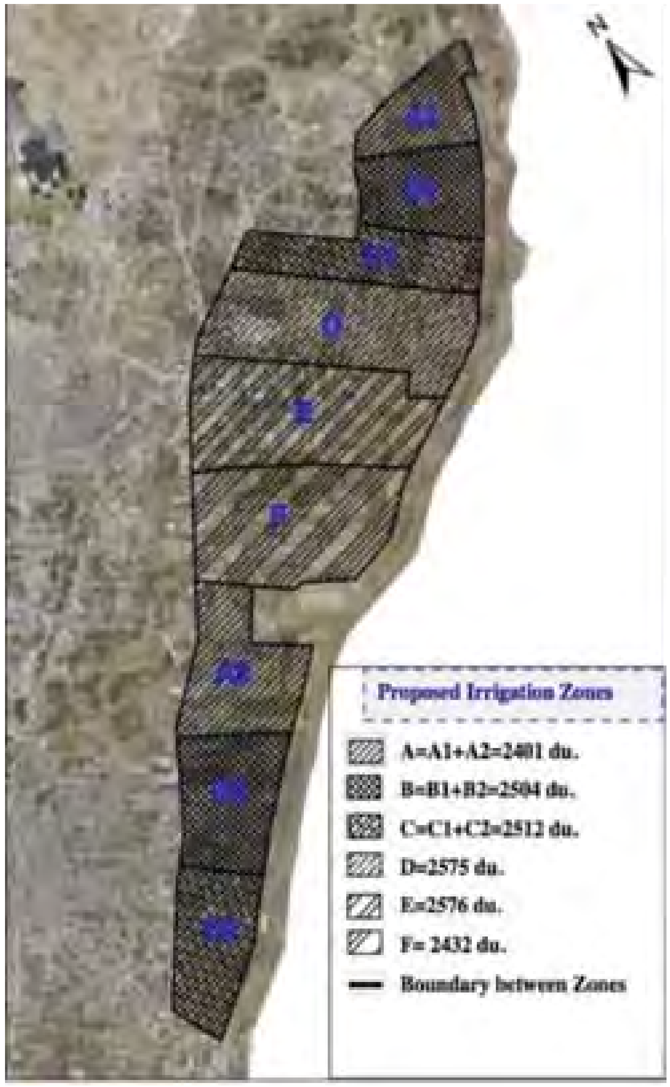

Figure 15: Proposed Irrigation Zones

Table 8: Pumping Schedule

	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7
Saturday	A1+A2	B1+B2	C1+C2	D	E	F	A1+A2
Sunday	B1+B2	C1+C2	D	E	F	A1+A2	B1+B2
Monday	C1+C2	D	E	F	A1+A2	B1+B2	C1+C2
Tuesday	D	E	F	A1+A2	B1+B2	C1+C2	D
Wednesday	E	F	A1+A2	B1+B2	C1+C2	D	E
Thursday	F	A1+A2	B1+B2	C1+C2	D	E	F
Friday	A1+A2	B1+B2	C1+C2	D	E	F	A1+A2

3 CRITERIA FOR CROP SELECTION

3.1 Background

The recovery and reuse component of NGEST is relevant and will be efficient only if all the infiltrated wastewater is recovered and reused, to preserve further deterioration of the quality of the aquifer used for drinking by an additional contamination of the infiltrated treated wastewater. The irrigation network has thus been sized to match with the total quantity of water infiltrated and recovered by the recovery wells and based on the cropping pattern around the project and water requirements per crops. To do so, two assumptions were made.

i. the availability of water provided by the implementation of the recovery and reuse scheme will increase number of farmers returning to their uncultivated lands;

ii. the owners and users of private irrigation wells will stop the operation of their wells to switch to the reused water.

3.1.1.1 Status of agriculture in the project area: water use, rain fed agriculture and land abandonment.

As emphasised by the survey carried out by the consultant, three quarters of the project area mainly depend on irrigation by private wells while rain fed agriculture takes around 24% of the total 12,068 du. It has been also clarified that about 18% of total cultivable land is in fact not cropped. This happens mostly because of the frequent land invasions from the Israeli army and the periodical spraying of herbicides by Israeli airplanes to keep clear the fields along the border. But the herbicides are in fact air borne on the close cultivated fields of the Gaza farmers, which kills the crops and makes farming conditions unhealthy. Furthermore, lack of financial resources to carry out cropping operations and water scarcity are other causes of land abandonment.

The survey showed that half of total farms have a mixed crop pattern (see Table 9), composed by arable, vegetable and fruit tree crops (perennials). Among the latter, citrus and olive play the most important role. Arable crops, such as wheat and barley, are also quite important as staple food for the household and can – for a certain extent – offer acceptable yields under rain fed conditions too (although wheat is also irrigated).

Table 9: Indicative cropping pattern of the project area

Crops and crop groups	%
Mixed arable and vegetable crops	21.91
Wheat	14.16
Mixed fruit tree crops	9.50
Olive	7.71
Mixed vegetable and fruit tree crops	7.10
Mixed vegetables	8.25
Livestock-fodder crops	4.22
Citrus	5.00
Onion	2.30
Barley	1.03
Potato	0.55
Uncultivated	18.27
Total	100

The vast majority of the agricultural products is sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. A minor part of products can be also exported in the West Bank and Israel, depending on the market demand. However, the government allows exporting fresh products only when domestic needs are satisfied, namely only production in excess (as reflected by low market price) can leave the Gaza Strip. In general, the value chains are very simple, no local food industries process local products, and wholesalers take the highest part of the crop value. Farmers' organisations are scarcely present in the project area, hence farmers work on individual basis without post-harvest facilities, so having a weak contractual power with respect to the wholesalers. Sheep and dairy cows represent the main livestock. Rearing structures and fodder crops (mostly alfalfa) takes about 4% of the area, but most the necessary feed is currently imported from Israel, so making the north Gaza livestock sector highly dependent from the neighbour.

With the foreseen availability of large quantities of water for irrigation, it is assumed that the removal of water constraint will reinvigorate agriculture in the target area. However, a more comprehensive strategy is needed to cope with the other current shortcomings. The institutional environment should be strengthened to provide effective advisory support to the farmers, who in the survey asked for specific technical assistance. Collective post-harvest services should be created by helping the farmers to establish associations, which will also foster their contractual power toward the wholesalers. Permanent crops and field structures should be systematically placed far from the border area with Israel. Fodder crops production should be enhanced.

3.2 Proposed Cropping Pattern

The cropping pattern showed in Table 10 is proposed to be implemented through the new irrigation scheme, in the entire target area (12,068 dun). It is highlighted that 65% of the cropping pattern is represented by tree crops.

Table 10: Proposed Crops and Crop Groups

Crops and crop groups	%
Citrus	22
Olive	23
Almond	10
Peach	7
Other fruit tree crops	3
Grains	12
Winter vegetables	4
Winter vegetables (GH)	3
Summer vegetables	6
Alfalfa (green fodder)	10
Total	100

The criteria followed by the consultant for the selection of the crops/crop groups and their relative share within the pattern are described below:

1. Farmers' preference and crop economic profitability.

The chosen crops are all already extensively grown in the target area, especially Citrus and Olive which are highly appreciated. Citrus has usually good market demand and Olive is important both for the traditional diet of the households and for the good market of the olive oil. The survey showed that about 39% and 16% of the interviewed farmers would introduce respectively olive and citrus trees in their farms, in case proper water supply will be ensured by the project.

Stone fruits are also well appreciated and farmers are familiar with the required cropping techniques. As emerged in the survey, 12% of the respondents declared they would grow stone fruits (or would increase their share) in case of irrigation supplied by the project.

Grains (Wheat and Barley) are traditional staple crops, quite crucial for food security.

Winter and summer vegetables are important cash crops for the local farmers but their cultivation is however affected by water availability in summer and by climatic conditions in winter. The survey showed that the majority of the interviewed farmers (54%) would grow more vegetables when water supply will be ensured in the right period. In order to intensify the cultivation of vegetables, the proposed cropping pattern includes a small share of tomato grown under greenhouse in winter, which is intended to satisfy the off-season tomato demand by consumers, allowing the farmers to fetch higher prices in the market.

Alfalfa (fodder crop). One tenth of the cropping pattern will be taken by alfalfa, a soil-improving fodder crop which is usually supplied green to the animals. If properly irrigated, alfalfa may produce plenty of fodder through three/four cuts per season. This crop, which typically remains over three years in the field, has high nutritional value. It can be grown either in pure stand either among fruit trees, being capable to fix nitrogen and make it available to the trees.

2. Water availability. The water requirements of the designed cropping pattern are compatible with the estimated amount of water made available by the aquifer together with the water deriving from the new WWTP.
3. Climate and soil suitability. Crops have been selected and crop cycles planned based on the eco-physiology of the crops, in terms of required soil characteristics and suitable temperature interval.

4 WATER RESOURCES REQUIREMENTS

4.1 Water Demand

Based on the newly proposed cropping pattern, a net daily water requirement for irrigation has been calculated as shown in the following table. Minimum demands occur during winter season, maximum demands occur in the summer season in the month of May.

Table 11: Net daily water requirement for proposed Cropping Pattern

Net daily water requirement for irrigation (m^3/day)	
month	m^3/day
Jan	39
Feb	43
Mar	19,698
Apr	36,807
May	45,781
Jun	43,405
Jul	42,238
Aug	35,893
Sep	19,309
Oct	10,433
Nov	2,333
Dec	0
Average	21,332

The water requirements presented in the previous table defines the net irrigation water requirements but do not consider the additional water that might be required by the local industries as well as the one needed for uses not directly connected to irrigation practices (such as the one required for washing, the one required for sanitary uses, etc.). Finally, Table 11 does not consider the impact of climate change to the irrigation water requirements.

The previous study has generally addressed this additional water needs by increasing the net irrigation water demand by a flat 15% during each month. Such practice is not correct since water needs for the industries and for non-irrigation practices do not vary in the same way that irrigation does. Furthermore, climate change in this part of the World does not necessarily means that more water will be needed but will, more likely, means that the distribution of the rain patter might change. A more appropriate approach is to explicit the additional water needs.

Finally, a 70,000 m^3/year has been proposed for the industrial activities (with a progressive increase from the current water use of 30,000 m^3/year to the project 70,000 m^3/year over a period of 25 years, 830,375 m^3/year has been considered for other uses (assuming 500 liters per habitants/day consider about 650 families with 7 people per family). This amount of water can be considering to be provided constantly during the year. To be note that this amount of water corresponds in a year to about 10% of the total irrigation demand. This means that summarizing 5% of climate change, 15% of yearly irrigation demand has been considered for other uses obtaining the same value of the original project but such volume will be distributing differently during the months of the year.

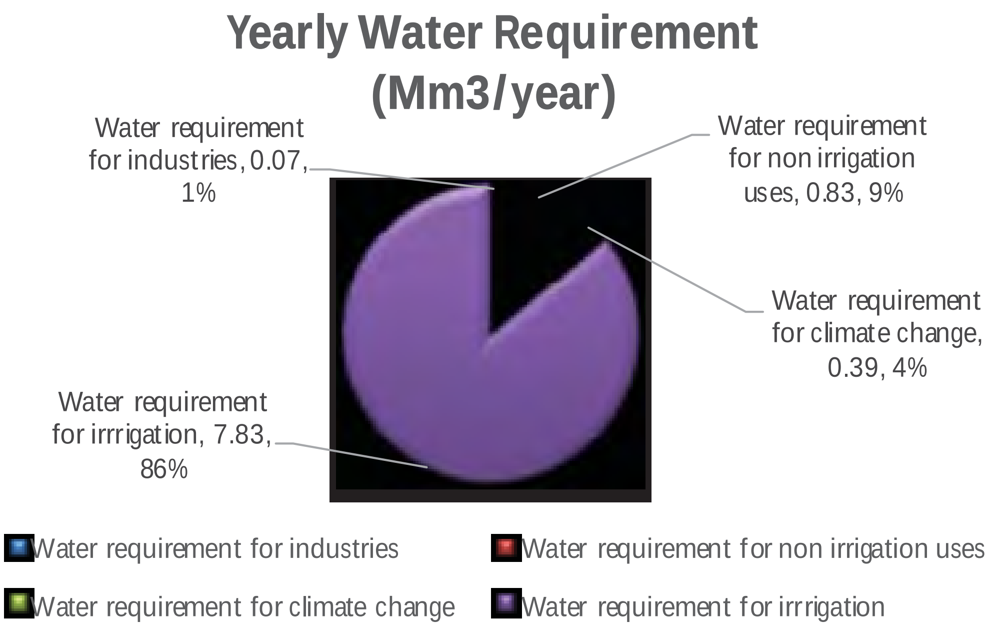

Figure 16 – Pipe chart with Yearly Net Water Demand for different uses

4.2 Irrigation Scheduling

Based on effective water requirement and the necessity of daily irrigation for the crops, the consultant wants to propose an irrigation pattern in which all sectors are evenly irrigated at the same time for 10 hours during low demand months (from October to February) and 12 hours during high demand months (from March to September).

Table 12: Irrigation scheduling

Daily irrigation schedule for all irrigation area	
month	Pumping hours
Jan	10
Feb	10
Mar	12
Apr	12
May	12
Jun	12
Jul	12
Aug	12
Sep	12
Oct	10
Nov	10
Dec	10

4.2.1.1 Water Savings

Differently from the existing project, the efficiency of the network has been divided into two terms: the efficiency of the pipelines equal to 5% (i.e. to consider lacks water during the transmission pipelines, for example in the joints, valves, etc.) and the efficiency of irrigation method equal to 80% (i.e. the lack of water from the gate farm to the roots of crops.

The gross water requirement i.e. the recovered water has been calculated and shown in the following tables.

Table 13: Water recovered for proposed Cropping Pattern

Water recovered (m^3/day)			Water recovered (Mm^3/month)	
month	m^3/day		month	Mm^3/month
Jan	4,060		Jan	0.13
Feb	4,065		Feb	0.11
Mar	29,927		Mar	0.93
Apr	52,439		Apr	1.57
May	64,246		May	1.99
Jun	61,120		Jun	1.83
Jul	59,585		Jul	1.85
Aug	51,236		Aug	1.59
Sep	29,415		Sep	0.88
Oct	17,736		Oct	0.55
Nov	7,078		Nov	0.21
Dec	4,009		Dec	0.12
Average	28,068		Total (Mm^3/year)	11.77

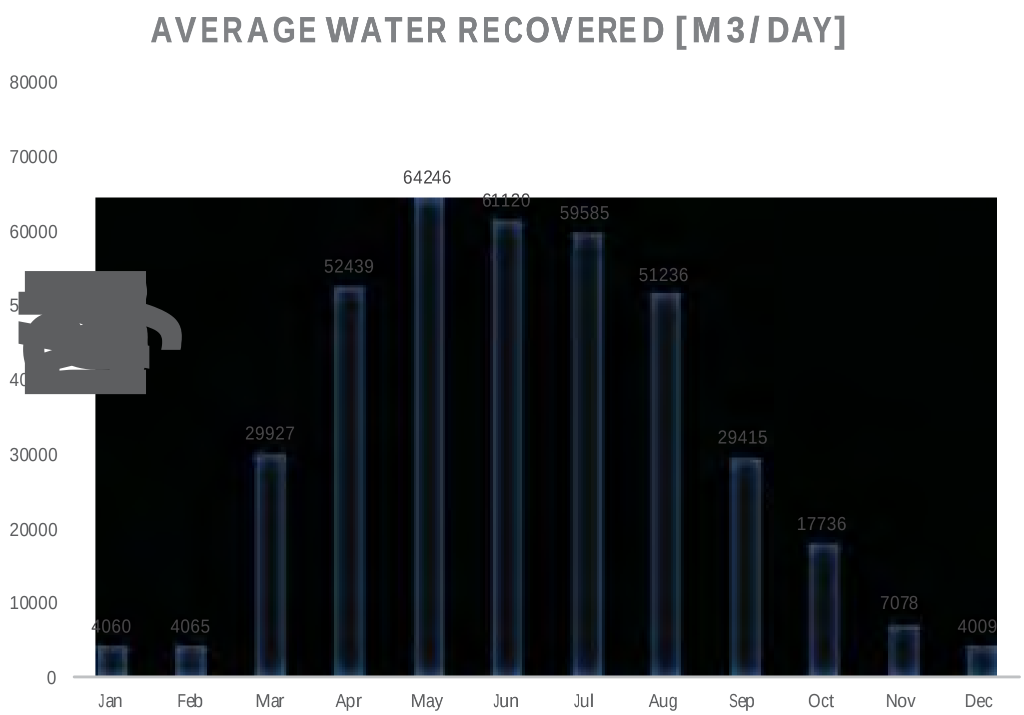

Figure 17: Histogram of water recovered (m^3/day)

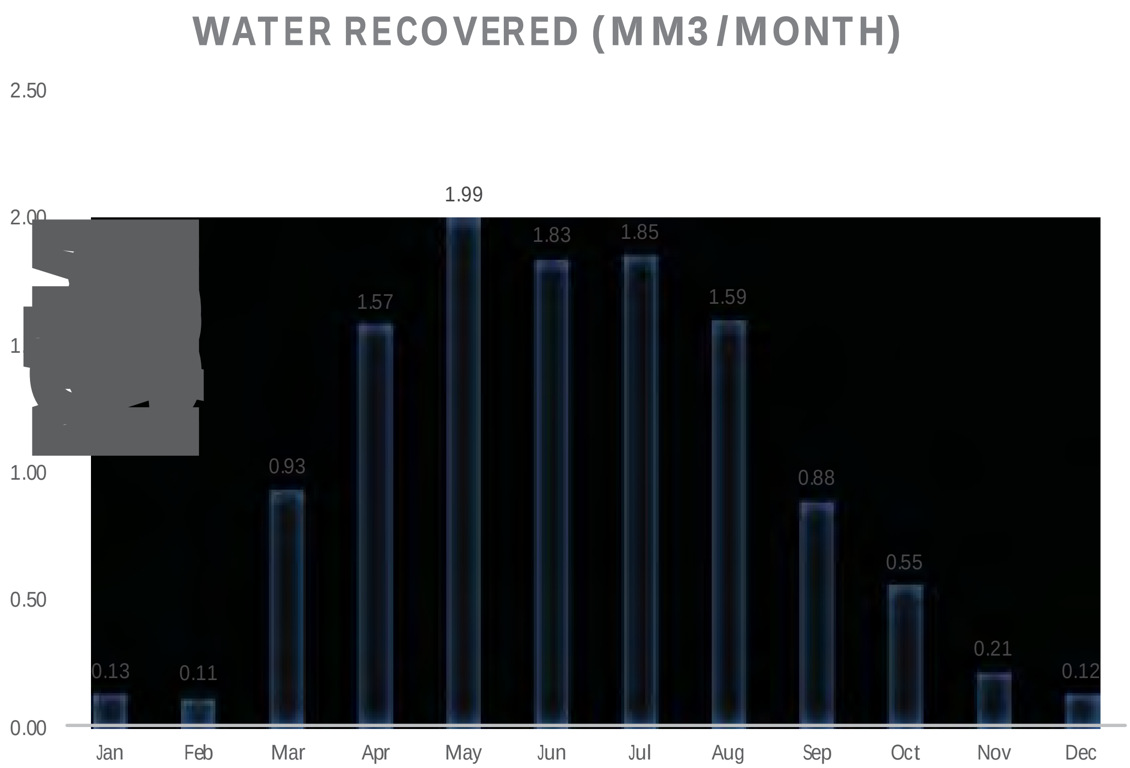

Figure 18 – Histogram of water recovered (Mm^3/Month)

As can be seen, the total water recovered per year is lower than total infiltrated waste water so the yearly water balance is positive.

The table below shows the hourly water recovered for each hour according the selected cropping pattern and irrigation scheduling.

Table 14: Hourly Water recovered for proposed Cropping Pattern according the proposed irrigation scheduling[3]

Water Recovered (m^3/h)	
month	m^3/h
Jan	406
Feb	407
Mar	2494
Apr	4370
May	5354
Jun	5093
Jul	4965
Aug	4270
Sep	2451
Oct	1774
Nov	708
Dec	401

[3] white cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

Average	2724

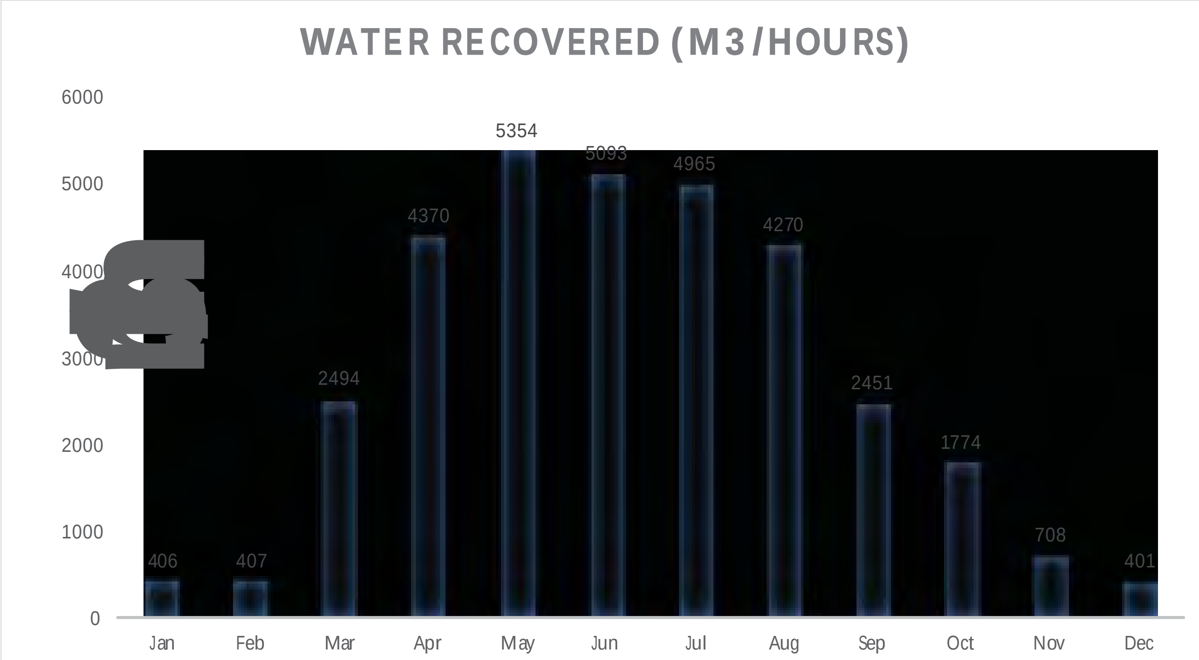

Figure 19: Histogram of the water (overaged over the day) recovered (m^3/hrs)

4.3 Irrigation Methods

The selection of the most appropriate irrigation method inside the farms depends on:

- Crop type,
- Soil characteristics,
- Investment costs of system.
- Ability of farmers to manage the system.

The common method of irrigation used by farmers in the Gaza Strip is surface irrigation which involves complete coverage of soil surface around the tree (small basin) with water. In the recent years using of more efficient irrigation method, like drip irrigation which is relatively expensive, has increased particularly for high price vegetables. The most appropriate efficient methods to be recommended under our conditions are sprinkler and localized irrigation system, which includes bubbler and drippers.

- *Sprinkler systems:* Applying of irrigation water in the form of a spray reaching the soil as rain. There are a variety of sprinkler systems including mini-sprinkler (30-80 l per hr.) which is used for irrigation of most citrus, olive and fruit trees. Macro-sprinklers can be used to irrigate cereals, fodder crops and industrial crops. Efficiency ranges from 70 to 80%.
- *Localized systems:* Water is applied more efficiently near the plant root zone, so that only the root zone gets wet and avoiding overlapping problems. These systems have low energy requirements (1-3 bar) but require high quality of irrigation water to prevent clogging problems. Thus, good filtration (90- 120 mesh screen or disc filter) unit is required.
- *Drip (Trickle) irrigation:* Applying water (4-8 l per hr.) continuously through drippers to each individual plant at limited rates. Its efficiency is high (up to 90%) and used for high value crops (vegetables and citrus). Drip

irrigation requires clean water without any particles or algae on it. Hazard categories include sand grains, precipitation of carbonates and algae.

- *Bubbler irrigation*: This system is more recommended as irrigation method for reclaimed water because exit openings are wider than of a dripper and thus less clogging problems. It can be used to irrigate citrus trees under our conditions. The irrigation efficiency is slightly lower than drip irrigation.
- *Sub-surface drip irrigation (SDI): This system is still not enough evaluated through trials under Gaza conditions.*

Appropriate irrigation systems for proposed crops:

- *Citrus and fruit trees:* bubblers, drippers and mini-sprinklers.
- *Fodder and grains:* macro-sprinklers
- *Vegetables and row crops:* In-line drippers

The rate of irrigation can be controlled accurately and nutrients can be also added with irrigation water (fertigation).

5 Irrigation System Review and Recommendations

5.1 Review of Original Detailed Design of the Irrigation Network

Based on existing (and more recent version) of the available documents, the consultant reviewed the irrigation network design prepared in 2010. The review process was somehow limited by the following factors:

- The original detailed design lack in clearly explanation of some of the design choices that were made in 2010. This is particularly evident while trying to understand the proposed functioning and management of the irrigation system as well as in relation to some of the choices that the designers made while selecting some components of the irrigation network. Further to that, tables providing calculation of the main hydraulic parameters (pressure, length, connection, etc.) cannot be linked to the layout drawings of the network itself making it very difficult to follow some of the logics adopted by the original designer and impossible to verify the design without having to recreate and recalculate all parameters independently.
- The material that was provided for the review is incomplete. Two important pieces of information were not provided: i) the final bill of quantities for both Phase I and Phase II of the Irrigation Network component, and ii) the detailed calculation on the operation and maintenance cost for both the recovery and the reuse schemes.
- Furthermore, multiple different version of the same irrigation network was provided thus making unclear to which version of the final design we should refer to. Lacking better guidance, the review process was conducted on the latest version received.
- Finally, all digital files lack a clear georeferencing making it impossible to correctly overlay the irrigation network on satellite image or aerial photography.

To overcome some of the limitation listed above it was necessary to create a computer model of the proposed network layout and, ultimately, re-calculate all the design parameters.

5.1.1 Consistency of the Irrigation Network Design

5.1.1.1 Parcel Incongruences

Several incongruences about parcels layout can be found in the detailed design. A detailed topographic and cadastral survey of the project's area appears to be a necessary requirement to better locate the pipelines layout. Few example are provided in Figure 20 and Figure 21.

Furthermore, It should be note that the geographical reference system was not provided with the original design and cannot be inferred by the available material. The layout of the drawing is not based on a common Geographic Reference System thus making the review process particularly difficult and, more importantly, proving a set of drawings that are often confusing and that will likely confuse the contractors that will need to use them as a base for construction. Our suggestion is that all available drawings (for both Phase I and Phase II) should be incorporated into a common geographical reference system (local topographic system or UTM-WGS84 projection) avoiding incongruences when a is necessary to produce a unique map for the entire project's area.

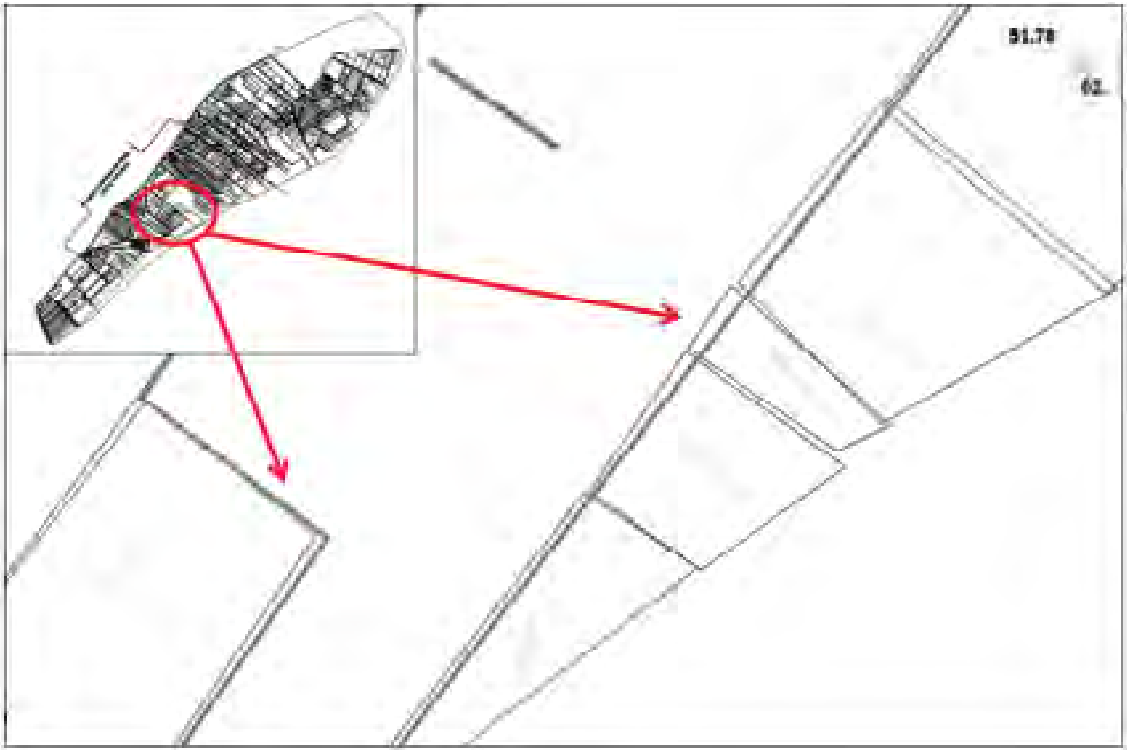

Figure 20: Arrows indicate incongruences between parcels

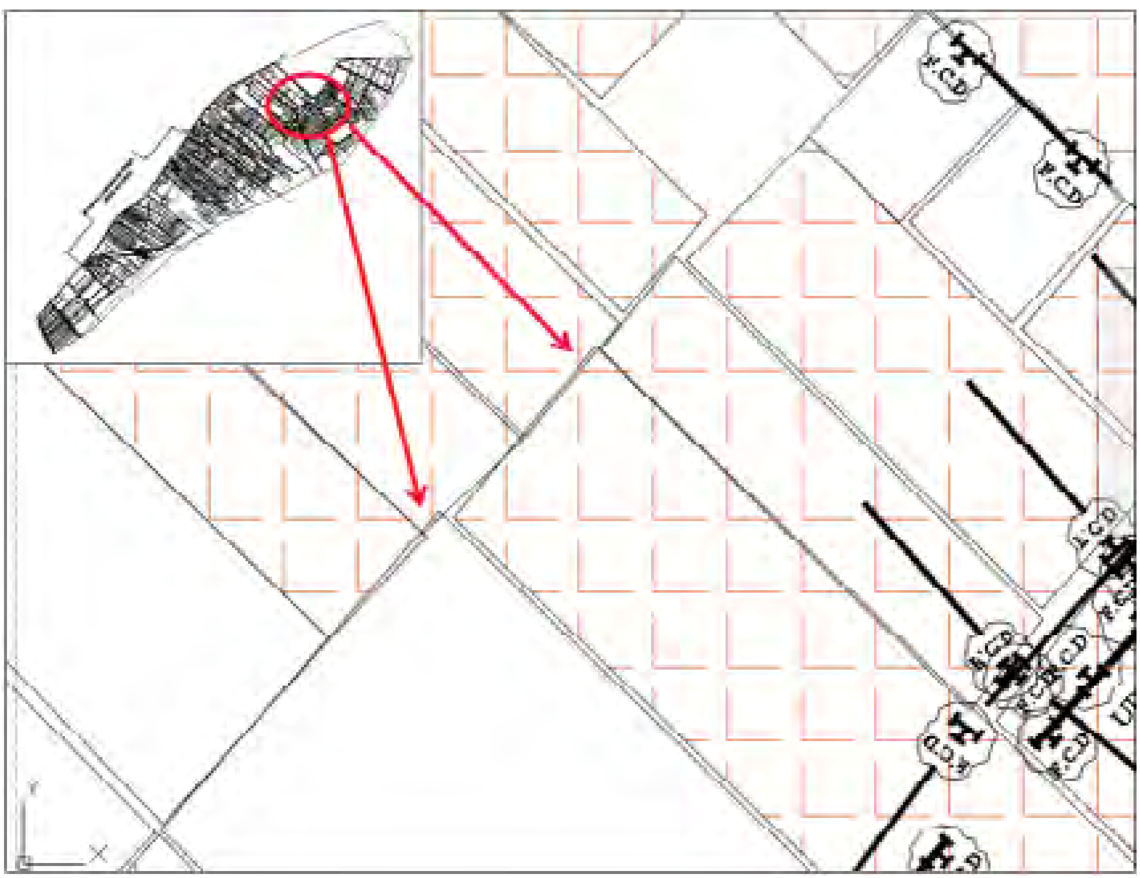

Figure 21: Arrows indicate incongruences between parcels

5.1.1.2 Pipeline functioning

Although general concept of functioning and network design results to be acceptable, some minor inconsistencies were found. Practically speaking it is not always possible to understand how the proposed distribution network might work once built as proposed by the original design.

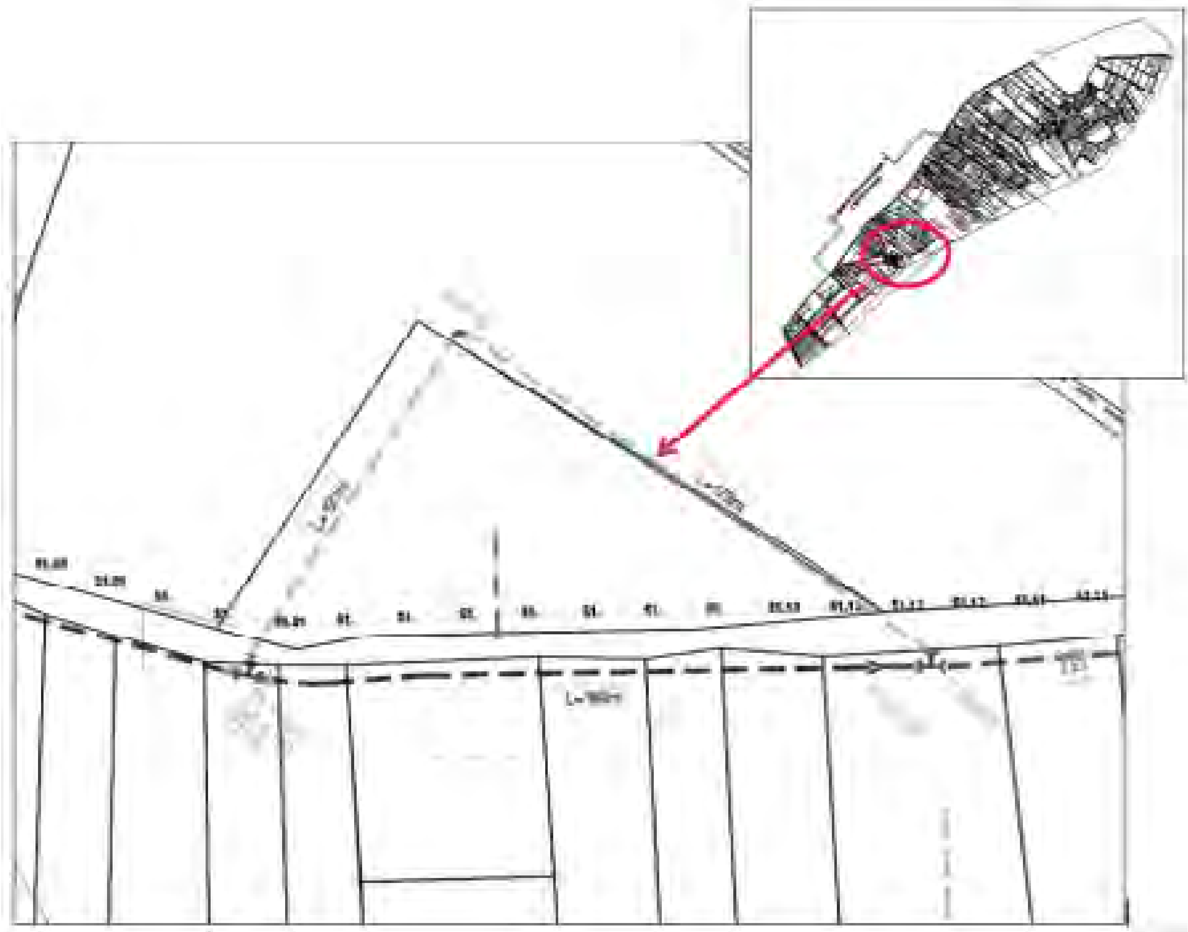

Figure 22: Arrow indicates a pipeline without any Farm connection and apparently without a sense to exist

Figure 23 : Arrow indicates a pipeline very long extending about 200m further the last Farm Connection

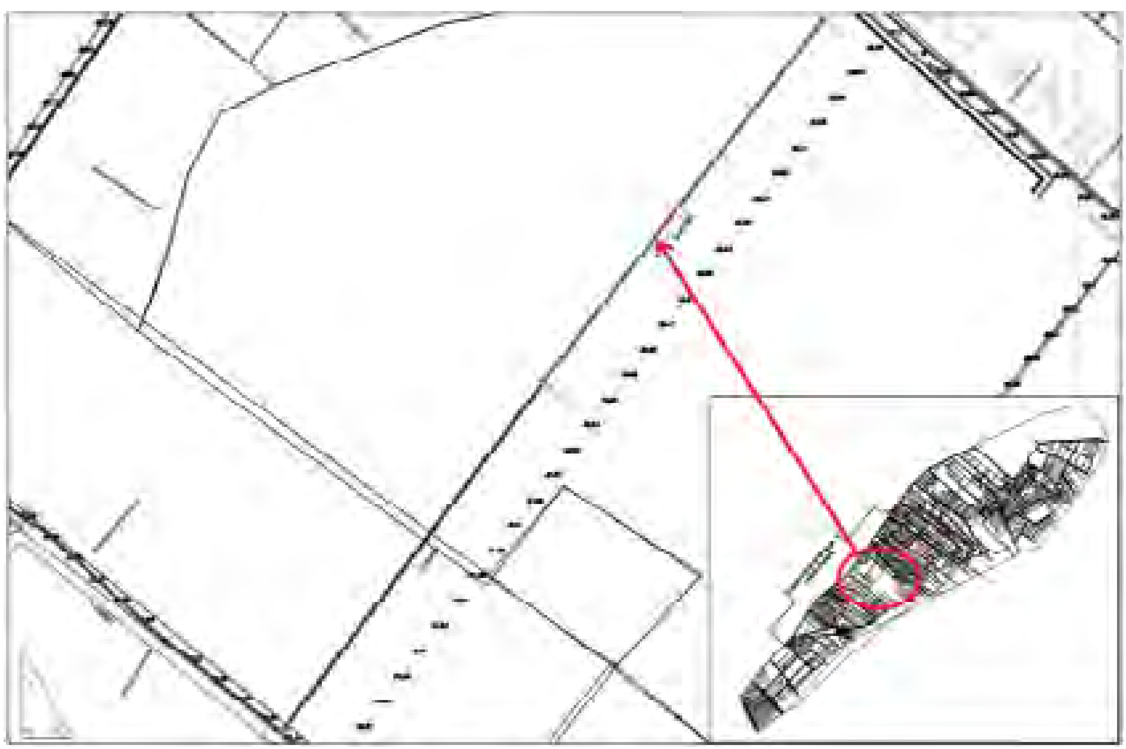

Figure 24: Arrow indicates a pipeline without any Farm connection and apparently without a sense to exist

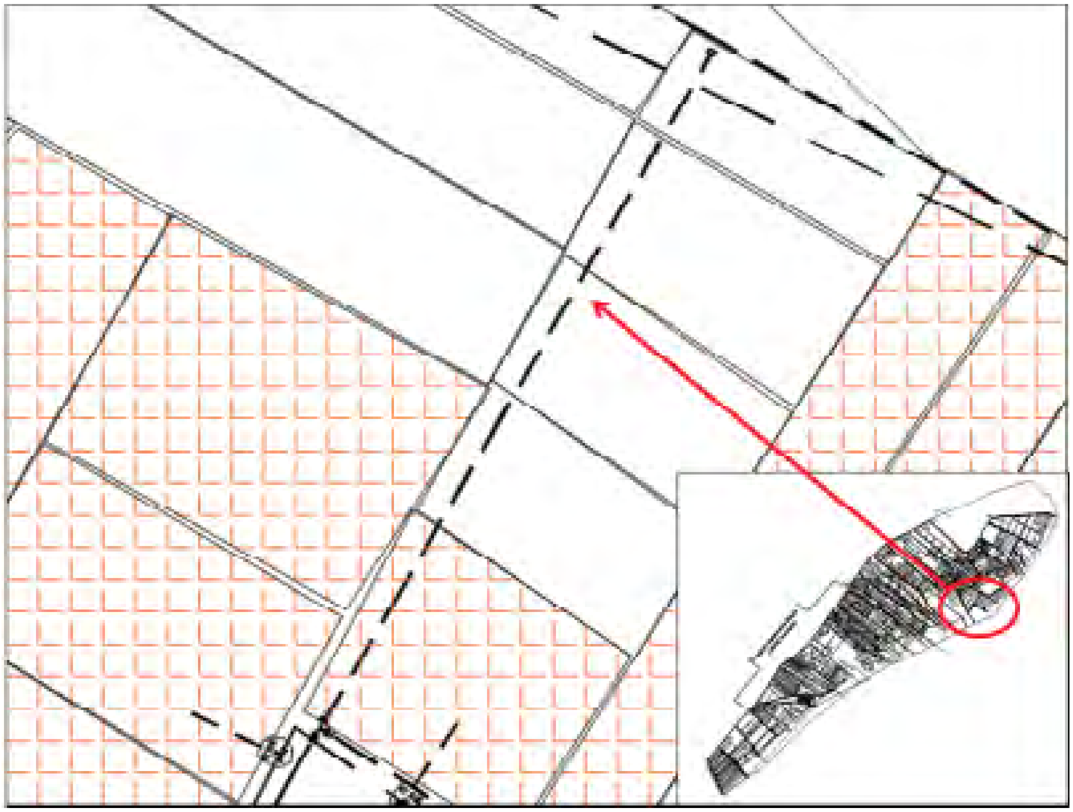

Figure 25 : Arrow indicates a pipeline without any Farm connection and apparently without a sense to exist

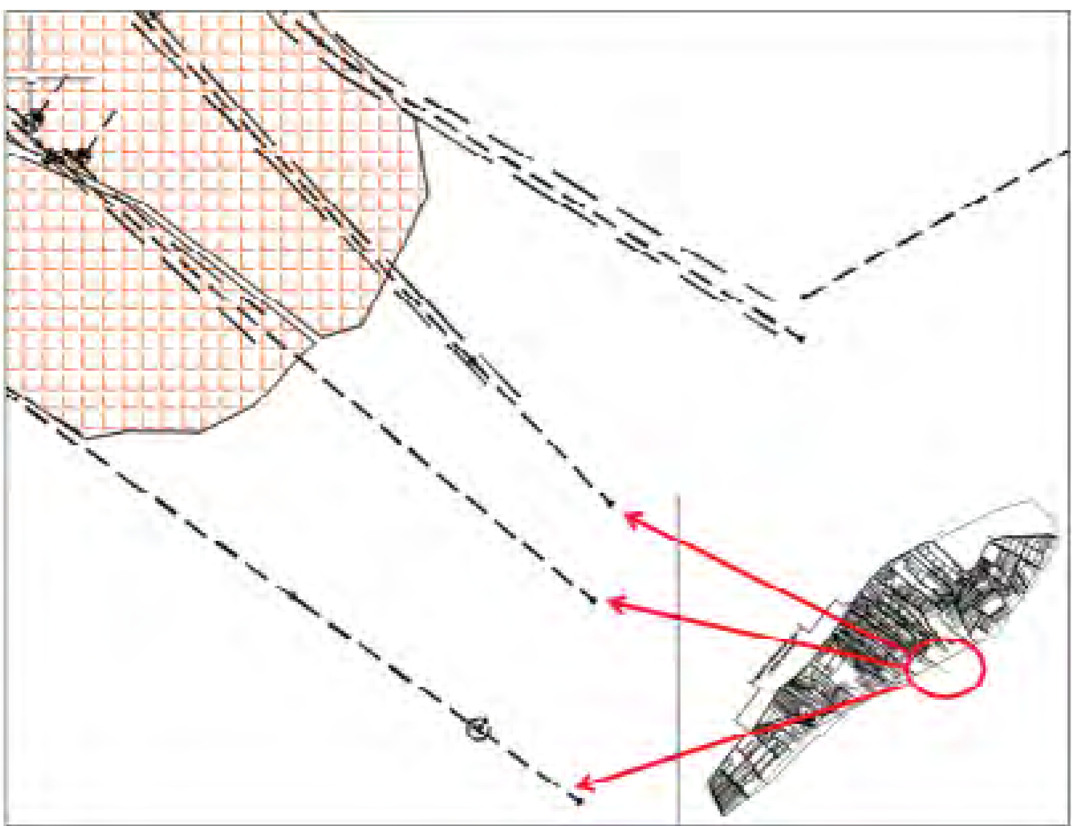

Figure 26: Arrows indicate some pipelines without any Farm connection and apparently without a sense to exist

Figure 27: Arrow indicates two pipelines: ones with Farm connections and the other closed and apparently without a sense to exist

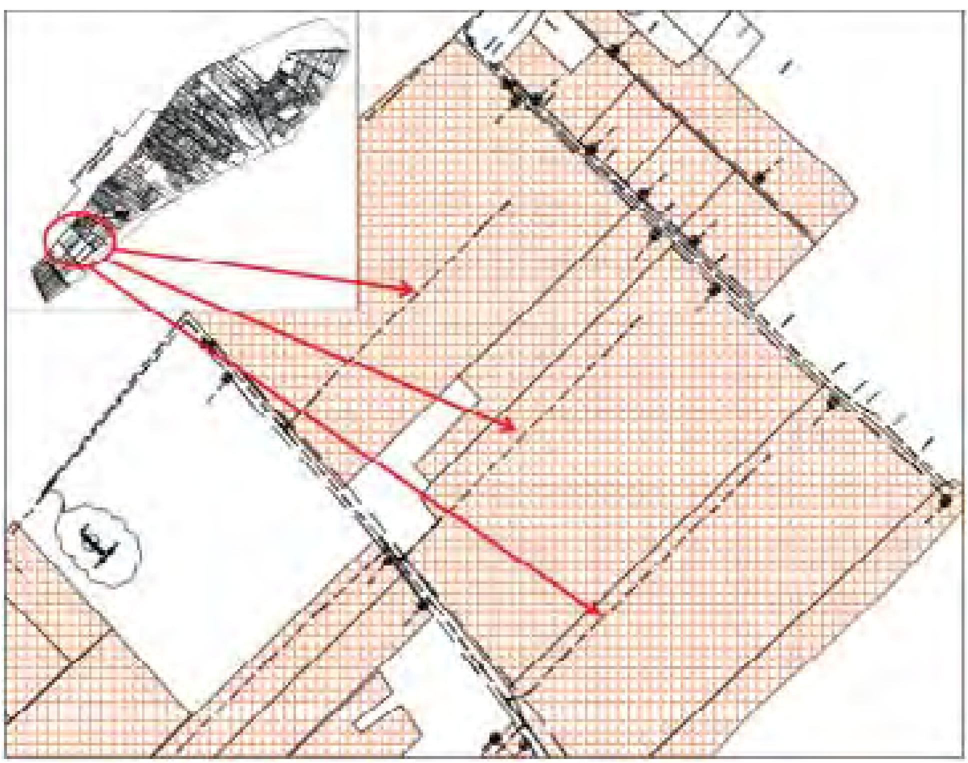

Figure 28 – Arrows indicate some pipelines without any Farm connection and apparently without a sense to exist

5.1.2 Evaluation of Key Hydraulic Parameters

One of the key design requirements for the irrigation system is the ability to deliver water at a pressure of at least 2.5 bar at each farm's gate. As previously mentioned, considering that the level of details provided by the original design is scarce, the verification of such hydraulic parameter over the existing detailed design has been particularly difficult and an Epanet model of the proposed network (the model encompasses the network from the downstream connection with the water tanks to the farm gates) has been developed according and following the available existing design documents. In particular:

- topography has been taken from available digital survey maps;
- hydraulic parameters and geometric characterization of the network have been taken as per the existing network design;
- Water Demand at the various networks' nodes was assigned to be congruent with the areas of the parcels and the proposed Cropping Pattern.

The functioning of irrigation network has been verified in the case of maximum demands from the system. It occurs during the months of June in scenario III as highlighted in the available documents.

Friction losses through pressure piping are based on Hazen-Williams formula:

Where:

V=velocity (m/s)

C=roughness coefficient

R=hydraulic radius (m)

S=friction head loss per unit length

Pipe roughness coefficient has been chosen according the following table:

Table 15: Roughness Coefficient

Pipe Material	New Pipe	Old Pipe
PVC, UPVC	150	130
PE	150	130
Steel (cement lined)	150	120
Asbestos, Cement	140	130

5.1.3 Pipe Material

Different pipe material can be used for water pipelines network and can be divided mainly into three categories:

- Metallic pipes: includes steel pipes, galvanized iron pies and cast iron pipes)
- Cement: pipes include concrete cement pipes and asbestos
- Plastic pipes: include plasticized polyvinyl chloride (PVC) pipes

Recently, the choice for irrigation network is usually made considering three materials: UPVC (for smaller diameter), Steel and Ductile Iron (for grater diameter), as explained in the original project.

The comparison between different pipe materials in terms of advantage or disadvantage in their use are well explained in the table below, extracted from the original project:

Table 16: Comparison between UPVC, Steel and Ductile Iron

Criteria	UPVC	Steel	Ductile Iron
Capital Cost	Low	High	Moderate
Operation and Maintenance Cost	Low	High	Moderate
Corrosion control	NA	Difficult	Easier
Chemical characteristics of the conveyed fluid	Not influenced	Not influenced	Not influenced
The source of pipes	Not local	Not local	Not local
Environment of the project area where the transmitted water is partially treated waste water	Can be used	Can be used	Can be used
Available experience	High	High	High
Pressure of pipeline	Moderate resistant	High resistant	High resistant
Field condition	Low adapted	Moderate adapted	High resistant

The consultants approved and recommend the use of UPVC pipes for diameter less that 600mm and Ductile Iron pipes for diameter greater than 600mm as per the original project.

Below a synthetic table summarizing the advantage in the use of PVC and Ductile Iron pipe well explained in the available documents.

Table 17: Advantages in using UPVC and Ductile Iron pipes.

PVC	Ductile Iron
1. Favorable initial and maintenance cost compared with other pipes of traditional materials for smaller sizes. 2. Longer length, depending on type and ease of joining reduce jointing costs. It is easy to bend. 3. Light weights resulting in lower handling and transporting costs and make it easier and faster to install. 4. Lower coefficient of friction permitting greater flows through a particular size. 5. Resistance to corrosion and built-up of deposits. 6. Good chemical resistance with non-absorbent walls. 7. Lower modulus of elasticity giving an advantage where there is soil movement or vibration. 8. Good tensile strength. 9. Thermal and electrical insulator. 10. No danger to health (non-toxic) and internationally	1. It is easier and less expensive to control corrosion on ductile iron pipe than it is on steel pipe, where Ductile Iron Pipe Corrosion Control is accomplished with Polyethylene Encasement 2. The largest practical advantage of Ductile Iron pipe compared with steel pipe is that Ductile Iron pipe is much easier to install properly. Handling, assembling, backfilling, and adapting to field conditions all are areas in which Ductile Iron pipe offers distinct benefits 3. Ductile Iron Pipelines Adapt to Field Conditions in Installation more than steel pipes. 4. Since Ductile Iron pipe design results in a thicker wall for a given set of parameters, Ductile 5. In all normally specified pipe sizes, cement-mortar lined Ductile Iron pipe has an inside diameter that is larger than the nominal pipe size. 6. Pumping costs are lower for Ductile Iron pipelines, this reduction in pumping costs will save the system owner

approved for potable water use and for stormwater and wastewater	7. significantly over the life of the pipeline 8. Protection systems, often a requirement for steel pipelines, involve higher design and installation costs. They require monitoring and maintenance over the lifetime of the pipeline. There are also costs associated with pumping water through a pipeline and these costs are directly related to pipe inside diameters.

The distribution system fixed points in the model are the ground tanks. The entire model has been divided into the 6 sectors A1, A2, B1, B2, C1, C2, D, E, F.

The demands of each farm connection have been calculated according the proposed Cropping Pattern and the proposed pumping schedule.

The number and size of pumps has been fixed according the following table as per the available design documents

Table 18: Pumping flow rate and pressure for each sector

Irrigation zone	**Output pressure in booster station (bar) when output flow is (m^3/h)**											**Max** flow of the zone
	1,000	**1,500**	**2,000**	**2,500**	**3,000**	**3,500**	**4,000**	**4,500**	**5,000**	**5,500**	**6,000**	
North A1	5.90	6.30	6.80	7.50								2,382
South A2	4.60	4.70	4.90	5.00								2,539
North B1	7.30	7.70	8.30	8.90								2,571
South B2	4.80	4.90	5.10	5.30								2,482
North C1	6.70	7.10	7.60	8.30								2,269
South C2	5.20	5.50	6.00	6.40								2,301
North D	6.90	7.00	7.20	7.40	7.60	7.80	8.10	8.50	8.90	9.20	9.70	5,444
North E	6.40	6.50	6.70	6.90	7.20	7.50	7.90	8.40	8.90	9.40	10.10	5,175
North F	5.90	6.00	6.20	6.30	6.50	6.70	6.80	7.10	7.40	7.60	7.90	5,159

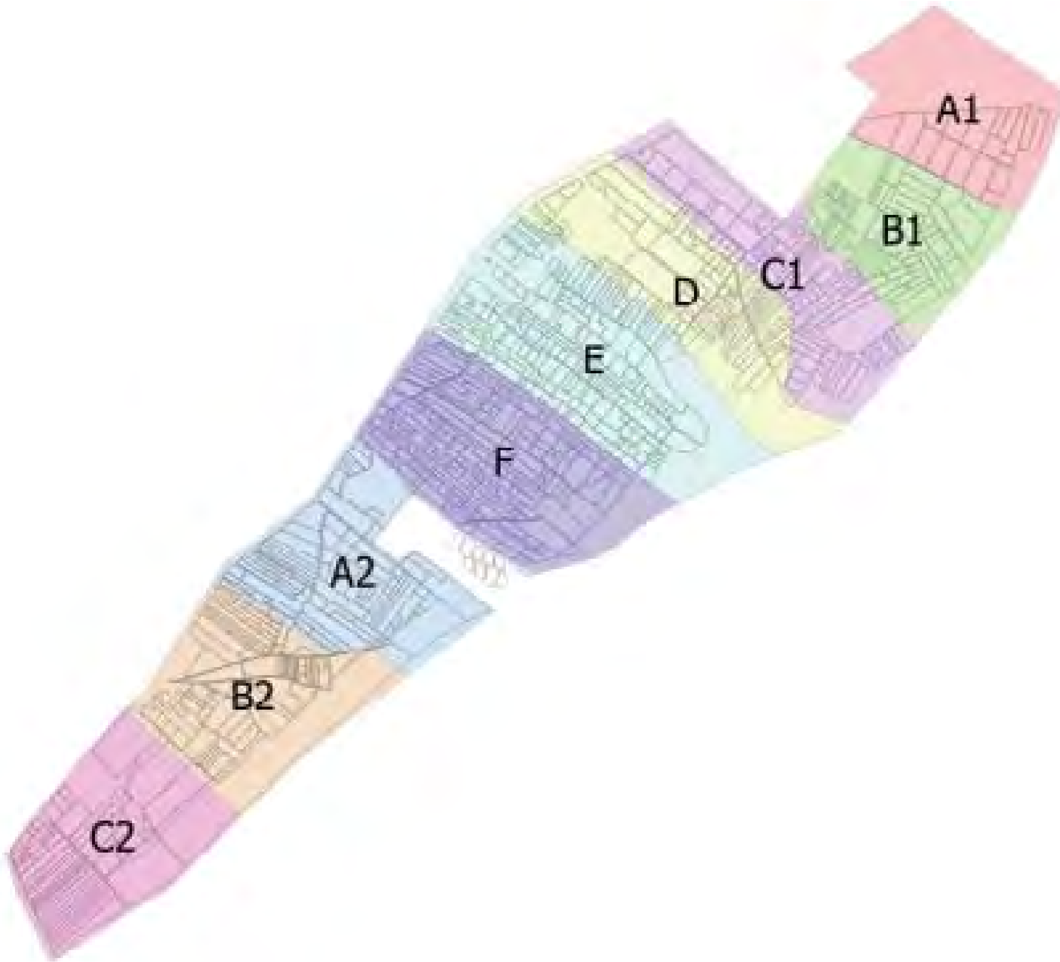

Figure 29: Project area divided into 6 main sectors

5.1.4 Results of Hydraulic Model for the Original Design

The hydraulic model highlights that most of the farm gates reach the desired head of 2.5 bar.

However, some nodes present pressure lower than this target values, usually located in the farthest point from water tank.

The following figure provides a snapshot(see red dots) of the network nodes where the desired head of 2.5 bar is not met at some point in time during the year.

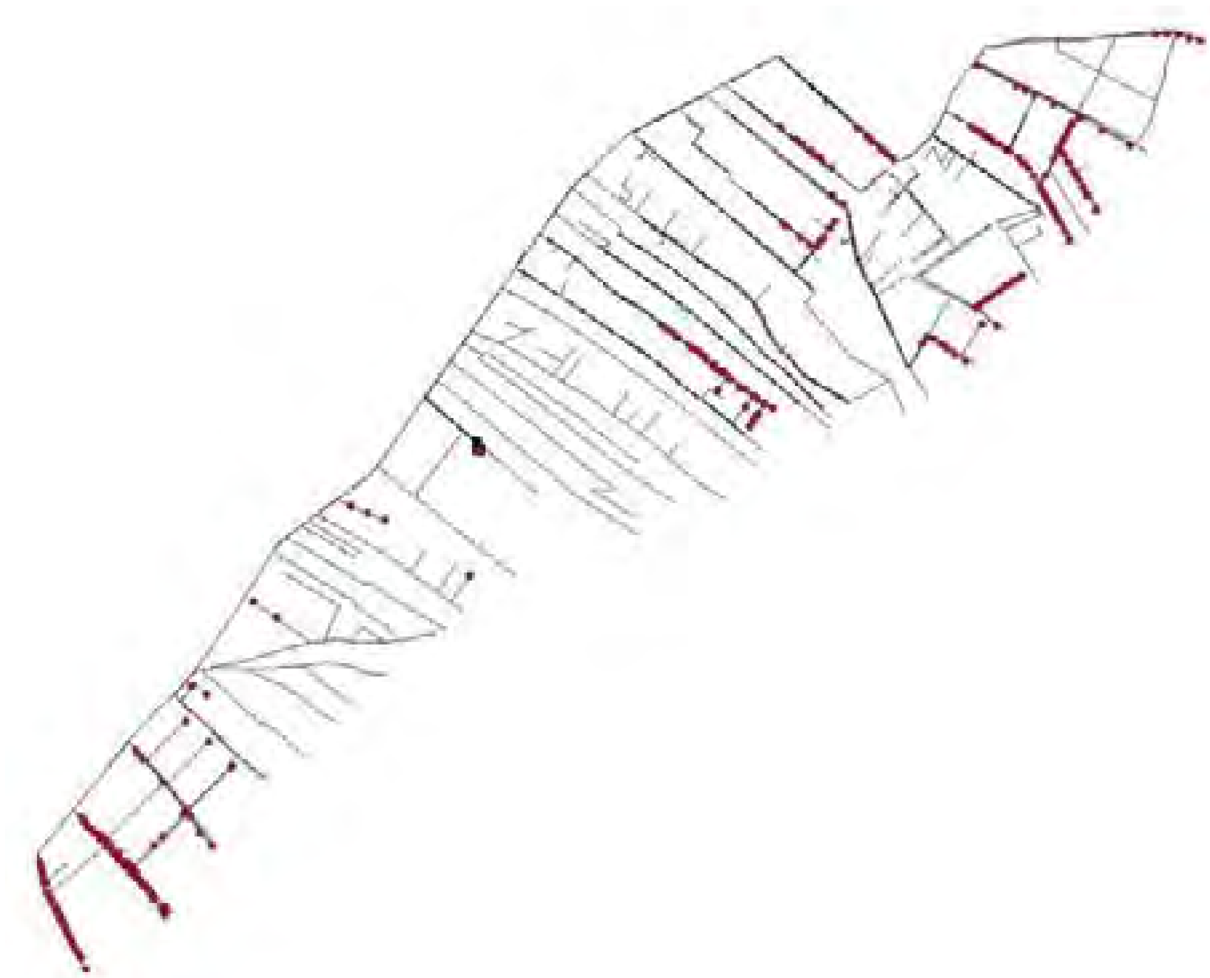

Figure 30: Gate farm with pressure below 2.5bar during the irrigation period (6 days)

This problem can be solved by increasing total pump head or by substituting some pipelines with others of greater diameter, so reducing the head losses and increasing pressure head at the farm gate. The second solution is the optimum one because in front of a limited increase of capital cost for the entire project (about 105,000 US$, 0.47% of the total investment cost for the irrigation network), it's possible to have the required pressure saving energy consumption and limiting in the same time excessive velocity of water flow through the pipelines.

5.1.4.1 Proposal for Network Improvements

A new Epanet model has been prepared to verify the pressure at the farm gate after the substitution of some pipelines with others of the same material but with greater diameter, to allow for reduced head losses through them.

A comparison between modified diameter in terms of total length for different pipe diameter from original irrigation network and the proposed ones can be seen in the following table.

Table 19: comparison between modified diameter in terms of total length for different pipe diameter from original irrigation network and the proposed ones

DN	Total length difference
	- sign indicates minor total length for selected diameter respect the original project + sign indicates greater total length for selected diameter respect the original project
90	-2528
110	574
140	-13707
160	4817
180	2962
200	3182
225	-604
250	3357
280	-363
300	716
355	708
400	886
500	-138
600	138

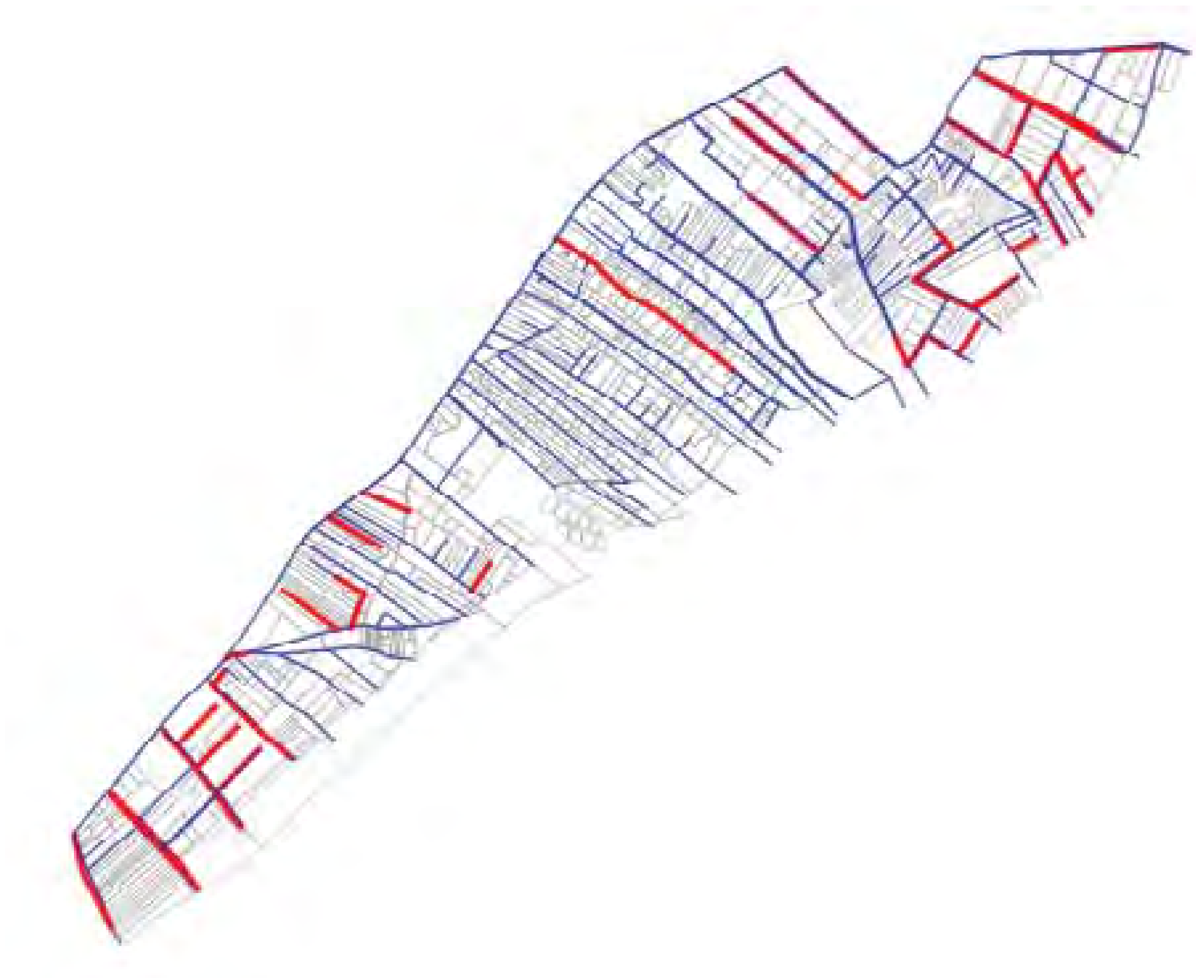

Figure 31: Irrigation network with highlight in red the pipes with proposed greater diameter

Annex 1 to this report provides a detailed set of drawings representing the modified irrigation network with the pressure estimated by the hydraulic model applying the proposed pipe diameter increase (highlighted in red color)

5.2 Irrigation Network Design Applying the New Cropping Pattern

5.2.1 Design Criteria and Parameters for a Peak Summer Day in May

The following design criteria and parameters are determined based on the analysis results for critical design requirements for the considered peak summer month.

Being the amount of water recovered during the peak water requirement in summer months greater that maximum capacity of wells, water storage is essential to guarantee the continuity of supplying during irrigation hours.

The month of May is the critical one for the design of tanks. Considering a maximum constant water supply from wells equal to 175 m^3/hour each (it varies from about 150 m^3/hour to about 200 m^3/hour per well) and the maximum water required per hour in the month of May during irrigation hours, it's possible to calculate the volume of water in the tanks that permits to guarantee the total volume required during the day. Obviously the pumps of the wells have to work for a longer period than booster pumping station to recharge the tanks at the end of irrigation period.

Below a table showing the calculation to estimate the minimum volume of the tanks, which results to be 8,000 m^3.

Time [Hours of the Day]	**Max Q** demand in May [m^3/h]	**Q supply** [m^3/h]	**Cumulative** demand [m^3]	**Cumulative** supply [m^3]	**Difference** [m^3]	**Hours per day to** recharge the tanks at the end of irrigation period [hours]
7-8	5,354	4,725	5,354	4,725	629	1.60
8-9	5,354	4,725	10,708	9,450	1,258	
9-10	5,354	4,725	16,062	14,175	1,887	
10-11	5,354	4,725	21,415	18,900	2,515	
11-12	5,354	4,725	26,769	23,625	3,144	
12-13	5,354	4,725	32,123	28,350	3,773	
13-14	5,354	4,725	37,477	33,075	4,402	
14-15	5,354	4,725	42,831	37,800	5,031	
15-16	5,354	4,725	48,185	42,525	5,660	
16-17	5,354	4,725	53,538	47,250	6,288	
17-18	5,354	4,725	58,892	51,975	6,917	
18-19	5,354	4,725	64,246	56,700	7,546	

Summarizing:

- Two water storage tanks of 4,000 m^3 each (8,000 m^3 altogether) are used where the slight increase compared to maximum required volume (7,546 m^3) in the size is to allow for proper connections, etc. For other months, this increased storage capacity will provide additional flexibility in the operation of the system. The capacities of water tanks satisfy the hydraulic and mechanical operational requirements.
- Maximum hourly pumping rate is about 6,000 m^3/hr. where the slight increase in the rate (9%) compared to maximum required (5,354 m^3/hr) is taken as a factor of safety and to allow for more flexibility in the operation.
- The 6,000 m^3/hr maximum and the 410 m^3/hr minimum hourly pumping rates are considered in the design of pumping station, trunk lines, irrigation networks and associated facilities.

5.2.2 Validation of the Existing Hydraulic Network with Proposed Cropping Pattern and Irrigation schedule

The maximum flow in the pipeline network during the peak month is comparable with that in the existing project, so the pipeline network is the same.

Also the proposed pipe material are suitable as said before.

As done before, an Epanet model has been performed to verify the hydraulic network considering a minimum head pressure at the farm gate of 2.5 bar.

Assuming the geometric and hydraulic characteristics of the network pipeline as per the previous project and assuming the proposed irrigation pattern (based on uniform irrigation across the entire agricultural area on 10 or 12 hours per day), it’s possible to satisfy the required head at the nodes, in particular during the maximum flow rate, with lower pumping heads than those assigned in the original project.

Dividing the entire area into two sectors for simplicity, named North and South sectors, comprising respectively previous sectors A1+B1+C1+D+E+F for an area of 8,402.50 du and previous sectors A2+B2+C2 for an area of 3665.50 donum, the pumping flow rate and pressure for each of them is shown in the following table.

Table 20: Pumping flow rate and pressure for north and south sectors

Irrigation zone	Output pressure in booster station (bar) when flow is (m^3/h)				Max flow of the zone (m^3/h)
	1,000	2,000	3,000	4,000	
North	5.8	6.1	6.3	6.5	3,728
South	4.8	5.0			1,626

Table 21: Flow through the irrigation network for north and south sectors during the year[4]

Flow (l/s)		
month	**north sector**	**south sector**
Jan	76	33
Feb	76	33
Mar	483	211
Apr	837	365
May	1,036	452
Jun	991	432
Jul	969	423
Aug	814	355
Sep	483	211
Oct	341	149
Nov	128	56
Dec	75	33
Average	526	229

Supposing to use analogue type of pumps as per the original project (duty point: 750 m^3/h – total head 6.5 bar), 5 pumps serve the north sector, 3 pumps serve the south sector while 2 pumps are in stand-by.

As per the original project, the booster pumps are located in a pumping hall together with the suction and pressure manifolds and with all necessary pipe works. The pumping station will serve both irrigation network, the south area with three irrigation zones and north area with six irrigation zones. The pumps are installed parallel and pumping from a common suction manifold into a common pressure manifold.

Table 22: Number of operating pumps and irrigation zones

Irrigation zone	Number of pumps	
North	5	Simultaneous pumping
South	3	

Drawings provided in annex 2 represent the proposed irrigation network with the results of hydraulic model applying the proposed Cropping Pattern.

5.2.3 Consideration about the implementation of irrigation network with the consultant's Cropping Pattern

As described before, respect to the original ones, the proposed Cropping Pattern allow to have some advantages, which the most important are:

[4] white cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

- Less amount of water per year for irrigation purposes. Other activities (industrial, farming, etc) can be developed in the area exploiting saving water
- Lower pumping head especially during the peak demands i.e. lower energy consumption and then lower operation costs.
- Lower total hours per year of pumps functioning i.e. lower pumps wear.
- Lower velocity of water inside pipes for most of the year i.e. lower pipes wear and lower surge pressure in case of rapid velocity change in the network

5.2.4 Energy Consumption

Based on the proposed Cropping Pattern and the assumptions made for the functioning of the entire irrigation system, a preliminary estimation of the power absorption and energy consumption is presented in Table 23 and Table 24.

Table 23: Power absorption for the booster pumping station[5]

Power Absorption (kW)		
Month	North Sector	South Sector
Jan	45	34
Feb	45	34
Mar	406	332
Apr	739	574
May	943	726
Jun	903	695
Jul	883	666
Aug	719	559
Sep	406	325
Oct	277	229
Nov	90	72
Dec	0	0
Average	**455**	**354**

Table 24: Energy consumption for the booster pumping station

Energy consumption (kWh)		
Month	North Sector	South sector
Jan	13,904	10,594
Feb	12,576	9,582
Mar	151,020	123,333
Apr	265,905	206,815
May	350,928	269,945
Jun	325,105	250,081
Jul	328,449	247,600

[5] White cells calculated on 10 hours pumping daily, shaded cells on 12 hours pumping daily

Aug	267,507	208,061
Sep	146,148	116,919
Oct	85,812	71,017
Nov	26,966	21,573
Dec	0	0
Average	164,527	127,960
Total (MWh/year)	**1,974**	**1,536**

Based on the above results, the total energy consumption for both the North and the South sectors is therefore:

TOTAL Energy consumption per year [MWh]	**3**,510

Referring to the original 2010 design, power absorption and energy consumption can be estimated based on the power head and flow corresponding to the water requirement from the system during the year as defined by the Cropping Pattern proposed in the original design. Corresponding values are presented in the table below:

TOTAL Energy consumption per year [MWh]	4,147

As can be seen, the new proposed Cropping Pattern allows for a saving of approximately 637 MWh per year. This is essentially due to a lower flow rate during most of the months of the year and a lower pumping head which, in turn, leads to a lower total energy consumption.

5.3 Capital Investments

Capital investments, as provided[6] by PWA for both the recovery and the irrigation schemes, are presented in the following Table 25.

Overall, Table 25 identifies a 28% increase in construction costs if compared with the original estimates presented in 2010. The major difference is due to the over 40% increase in construction costs associated to the implementation of the irrigation network which now is projected to cost US$ 22,000,000 instead of the original estimated US$ 15,649,730.

Table 25: Capital Investments for the Recovery and Irrigation Schemes

Implementation Stage			**Phase I**	**Phase II**
Item No.	**Description**	**Total (US$)**	**US$**	**US$**
1	General Items	$262,400	$131,200	$131,200
2	Circular Tank 4,000 m^3 (2 Tanks)	$1,061,300	$530,650	$530,650
3	Booster Site (Civil)	$511,000	$511,000	$-
4	Mechanical Building	$2,285,150	$340,000	$1'945,150
5	Electrical Building	$1,060,000	$1,060,000	$-
6	Guard Room	$15,500	$15,500	$-
7	Recovery Wells (27 Wells)	$3,270,000	$1,816,667	$1,453,333
8	Monitoring Wells (10 Wells)	$260,000	$130,000	$130,000
9	Well Networks (approximately 6.7 km)	$707,000	$707,000	$-
10	SCADA System	$1,961,250	$1,321,250	$640,000

[6] At the time this evaluation was prepared not all the documentation related to the original design was made available to the consultant. The bill of quantities for the irrigation scheme was not provided and the consultant had to rely on costing adjustments provided by PWA.

11	Electric Works	$2,885,897	$1,885,897	$1,000,000
12	Irrigation Network (approximately 128 km)	$22,000,000	$6,015,625	$15,984,375
	Grand total	**$36,279,497**	**$14,464,789**	**$21,814,708**

5.4 Operation and Maintenance Costs

The following Table 26 summarizes the Operation and Maintenance cost for both the recovery and the irrigation system broken down per construction phase. The same items of the original project have been considered (Manpower, power consumption, maintenance and repair works, consumables) but these values could not be verified (except for the power consumption) as the original Operation and Maintenance 'Annex 7' O&M calculation sheet was not available.

Table 26: Yearly O&M Costs associated to the recovery and irrigation schemes

Operation and Maintenance Cost		**Phase I**	**Phase II**
Description	**US$/year**	**US$/year**	**US$/year**
Manpower	$150,000	$90,000	$60,000
Power consumption	$933,660	$311,220	$622,440
Maintenance and repair works	$83,345	$27,782	$55,563
Consumables & Miscellaneous	$76,960	$25,653	$51,307
Total O&M cost USD/year	**$1,243,965**	**$454,655**	**$789,310**

The only difference in O&M costs between the original design and the proposed alternative is due to the reduction in power consumption and cost of energy per MWh (which we have assumed to be in the range of 133 US$/MWh) and – in turn – in power costs.

5.5 Construction Stages

In agreement with the original design, four tender packages are recommended for the implementation as defined in the following Table 27:

Table 27: Recommended tender packages

ID	**Phase**	**Package**	**Description**	**Cost [US$]**
A	I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$8'449'163,67
B		2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)	$6'015'625,00
C	II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$5'830'333,33
D		2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)	$15'984'375,00
			TOTAL	**$36'279'497,00**

State of Palestine

Palestinian Water Authority

دولـــــة فلسطيـن

سلطة المياه الفلسطينيـة

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 4

DRAFT Complementary Feasibility Study

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

May 2017

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CMWU	Coastal Municipal Water Utility
CP	Cropping Pattern
EQA	Environment Quality Authority
FAO	Food and Agriculture Organization of the United Nations
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGEST	North Gaza Emergency Sewage Treatment
NWC	National Water Company
PWA	Palestinian Water Authority
ToR	Term of Reference
UAWC	Union of Agricultural Work Committees
WB	World Bank
WSRC	Water Sector Regulatory Council
WUA	Water User Association
WWTP	Waste Water Treatment Plant

1 Executive Summary

1.1 Key Results and Recommendations

Key results of this DRAFT Complementary Feasibility Study are as follows:

- By improving the original design of the water reuse (irrigation) scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern, it is possible to save nearly 3.2 Millions of Cubic Meter of water per year (MCM/year) or 21.5% less water than what was required by the original 2010 design. Less water requirements also leads to reduced energy needs for the recovery and water extracted from the aquifer. More precisely, the proposed changes will save 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation schedule that largely differs from the original by providing water to the entire irrigation project each day (instead of on a 6-day rotation with 12 lots irrigated 2 at a time once a week). The newly proposed irrigation schedule hinges on the idea of delivering a constant amount of water to the farm gate for 12 hours per day (10 hours per day during the coldest months of the year). Farms with different sizes will receive the necessary amount of water thanks to flow reducers that now come standard with many commercially available manholes. Furthermore, the possibility to pump water into the system on a constant rate through the day drastically reduces the complexity of managing the irrigation scheduling and eliminates the risk of overdrawing water from the storage tanks and stalling the system.
- Palestinian law restricting the use of treated wastewater in irrigation does not apply to the NGEST water reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that is allowed to be infiltrated into the aquifer: the quality must be either moderate ("C"), good ("B"), or high ("A"). Utilizing poor ("D") wastewater for aquifer recharge is prohibited.
- If the proposed Cropping Pattern and Irrigation Methods are implemented, the construction of the water recovery and reuse (irrigation) scheme is feasible even if the entire investment (Phase I and Phase II) is paid by the farmers. Nevertheless, because developing a large investment in Gaza presents risks that are uncommon in other parts of the World, Scenario 3, where construction costs would be paid by the government and not charged back to the farmers, is presently being suggested. This scenario assumes that the capital investment necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmers.

Some of the key recommendations after reviewing the original design of the Irrigation Project are:

- Design drawings for the water reuse (irrigation) scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a precise cadastral survey has been provided.
- The design of the network could be revised to consider the reduced flows that come with the newly proposed Cropping Pattern. The need for such a revision should be discussed with PWA before making final recommendations.

- An Irrigation Advisory Service (IAS) should be established to manage and operate the recovery and reuse schemes, as well as to provide a platform for inter-ministerial and local communal cooperation for the project and provide technical and other assistance to farmers.
- Managing Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural resource. Monitoring is an integral part of MAR management and should be robustly undertaken to both determine the effectiveness of the recharge scheme and to investigate the sustainability with respect to human and environmental health.

1.2 Project Background

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

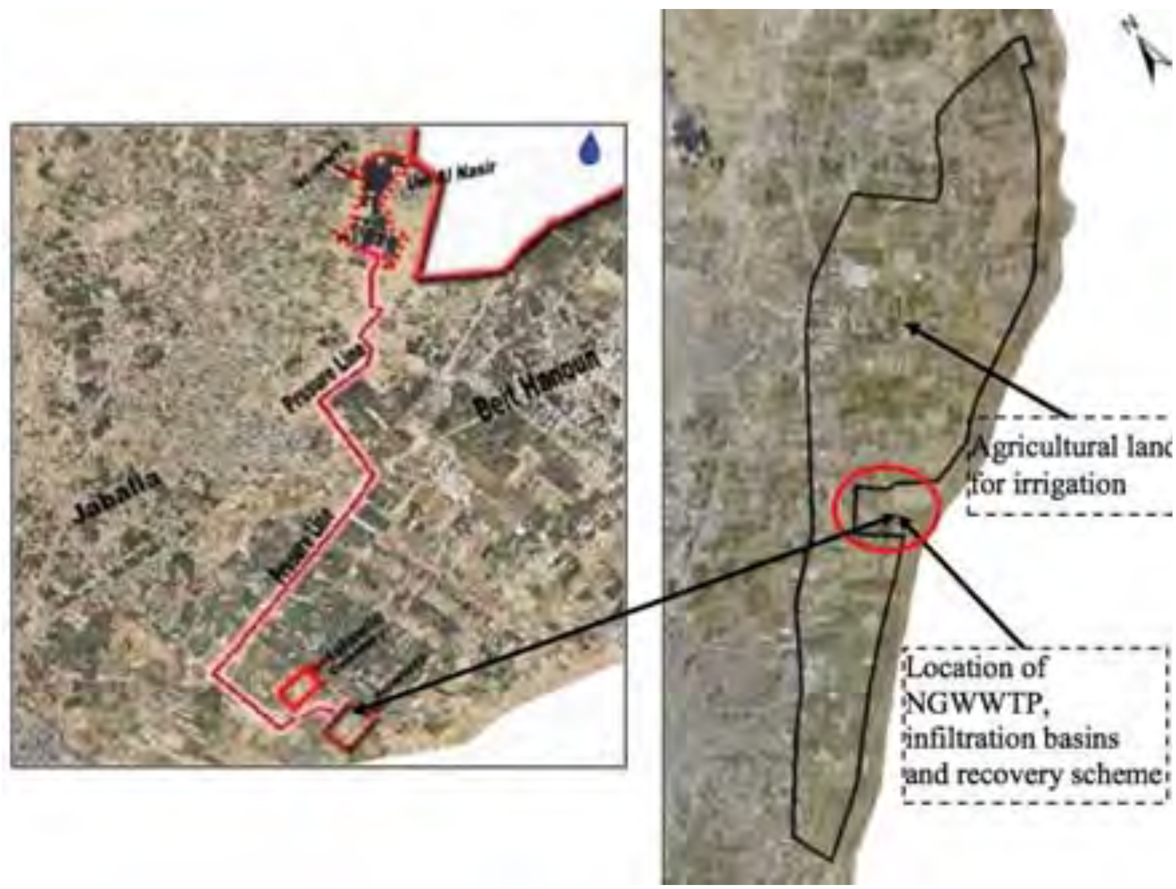


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

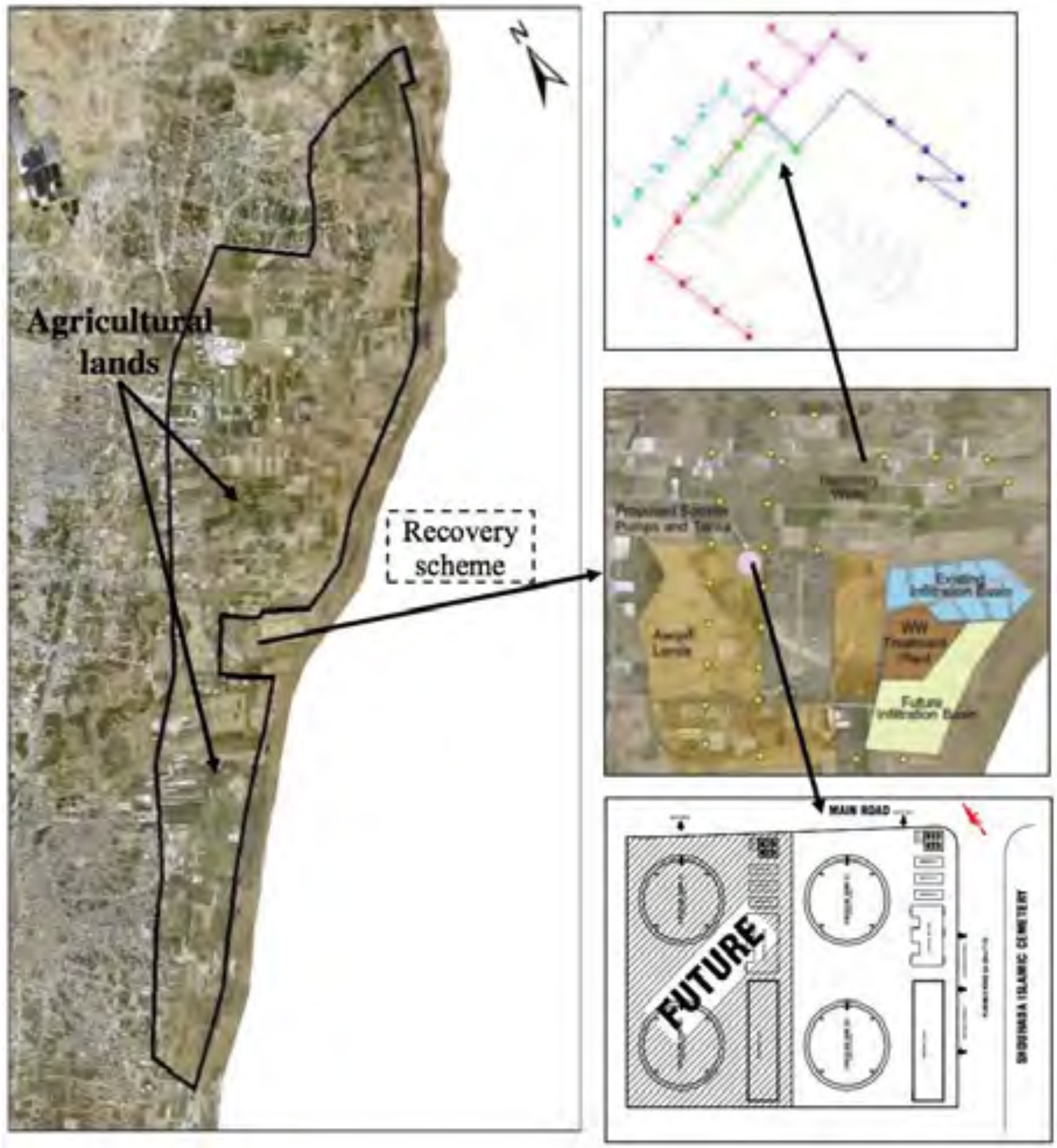


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, supplementary phase was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The treated sewage effluent will be disposed of into infiltration ponds, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 27 recovery wells, put into a storage reservoir, and distributed throughout the network for irrigated agriculture.

A gross agricultural area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit from the recovered water as well as the treated sewage sludge. This project component, known under the name of 'Supplementary Project', is subdivided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse (Irrigation) Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary phase has been subdivided into three stages:

The **first stage**, originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 15 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells - and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume from reaching agricultural and municipal wells located beyond the recovery wells.

The **second stage**, now scheduled for completion by the year 2018, would extend the recovery system by a second row of 12 supplementary wells (along with the previous 15 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated waste water infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank, booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **third stage**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

1.3 The Present Study

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare a Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and make the project feasible. To carry out its task, this project has drawn upon massive data collection, field visits, and state-of-the-art computer modeling in order to best understand the irrigation project's hydraulics and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

1.4 Baseline Survey

1.4.1 Field Survey

The foundation of this baseline assessment and a primary tool for collecting first-hand current data, the field survey aimed to **investigate the characteristics of the farming system** in the project area. A questionnaire was developed and tested in coordination with PWA. The questions were focused on the farm cropping system, market channels, selling prices, and incomes. Special emphasis was given to the water issue, by inquiring about the current use of water on crops, irrigation methods and the source and cost of water. Specific questions were dedicated to understanding the farmers' willingness to change/enlarge their cropping pattern and the role played by the farmers' associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017 by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 3.

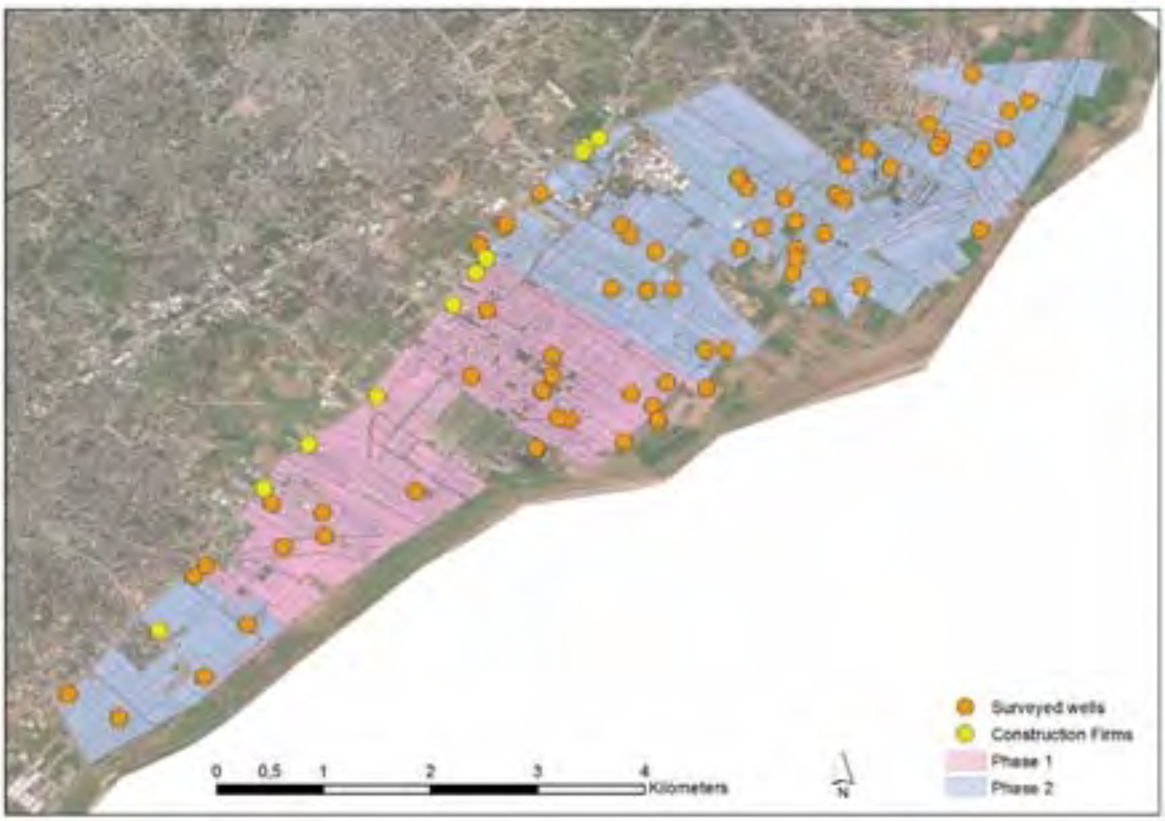


Figure 3: spatial location field survey

The survey resulted in the collection of **420 farm questionnaires**, **9 farm inputs questionnaires**, and **11 industries questionnaires**. The paragraphs below summarize the results obtained from the analysis of the questionnaires.

1.4.2 Land Tenure and Cropping System

1.4.2.1 Farm size and land tenure

The Project area extends for 1,207 ha (12'068 du). As shown in Figure 4, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 du are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

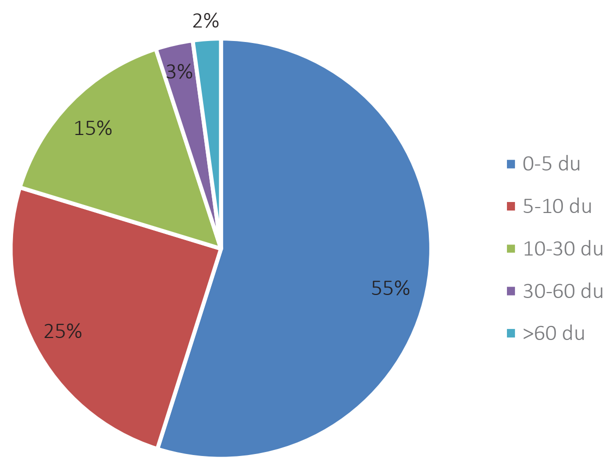


Figure 4. Distribution of farms by size.

1.4.2.2 Cropping System

The cropping pattern of the project area is shown in the following Figure 5.

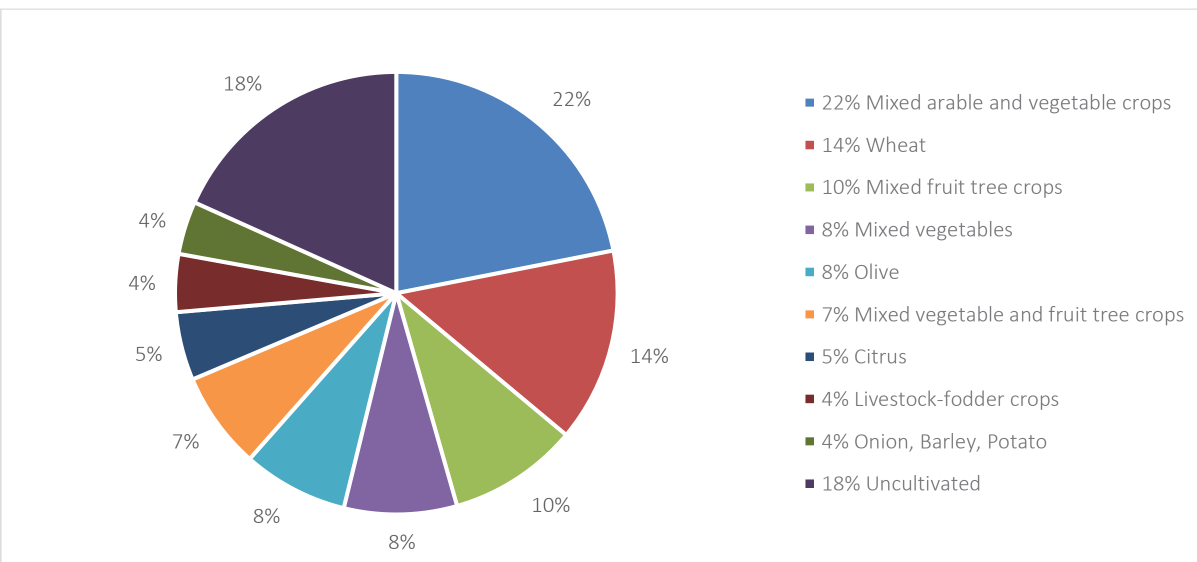


Figure 5. Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops; almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 7). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 7).

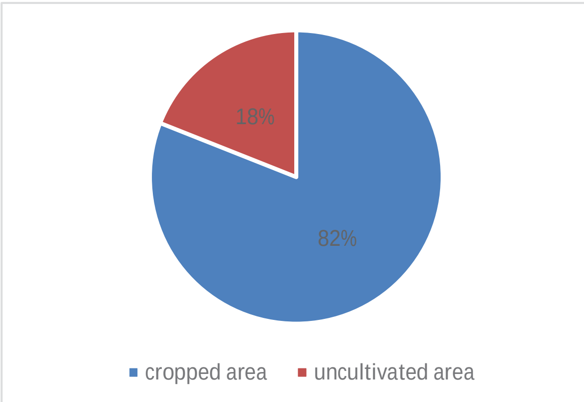


Figure 6. Cropped and uncultivated area.

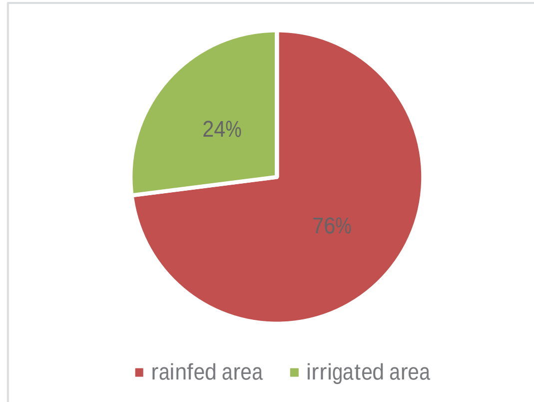


Figure 7. Irrigated and rainfed area.

1.4.3 Crop Water Requirements and Water Consumption in Agriculture

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well (“collective well”) is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the “collective well” system owned by the remaining 8%.

Wells must be authorised by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also “non-legal” wells, estimated to be 5-6 times the number of the legal ones. The government does not close these wells but new unauthorised wells cannot be drilled.

The survey determined that water cost ranges from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

Figure 8 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

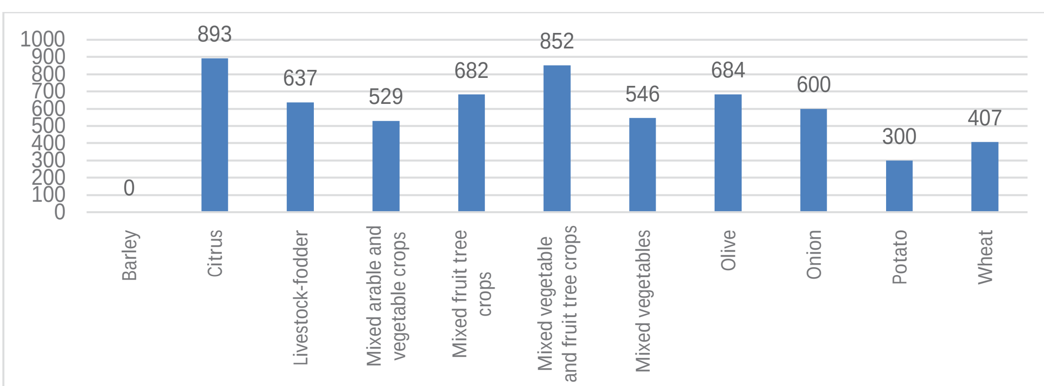


Figure 8. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m3/du); Barley is rainfed.

The **total crop water requirements** for the agriculture currently developed across the whole 15,000 du is estimated to be **5.8 Mm^3/year** with an **average daily water requirement of 15,990 m^3/day**.

1.4.4 Causes of the Present Land Abandonment

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is represented by the frequent **land invasions from the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, and periodically sprays herbicides to keep the field clear, which kill the crops and make the farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out the cropping operations (23%); and **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

1.4.5 Water Consumption in the Industries

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 3 their localisation): generally, most of them are small factories (less than 10 employees), operating only a few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%) of them is using private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

1.4.6 Value Chain

Gaza Strip, with its high population density and reduced connections to a production system because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

Interviews with the producers showed that the vast majority of the agricultural products are sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

The market chain of horticultural and fruit products is as follows:

farmers → traders or intermediary (middle man) → retailers → consumers.

Next table summarises revenues, costs and margins for the different crops.

Table 1. Summary of the single accounts cultivation statements of agricultural products

Farm/Crops	Revenues	Cost	Margin	Net margin per kg	Net margin + LH[1] per kg
Apple	1,000	2,495	-1,495	-2.99	-2.81
Barley	655	1,630	-975	-2.02	-0.36
Citrus	3,494	3,172	322	0.19	0.52
Lemon	1,400	2,048	-648	-0.65	-0.33
Livestock	1,582	2,310	-728	-	-
Melon	2,400	2,401	-1	0	0.17
Mixed arable and vegetable crops	3,226	2,267	959	0.36	0.59
Mixed fruit tree crops	2,487	2,472	15	0.02	0.34
Mixed vegetables and tree crops	3,444	1,667	1,777	0.81	0.92
Mixed vegetables	3,407	3,061	346	0.11	0.33
Olive	806	2,376	-1,570	-2.92	-2.05
Onion	675	1,837	-1,162	-2.58	-0.58
Peach	1,000	1,055	-55	-0.11	0.07
Potato	2,500	1,656	844	0.34	0.50
Wheat	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

1.5 Assessment of the NGEST Recovery and Reuse (Irrigation) Schemes

1.5.1 *Project Recovery Scheme*

The recovery scheme comprises a system of 27 recovery wells and all related connection pipes as well as 10 monitoring wells. The following three sections provide a more detailed description of each component.

1.5.1.1 Recovery Wells

There are 27 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 zones (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 9. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

The recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the wells.

[1] LH: Labour Harvesting

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October, which is equal to 50,885 m^3/day. The total number of wells is 27 where each should have a capacity of pumping between 150 m^3/hr to 200 m^3/hr. 25 out of the 27 wells are assumed to be operational always with a capacity of 170 m^3/hr. The two additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure.

According to the numerical modelling results, the exact location of the 27 wells was defined to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 9 shows the locations of the recovery wells.

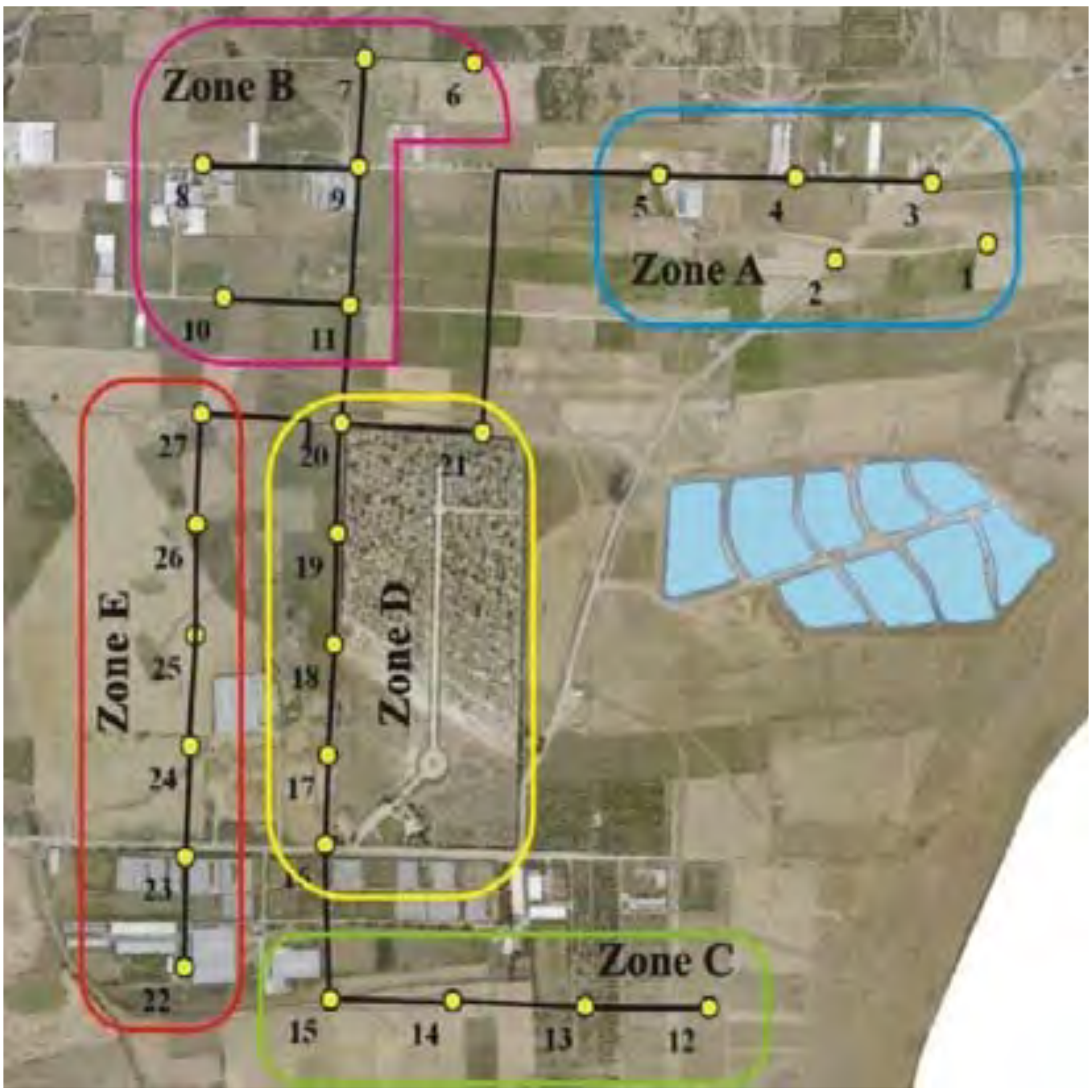


Figure 9: Location of the 27 Recovery Wells

1.5.1.2 Collection Pipes

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 10. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

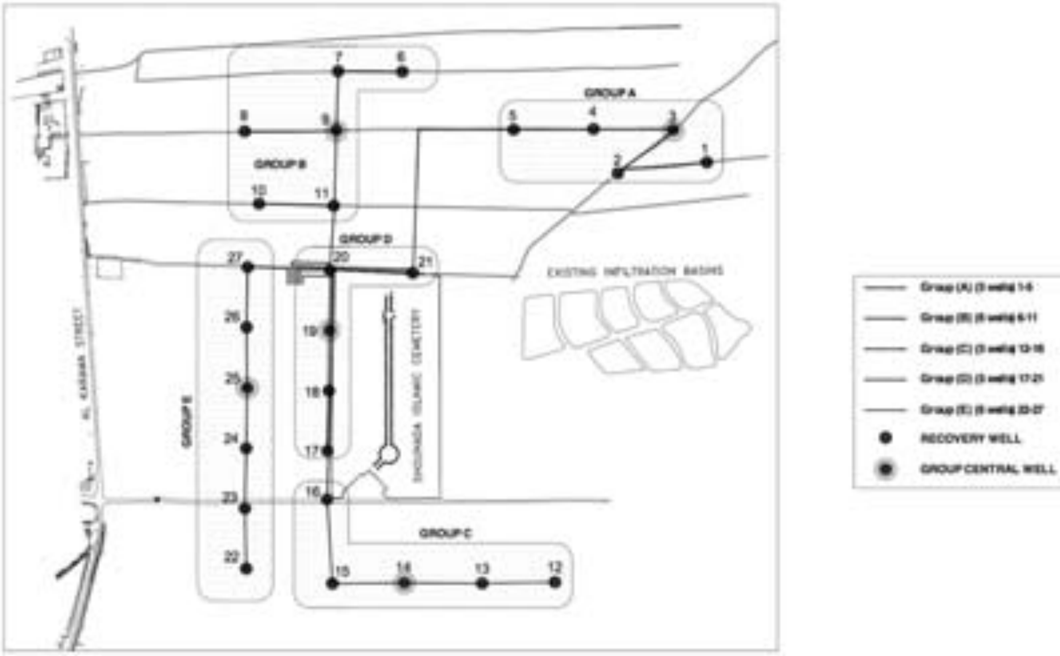


Figure 10: Wells grouping and Piping System

1.5.1.3 Monitoring Wells

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore be taken and analysed randomly at farm level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 42 monitoring wells will be implemented by using the 5 existing monitoring wells, the 27 newly built recovery wells and 10 new monitoring wells.

The location of the 42 monitoring wells is provided in the following Figure 11.

Figure 11: Location of the existing and newly proposed monitoring wells

1.5.2 Project Reuse (Irrigation) Scheme

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 12. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 13.

In accordance with irrigation requirements, irrigation was to be carried out on a six-days rotational basis over six zones of almost equal sizes, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F as shown in the following Figure 13. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 14.

Figure 12: Location of agricultural land

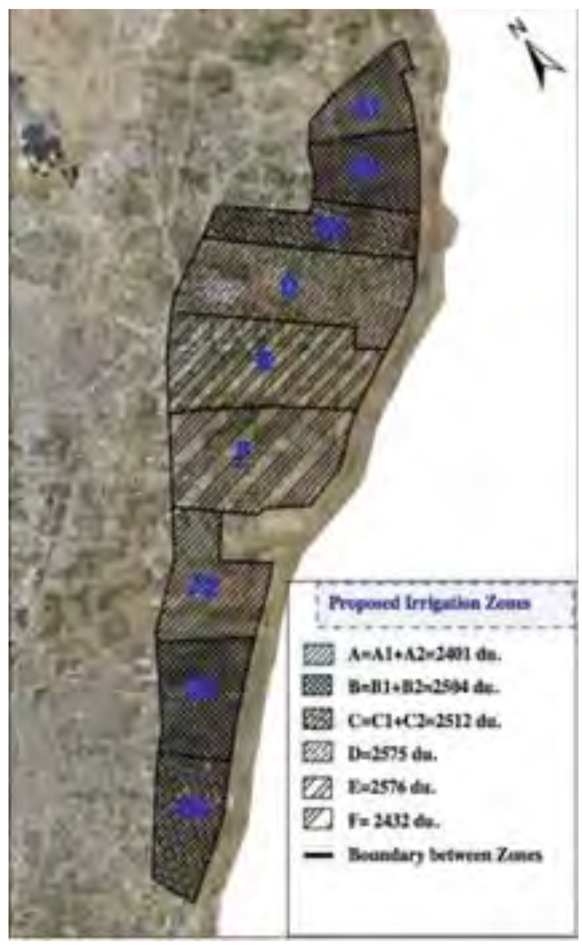


Figure 13: Proposed Irrigation Zones

Figure 14: General Layout of the Originally Proposed Irrigation Network

1.5.3 Review of the Reuse (Irrigation) Scheme: additional findings and recommendation

1.5.3.1 Additional Findings

In addition to the key findings listed in Section 1.1 above, the following achievements were obtained while reviewing the original design of the Irrigation Project:

- A review of the original irrigation project layout that allowed to resolve some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gates (the original design failed to do so for a sizable number of farms);
- A review of the original design for the recovery scheme confirming its validity;
- A review of the original design for the reuse (irrigation) scheme confirming the selection of materials, the general layout and the selection of the pumping system;
- The overall cost for the construction of the water reuse (irrigation) scheme has significantly increased (nearly 40% increase) from its original estimation. Although this might be justifiable in the context of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%.

1.6 Project's Feasibility

1.6.1 Micro and Macro Economic Evaluation

A Cost-Benefit Analysis (CBA) has been conducted to assess the proposed investment from both a financial and an economic stand point. Costs and Revenues of the water recovery and reuse (irrigation) schemes have been estimated at a micro and macroeconomic level.

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

The newly proposed development plan assumes that the entire project area (Phase I + Phase II) will be able to adopt the design cropping pattern over a four-year period. The adoption of the new cropping pattern involves not only planting new crops but also all the necessary work required to modernize the farm and adapt it to the proposed irrigation method. The cost for the adoption of the cropping pattern and the modernization/development of the farms is expected to be 4.7 Million ILS (approximately 1.3 Million US$) per year for a period of four years.

Farmers will require intense training to be able to implement the proposed plan. Further to that, maximizing the output of the irrigation project will require the farmers to cooperate via Water User Associations (WUAs) and the irrigation scheme to be maintained and managed via an Irrigation Advisory Service (IAS). The Micro-Economic analysis assumes that WUAs will incur an initial cost of 3 Million ILS (approximately 0.8 Million US$) over a period of two years. Costs for operating and maintaining the IAS is assumed to be borne by the government and not charged to the farmers but this proposal needs further discussion with PWA's before it can be considered final.

Finally, operating and maintaining the system (on-farm and off-farm and including the water recovery and reuse schemes) will cost over 4.9 Million ILS (approximately 1.3 Million US$) per year including 0.3 Million ILS/year (approximately 80,000 US$) to account for the running costs of the WUA. Farmers will pay for the O&M and WUA costs through their water bills. Water consumed by each farm will be metered at the farm gate. Gross Irrigation water demand, excluding water needs for the Industries (estimated to be 70,000 m^3/year) but including all water losses and climate change, is estimated to be 11,110,000 m^3/year. The net irrigation water requirements (after all system losses are considered), is estimated to be 7,833,484 m^3. Farmers will be charged for the water delivered to their farms and this translates into a water tariff of 0.63 ILS/m^3 to pay for O&M and WUA costs.

On the other hand, the new cropping pattern and modernized irrigation methods will enable the irrigation project and the farmers to generate a stream of revenues that, after the first three years, should provide a steady income of over 30.7 Million ILS/year (over 8.5 Million US$/year).

From a macroeconomic perspective, several different investment scenarios were evaluated. Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

- (1) Capital Investment for the Water Recovery Scheme;
- (2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm's Gate;
- (3) O&M Cost for the Water Recovery Scheme;
- (4) O&M Costs for the Water Reuse (Irrigation) Scheme;
- (5) Capital Investments for Farm's Development.

The five scenarios are defined as follows:

- Scenario 1 - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under such scenario farmers would pay back the full cost for the construction of both the water recovery and the water reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;

- **Scenario 2** - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built and paid by the farmers;
- **Scenario 3** - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmer;
- **Scenario 4** - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that farmers will have to pay back the cost for the construction of Phase II of both the recovery and the reuse scheme. Government/Donors would cover the cost for the construction of Phase I. Farmers would pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered by the Government/Donors for the number of years required for the farmers to pay back the construction of Phase II.
- **Scenario 5** - Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for as many years as it takes for the farmers to be able to pay back for the improvement of their own farm. After that point, farmers will be responsible for paying O&M costs for the whole system.

1.6.2 Results of the Financial Analysis

The Government's ability to pay for the set up and operation of the NGEST Irrigation Project during the next 25 years (the so called 'Reference Period') is critical to the success of the investment and for achieving the overall objectives of this supplementary phase. From this perspective, the investment project should be financially sustainable without any difficulties regarding the fulfilment of its financial obligations during the reference period.

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

To determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

A discount rate of 5% was assumed for this project. Results with a discount rates of 3% and 7% were also calculated to test the sensitivity of the financial model.

The results of the financial analysis are presented in the following Table 2.

Table 2: Results for the financial indicators

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)	Note
	3%	5%	7%	3%	5%	7%		
1	30.551	2.574	-16.780	1,062	1,006	0,954	5,23%	
2	12.959	718	-7.908	1,064	1,004	0,947	5,14%	
3	149.706	114.653	88.791	1,304	1,274	1,244	31,02%	*Recommended Scenario
4	127.456	88.722	60.582	1,259	1,212	1,167	16,07%	17 years of subsidies to repay the phase II investment.
5	155.425	119.953	93.715	1,316	1,286	1,258	33,54%	5 years of subsidies to repay the investment at farm level

1.6.3 Results of the Economic Analysis

The economic analysis measures the project benefits depending on the following: the costs avoided due to project implementation and the external benefits arising from the implementation, which are not included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion (fiscal correction and labour cost correction from financial to economic) between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. Moreover, these externalities should have a monetary equivalent.

The main results of the economic cost benefit analysis are presented in the following Table 3.

Table 3: Main Results of the Economic Cost Benefit Analysis

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)
	3%	5%	7%	3%	5%	7%	
1	124.102	82.112	52.243	1,252	1,196	1,144	13,72%
2	51.291	33.420	20.586	1,254	1,194	1,137	12,62%
3	132.443	89.958	59.633	1,511	1,482	1,454	15,17%
4	130.885	88.143	57.658	1,462	1,416	1,371	14,64%
5	132.843	90.329	59.978	1,523	1,496	1,469	15,24%

As seen from this analysis, if the proposed Cropping Pattern and Irrigation Methods are implemented, the construction of the water recovery and reuse (irrigation) scheme is feasible even if the entire investment (Phase I and Phase II) is paid by the farmers. Nevertheless, because developing a large investment in Gaza presents risks that are uncommon in other parts of the World, **Scenario 3,** where construction costs would be paid by the government and not charged back to the farmers, is presently being suggested. This scenario assumes that the capital investment necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmers.

2 MANAGED AQUIFER RECHARGE

2.1 MAR in the NGEST Project

Managed aquifer recharge (MAR), also known as enhanced recharge, water banking and sustainable underground storage, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can be used to store water from various sources, such as stormwater, reclaimed water, mains water, desalinated seawater, rainwater or even groundwater from other aquifers. With appropriate pre-treatment before recharge and sometimes post-treatment on recovery of the water, it may be used for drinking water supplies, industrial water, irrigation, toilet flushing, and sustaining ecosystems. The figure below shows the basic MAR process for an unconfined aquifer.

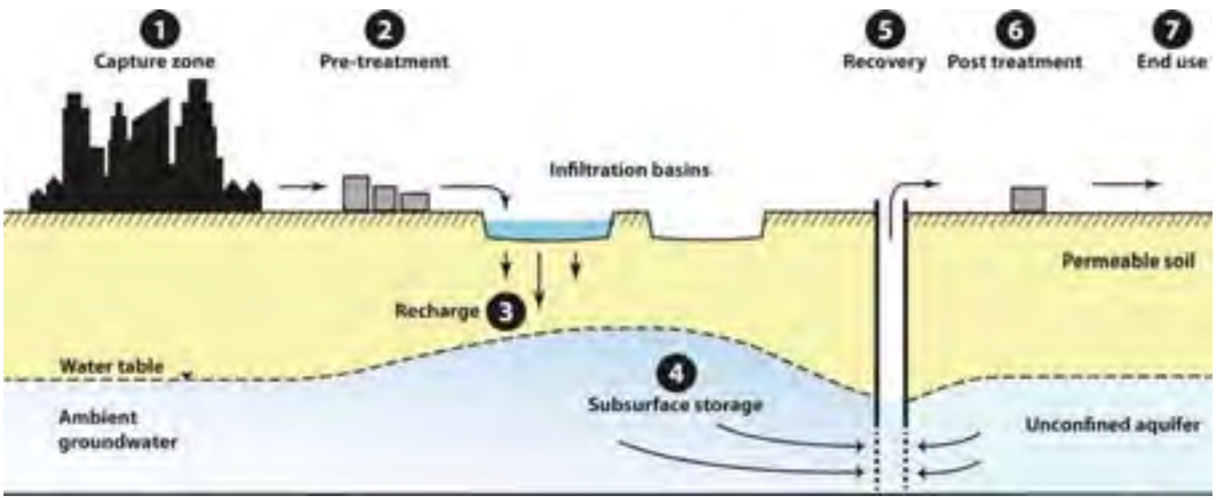


Figure 15: Schematization of Managed Aquifer Recharge System (Source: Dillon, 2009)

Several past documents describe the NGEST Project as if it is a treated-wastewater-for-irrigation project. It is not. Rather, it is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation. The difference is significant and has considerable implications for the feasibility and sustainability of the project. Outlined below are some of the central considerations and concerns for managing this segment of the project.

2.2 Regulatory Issues

The main objectives of MAR regulations should be the protection of groundwater from pollution and the assurance of public health. Topics covered in a regulatory framework often include technical issues, water quality requirements to protect groundwater and human health, regulations on the authorization to recharge and to recover water, and institutional arrangements (NRC, 2008). It is also important to determine at which point water should be submitted to regulations: at point of use, at the point of withdrawal from the aquifer or before recharge?

The quality of the water extracted from the aquifer should meet the most stringent standards related to the intended water use. The quality of the water of a recharged aquifer is a function of multiple factors, including:

- the quality of the recharge water;
- the recharge method used;
- the physical characteristics of the vadose zone and the aquifer layers;
- the water residence time;
- the amount of blending with other sources;
- the history of the recharge.

Setting requirements for indirect recharge is not an easy task. The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, thanks to retention and oxidation processes. These processes affect organic matter, nutrients, microorganisms, heavy metals and trace organic pollutants. However, though much is known about these processes (Bouwer, 1996; Drewes & Jekel, 1996), forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is complex. Performances depend on a number of factors such as depth of the unsaturated zone, physical and mineralogical characteristics of the soil layers, heterogeneity, hydraulic load, infiltration schedule and infiltrated water quality (Dillon, 2009).

Therefore, particularly when transfer through the vadose zone is part of the treatment intended to bring the water up to the required water quality, pollutant removal tests should be performed, at the laboratory and onsite, to ensure the water achieves the desired quality. The example of the Dan Project in Israel shows that submitting secondary effluents to a Soil Aquifer Treatment system in a dune sand aquifer can result in the production of a nearly potable water (Sack, Icekson-Tal & Cikurel, 2001).

The complexity of reactive transport processes in the unsaturated zone highlights two of the main stumbling blocks that must be taken into consideration if treated wastewater is being considered for MAR: one specific challenge is to have numerical models that can include all of the hydro-biogeochemical processes involved in reactive transport, while a second, more operational, is the need to have a complete biogeochemical and hydrogeological characterisation specific to each MAR site. These should be taken into consideration in assessing the capacity building needs of PWA, EQA and other stakeholders involved in managing the NGEST project.

Several countries (the United States and Australia, for example) have developed guidelines for the use of treated wastewater for recharge (USEPA 2004, 2012; WHO 2006a, b). These guidelines focus mainly on the health and environmental risks that result from the presence of pathogenic microorganisms, suspended solids and dissolved organic carbon in this water. There are few recommendations concerning trace element contents in water (e.g. USEPA 2012), except as concerns five trace metals. These are: (i) arsenic; (ii) nickel, which is only weakly toxic but which accumulates in plants; (iii) cadmium, which is considered to be the metallic pollutant of greatest concern due to its rapid accumulation in plants and its proven toxicity even at low concentrations (acceptable daily intake (ADI) 0.057 mg/day/individual); (iv) mercury, which can be highly mobile; and (v) lead, the injection of which, even at low doses, can cause neurotoxic and hepatotoxic disturbances (Dillon et al. 2009a).

Although these guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse. Land use planning and environmental impact assessment legislation add to the complexity of the regulatory frameworks currently available for MAR schemes. See Annex 7 for international case studies on regulating MAR systems.

2.2.1 *Implications for the Application of Palestinian Wastewater Regulations*

The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater. As has been discussed in past NGEST documents, the Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced. There has been some expressed concern whether this regulation applies to the NGEST irrigation scheme, which would significantly restrict the types of crops farmers could grow in the project area and, as a result, have severe implications for the financial sustainability of the project.

But the concern of whether the regulation applies to the irrigation scheme stems from the misunderstanding of the nature of this project highlighted at the beginning of this section. The NGEST project does not entail using treated wastewater for irrigation *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. The recovered water, therefore, is no longer "treated wastewater," and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.

That being said, the regulation also covers the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A"). See the below Table 4 for the basic parameters for each category.

Table 4: Palestinian reuse standards (PS 742/2003)

Class	Quality	BOD mg/l	TSS mg/l	Feacal Coliform MPN/100ml
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000
D	Low	60	90	1,000

The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.

The project, therefore, is in complete compliance with the Palestinian regulation.

2.3 Operation and Maintenance

Clogging appears to be the most limiting technical problem in artificial recharge and can only be managed with regular maintenance and pretreatment. Clogging can be caused by various mechanisms like physical clogging by suspended solids, chemical clogging due to precipitation or clay dispersion, mechanical clogging due to entrapped air or biological clogging due to microbial growth (Pyne, 1995; Pérez-Paricio and Carrera, 2001; Bouwer, 2002). Clogging leads to the decrease in porosity and hydraulic conductivity and is experienced at the bottom of infiltration basins as well as around injection wells. There are two basic principles for the management of clogging: (a) pretreatment of recharge water and (b) redevelopment (Brown et al., 2006).

Apart from maintenance related to clogging, regular inspections of the facility are needed to assess if any repair works or cleaning is needed. This could include the cleaning of any screens, change of batteries, lubrication or replacement for equipment prone to wear and tear, repair of damage done by natural forces or vandalism. If mechanical or electrical parts are involved their proper functioning needs to be tested.

2.4 Monitoring Program and Data Collection

Monitoring is an integral part of MAR management and should be undertaken to both determine the effectiveness of the recharge scheme and to investigate the sustainability with respect to human and environmental health. The minimum monitoring requirements should guarantee that no groundwater contamination occurs or at least can be detected early. Minimum parameters should be TSS, TDS, nitrate and E.coli. Depending on the hazards present in the catchment further parameters like organic contaminants (pesticides, oil, MTBE, etc) should be added.

Monitoring starts with baseline monitoring i.e. the investigation of the current situation before the MAR scheme is implemented and should cover spatial and temporal variability. Validation monitoring determines the actual performance of the MAR scheme and is essential if the natural attenuation processes are part of the treatment scheme. For quality monitoring, mean concentrations in source water rather than peak values are needed. If pathogens are of concern, E.coli, coliphage and clostridium spores (NRMMC-EPHC-NHMRC, 2009b) or rotavirus, Cryptosporidium parvum and Campylobacter (WHO, 2004) could be measured as pathogenic indicators. Typical herbicide parameters could be simazine and chloripyrifos (Swierc et al., 2005). Conservative tracers in source and groundwater can help determine the amount of mixing.

Reliable predictions of groundwater flow are possible only if the aquifer system is well known, which means that sufficient data need to be available to work out well-calibrated hydrodynamic numerical models. Obtaining representative groundwater samples requires properly constructed wells, an appropriate pumping mechanism, proper flushing of the well and correct sample preparation, storage and preservation and should hence only be undertaken from skilled personnel. There are a number of guidelines outlining proper groundwater sampling techniques (Schuller et al., 1981; Barcelona et al., 1985; Johnston, 2007; Sundaram et al., 2009).

2.4.1 Monitoring Strategy and Plans

Before preparing a groundwater monitoring plan, the overall strategy of the groundwater monitoring program should be defined to guide the development of the plan. In this sense, "strategy" refers to the manner in which a hypothetical release from a regulated unit will be detected or measured. Examples of issues that should be addressed when developing a monitoring strategy include:

- The type of monitoring data needed;
- The locations (both horizontal and vertical) from which the samples are to be collected (i.e., definition of "target monitoring zones");
- The manner in which the samples will be obtained; and

- The ability of the monitoring features to rapidly detect a change in groundwater quality.

Development of a groundwater monitoring strategy is illustrated in Figure 16 and Figure 17. As shown in these figures, the potential sources of contamination and the aquifer of concern should be characterized before developing a groundwater monitoring strategy because selection of target monitoring zones cannot be made until the source and the aquifer have been evaluated, usually through a detailed hydrogeological evaluation of the site. When evaluating the ability of a monitoring system to rapidly detect a release from a potential source, the impact of preferential flow paths and vertical gradients should be carefully evaluated; a two-dimensional analysis of groundwater elevation may not reveal actual upgradient or down gradient locations of groundwater flow. The presence of vertical gradients may significantly effect the selection of monitoring locations.

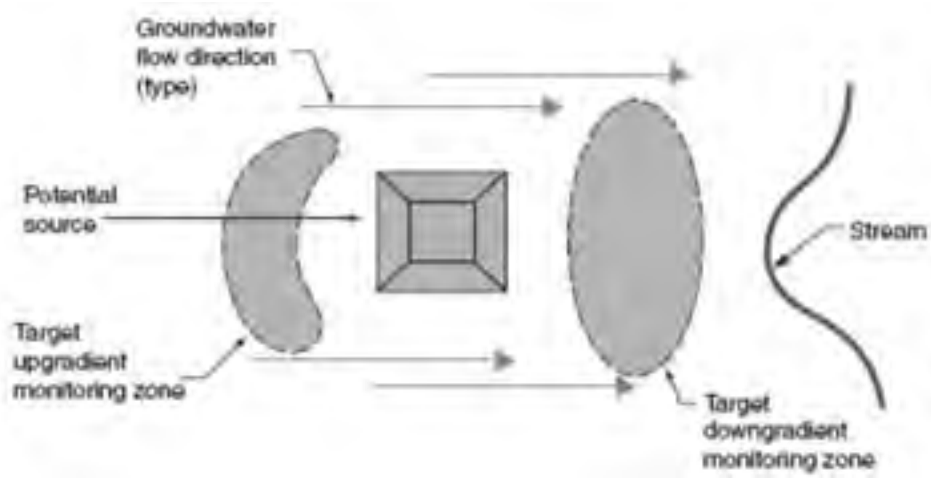


Figure 16: Plan view of typical unconfined aquifer groundwater monitoring system

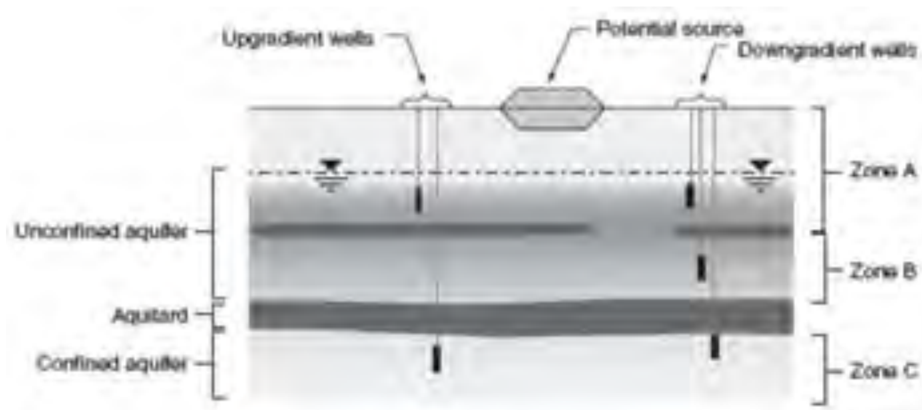


Figure 17: Vertical cross section of target monitoring zones.

2.4.2 *Monitoring Locations and Parameters*

Locating the appropriate monitoring point locations is essential in designing a monitoring network capable of providing data of adequate quality. Selected monitoring locations should provide the most reliable data needed to detect or assess a groundwater contaminant plume. To verify that the monitoring network can accomplish this goal, target monitoring zones must be selected based on the site hydrogeologic conditions and anticipated contaminant pathways. Figure 18 shows the recommended locations of the monitoring wells which was set up based on the location of the recovery wells.

The groundwater monitoring program in the NGEST Project is designed to evaluate the status of the groundwater quality after infiltration of partially treated and treated wastewater. The monitoring wells are distributed in two rows: around 400 to 500 m from the infiltration basin and the second row will be of 1100 to 1200 m from the basin. The first monitoring well row should be located before the first row of the recovery wells in the direction of the infiltration basin, and the second row of the monitoring wells should be located after the second row of the recovery wells to check the quality of groundwater outside the recovery wells areas. The monitoring network will also use the existing 5 monitoring wells constructed recently by PWA and used to monitor the infiltration basin. In addition, the recovery wells will be part of the monitoring network as shown in Figure 18.

Figure 18: Monitoring wells location

The main objective of monitoring is to check the groundwater quality after infiltration and check the operation of SAT process. The consultant made extensive reviews of similar projects such Gosh Dan Project where several parameters are monitored. Among these parameters, the consultant proposed in Table 5 some parameters which would reflect the status of groundwater after infiltration and could be analysed in Gaza Strip laboratories.

Table 5: Monitored Parameters and Frequency of Monitoring

Parameter	Frequency of Monitoring
Water Level	Monthly
pH	Four Times a year
TDS	Four Times a year
BOD	Four Times a year
COD	Four Times a year
DOC	Four Times a year
TC	Four Times a year
Ammonia as N	Four Times a year
NO_3	Four Times a year
NO_2	Four Times a year
T.N	Four Times a year
Cl	Four Times a year

Parameter	Frequency of Monitoring
Detergent	Four Times a year
F.C	Four Times a year
Phosphorus	Four Times a year
Heavy Metals	Four Times a year
O_2	Four Times a year
Nitrogen and Oxygen Isotopes	Four Times a year
Mg	Four Times a year

Samples will be collected from the monitoring wells to characterize the geochemistry of groundwater. The nitrogen and oxygen isotopes of groundwater nitrate will be used in conjunction with other geochemical data to place constraints on potential nitrate sources.

2.5 Recommendations

2.5.1 Regulating Extraction

MAR is one of the measures that can be implemented to secure water supply, compensate for some effects of climate change and, more generally, handle the quantity and quality of groundwater bodies. It is not, however, a substitute for groundwater management based on decreasing abstraction and adapting withdrawal to resource availability.

There are a number of private wells in the Gaza Strip, only some of which are officially registered. Thousands of wells are estimated to have been drilled without authorization, which has contributed to more rapid deterioration of the aquifer. (UNEP, 2014) To protect the aquifer and for the success of the NGEST project, both the authorized and unauthorized agricultural wells should cease operation.

In order to do that, PWA, which is the institution responsible for issuing and renewing licenses for agricultural wells, plans to include a new clause in the next annual renewal of licenses that specifies that the operation of an agricultural well should be stopped when reuse water is available. At the same time, the voluntary adhesion to the new irrigation scheme shall be pursued.

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

2.5.2 MAR Training

There are various institutes within the Gaza Strip that currently provide training regarding water and wastewater management. These institutes should be encouraged to establish short courses for MAR operators and regulators. These could also help ensure risk management plans are designed and implemented effectively and management issues are understood and addressed.

More is said on the needs of MAR training in the section on Institutional Capacity Building.

2.5.3 Aquifer Protection

Enforcement measures against illegal use, abuse and deteriorating groundwater conditions should also be introduced as well as legislation to create water resources protection zones for drinking water resources. It is recommended to develop a holistic MAR strategy and to implement transparent and comprehensive regulations specifying maintenance, monitoring and reporting requirements. Regulations should also address water allocation, ownership issues and demand management.

3 INSTITUTIONAL FRAMEWORK

3.1 Overview

The institutions most likely to be involved in the implementation and oversight of the NGEST irrigation system consist of the following:

- PWA and MoAg will cooperate to set up WUAs. Both PWA and MoAg will monitor the project's implementation.
- IAS will manage the NGEST recovery and reuse schemes and be responsible for O&M of the network. WUAs will be part of the IAS so that they are fully involved with the project management. Until the IAS and WUAs are created, CMWU should operate and manage the network.
- EQA will monitor the work to ensure it does not cause environmental harm and will cooperate with PWU in setting any water quality/use standards.
- MoLG will coordinate with municipalities, the CMWU, the WUAs and other stakeholders in the water distribution system.
- MoH will monitor the work to ensure it does not cause harm to human health and will cooperate with PWU in setting any water quality/use standards.

3.2 Institutional Framework Under the New Water Law

The water sector reform process currently underway in Palestine began in earnest in 2009, with the endorsement of the "Action Plan for Reform" by the Cabinet of Ministers, which led to the definition and implementation of a comprehensive program of institutional and legislative reforms, culminating in the passage of a new water law in 2014. The new law "aims to develop and manage the Water Resources in Palestine, to increase their capacity, to improve their quality, to preserve and protect them from pollution and depletion, and to improve the level of water services through the implementation of integrated and sustainable water resources management principles". Of particular importance, the law identifies the roles and relations among the various water sector institutions.

Perhaps the most significant institutional change brought about by the new water law is that the Palestinian Water Authority's (PWA) role of regulating service providers has been given to a new independent entity, the Water Sector Regulatory Council (WSRC), which was established in late 2014. Its objective, as defined by the law, is to "monitor all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management, with the aim of ensuring water and waste water service quality and efficiency to consumers in Palestine at affordable prices."

In addition to measuring the efficiency and performance of the service providers, WSRC is mandated with economic regulations regarding tariffs and cost of development and supply of water, including:

- Approval of water prices, costs of supply networks and other services required for the delivery of water and waste water services;

- Issuance of licenses to Regional Water Utilities and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of wastewater, and the levying of license fees;
- Monitoring operation processes related to the production, transport, and distribution of water and operational processes of wastewater management; and
- Monitoring the compliance of the National Water Company and Service Providers with the adopted standards for the provision of water and sanitation services. Monitoring water supply agreements.

Furthermore, WSRC can conduct inquiries, investigations and inspections, but does not impose fines or other financial sanctions. The powers of WSRC to enforce compliance with regulation (for instance enforcing the water quality standards) are not defined in its mandate.

Another major institution created by the new water law is the National Water Company (NWC). The existing West Bank Water Department (WBWD) will undergo a transitional period of financial and management upgrade to be followed by the establishment of the NWC, which will be a publically owned water company to cover the Gaza Strip and the West Bank.

The NWC will oversee supply and sale of bulk water to water undertakings, local authorities, joint water councils and associations. It extracts or develops any resource and transmits it in bulk based on a license issued by PWA. Points of delivery of the bulk water are Regional Utilities for all water users (other than for irrigation) and Water Users Associations (WUA) for irrigation water.

The water sector is centralised in terms of strategy, policies, project development and identification of bulk water supply, yet decentralised to the point of fragmentation among municipalities in the provision of services. Customer water services are currently provided by 300 water service operators across the country. Most of them (> 90%) are not independent water companies, but rather small technical branches of municipalities (PWA, 2003). Many of these municipal branches have very low levels of financial autonomy and suffer from both a lack of technical skills and political interference.

In order to improve efficiency in the provision of services and achieve economies of scale, the new water law seeks the creation of Regional Utilities and WUAs for water distribution. Individual water departments in the municipalities will first consolidate to form Joint Services Councils and eventually amalgamate even more to form the Regional Utilities (RU), ideally four: three in North, Center, and South of the West Bank; and the fourth in Gaza. The Gaza structure is nearly completed as the Coastal Municipal Water Utility (CMWU). Irrigation water services will be administered through Water User Associations (WUA), which are to be established according to a regulation that will be proposed jointly between the PWA and the Ministry of Agriculture (MoAG). According to the Water Sector Reform Plan 2016-2018 and confirmed by representatives of PWA in May 2017, a by-law on WUAs is currently under review by the Cabinet of Ministers.

The figures below depict the institutional framework before and after the law. Table 6 and Table 7 identify the new roles and inter-related responsibilities of the various entities. Annex 1 further elaborates on these relationships.

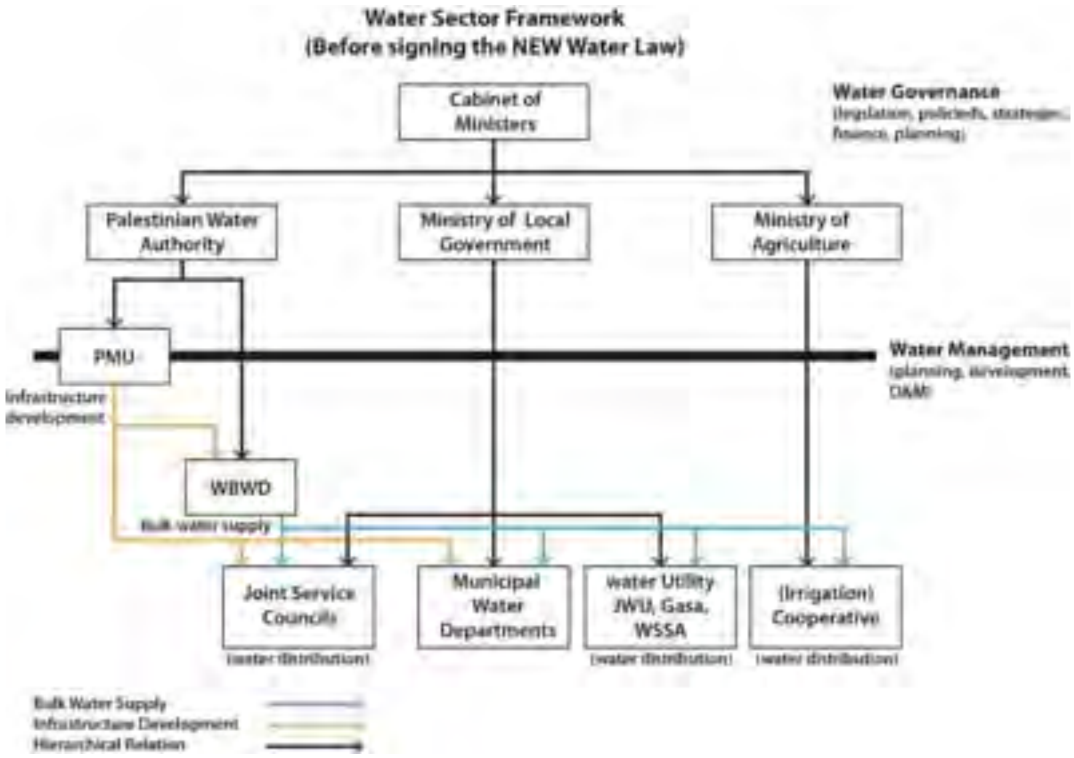


Figure 19: Institutional Framework before signing the law (Source: Water Governance, 2015)

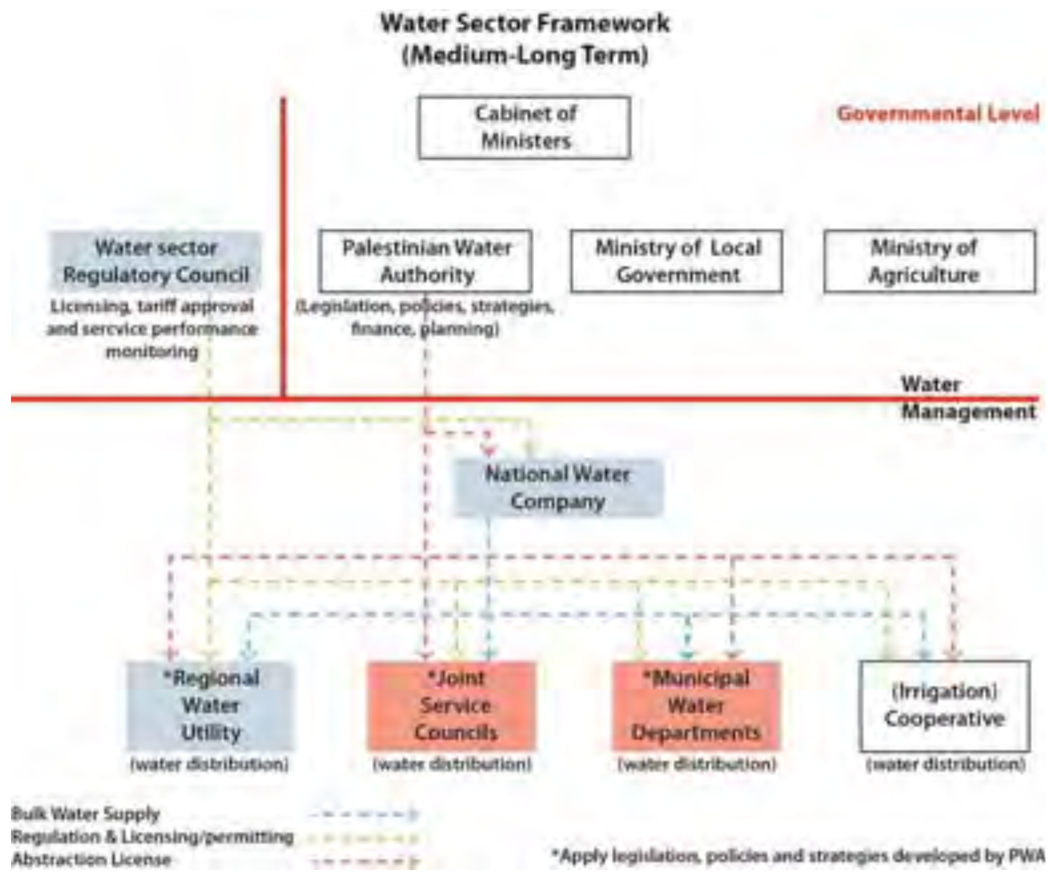


Figure 20: Institutional Framework after signing the law (Source: Water Governance, 2015)

Table 6: Institutional mapping of roles and responsibilities in the water sector at central government level according to the new water law. *Allocation of roles across ministries and public agencies*

AREA	WATER RESOURCES	WATER SUPPLY			Wastewater Treatment
		Domestic	Agriculture	Industry	
Strategy, priority setting and planning, including infrastructure	PWA	PWA	PWA	PWA	PWA, MOH, EQA
Policy Making	PWA	PWA	PWA	PWA	PWA, EQA, MOH
Information, monitoring and evalutation	PWA EQA, envt condition MOH, health qlty	WSRC EQA MOH	WSRC EQA MOH	WSRC EQA MOH	PWA, EQA, WRSC, MOH
Stakeholders engagement, citizen's awareness	PWA EQA MOLG MOH	PWA MOLG MOH	PWA MOA MOH	PWA MOH	PWA EQA MOH

Table 7: Institutional mapping of roles and responsibilities in the water sector at central government level according to the new water law. *Institutional mapping for quality standards and regulation*

AREA	WATER RESOURCES	WATER SUPPLY			Wastewater Treatment
		Domestic	Agriculture	Industry	
Allocation of uses	PWA	PWA	PWA	PWA	PWA, MOH, EQA
Quality standards	PWA, MOH	PWA, MOH	PWA, MOH, MOA	PWA, MOH	PWA, EQA, MOH, MOA
Compilance of service deliverys	WSRC	WSRC	WSRC	WSRC	WSRC
Economic regulations (tariffs)	PWA	PWA	PWA	PWA	PWA
Environmental regulation	PWA, EQA	PWA, EQA	PWA, EQA, MOA	PWA, EQA	PWA, EQA

The above list is not comprehensive as it does not include, for example, the Ministry of Finance.[2] It is also important to note that the Water Law of 2002 called for the establishment of the National Water Council, to be made up of representatives from several ministries. Though established, the Council was never effective.[3] The new Law of 2014 does not refer to the Council so it is presumably defunct.

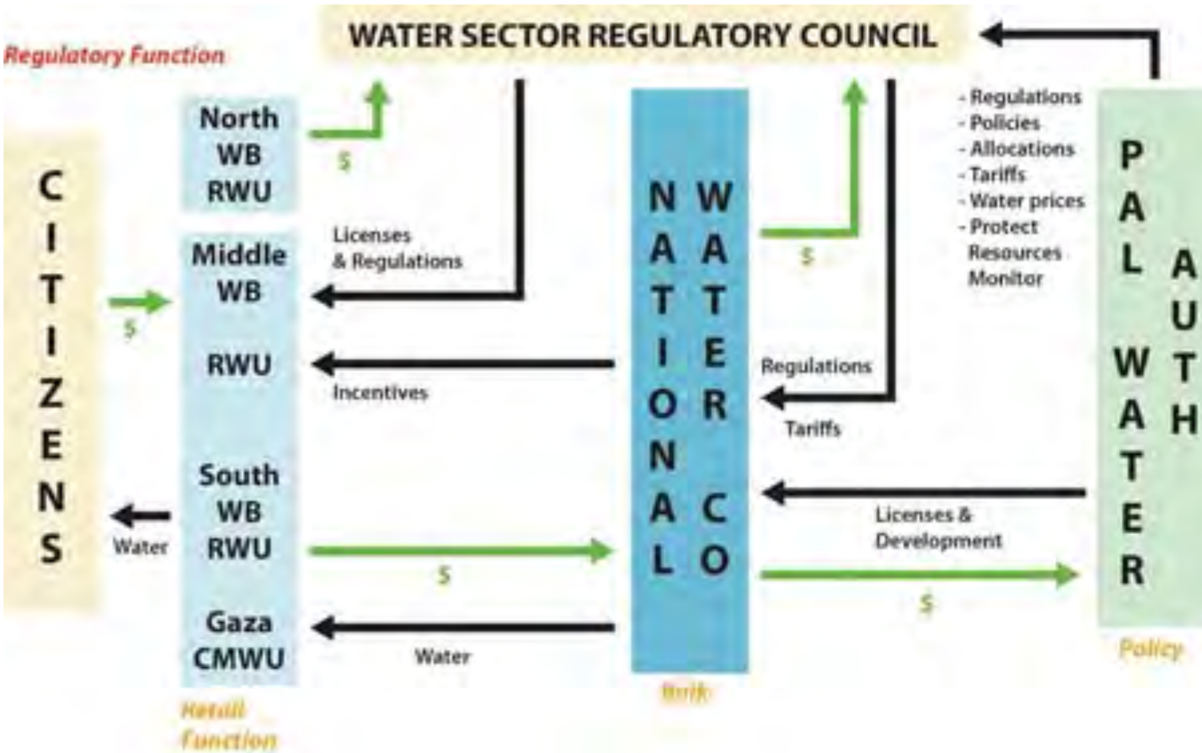


Figure 21: Water Sector Regulatory Council Functional Structure

The figure above illustrates the functional structure of the water sector entities according the 2014 Water Law. Arrows in black are functions whereas arrows in green show the direction of flow of funds. As seen, the consumers (citizens) pay the respective retail unit (CMWU, for example) for the water delivered. The retail unit then pays both the bulk supplier for the water supplied and the regulator for its services such as license fees, whereas the bulk supplier pays the PWA for licenses granted to exploit and develop the supply sources.

3.3 Key Institutions for the NGEST Irrigation Scheme

Various Palestinian institutions will be directly involved with the recovery and reuse scheme of the NGEST Project: PWA; MoAG; CMWU; WSRC; and WUAs. Indirectly, several other ministries are also implicated, including the Environmental Quality Authority (EQA), Ministry of Local Government (MoLG), and Ministry of Health (MoH). Each is briefly considered in turn below.

[2] The list would also normally include the Ministry of Planning but it was apparently dissolved by Hamas in October 2016.

[3] The NWC has not held a single meeting since its establishment.

PWA and MoAG will need to cooperate with one another in multiple areas for the NGEST irrigation scheme. First, they must work to create WUAs through WUA-specific legislation. Establishing WUAs on the basis of specific legislation means that their purpose can be clearly specified from the outset as can the manner in which they are to be established and operated. It also means that the legislation can take account of the specific nature of WUAs through, for example, the provision of suitable and appropriate governance structures that are designed to promote transparency and effective rule making. There is allegedly a draft by-law on WUAs at the Cabinet. Its contents are unknown to the Consultant.[4]

Additionally, PWA and MoAG will need to jointly monitor the project's implementation, and provide farmers in the project area with support. MoAg will need to closely supervise farmers' activities, irrigation methods and application rates as well as collect sampling and do testing of crops and soils. Local WUAs should also be involved with the system's management and water distribution. PWA, MoAg, and the WUAs efforts may best be organized through an Irrigation Advisory Service (IAS) recommended by this *Report*. The IAS would provide a platform for multi-stakeholder communication and gather the requisite expertise for running the project in one office. Given the multiple ministries responsible for monitoring, the IAS may also serve as the gathering point for monitoring data.

Because the IAS and WUAs do not yet exist, the CMWU is best positioned to run the irrigation scheme in the meantime. The CMWU, as the water utility in the Gaza Strip, currently handles municipal water supply as well as sewerage and WWTPs, including house connections and operation and maintenance, so it already has experience in this area. The existing sewerage fee is charged by the CMUW, so any additional wastewater fee could potentially be added to the same bill of water.

While it manages the system, CMWU would be responsible for the establishment of the conveyance system, metering of farm off-take points, contracting with farmers and tariff collection. It would also be responsible for recharge of the surplus effluent. Until the IAS and WUAs are established, CMWU will be responsible for control of water demand and should work with MoAg to coordinate with farmers to ensure equitable and suitable distribution of recovered water according to crop requirements.

Whatever entity is managing the irrigation network – either CMWU or IAS – that entity will be responsible for the recovered water quality and be subject to audits and check sampling by EQA. EQA will monitor the work to ensure it does not cause environmental harm and will cooperate with PWU in setting any water quality/use standards. Additionally, MoH should be involved in monitoring to ensure the application of recovered water does not cause harm to human health and should cooperate with PWU in setting any water quality/use standards. Finally, MoLG will coordinate with Local Government Units (LGU), municipalities, CMWU, WUAs and other stakeholders in the water distribution system.

In Annex 2, 3 and 4 are presented several case studies of successful institutional set-up (including water users involvement) in irrigation and drainage in developing countries.

[4] The draft by-law as well as several other documents were requested but not received.

3.4 Institutional Capacity Assessment

There are a number of particular skills that need to be developed for the successful implementation of the NGEST project, including management of MAR and sludge as well as the design, operation and maintenance of modern irrigation technologies. There are also a range of specialized technologies that must be mastered, including groundwater modelling and GIS remote sensing. Communication and cooperative approaches should also be fostered through trainings on developing the IAS or community awareness raising to bolster support for the project.

In order to adequately assess the specific capacity development needs for each aspect of the project, this *Report* has interwoven capacity building throughout each section: Managed Aquifer Recharge; Farmer Assistance; IAS; WUAs; and Operation and Maintenance of the Irrigation System. Therefore, although there are recommendations below for Institutional Capacity Building, overall capacity development should be viewed through the context of the entire *Report*.

3.5 Recommendations

A capacity development system for the Water Sector already exists and a substantial amount of resources are being invested to enhance capacities in the water sector in Palestine. (PWA, 2016) Compared to other countries, where capacity development efforts have to be developed from scratch, Palestine boasts a substantial foundation of sufficiently developed institutions and high number of human resources investments. Palestinian Universities, polytechnics, industrial secondary schools and vocational training schools produce a constant inflow of trained professionals for the water sector, and international donors have expended considerable sums for training of water sector stakeholders. See Annex 6 for a list of current capacity development initiatives.

However, there needs to be a better coordination of capacity development initiatives with policies and strategies so that there is a more efficient utilization of resources and the training better meets the needs of the sector. In particular, PWA, WSRC as well as the NWC, RU and WUAs need targeted capacity building to implement the water law, to make effective and efficient use of increased investments, and to maintain the existing and new infrastructure.

In addition to supporting the reform process through capacity development, work needs to be done to create an environment in which skill and knowledge acquisition can take place, including, for example, fostering a professional atmosphere in which technical growth is rewarded and there are incentives for participation, allocating a sufficient budget for on-going development, and ensuring monitoring and follow-up of capacity development efforts.

Below is a truncated list of institutional capacity building recommendations. As mentioned above, for a more detailed analysis of capacity development needs, see the other relevant sections of this *Report*.

- Capacity Development Coordination

There is a need for sector-wide monitoring and evaluation of capacity development interventions. The current lack of the monitoring and evaluation is directly correlated with the need for coordination, but also lends itself to the mismanagement of limited resources, decline in performance and loss of value for money spent. It is expected that the newly created Capacity Development Directorate of PWA will lead this coordination as well as execute the recommendations contained in PWA's Water Sector Capacity Development Policy and Strategy of 2016.

- Focus on Practical Skills

There should be increased focus on the development of practical knowledge and competencies to address existing and emerging water sector challenges, for example negotiation with the Joint Water Committee, and how to build, manage, repair and renew a technical irrigation system.

- Encourage On-going Capacity Development

Water professionals need to refresh and expand their knowledge base in a number of training days each year to be able to excel in their work. Organizational Capacity Development (action) plans, covering a 3-5 year period, should be prepared by the relevant units and persons within the respective organizations. These plans should be approved by the organization itself, endorsed at national level, and updates should be made annually.

- Help Prepare CMWU

Because CMWU will likely handle the operation and management of the NGEST irrigation scheme until the creation of the IAS and WUAs, the capacity of CMWU should be expanded to provide this service. Additionally, there may be the need to modify the current mandate of the CMWU to reflect this change.

- Sludge Management

Training is needed that tackles sludge collection, treatment, or dumping and sludge management. Sludge represents a completely new sector, which should be organized and well regulated in order to benefit from it.

- MAR Training

A simplistic view that treating water to near drinking standards before recharge will protect the aquifer and recovered water is incorrect. For example chlorination, to remove pathogens that would be removed in the aquifer anyway can result in water recovered from some aquifers containing excessive chloroform. In some locations, drinking water injected into potable aquifers has resulted in excessive arsenic concentrations on recovery due to reactions between injected water and pyrite containing arsenic. Source water that has been desalinated to a high purity dissolves more minerals within the aquifer than water that has been less treated.

Hence the ministries responsible for the MAR scheme need to understand how this aquifer will interact with the recharged water. More specifically, they should have hydrogeological and geotechnical knowledge, as well as knowledge on water storage and treatment design, water quality management, hydrology and modelling, monitoring and reporting. They need to understand d pathogen inactivation and biodegradation. The response of an aquifer to any water quality hazard depends on specific conditions within the aquifer, including temperature, presence of oxygen, nitrate, organic carbon and other nutrients and minerals, and prior exposure to the hazard, so the ministries should receive adequate training on these subjects.

Additionally, EQA and PWA (and any other ministry that will regulate the MAR scheme) should acquire basic stratigraphic and hydrogeological information for each well drilled. This information should be stored in departmental data bases, which would ideally be publically accessible on the web.

- Create a MAR Unit

The human resources at PWA are limited as the number of staff is already not sufficient to perform all needed tasks (e.g. data evaluation, quality control) let alone to fulfil new tasks related to MAR. If MAR activities are to be pursued, it is highly recommended to create a MAR unit with competent staff to be able to perform the additional work load either within PWA, EQA, or as a sub-committee within the IAS. It is recommended that strategic planning and the development of a regulatory framework as well as the oversight of MAR activities should be undertaken by the PWA/EQA. Any future technical cooperation on MAR should clearly define responsibilities and objectives of both partners and allow sufficient time for a successful cooperation.

4 FARMER ASSISTANCE

4.1 Present Farmers' Organisations

The Union of Agricultural Work Committees (UAWC) is the main organisation[5] active in the project area, already working with a few farmers. UAWC is a non-profit organisation founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union aims to help Palestinian farmers to market their produce and provides agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions.

Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors, in the West Bank and Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in different Palestinian rural areas. UAWC receives funding from numerous western governments and aid organisations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organisations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like MoAg is also established with international development agencies, like FAO.

The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, including: land reclamation; building greenhouses; products quality enhancement and new crops introduction. Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistical and financial support for exporting goods such as strawberries and medical herbs, which usually ensure a good revenue.

4.2 Improving Farmers Technical Skills

The farmers interviewed during the baseline survey stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.

According to the outcomes of the baseline survey and the agronomic characteristics of the new proposed irrigated cropping system, the following training and technical assistance needs have been identified for the farmers:

- Training on appropriate use of irrigation

[5] Other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

So far, the irrigation practice has been left in the domain of individual farmers without any technical assistance. Underground water is being managed without considering the actual water requirements of crops, after computing the water balance of the area. Without an appropriate approach to irrigation, the amount of water supplied to crops is often under- or overestimated hence causing low yields and problems of uncontrollable pests and diseases on the cultivated crops. The envisaged training program has the objective to make the farmers fully capable to design an irrigation plan suitable for their cropping pattern for various irrigation methods (e.g. surface, sprinkle or drip irrigation).

- Training on integrated pest management (IPM)

It has been observed that use of pesticides on crops is often high in north Gaza, although these products are quite expensive since imported from Israel. Pests outbreaks are common in the target area, probably because of irrigation misuse (see above). However, farmers lack specific knowledge on effective methods for preventing pests and diseases, which should allow them to drastically reduce the amount of sprayed pesticides, so saving money and making the farming environment healthier. The IPM method has been conceived in the '70. It is a pest control strategy that uses a variety of complementary strategies including: mechanical devices, physical devices, genetic, biological, cultural management, and chemical management. These methods are done in three stages: prevention, observation, and intervention. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. IPM practices have been so far successfully implemented on vegetables and fruit tree crops which represent 65% of the new cropping pattern proposed for the project.

- Training on Integrated Plant Nutrient Management (IPNM)

This methodology has been devised by the Food and Agriculture Organization of the UN (FAO, 2006). It allows to match crop nutrient needs with sufficient accuracy to prevent surplus of fertilization. This in turn limits soil and water chemical pollution which usually is a consequence of the use of mineral fertilizers. The purpose is to maintain or enhance soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients, including biological nitrogen fixation. IPNM focuses first on the seasonal or annual cropping system (namely, the entire crop rotation applied by a farm), rather than on an individual crop; secondly, on the management of plant nutrients in the whole farming system; and, thirdly, on the concept of village or community areas rather than individual fields. The proper application of IPNM, among others, allows to minimize the use of mineral fertilizers which are particularly costly in Gaza, because imported and from Israel.

- Farming field schools (FFS) for effective training on IPM and IPNM

The Farmer Field School (SUSTAINET, 2010)is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It was initially developed to help farmers tailor their IPM practices to diverse and dynamic ecological conditions, but subsequently the method has embraced also other relevant topics for improving farmers' technical skills. In regular sessions from planting till harvest, groups of neighboring farmers observe and discuss dynamics of the crop's ecosystem, under the guidance of a facilitator (usually an agricultural extensionist, well trained on running a FFS). Simple experimentation helps farmers further improve their understanding of functional relationships within the agro-ecosystem (e.g. pests-natural enemy population dynamics and crop damage-yield relationships). In this cyclical learning process, farmers develop the expertise that enables them to make their own crop management decisions. Special group activities encourage learning from peers, and strengthen communicative skills and group building.

4.3 Building Farmers’ Capacity Along the Value Chain

- Supporting farmers in establishing organizations

Collective action can create a more effective market chain that is more stable and can produce the products required at the time needed and of the quality wanted. As a group, producers can provide a more stable and higher quality supply of raw material, which also improves the economic efficiency of the value chain. The higher bargaining power and improved access to markets for group members are made possible by creating a link with other actors along the chain (retailers, traders and processors). However, a farmer organisation cannot be simply created by a top-down approach from the government (for example, by providing strong subsidies to farmers if they join an organisation; or providing inputs for free). Many worldwide experiences clearly show that farmers organisations (under the shape of cooperatives, associations, etc.) fail when members are not fully convinced that collective action is really an opportunity for them to grow and improve their lives. Farmer organisations also fail when their members do not firmly aim at economic independence, but rather rely on external aid. The survey carried out in the project area highlighted that farmers work on individual basis. Even when they share collectively the same private well, everybody keeps on working on his own. It is also noted that only one organisation is existing in the project area, joining a small number of farmers.

To cope with this reluctance toward cooperation, farmers should be invited - through a tailored training programme - to progressively share their activities. For instance, an initial stage of farmer collective action may be started just by purchasing the farming inputs together, which will allow a discount from the seller. Then, farmer collective action can further evolve in growing crops together, according to a cropping plan that has been specifically designed to meet the market needs in a certain period of the year. When collective crop production is finally carried out relationships with the merchants (wholesalers, traders at any level of the supply chain) can be strengthened and options of contract farming may become feasible. Furthermore, associated farmers may start processing the raw materials and their marketing action will become more targeted and complex. By following this progressive process, the farmers’ organisation purchasing power and its share of added value along the supply chain will increase.

- Training on post-harvest operations and food processing and establishing suitable physical structures.

This training programme requires high investments and well established farmer’s organisations, which will handle the operations and run the post-harvest and processing structures. The survey carried out by the consultant highlighted that in northern Gaza the existing food industries do not buy raw food materials from the local farmers but they rather import it from Israel, probably because the industry cannot find the required amounts according to its needs. While this specific demand from the industry could be properly satisfied by an organised group of farmers (see above), on the other hand organised and well trained farmers could start simple post-harvest processing activities, such as sorting and packing fresh fruit and vegetables; preparing plant preserves, purée, jams, etc. Another option would be processing dairy products, considering the good milk production from cows, sheep and goats which are being reared in the project area.

All the above-mentioned activities will improve products quality and introduce new products into the local market which will increase the farmers’ earnings.

However most of the farmers seem they cannot afford the cost of the initial investment (e.g. purchasing a refrigerator unit, packaging materials, other equipment for processing), nor bank loans seem available in north Gaza. Therefore, external aid should be foreseen together with sound training sessions.

5 OPERATION AND MAINTENANCE OF THE IRRIGATION SYSTEM

5.1 Background

Irrigated agriculture, accounting for some 85% of total water use, is by far the largest consumer of the resource is Gaza. However, the water use is inefficient and agriculture has a low productivity and yield. This situation is not only due to a lack of appropriate irrigation infrastructure and maintenance, but also due to uncoordinated actions among institutions responsible for policy making, planning, and implementation.

Traditional irrigation management in Palestine is community-based and informally organized around private wells in Gaza or springs in West Bank. Whereas in the Gaza strip a small group of farmers share the operation and costs of a private irrigation well and organize the supply of water among themselves on a rotational basis, in the West bank, common irrigation schemes can supply up to a few hundred farmers and thousands of dunums, depending on the size of the spring. The organizational level is thus quite elaborate in West Bank, dealing with O&M, billing, and scheduling for hundreds of farmers in some cases. Still it is mainly informal, the number of WUAs in the Palestinian territories is very limited and the registered ones are very few. Institutional involvement in irrigation, therefore, has been very weak and limited to the licensing of agricultural wells.

5.2 Management Structure

As discussed above, the new Palestinian water law mandates that irrigation water supply be managed by Water User Associations (WUAs). It is envisioned, therefore, that a significant portion of the management of the NGEST irrigation system will be by WUAs in the project area. Given the scale and complexity of the project infrastructure, however, it is suggested that, overall management is handled by the IAS, with members of WUAs as part of the IAS. This way, WUAs can be fully involved but not given the impossible task of starting from scratch with such a sophisticated system.

Because neither the IAS nor WUAs exist yet, it is recommended that CMWU manages it temporarily.

The time of transition while the IAS and WUAs are created is an opportunity: an opportunity to put the necessary legal, institutional, and infrastructural mechanisms in place to ensure effective and sustainable organizations. The information and recommendations contained in this *Report* are aimed at aiding in that endeavour.

5.2.1 WUAs in Gaza

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – a “collective well”. Namely, a farmer owns one well and other neighbouring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The survey shows that 92% of the farmers depend on the “collective well” system, owned by the remaining 8%.

Usually, the farmers using a collective well do not sign any formal agreement, neither are they linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmers do not pay his share in due time, thus undermining the efficient operation of the well.

The few existing WUAs in Gaza are generally small and loosely organized. This low level of organization makes it difficult to initiate joint actions. They are also faced with harsh economic and financial circumstances, including a very limited access to the international market for agricultural products. Nevertheless, it is expected that WUAs will become platforms for stakeholders' engagement, as they are designed with that purpose in mind.

5.2.2 Common Tasks of WUAs

The main tasks and activities commonly found in WUAs include:

- Choose and specify the joint water source and take part in the planning, designing and implementation.
- Define the roles and responsibilities to manage, operate and maintain the joint water source and its structures.
- Solve conflicts among water users by achieving a fair water distribution among the users.
- By mutual control and increased sense of ownership and responsibility, reduce violations over water.
- Take part in the tasks and functions for the management of I&D projects.
- Help to develop irrigation efficiency at a field and network level, also by facilitating the spreading of modern irrigation techniques.

5.2.3 Training Needs and Capacity Building

In order to ensure a sound, grass-root establishment of WUAs, a capacity building program should be carried out to create awareness among farmers on the advantages of operating together. Moreover, farmers will learn how to work as a group, sharing duties and rights, in a such a way that water will be equally distributed according to the planned irrigation schedule, which in turn will prevent disputes among users. The farmers will also acquire how to solve possible conflicts arising within the association.

On-farm technical assistance and training on I&D topics, in conjunction with best agricultural practice, shall be assured by the local IAS (Table 8).

Table 8: WUA capacity building and training needs; estimated costs for 20 farmers

TOPIC	DURATION (Days)	ESTIMATED COST (US$)
Capacity building and awareness	10	80,000 US$
Operation and maintenance of traditional irrigation schemes	10	80,000 US$
Operation and maintenance of modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc.	10	80,000 US$
Operation and maintenance of on-farm drainage systems	5	40,000 US$
Field application the agro-meteo recommendations	5	100,000 US$

	Total	380,000 US$

5.2.4 Economic sustainability of WUAs and Costs

While they may be entitled to claim subsidies or state assistance, WUAs are usually largely self-financing, the bulk of their income being provided by their participants. It is presumed that in the first 3 to 5 years, farmers will cover only those costs which are related to a WUA's management (financial and administrative affairs) and are necessary to run the organization's basic activities (e.g. office rent, administration staff salaries etc.). At a later date, farmers could pay a variable quota related to covering I&D operation costs. This could be done by paying member fees charged on an annual or monthly basis, or calculated in proportion to farm size.

In the initial period, costs related to I&D infrastructure maintenance and possible extension and/or modernization should be incurred by CMWU, not the farmers. Nevertheless, it is envisaged that in parallel with the process of WUAs becoming fully operational, their members contribution to such costs will increase gradually with the final objective of ensuring associations' financial independence (i.e. covering own costs of operating and maintaining infrastructure under their authority).

It should be noted that, because they are non-profit, WUA-specific legislation could confer powers on WUAs to take and impose compulsory measures. These can include: the right to impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; the right to make binding operational rules concerning, for example, the use and allocation of irrigation water; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts (FAO, 2007).

Table 9 shows an estimated cost breakdown for the establishment and operation of a WUA (gathering approximately 20 farmers) in the area of the NGEST Water Reuse Scheme.

Table 9: Estimated costs for the establishment and operation of one WUA, for 1 year

ITEM	UNIT	COST (USD)
4x4 car	1	25,000 USD
Office automation equipment for administrative affairs	Forfeit	25,000 USD
Salary for administrative staff	1	30,000 USD
Capacity building and Training for WUA	380,000 US$ (see Table 8)	
Running costs	Forfeit	20,000 USD
	Total	480,000 US$

5.3 Cost Sharing Mechanisms

Typically, WUA costs include some, or all, of the following (FAO, 2003):

- The cost of obtaining a permit to abstract and use water and/or to drain water or to dispose of wastewater together with any water use and wastewater disposal charges payable pursuant to such permit;
- Charges in respect of water supplied to the WUA on a contractual basis by a state agency (such as an irrigation agency) or some other bulk water supplier;
- The WUA's own costs of operating and maintaining the infrastructure under its authority which may include staff salaries, office expenses (including the costs of rent, utilities and communication), operation costs including the costs of electricity if pumps are used, system maintenance including routine and annual maintenance, the maintenance of an emergency reserve fund, small replacement fund, transport expenses, purchase of equipment, social charges and taxes; and
- Investment costs for the construction, rehabilitation or reconstruction of infrastructure.

As mentioned above, a key feature of WUAs across the world is that they are usually self-funding, at least as far as operating costs are concerned. The typical sources of WUAs finance include fees and charges for services provided by WUAs to its participants (in majority of cases this is the main part of WUAs income; such fees and charges include WUAs administrative costs), borrowing, grants and subsidies, income from assets or capital owned by WUAs, and fines from participants who have breached its operating rules.

Fees and charges can include:

- Irrigation water supply charges;
- Drainage charges;
- Annual membership fee; and
- Any other charges levied by WUAs.

The way in which the level of fees is determined can be left up to WUAs or specified in the relevant legislation. The amounts payable by individual WUA participants are assessed based on e.g. the volume of water supplied (if the main WUA service is water provision), flat rate charged per hectare of land (in case of a range of different and not easily measurable services provided by WUA), or value of possessed agricultural land. At this stage, a proposal is made to charge water to the farmers based on the water delivered to their farms and in order to recover costs for O&M and WUAs. The proposed tariff is 0.63 ILS/m^3 of water.

In case farmers are unable to pay charges until after the irrigation season is over and they have harvested their crops, a range of methods is applied to overcome the problem, such as: participants paying deposits in respect of the service to be provided, WUAs borrowing money by way of a loan or bank overdraft or issuing bonds, or finally, WUAs receiving governmental or other grants.

It is recommendable that a WUA fund can be established to provide cost sharing bases for matching grants to assist the establishment and start up of WUAs (having an initial capital of US$ 1 million). This is deemed important otherwise WUAs may fail due to low membership dues from the majority of small farmers.

5.4 Coordination Between WUAs, Farmers, and Ministries

In order to lay the ground for an improved administrative structure for irrigation and drainage in the future, it is advisable to establish a body that will work towards better inter-agency coordination between different ministries, particularly between PWA, CMWU and MoAg and is able to include local farmers in the decision-making process. The agency should have an overall objective of working towards improved efficiency of water use in the irrigation sector and overall increased efficiency of the agricultural production. At the beginning, the agency could operate on a pilot scale, e.g. focus on implementing on-farm modernized irrigation system in the NGEST Project area and/or implementation of modernisation programme for off-farm irrigation and drainage facilities. The agency recommended to fill this role is the Irrigation Advisory Service (IAS).

5.5 Irrigation Advisory Service (IAS)

Often introduction of more effective irrigation technologies and techniques as well as rehabilitation of irrigation and drainage facilities *per se*, does not improve significantly the efficiency of water use and overall agricultural production. The key is to help users (farmers) in applying and adopting new methods into/onto their fields and limit the problems resulting from insufficient know-how and inadequate handling. Experience of countries with irrigated agriculture shows that introduction of Irrigation Advisory Service (IAS), which assists farmers, helps to address these problems. The typical scope of IAS services includes:

- Crop water management and scheduling services;
- Irrigation performance analysis services;
- Advice on design, installation, of irrigation equipment;
- Irrigation management support services (from both administrative and technical perspective);
- Advice on environmental and, in particular, water quality aspects;
- Agricultural advisory services; and
- Training of farmers.

IAS can be provided by several different bodies - private, public or co-operative - each with their specific capabilities, resources and mandate. Those can include irrigation agencies, agricultural agencies, extension services, NGOs and irrigation equipment producers or consultants. Two aspects, critical for the success of IAS, should be highlighted, these are:

- Providing a suitable legal framework and institutional setting for IAS functioning; and
- Ensuring IAS financial sustainability (paramount especially in developing countries where often insufficient or no resources are made available for such purpose).

Some examples of institutional set-ups concerning IAS in developing countries are presented in Annex 2. The Nigerien case study has been presented in more detail due to significant gains made in the country's irrigation sector thanks to the active role of IAS and application of inexpensive technologies.

The NGEST Water Reuse Scheme would greatly benefit from hosting its own resident IAS.

5.5.1 IAS structure and Composition

The IAS should have a nimble structure, with one director managing a multi-disciplinary technical team: in total, 14 people from the CMWU, MoAg and representatives from local WUAs. Table 10 illustrates the proposed IAS composition.

The IAS shall be assisted for field activities by the existing local staff of the CMWU and MoAg, and act as coordination unit for related on-farm initiatives. The IAS shall be directly linked with the future WUAs that will be established to manage irrigation water distribution. Furthermore, efforts shall be made to link IAS with the private sector as well. For instance, when a group of farmers will be willing to upgrade the on-farm irrigation scheme, the IAS shall make the technical designs as well as support the farmers to identify a reliable retailer, by also checking whether the quality of the goods matches the required quality standard.

Table 10: IAS Staff Composition

NO.	AREA OF EXPERTISE	INSTITUTION	QUALIFICATION
1	I&D	CMWU	PhD, Director
2	On farm irrigation technology	CMWU	Eng.
3	On farm drainage	CMWU	Eng.
4	Land reclamation	CMWU	Eng.
5	Water distribution	CMWU	Eng.
6	Information Technology	CMWU	Eng.
7	Relationships with WUAs	PWA	Eng.
8	Plant Production and Soil Fertility	MoAg	MSc
9	Plant Protection	MoAg	MSc
10	Agro-meteorology	MoAg	MSc
11	Rural Extension	MoAg	MSc
12	Research & Development - Water Engineering	PWA	PhD
13	Research & Development - Irrigation & Drainage	PWA	PhD
14	Administration		

5.5.2 Typology of Delivered Services

The IAS is expected to deliver extension and technical advice to the farmers under its jurisdiction, such as:

- Operation and Maintenance of the Recovery Scheme
- Operation and Maintenance of the Irrigation/Reuse Scheme

- Good practice on land levelling;
- Identification of good on-farm irrigation methods, tailored to soil characteristics and cropping system;
- Irrigation scheduling and water amount according to crop needs over the growing season;
- Fertilization plan, according to water actually available over season and irrigation schedule;
- Good practice of operation and maintenance of the irrigation system;
- Agro-meteo information to support decision-making on pests and diseases control strategies, following the method of the Integrated Pest Management (IPM);
- Advice, capacity building and training support to the local WUAs for their set up and operation;
- Mediation with retailers about the procurement for farmers of irrigation equipment and materials.

5.5.3 Training Needs

An effective implementation of reforms in the irrigation and drainage sector depends to a large extent on prolonged training of irrigation agencies/irrigation advisory service staff. This means that training and related activities should not constitute a short-term effort but become part of a long-term program that eventually evolves into a consultative, problem-solving process that encompasses ongoing technical guidance and consultation between irrigation advisory staff and other I&D stakeholders (WUAs, farmers organizations etc.)

From this perspective, training should cover a broad range of areas and address both technical requirements (e.g. related to engineering, agriculture, and socio-economy) and management needs (i.e. financial, administrative, auditing and monitoring aspects), but above all, develop skills in assisting stakeholders to build their knowledge and experience.

In addition, training should set up the conditions to allow technicians and researchers, coming from different areas of expertise, to work together to cooperate with farmers, as individuals and/or united in WUAs. In other words, training should aim at establishing a real multidisciplinary work team.

The following training needs for a potential IAS team have been identified (see Table 11).

Table 11: Capacity building and Training needs; participants and estimated costs for IAS team

TOPIC	NO. PARTICIPANTS	DURATION (Days)	ESTIMATED COST (US$)
Facilitation and training skills	14	30	168,000 USD
Design, operation and maintenance of modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc. Basic level.	7	15	42,000 USD
Design, operation and maintenance of modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc. Advanced level.	7	10	28,000 USD
Design, operation and maintenance of modern on-farm surface irrigation systems.	7	5	14,000 USD
Design, operation and maintenance of on-farm drainage systems.	8	7	22,000 USD
On farm drainage, drainage water removal and	8	10	32,000 USD

conveyance out of the irrigation areas towards the drainage outfalls			
Soil pedology, salt leaching, land reclamation	7	5	14,000 USD
Computer models application in I&D	7	5	14,000 USD
GIS and remote sensing application for improved water management in I&D	11	5	22,000 USD
I&D management transfer (including participatory irrigation management/WUAs formation process and backstopping)	11	15	66,000 USD
Study tour to abroad (to be selected)	11	7	77,000 USD
Use of the agro-meteo stations network. Interpretation of weather forecasting and recommendation for farmers	11	15	165,000 USD
Irrigation methods and schedule for effective pest and disease control	11	7	30,000 USD
Basic training to CMWU and MoAg local team on the scope and organization of IAS	40	4	64,000 USD
		Total	758,000 USD

5.5.4 Economic Sustainability of IAS and costs

The cost of the salaries of the IAS members will be covered by the concerned ministries: an extra allowance of 30% of the basic salary shall be considered in order to provide an incentive to work on the proposed IAS.

Table 12 shows the breakdown of costs for the establishment and operation of one IAS. While the items to be considered as intrinsic costs for the ministry were not identified, the additional services costs are here listed.

Table 12: Estimated costs for the establishment and operation of one IAS, for 1 year

ITEM	UNIT	COST (USD)
Two-storey building (400 m^2) for IAS office, training room, equipment, etc., including furniture	1	350,000 USD
4x4 car	2	50,000 USD
Tractor trailer	1	70,000 USD
Small Backhoe/Loader tractor	1	40,000 USD
Office automation (PC desktops; laptops; printers, internet, etc.)	Lump Sum	50,000 USD
Field equipment: automatic levels and staff gauges, simple hand held GPS equipment, Digital Cameras," Idrometers", 3 inch hand augers to take soil samples, water quality comparator hand held kits, flow measurement devices such as 6 inch Parshal Flumes, hand tools for canal maintenance	Lump Sum	100,000 USD
Salaries for IAS staff members (+ 30%)	14	Ministry intrinsic cost
Capacity building and Training for IAS Staff	758,000 USD (see Table 11)	

Dissemination and communication activities	Lump Sum	Ministry intrinsic cost
Running costs	Lump Sum	Ministry intrinsic cost

5.6 Recommendations

- Create an Irrigation Advisory Service

The establishment of an Irrigation Advisory Service is proposed as highly strategic in view of the NGEST Water Reuse Scheme in Northern Gaza and as a pilot for the rest of Gaza.

IAS shall manage the NGEST reuse scheme, in cooperation with MoAg and WUAs. It will have the shape of a public inter-ministry agency and the capacity and skills to advise farmers about on-farm Irrigation and Drainage (I&D) and appropriate water-saving crop management; in addition, the Service shall recommend the best irrigation schedule as a function of rain and pests and diseases probability.

The IAS shall have a nimble structure, with one director managing a multi-disciplinary technical team: in total, 14 people from CMWU, MoAg, and WUAs.

Training has to be considered as part of a long-term program that eventually evolves into a consultative, problem-solving process that encompasses ongoing technical guidance and consultation between irrigation advisory staff and other I&D stakeholders.

- Immediately pass enabling legislation for the creation of WUAs

There should be specific WUA legislation addressing the establishment and operation of a WUA. Although there is no "blueprint" for the design of WUAs (just as each irrigation system is different so it is likely that each individual WUA will be different), common themes in WUA legislation across the world offer guidance. In particular, the role of an effective WUA law is to set out the basic parameters within which the design of each individual WUA can be crafted. At the same time, such a law must set out minimum criteria necessary to ensure transparency and robust governance structures while conferring substantive legal rights and duties on WUA members.

One of those substantive legal rights is the long term right to abstract water from a natural source or, more commonly, a long term contractual right with a bulk water supplier (e.g. the new National Water Company). Annual contracts with no legislative backing offer little in the way of water security. What if there is a dispute? How can a WUA be sure that the supplier will enter into a new contract the following year? Ideally such contractual arrangements should be backed up with legislation that should also specify that within their service area WUAs are to have an exclusive right to supply irrigation water.

Additionally, WUAs will very often need to have express legal rights to use publicly owned irrigation infrastructure. If WUAs do not have such rights or if they are weak or vague then very quickly problems regarding responsibility for maintenance can arise with no-one willing to undertake this. (FAO, 2003)

According to the Water Sector Reform Plan 2016-2018 and confirmed by representatives of PWA in May 2017, a by-law on WUAs is currently under review by the Cabinet of Ministers. Its contents are unknown to the Consultant, so it is unclear whether these issues have been addressed.

6 PROJECT ECONOMICS AND FINANCIAL SUSTAINABILITY

6.1 Micro-Economic Conditions

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

This section of the *Report* assesses what the net income for farmers would be with and without the project and assesses the availability in the farmers' budget to pay for water.

6.1.1 Evolution of the Cropping Pattern

The analysis assumes that famers will be able to fully implement the proposed cropping pattern and irrigation methods over a period of four years. These changes, changing the existing land use and planting trees and vegetables, are expected to increase land productivity.

The analysis of the value chain has shown that some crops such as fresh fruit (peaches, apricots, plums) are scarcely produced and often imported goods. Olive, as a crop to produce olive oil, is often sold at a low price and profitability might be improved by nearly 50% if olives, especially the better-preserved ones of the right variety, are processed into eatable olives. The new cropping pattern also includes almond as a profitable and long-lasting, easy to preserve, type of crop.

The newly proposed cropping pattern cannot produce the desired increase in production and profits unless farmers are extensively trained (see above for specific recommendations on capacity building for water user associations and farmers). Furthermore, It would be desirable for farmers to unite in associations or cooperatives to jointly handle the supply chain through the use, for example, of refrigeration storage facilities that allow the consumption of perishable products over a longer period of time.

Table 13: Evolution of the Cropping Pattern

					Land Development Over Time [Years]			
	BEFORE		**AFTER**		**Y1**	**Y2**	**Y3**	**Y4**
Crops and crop groups[6]	**%**	**du**	**%**	**du**	du	du	du	du
Citrus	5	603	22	2,655	1,116	1,629	2,142	2,655
Olive	8	930	23	2,776	1,392	1,853	2,314	2,776
Almond	2	272	10	1,207	506	739	973	1,207
Peaches	5	587	7	845	652	716	780	845

[6] Crops marked in red are those that, in future conditions, will occupy less land if compared to present conditions

Other fruit tree crops	5	544	3	362	499	453	408	362
Grains*	31	3.684	12	1,448	3,125	2,566	2,007	1,448
Winter vegs	13	1.603	4	483	1,323	1,043	763	483
Winter vegs (tomato in greenhouse)	1	121	3	362	181	241	302	362
Summer vegs	8	1.009	6	724	938	867	795	724
Alfalfa (green fodder)	4	509	10	1,207	684	858	1,032	1,207
Uncultivated	18	2.205	0	0	1,654	1,102	551	-
Total	**100**	**12.068**	**100**	**12,068**	**12,068**	**12,068**	**12,068**	**12,068**
* grains: wheat + barley								

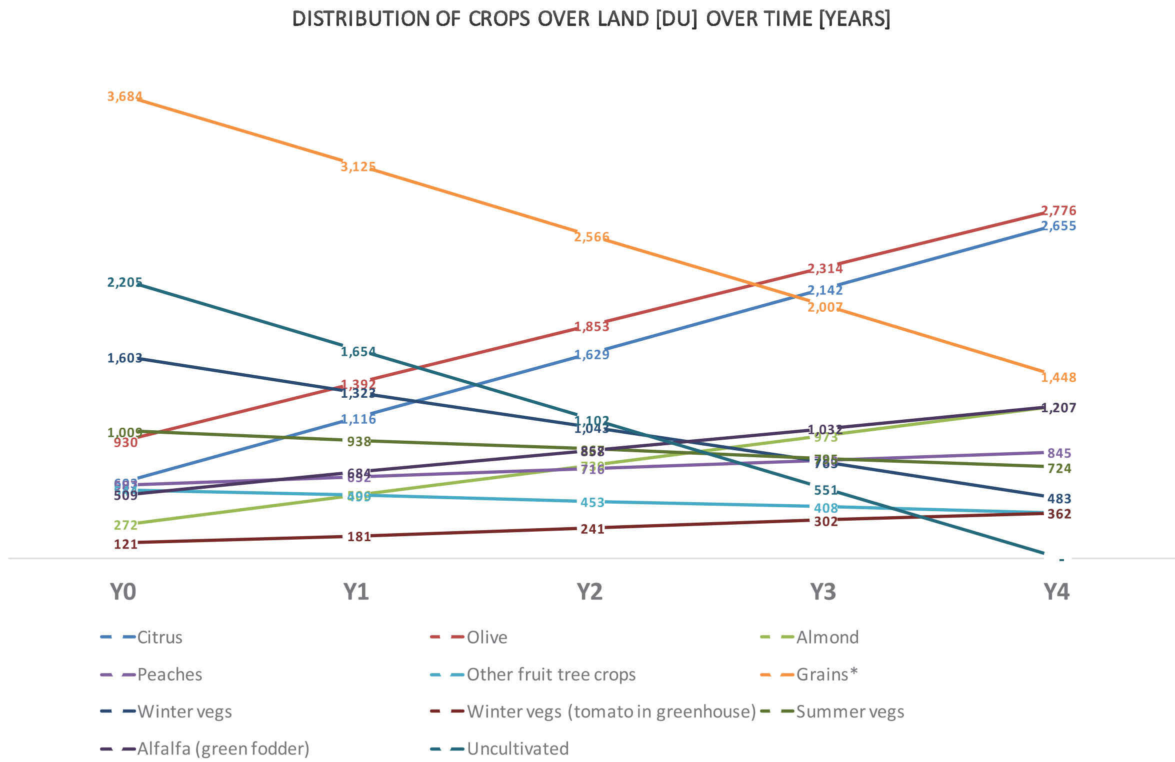


Figure 22: Evolution of the cropping pattern over land [du] over time [years]

6.1.2 Farm-Level Investments

Investments at the farm level would be largely spent on an increase in tree plantations and greenhouses placed in areas located away from the border with Israel.

The following table summarizes investments, expressed in Israeli New Shekel (ILS) per dunum (du) by type of crop and by type of material / activity required to produce such crop.

Table 14: Farm-level Investment [ILS] per dunum [du]

Crops and crop groups	Farm-level Investment [ILS/du] Green house	Trees	Irrigation grid	Labour	Machinery	Inputs	Total
Citrus		400	380	400	0	200	1,380
Olive		800	380	400	0	200	1,780
Almond		1,20	380	400	0	200	2,180
Peaches		1,00	380	400	0	200	1,980
Other fruit tree crops							-
Grains*							-
Winter vegs							-
Winter vegs (tomato in greenhouse)	37,500		492				37,99 2
Summer vegs							-
Alfalfa (green fodder)			1,080	80	0	200	1,360
Uncultivated							

Considering the evolution of the cropping pattern, total investments at farm level are provided in the following Table 15.

Table 15: Farm-level investments evolution during four years of full stage

	Farm-level Investment at (ILS x 1,000)			
Crops and crop groups	Y1	Y2	Y3	Y4
Citrus	708	708	708	708
Olive	821	821	821	821
Almond	509	509	509	509
Peach	128	128	128	128
Other fruit tree crops				
Grains*				
Winter vegs				
Winter vegs (tomato in greenhouse)	2,292	2,292	2,292	2,292
Summer vegs				
Alfalfa (green fodder)	237	237	237	237
Total ILS x 1,000	**4,695**	**4,695**	**4,695**	**4,695**

Based on the new cropping pattern, balance sheet statements have been re-calculated by considering:

- a new cultural organization;
- more modern and efficient farming practices due to training activities and better extensions services;
- better and more effective phytosanitary defence;

- a more rational distribution of the irrigation network of the farm;
- a sizable reduction in net irrigation water demand;
- a higher production, especially of the tree plants due to increased attention to thinning, correct ripening and fruit calibration;
- a water tariff based on the 0,63 ILS/m^3.

6.1.3 Water Tariff

The water tariff has been prudently calculated including the effect of climate change, system losses, unexpected events due to pipe breaks, possible defects and/or breaks of the water metering system, possible reading errors of the water metering system and considering a margin of tariff increase of about 40%.

The balance sheet was calculated on the basis of a ILS/m^3 fee of 0.63 derived from the following calculation:

Annual Cost for O&M and WUAs/IAS [ILS/year]	Gross Water Requirements [m^3/year]	Net Irrigation Water Requirements [m^3/year]	Tariff ILS/m^3
4,956,799.90[7]	11,110,000	7,833,484	**0,63**

The details of the number presented above are given in the following Table 16:

Table 16: Gross and Net Irrigation Water Requirements at farm level and excluding industries

Type of Crop	Net Irrigation Water Demand	Gross Irrigation Water Demand
Crop	m^3/year	m^3/year
Citrus	2,196,183	3,114,835
Olive	1,957,104	2,775,750
Peaches	531,016	753,138
Grains	448,785	636,509
Other fruit	225,297	319,538
Summer vegetables	470,724	667,626
Winter vegetables	141,871	201,216
winter tomato greenhouses	51,337	72,811
Almond p	750,992	1,065,128
alpha-alpha p	1,060,174	1,503,639
Total m^3/year	**7,833,484**	**11,110,191**

[7] The annual cost of the WUAs is assumed to be 300,000 ILS and added to the O&M costs.

6.1.4 Breakeven Point of Water Tariff

In order to better qualify how the balance sheet of each individual crop changes by changing the water tariff, the break-even point between costs and revenues was estimated for each crop. The results, displayed in the following table, show that a large part of the crops have the costs and revenues balance between a tariff of 0,90 ILS/m^{3}and of 2,49 ILS/m^3.

Water price sensitivity is lower in summer and winter vegetables, while only vegetables grown in the greenhouse can withstand a high cost per cubic meter of water.

Table 17: Water tariff that involve zero net margin

Crops	olive	citrus	peaches	grain	other fruit crop	summer vegetable	winter vegetables	winter greenhouses	almond	alpha alpha
water tariff ILS/m^3	1.00	1.63	2.49	-0.89	1.76	3.31	6.56	42.51	0.90	1.14

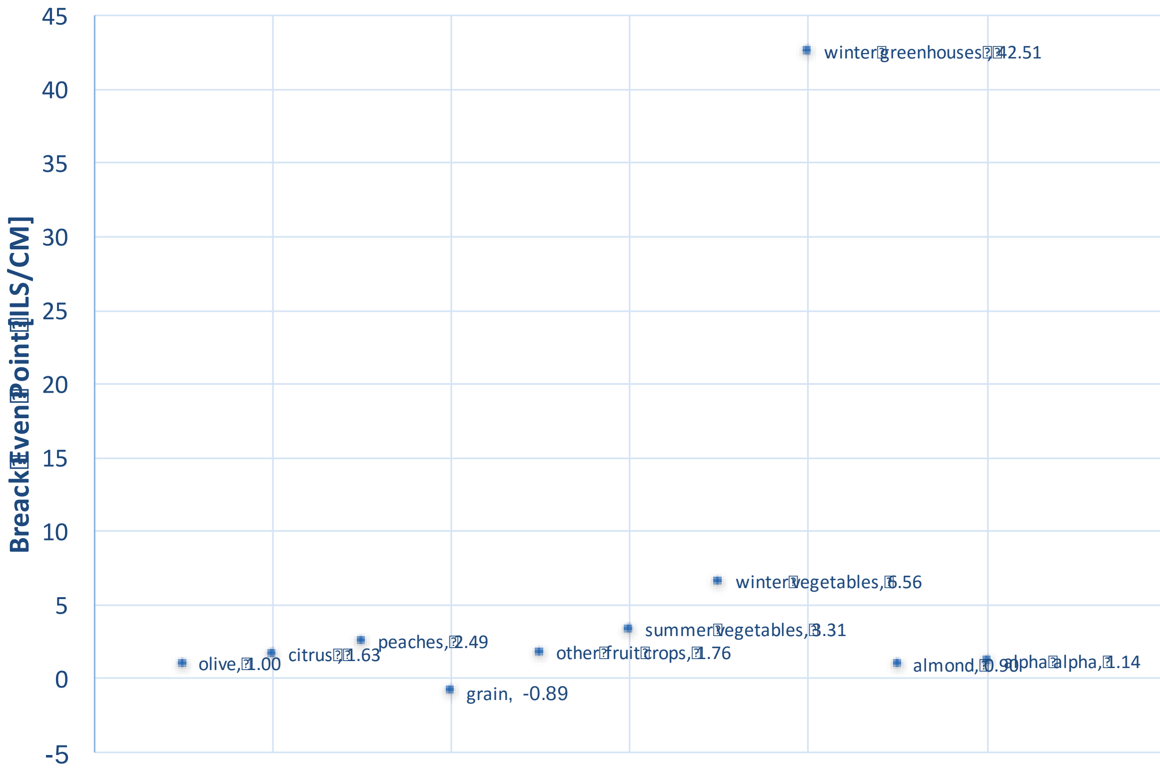


Figure 23: Water tariff that involve zero net margin

It is assumed that the following costs will be paid by the farmers: the Operation & Maintenance (O&M) costs of the irrigation network inside the farms; and the costs for training and operation of the Irrigation Advisory Services (IAS) and Water User Associations (WUA). The farmers would be charged based on the actual water they consume. Water consumption is measured by a water meter installed at the manhole located at the farm gate.

6.1.5 Balance Sheet for the Cropping Pattern

A summary and detailed analysis for both costs and revenues associated with each crop as suggested by the newly proposed cropping pattern is provided in the following series of tables.

Table 18 Summary of the Financial Costs [ILS x 1,000]

Crops	Y1	Y2	Y3	Y4
Citrus	2,493	3,639	4,784	5,930
Olive	2,253	2,999	3,746	4,493
Peaches	995	1,094	1,192	1,291
Grains	3,584	2,943	2,302	1,661
Other fruit crops	857	779	701	622
Summer vegetables	2,118	1,957	1,796	1,635
Winter vegetables	2,854	2,250	1,646	1,042
winter tomato greenhouses	486	648	810	972
Almond	599	875	1,152	1,429
alpha-alpha	777	975	1,173	1,371
Total for the Financial Costs [ILS x 1,000]	**17,016**	**18,159**	**19,302**	**20,445**

Table 19: Summary of the Financial Revenues [ILS x 1,000]

	Y1	Y2	Y3	Y4
Citrus	3,456	5,044	6,632	8,220
Olive	2,672	3,558	4,444	5,329
Peaches	1,792	1,969	2,146	2,323
Grains	2,109	1,732	1,355	978
Other fruit crops	1,253	1,139	1,024	910
Summer vegetables	3,751	3,466	3,181	2,896
Winter vegetables	5,158	4,066	2,975	1,883
winter tomato greenhouses	1,901	2,534	3,168	3,801
Almond	728	1,065	1,401	1,738
alpha-alpha	1,077	1,351	1,626	1,901
Total for the Financial Revenues [ILS x 1,000]	**23,898**	**25,924**	**27,951**	**29,978**

The detailed balance sheet for each crop are provided as follows:

Table 20: Balance sheet for Citrus

	Revenues	**Q.ty kg/du**	**ILS/kg**	**ILS/du**	***Margin***
		1,800.00	1.72	***3,096.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	80.00	5.00	400.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.			-	
Plant Protection*	kg.	4.00	100.00	400.00	
irrigation	m3	827.20	0.63	523.43	
Harvesting - Labour	dd	14.00	40.00	560.00	
Harvesting - machinery	h			-	
Depreciation of the plant	**1,380**	duration years	35.00	39.43	
TOTAL				***2,272.86***	***823.14***

Labour & Enterprise					1,383.14
***aver. q.ty*aver. Prices**					

Table 21: Balance sheet for Olive

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
olive oil 50%		45.00	16.00		
tables olive %		300.00	4.00	***1,920.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	450.00	0.50	225.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	3.00	40.00	120.00	
irrigation	m3	705.10	0.63	446.17	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h	5.00	6.00	30.00	
Olive's milling	kg.	45.00	3.50	157.50	
Depreciation of the plant	**1,780**	duration yrs	40.00	44.50	
TOTAL				***1,663.17***	***256.83***
Labour & Enterprise					576.83

Table 22: Balance sheet for Peaches

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		1,100.00	2.50	***2,750.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	628.60	0.63	397.76	
Harvesting - Labour	dd	4.00	40.00	160.00	
Harvesting - machinery	h			-	
Depreciation of the plant	1,980.00	duration yrs	35.00	56.57	
TOTAL				***1,584.33***	***1,165.67***
Labour & Enterprise					*1,325.67*

Table 23: Balance sheet for Grains

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		450.00	1.50	***675.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.33	60.00	79.80	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	100.00	0.50	50.00	
Irrigation pipes (/5 y)	ml	1400.00	0.70	196.00	
Plant Protection	kg.	4.00	15.00	60.00	
irrigation	m3	309.90	0.63	196.10	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h			-	
Seedings	kg.	20.00	2.25	45.00	
TOTAL				***1,146.90***	***(471.90)***
Labour & Enterprise					*(151.90)*

Table 24: Balance sheet for Other fruit crop

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		750.00	3.35	***2,512.50***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.50	60.00	150.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	250.00	0.50	125.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	622.30	0.63	393.77	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h	5.00	6.00	30.00	
Depreciation of the plant	1,800.00	duration yrs	20.00	90.00	
TOTAL				***1,808.77***	**703.73**
Labour & Enterprise					**1,023.73**

Table 25: Balance sheet for Summer vegetables

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		5,000.00	0.80	***4,000.00***	

	Costs	Q,ty/du	ILS/unit.	ILS/dun	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	500.00	0.50	250.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	15.00	25.00	375.00	
irrigation	m3	650.10	0.63	411.36	
Harvesting - Labour	dd	15.00	40.00	600.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				***2,258.36***	***1,741.64***
Labour & Enterprise					***2,341.64***

Table 26: Balance sheet for winter vegetables

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		3,000.00	1.30	***3,900.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	50.00	5.00	250.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	12.00	25.00	300.00	
irrigation	kg.	293.90	0.63	185.97	
Harvesting - Labour	dd	20.00	40.00	800.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				***2,157.97***	***1,742.03***
Labour & Enterprise					2,542.03

Table 27: Balance sheet for *winter tomato greenhouses*

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		7,000.00	1.50	***10,500.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	

Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	25.00	25.00	625.00	
irrigation	m3	141.80	0.63	89.73	
Harvesting - Labour	dd	30.00	40.00	1,200.00	
Harvesting - machinery	h			-	
Seedings	kg.	0.02	8,000.00	120.00	
Depreciation of greenhouse	mq	750.00	50.00	1,875.00	** 20 year*
TOTAL				***4,559.73***	***5,940.27***
Labour & Enterprise					7,140.27

Table 28: Balance sheet for *Almond*

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		180.00	8.00	***1,440.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	8.00	25.00	200.00	
irrigation	m3	622.30	0.63	393.77	
Harvesting - Labour	dd	3.00	40.00	120.00	
Harvesting - machinery	h			-	
Depreciation of the plant	2,180.00	duration yrs	25.00	87.20	
TOTAL				***1,270.97***	***169.03***
Labour & Enterprise					289.03

Table 29: Balance sheet for *Alpha alpha*

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		4,500.00	0.35	***1,575.00***	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	0.00	100.00	-	
Chemical Fertilizers	kg.	0.00	5.00	-	
Organic Fertilizers	kg.	0.00	0.50	-	

Soil Disinfection	kg.			-	
Plant Protection	kg.	0.00	25.00	-	
irrigation	m3	878.50	0.63	555.89	
Harvesting - Labour	dd	6.00	40.00	240.00	
Harvesting - machinery	h			-	
Depreciation of the plant	1,360.00	duration yrs	4.00	340.00	
TOTAL				***1,135.89***	***439.11***
Labour & Enterprise					679.11

6.2 Macro-Economic Conditions

6.2.1 Methodology

Cost-benefit analysis (CBA) is a formal analysis technique used in public and private investment projects (Rakhra, 1991) as well as in programs and policies (Stoica, 2005) in order to make a comparative assessment of all the benefits and costs anticipated. It also represents an attempt to measure the costs endured and gains earned by a community or a private company after the project is implemented.

CBA proves its usefulness in feasibility studies (from an economic, environmental, social or technological perspective) by selecting the optimal option for investment projects (Hanley and Spash, 1993). The purpose of using CBA in a sector is to set up pragmatic administrative rules in order to *allocate resources efficiently*.

The use of cost-benefit analysis contributes to determining the financial sustainability as well as profitability of the NGEST water reuse scheme. It also:

a) highlights the economic and financial viability of the NGEST water reuse scheme for different scenarios;
b) enables the identification of possible errors in the design or implementation phase (incorrect information, unrealistic hypotheses, etc.); and
c) enables the correction needed to properly conduct the NGEST water reuse scheme.

6.2.2 General Project Assumptions

Within the CBA, costs are presented in terms of capital investments and operation and maintenance (O&M); the first being a one-time cost and the second being a recurring, yearly, cost.

The entire water recovery and re-use scheme requires capital investments to be implemented over time to provide water in two separate areas (Phase I for 500 ha and Phase II for 1,000 ha). The implementation of each phase has been subdivided into two separate tendering packages. The details are provided in the following Table 30.

Table 30: Investment required for the implementation of the recovery and irrigation schemes

Phase	Package	Description	Cost US$	Cost ILS x 1,000
I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$8,449,164	30,518
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)	$6,015,625	21,728
II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$5,830,333	21,059
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)	$15,984,375	57,736
			$36,279,497	**131,042**

A distribution of the capital investments over time for each phase and for each tender package is provided in the following Table 31 where costs are expressed in ILS per 1,000.

Table 31: Phase I e Phase II implementation stage

Phase	Package	Description	Phase 1	Phase 2	Y1	Y2	Y3
			ILS x 1,000		*ILS x 1,000*		
I	**1**	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	30.518		30.518		
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		21.728		21.728	
II	**1**	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	21.059			21.059	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)		57.736			57.736
		TOTAL [ILS x 1,000]	**51.578**	**79.464**	**30.518**	**42.788**	**57.736**

The O&M cost are provided in the following Table 32.

Table 32: Annual O&M costs (US$)

Operation and Maintenance Cost		Phase I	Phase II
Description	USD	USD	USD
Manpower	150,000	90,000.00	60,000.00
Power consumption	978,953	326,317.56	652,635.11
Maintenance and repair works	83,345	27,781.67	55,563.33
Consumables & Miscellaneous	76,960	25,653.33	51,306.67
Total O&M cost USD/year	**1,289,258**	**469,752.56**	**819,505.11**

Table 33: Annual O&M costs (ILS)

Operation and Maintenance Cost		Phase I	Phase II
Description	ILS	ILS	ILS
Manpower	541,800.00	325,080.00	216,720.00
Power consumption	3,535,977.04	1,178,659.01	2,357,318.03
Maintenance and repair works	301,042.14	100,347.38	200,694.76
Consumables & Miscellaneous	277,979.52	92,659.84	185,319.68
Total O&M cost USD/year	**4,656,798.70**	**1,696,746.23**	**2,960,052.47**

Other costs that are included in this CBA are the water tariff, assumed to be 0.63 ILS/m^3, and the investments required at the farm level to support the introduction of the proposed cropping pattern as detailed in the Micro-Economic Conditions section.

Costs for supporting and training the Irrigation Advisory Services (IAS) and Water User Association (WUA) are assumed to cost 3,000,000 ILS, divided in 2,000,000 ILS for the first year and 1,000,000 ILS for the second year.

6.2.3 *Financial Analysis*

The financial analysis indicates whether the project will generate a positive net cash flow during the evaluation period (profitability) and whether the cumulative cash flow from the start of investment until the final prediction is negative (sustainability).

The analysis of the investment project's cash flow includes both the evaluation of the cash outflows (investment costs as well as and costs at farm level) and cash inflows (revenues at farm level, industries, grant and subsidies). As opposed to the economic analysis, in the financial analysis the cash flow does not include amortization, reserves and other accounting items.

From this perspective, the financial analysis was conducted with the following steps:

1. Estimating revenues and costs of the NGEST area farms and assessing the implications of these parameters on cash flow;
2. Defining the financing sources of investment and analysing the financial profitability.
3. Determining the funding gap in achieving the investment project and identifying the best mechanisms to attract funding;

4. Checking whether the estimated cash flow could ensure the proper operation of the NGEST project. The investment project is financially sustainable if there is no risk of running out of cash during the operation.

For the financial analysis, the following costs and revenues were taken into account:

Cash Outflows (Costs)

- Capital cost – recovery wells, farm investment
- Costs related to the IAS and WUA operation and training
- Operation Costs at farm level including water tariff

Cash Inflows (Revenues)

- Revenues at farm level derived from the new cropping pattern
- Water tariff paid by Industry based on 1 ILS/m^3 per 70,000 m^3 /year
- Reduction of time spent in management of private wells
- Investments paid by Government/Donors
- Public Subsidies based on farm water tariff of 0.63 ILS/m^3

The financial analysis carried out as part of the project's CBA uses market prices (which include VAT and indirect taxes) to check the balance of the investment and the sustainability of the project.

The cash flows accumulated in different years during the evaluation period (25 years) require a fair discount rate. The financial discount rate allows to account for the influence of time on the value of money and reflects the opportunity cost of the investor’s capital.

In general, it is recommended to use a discount rate of 5%, but the model also used 2 more points (7%) and less (3%) to evaluate the sensitivity of the net present value.

6.2.3.1 Scenarios

Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

- (1) Capital Investment for the Water Recovery Scheme;
- (2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm’s Gate;
- (3) O&M Cost for the Water Recovery Scheme;
- (4) O&M Costs for the Water Reuse (irrigation) Scheme;
- (5) Capital Investments for Farm's Development.

The five scenarios are defined as follows

- **Scenario 1** - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under such scenario farmers would pay back the full cost for the construction of both the water recovery and the water reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- **Scenario 2** - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built and paid by the farmers;

- **Scenario 3** - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmer;
- **Scenario 4** - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that farmers will have to pay back the cost for the construction of Phase II of both the recovery and the reuse scheme. Government/Donors would cover the cost for the construction of Phase I. Farmers would pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered by the Government/Donors for the number of years required for the farmers to pay back the construction of Phase II.
- **Scenario 5** - Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for as many years as it takes for the farmers to be able to pay back for the improvement of their own farm. After that point, farmers will be responsible for paying O&M costs for the whole system.

A schematic representation of the five scenarios is provided in the following Table 34.

Table 34: Project Scenarios

Scenario	Description	Cost Paid by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investments for Farm's Development	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Government and not charged to the Farmers		x	x	x	Paid by the Government and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Government until Farmers have paid back the Construction of Phase II	x	x	Paid by the Government and not charged to Farmers	x
5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5).	Paid by the Government and not charged to the Farmers		Subsidized by Donors/Government until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)		x	Paid by the Government and not charged to Farmers	

6.2.3.2 Financial Sustainability of the Investment Project

The Government's ability to paid for the set up and operation of the NGEST Irrigation Project during the next 25 years (the so called 'Reference Period') is critical to the success of the investment and for achieving the overall objectives of this supplementary phase. From this perspective, the investment project should be financially sustainable without any difficulties regarding the fulfilment of its financial obligations during the reference period.

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

In order to determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

FNPV represents the amount calculated when the estimated investments and operating costs of the project are deducted from the present value of the projected revenues. The investment project is profitable in the financial sense if FNPV has a positive value.

FIRR represents the discount rate for which FNPV is zero or which equals the present value of the financial cash flows projected for the reference period. If this indicator is less than the cost of the capital, the project is not profitable. When it is higher than the cost of capital, the project is acceptable because it will generate a positive FNPV.

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

6.2.4 Main Results of Financial Analysis

Table 35: Main Results of the Financial Analysis

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)	Note
	3%	5%	7%	3%	5%	7%		
1	30.551	2.574	-16.780	1,062	1,006	0,954	5,23%	
2	12.959	718	-7.908	1,064	1,004	0,947	5,14%	
3	149.706	114.653	88.791	1,304	1,274	1,244	31,02%	
4	127.456	88.722	60.582	1,259	1,212	1,167	16,07%	17 years of subsidies to repay the phase II investment.
5	155.425	119.953	93.715	1,316	1,286	1,258	33,54%	5 years of subsidies to repay the investment at farm level

6.2.5 Economic Analysis

An economic analysis for major investment projects determines if the project contributes significantly to total economic welfare. It measures the project benefits depending on the following: the costs avoided due to project implementation and the external benefits arising from the implementation, which are not included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. These externalities should be given a monetary equivalent.

In the economic CBA, some cost/benefits cannot be expressed in monetary units but only in qualitative terms. These costs/benefits are:

- Preservation and improvement of the quality of space for human life, as in the case of water pollution when human settlements located near water lose their basic quality.
- Prevention of flora and fauna destruction.
- Maintenance of natural system which will have a positive effect on people, like better mental condition and richer intellectual activities.

Benefits that cannot be expressed in monetary value are also called “intangible” benefits. Those benefits have been ignored in the cost-benefit analysis of the project. The reason is that these benefits cannot be assessed, and their detailed qualitative effects can be better described in an environmental impact assessment.

In the economic cost-benefit analysis the costs are expressed in accounting prices, and are measured in terms of 'resource' cost or 'opportunity' costs.

The economic analysis could be briefly described with the following steps:

- Conversion of market prices into accounting prices;
- Update the estimated costs and benefits;
- Calculation of economic performance indicators (Economic Net Present Value, Economic Rate of Return, benefit/cost ratio).

The corrections to be considered in the economic analysis are the following:

Fiscal Corrections. Fiscal Corrections are necessary because some transfers from one agent to another should be seen as pure transfers, without having an economic impact. For example, the subsidies provided by the government to those who want to invest in the NGEST Irrigation Project represent a pure transfer offering advantages to the beneficiaries, but not creating economic value. The fiscal corrections are made for indirect taxes (VAT), subsidies and pure transfer payments (employer's obligation to pay social security contributions) which are generally included in the eligible costs and/or operating or maintenance costs. However, the prices should also include direct taxes. In addition, if certain indirect taxes/subsidies are aimed at correcting externalities, then they will be included in the analysis. In order to assess the project's economic impact, information on the tax system in the West Bank and Gaza, as calculated by World Bank, was used as presented in the following Table 36.

Table 36: Direct and indirect taxation in Gaza and West Bank

Tax or Mandatory Contribution	Payment (number)	Notes on Payments	Time (hours)	Statutory Tax Rate	Tax Base	Total Tax Rate (% of Profit)	Notes on TTR
Corporate Income Tax	2		18	15% - 20%	Taxable Profit	14.23	
Capital Gain Tax	1			15% - 20%	Capital Gains	0.76	
Municipal Business Tax	1			17%	Rental Value of Building	0.28	
Employee Paid - Personal Income Tax	12		96	5% - 20%	Taxable Salaries	0	withheld
Irrecoverable VAT (on fuel)	0			15%	Fuel Consumption	0	
Value Added Tax (VAT)	12		48	16%	Value Added	0	not included
Totals	28		48			15.27	

Correction of labour cost from financial to economic. The correction of financial costs to economic costs of the price of labour has been made. The coefficient used to correct the financial value was 0.3 to consider taxation and social charges.

To carry out a neutral evaluation, positive and negative externalities of the project were not considered.

Based on the consideration presented above, the main results of the economic cost benefit analysis are presented in the following Table 37.

Table 37: Main Results of the Economic Cost Benefit Analysis

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)
	3%	**5%**	**7%**	**3%**	**5%**	**7%**	
1	124.102	82.112	52.243	1,252	1,196	1,144	13,72%
2	51.291	33.420	20.586	1,254	1,194	1,137	12,62%
3	132.443	89.958	59.633	1,511	1,482	1,454	15,17%
4	130.885	88.143	57.658	1,462	1,416	1,371	14,64%
5	132.843	90.329	59.978	1,523	1,496	1,469	15,24%

6.3 General Aspects

6.3.1 Financing Mechanisms

The sources of funding provided by the various scenarios of the project are:

- government financial sources
- financial sources of international cooperation
- private financial sources

While government finance and international cooperation does not have direct impacts on the financial market system, it is necessary to provide support and guarantees to a private financing system. As we know the banking system requires, turning on a loan, guarantees and payment of the price of money (interest).

Farmers will need to have access to a banking system and most of them do not have enough income or capital to finance investment in farms or parts of the project, so it is necessary to provide them with support tools.

- First, the government must provide for a national guarantee fund supporting the banking system for when, due to personal problems or because of adverse meteorological conditions or distortions in market prices, the farmer is unable to repay the annual instalment of the loan.
- The second important thing is government or donor support for bank interest payments, given the high price of money locally. Farmers can repay the loan principal, but hardly the interest portion.

6.3.2 Job Impacts

The project in its full version creates new employment, the estimate of the level of direct employment is about 150 new employees and the job security for current employees.

Table 38: Job Created

Job created			**days/year**
job days created at Farm level			**23.741**
job days created WUAs			**4.400**
Job days created O&M			**4.840**
total job days created			**32.981**
Incremental labour	dd	**32981**	**+ 34%**
	n.people	150	

The government may provide for subsidies for young farmers who undertake to work on the farm in order to reduce youth unemployment.

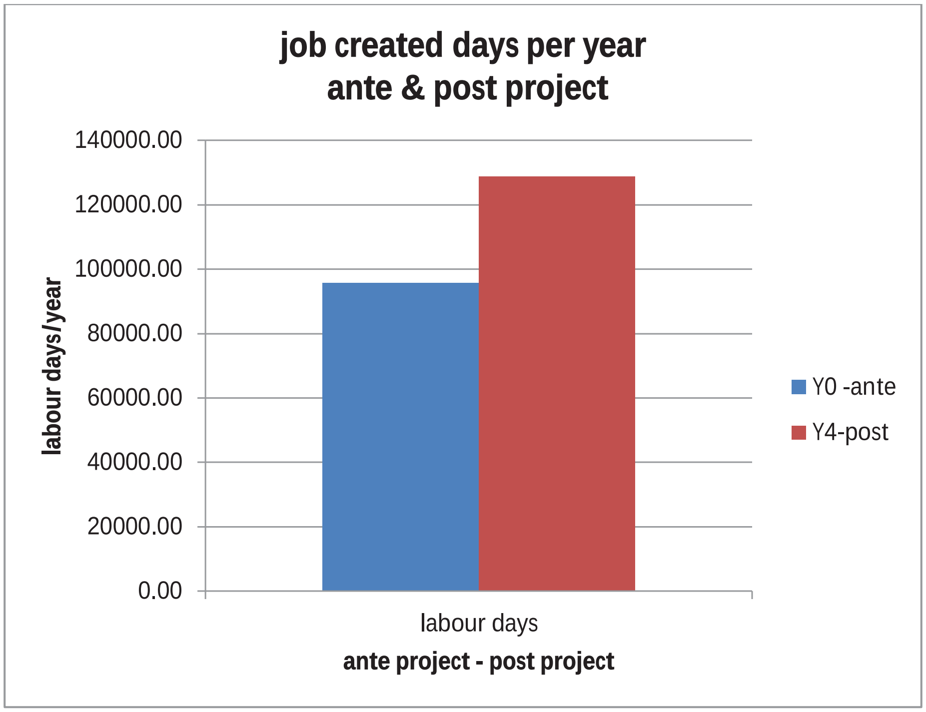


Figure 24: Job created per year before and after the project is implemented

7 CONCLUSION

This *DRAFT Complementary Feasibility Report* brings mostly good news. By reworking the original design, the project can save 21.5% of the water use while using 15% less energy, and can operate with a less complex irrigation schedule. It was determined that the project is in full compliance with Palestinian law, and should be financially sustainable by farmers. The review resulted in a new cropping pattern and design network, and offered innovative solutions to project O&M through a new IAS agency.

This *Report* also confirmed the validity of the original design for the recovery scheme and of the original design for the reuse (irrigation) scheme, confirming the selection of materials, the general layout and the selection of the pumping system. The newly proposed system fixes design inconsistencies of the original so that a minimum water pressure of 2.5 bars is provided to every farm gate.

The good news, however, is contingent. The water and energy savings, simplified irrigation schedule, and farmer profitability are contingent on improving the original design of the reuse scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern. The project's compliance with Palestinian law is contingent on a minimum level quality of water coming from the WWTP and being disposed of in the infiltration basins. And the project's feasibility and success overall are contingent on carrying out robust capacity building for ministerial and farmer stakeholders, and of adequately monitoring the Managed Aquifer Recharge component of the project.

8 ANNEXES

8.1 Annex 1: Roles and Responsibilities of Water Sector Entities as Defined By The Palestinian Water Law Of 2014[8]

FUNCTION	BY	OVERSEERS/PARTIES
Allocation of water resources	PWA	Other official and relevant authorities
Preparing general water policies, strategies and plans, seeking approval thereof, and ensuring their implementation	PWA	Relevant parties, as well as the Cabinet of Ministers
Protection zones to prevent pollution	PWA	In cooperation and coordination with relevant authorities
Licensing and development of Water Resources and utilization	PWA	In cooperation and coordination with the relevant authorities
Measures and plans as required to establish and develop the National Water Company and the Regional Water Utilities	PWA	In coordination with the relevant authorities
Supervising the organization of awareness raising campaigns in the sphere of water and wastewater and promoting the use of water saving fixtures	PWA	In coordination and cooperation with the relevant authorities
The development of plans and programs for capacity building, training and qualification of technical staff working in the water sector and supervising their implementation with the aim of improving the management of water resources	PWA	In cooperation and coordination with the relevant authorities
Equitable distribution and optimal use of water to ensure the sustainability of ground and surface Water Resources	PWA	In cooperation and coordination with the relevant parties
Developing solutions and suitable alternatives in cases of emergency and contingency to ensure the continuity of water provision services	PWA	In coordination with Service Providers and relevant parties
Scientific research and studies related to water and wastewater	PWA	Specialized and relevant authorities
Partake in the development of approved standards of water quality for various uses	PWA	In coordination and cooperation with the competent authorities

[8] Taken from Water Governance In Palestine: Sector Reform To Include Private Sector Participation, 2015.

FUNCTION	BY	OVERSEERS/PARTIES
All revenues collected	PWA	Deposit in the account of the Public Treasury
Accounts of the Authority and its records and all its financial affairs shall be regulated and audited	PWA	Ministry of Finance and Planning
Head of PWA appointment	PWA	Presidential Decree upon the recommendation of the Cabinet of Ministers
Deputy Head	PWA	Decision of the Cabinet upon a recommendation from the Head of PWA
Preparation of budget and financial reports	Head of PWA	Cabinet of Ministers for approval
Signing local and international water agreements on behalf of the Government	Head of PWA	Prior authorization from the competent and relevant authorities
Preparation of periodic reports concerning the activities of PWA and quality of performance, and the proposal of solutions for overcoming obstacles that hinder the progress of work	Head of PWA	To the Cabinet of Ministers
Establishment	WSRC	Decision of the Cabinet of Ministers
Regulating WSRC	WSRC	Be pursuant to this law
Reporting	WSRC	Cabinet of Ministers
Appointing Board of Directors	WSRC	Presidential decree , Cabinet recommends
Board Remuneration	WSRC	Regulation by Cabinet
Performance incentives	WSRC	Regulation by Cabinet
Internal regulations	WSRC Board	Approve and submit to Cabinet
Annual budget submittal	WSRC Board	Approve and submit to Cabinet
Audited financial reports submittal	WSRC	Relevant authorities
Audit and review of finances	WSRC	Official monitoring authorities
Regulating staff	WSRC	Board recommends to Cabinet
Issuing licenses and fees	PWA	Regulation from Cabinet
Terms of license stipulate prior approval	PWA	Competent authorities
Domestic harvesting	PH and Environ standards	Relevant official authorities
Prior use rights of Springs/wells and fees	PWA	Cabinet of Ministers
Licensing and registry and payments of fees	PWA	Right for public access to information
Water and wastewater tariffs	PWA	Regulation from Cabinet
Unified Bulk Water tariff	PWA	Regulation from Cabinet
Water prices	Service Providers	WSRC approves based on tariff regulations
- Regulation to create environment that would encourage private sector investment in water	PWA	Cabinet of Ministers

FUNCTION	BY	OVERSEERS/PARTIES
Capital of National Water Company	PWA	Decision by Cabinet
Financial affairs of National Water Company	PWA and MoF	Regulation from Cabinet
Water supply tariff and related services proposal	PWA	WSRC
Develop Unified Water Tariff Regulation	PWA	
Board of National Water Company	PWA	Cabinet decision
Quarterly and annual reports	NWC	WSRC and Cabinet
Establishing Regional Water Authorities	PWA	in coordination and cooperation with the relevant competent authorities
All matters	RWAs	Regulation from Cabinet
Provision of water and wastewater services	RWAs	Regulation from Cabinet
Establishing Water Users Association, joint recommendation	PWA jointly with MoAg	Regulation from Cabinet
Protect water resources and facilities and prevent their pollution by partaking proactively	PWA	Environmental Law and in coordination and cooperation with the authorities specialized in the protection of water resources and the prevention of their pollution
Regulation for protection of Water Resources and facilities	PWA	PWA recommends and Cabinet issues
Consideration of Water Resource Protection Zone and publication of notice	PWA	In coordination with other relevant parties and a regulation from Cabinet
Provide alternative resource to protected zone	PWA	As may be available, or compensate for damage as per existing laws
Applying penalties to specific offences	PWA	
Exercising current responsibilities	Existing institutions	Till RWAs and WUAs are established
Rehabilitate facilities of West Bank Water Department and in the transition period	PWA	Movable and immovable assets to PWA, powers and responsibilities to the National Water Company
West Bank Water Department final status	PWA	All assets, powers and responsibilities to the National Water Company
Regulations to implementation the Law	PWA	Cabinet issues regulations recommended by PWA

8.2 Annex 2: Example of Irrigation Advisory Services in Other Countries

8.2.1 NIGER

In Niger the government, apart from large scale irrigation schemes, supported also small- to medium-scale irrigation cooperatives (located on the perimeter of the large-scale projects) by providing them with technical extension support through the National Office of Hydro-Agricultural Perimeters. However, due to insufficient budget and incentives for efficient service provision, this technical support was weak. As a result farmers lacked knowledge and availability of irrigation technologies and maintenance service and lacked finance. These problems were addressed through the World Bank financed Pilot Private Irrigation Project that focused primarily on the poorest farmers and on selected private commercial irrigators. A private irrigation advisory body called the Nigerien Association for Promotion of Private Irrigation (Association Nigérienne de Promotion de l'IrrigationPrivée, ANPIP) became the implementing agency for the project. It took care of the promotion of small-scale irrigation technologies through information and assistance to farmers to access the technical and financial resources required for their adoption. ANPIP carried out promotional campaigns in support of the government's private irrigation development strategy; facilitated small farmers' access to legal and administrative assistance for obtaining tenurial security; and provided assistance, upon demand, in preparation of irrigation projects and in establishing economic interest groups. Tasks contracted out to consulting firms included testing and evaluating technologies, promoting grassroots savings and credit schemes (by an NGO), and project related evaluation studies and periodic audits.

The project has strongly supported the national agricultural strategy to increase productivity. Significant gains made in Niger’s irrigation sector included:

- ANPIP grew gradually from a small group of 10 people to 19 decentralized committees constituting 13,500 farmers;
- An information campaign about the new national irrigation policy (through printed booklets, a prospectus, and radio and TV commercials) reached 2,000 representatives of farmers, and administration and traditional authorities. Following this campaign, over 1,500 economic interest groups were established with membership of over 15,000 farmers;
- The training component included 382 training sessions covering 4,150 participants, and it was complemented by radio, television, newspaper, a printed handbook, and demonstrations in the local market;
- The project introduced the treadle pump and promoted the tubular borehole, submerged pumps, motor pumps, and irrigation via buried pipes as components of comprehensive on-farm water systems. Farmers pay the full cost of the technologies;
- Cultivated area increased by about 63 percent, and yields of major crops increased by 27 to 32 percent (onion and sweet pepper, respectively).

The implementation of the Pilot Private Irrigation Project encompassed the following lessons learned:

- The shift of project administration from government to a private agency (ANPIP) enabled a private sector management style, and the legal and administrative flexibility to execute the project;
- Promotion of private ownership of treadle pumps and improved irrigation technologies, with incentives for good operation and maintenance, was undertaken. In relying on genuine demand in deciding the location of local pump manufacture, the project increased the chances that the nascent treadle pump market would be sustained in the long run;

- Giving farmers a menu of technology options allowed them to choose the level of technology and investment appropriate to their farming conditions;
- Making available simple, locally made, and affordable technologies, and training local craftspeople to manufacture and repair treadle pumps, kept the supply chain between farmer and manufacturer as short as possible, ensuring that pump parts and repair expertise would be locally available. Adaptations to irrigation technologies reduced their prices; and
- Linking these basic technical changes with other changes, such as a sound irrigation policy, available credit, land tenure security procedures, and effective monitoring of project success, facilitated adoption and contributed to the program's success.

(Agriculture Investment Sourcebook, World Bank, 2006)

8.2.2 PHILIPPINES

In the Philippines water resources management is a responsibility of the national Government. In 1963 a government-owned and controlled corporation primarily responsible for irrigation development called National Irrigation Administration (NIA) was established. In particular, NIA plans, designs, constructs and rehabilitates all types of irrigation structures in the country. It operates, maintains and administers all national-scale, major irrigation infrastructure. In case of communal irrigation systems (secondary canals and on-farm facilities) it supervises their operation and maintenance delegating their partial or full management to organized associations and cooperatives (irrigation associations) who can count on its technical assistance and managerial training. NIA also charges and collects fees for water use for irrigation and promotes private sector participation in irrigation and drainage.

8.2.3 TUNISIA

In Tunisia the central government through the Ministry of Agriculture is the main player providing the lead and support for irrigation development and its management. However, the main advisory services are in support of agricultural inputs rather than water. Still training in irrigation is organised for farmers and there is extensive use of TV and radio (both judged as a very successful way of getting information to the extensive rural areas).

8.2.4 JORDAN

Jordan has a small irrigation area confined mainly to the Jordan valley, which comes under the jurisdiction of the Jordan Valley Authority (JVA) for water management. Most farms are privately owned but the JVA has set up an Irrigation Advisory Unit which offers design and on-farm management support and has introduced participatory management approaches. The Ministry of Agriculture has the responsibility for providing agriculture extension services.

8.2.5 CYPRUS

Cyprus has a relatively small irrigated area (40,000ha). IAS is free of charge to farmers and include on-farm irrigation, which is provided by the Water Use Section (WUS), a branch of the Department of Agriculture. WUS employs less than 50 technical staff and provides planning and design services as well as scheduling information and farmer training as of 1965.

8.3 Annex 3: Example of Water User Associations in Other Countries

8.3.1 INDIA

Rajasthan is the largest state of India (supporting about 50 million people) with 10% of the national area and only 1% of the country's water resources. Agriculture accounts for 83% of the total water use. Water resources management in Rajasthan has been affected by weak capacity and uncoordinated effort among water sector departments, a weak regulatory framework, poor management practices and unsustainable use of resources, and high recurrent cost of water delivery. Problems are inherent in past approaches based entirely on public sector resource management, with a lack of beneficiary participation in scheme management and financing.

In order to support Rajasthan in ensuring long-term, sustainable use of increasingly scarce water resources and in improving the water use efficiency for agriculture, the World Bank launched The Rajasthan Water Sector Restructuring Project (RWSRP). The project seeks to achieve the above-mentioned objectives through increase in:

(a) system efficiency by downsizing and improved coordination and rationalization of public sector agencies;

(b) involvement of users and the private sector in design and management of systems; and

(c) cost recovery from users.

Specifically, RWSRP finances:

- Water sector institutional restructuring and capacity building through creation of a state water planning department, modernization of the water sector department, and piloting a community-driven institution for groundwater management;
- Improving irrigation system performance through the formation and fostering of 620 WUAs, rehabilitation of irrigation schemes, strengthening of agricultural extension, and enhancing safety of 16 dams supplying the project area;
- Capacity building for a project management unit to ensure the effective implementation and coordination of activities involving several government departments.

The WUAs, over time and in close coordination with the Irrigation Department, are expected to take over the operation and management (O&M) of surface irrigation systems up to the distribution level. The Government of Rajasthan has committed to moving toward full cost recovery of O&M costs. The rehabilitation of irrigation schemes (about 90 major, medium, and minor schemes) also involves participation of WUAs, which contribute 15 percent of the rehabilitation costs.

The project would support at least three pilot schemes for a community-driven approach to groundwater management. This would involve the establishment of groundwater conservation districts (GCDs) covering identified aquifer areas with water depletion and quality problems. The GCDs would include an elected body of stakeholder representatives (rural and urban communities, farmers, industry, state agencies, and local government) empowered to develop and implement groundwater management plans, involving both supply- and demand-side approaches for groundwater management. The plans would be prepared at the village level by the Groundwater Management Associations and integrated at the community level by the Gram Panchayat Level Committees, with assistance from NGOs and technical support groups.

The project includes a pilot scheme on “commercialization of irrigation services” in a distributory command, which would develop a farmer-owned and -managed utility for the management of a larger command area on a commercial basis. The core function of this entity is to provide water to farmers and other users, and to manage and maintain the water supply assets, including irrigation and drainage facilities. The farmer company would develop into an autonomous entity that would operate on commercial lines and have a bulk water entitlement from the Irrigation Department.

The implementation RWSRP brought the following lessons learned:

- A strong government commitment to fiscal and institutional reform at the highest level, and a sound legal framework, is critical to the successful formation and operation of WUAs. WUAs can effectively and efficiently implement rehabilitation, if they are empowered early in the process;
- Agricultural demonstration programs for application technology should focus on a few high-quality demonstrations that can be replicated with good results;
- Minimizing the turnover of senior staff will improve the effectiveness and timeliness of the implementation of project activities;
- Funding from increased water charges can make funds available for O&M, improving the state's overall recurrent budget situation; and
- Hybrid policy and multisectoral, statewide investment projects are complex. Investments are better concentrated on a few critical issues. This lesson is reflected in the design of this project, which has limited project period objectives but is set in a longer-term context.

(Agriculture Investment Sourcebook, World Bank, 2006)

8.3.2 MALI

The Office du Niger in Mali was created during colonial times to produce cotton, but in the 1950s cotton cultivation was abandoned because of waterlogging, and rice became the dominant crop. In the early 1980s, financing agencies stimulated reform gradually by promoting small steps of change, such as establishment of village-level WUAs that could implement maintenance at secondary and tertiary canal levels. The Office du Niger agreed to allow tenant farmers to have long-term rights to remain on their plots. By 1984, the financing agencies had obtained the agreement of the government to grant farmers freedom to market their grains. They promoted successful distribution of small threshers and hullers, which broke the dependence of farmers on the Office du Niger for threshers and hullers. In 1987, financing agencies promoted adoption of a new farming license that gave farmers permanent tenure if they agreed to cultivate rice intensively and pay the water charge.

Adoption of participatory irrigation management occurred in Mali in the mid-1990s with an act of parliament and policy declarations by the prime minister. This reform granted partial authority of WUAs over operation and maintenance and dispute resolution and full responsibility to pay for operation and maintenance. Staff of the Office du Niger were made responsible to elected farmer representatives through joint management committees at secondary and main canal levels. Elected farmers represented half of the membership of these committees, each covering about 5,000 to 8,000 hectares. Farmers prioritized maintenance works and arranged three-year operation and maintenance contracts, which are now signed between government, farmers and the Office du Niger.

Market liberalization and better land tenure gave farmers the incentives to improve production, and rice yields increased from 2 tons/ha in 1982 to 6 tons/ha in 1996. This gave farmers sufficient confidence in scheme management that they agreed to a 50-percent increase in the water charge. The experience of the Office du Niger suggests that a series of modest infrastructure improvements and reform steps worked better than if financing agencies had refused to provide assistance unless the Government agreed to a comprehensive reform all at once. This approach matches the capacity level of the farmers and may be a suitable model for other low-income countries with a low level of literacy (Irrigation Management Transfer, FAO, 2007).

8.3.3 ALBANIA

In 1994, Albania adopted irrigation management transfer after a period of civil unrest that followed collapse of the central government in the early 1990s. By 1994, most of the irrigation infrastructure was badly deteriorated or damaged. At first, the irrigation agency resisted management transfer. Farmers lacked money to pay the cost of operation and management. However, the Government and the World Bank agreed on a programme to transfer management to WUAs and rehabilitate irrigation systems. The WUAs played a key role in planning, supervising rehabilitation, collecting water charges, and paying part of the cost of rehabilitation. This participatory role helped to generate a new feeling of ownership of the systems by farmers. Extensive training was given to farmers in technical, financial, administrative and agricultural topics. Agency staff were trained and reassigned. By 2001, Albania had 404 WUAs and 22 WUA federations, serving a total area of 169 550 ha (Irrigation Management Transfer, FAO, 2007).

8.4 Annex 4: Case Study - Irrigation and Drainage in Egypt

8.4.1 Background

In Egypt, similar to Palestine, over 90% of water use is in agriculture that at the same time is the lowest yielding and least efficient user of water.

The Egyptian Ministry of Water Resources and Irrigation (MWRI) plays a strategic and operational role in the irrigation and drainage sector. The first comprises the leading role in national planning and policy making.

Egypt's main water and irrigation strategy focuses on the development and conservation of water resources. This is achieved through adopting water rotation for irrigation canals, limiting the rice growing areas, lining irrigation canals in sandy areas and prohibiting surface irrigation in the new developed areas outside the Nile basin.

Egypt's recent water resources policies include different structural and several non-structural measures. Structural measures include: irrigation structures rehabilitation; improvement of the irrigation system; installation of water level monitoring devices linked to the telemetry system; and expansion of the tile drainage system. Non-structural measures include: expansion of water user associations (WUAs) for irrigation ditches; establishment of water boards at district levels; promotion of public awareness programmes; and involvement of stakeholders (FAO, 2005).

Regarding the MWRI's operational role, currently the Ministry is undergoing gradual handing over of responsibilities to the lower administrative tiers (see the following sections) but still includes tasks both at the national (e.g. implementation and operation of the Nile related infrastructure, the irrigation and drainage canals and the coastal lakes) and the district level. The Ministry includes various departments and sectors. From the irrigation and drainage perspective the most important units include (MWRI, 2005):

- Irrigation Department (composed of the following sectors: Irrigation, Groundwater, Horizontal Expansion Projects, Irrigation Improvement, and the Nile Protection Bureau);
- Egyptian Public Authority for High Dam and Aswan Dam;
- Egyptian Public Authority for Drainage Projects;
- Mechanical and Electrical Department; and
- Institutional Reform Unit (IRU) that has been established to guide the process of the development of the MWRI's vision and strategy as well as initiate and coordinate the implementation of the institutional reform of water resources management in Egypt.

At the lower administrative tiers, the MWRI has 22 Irrigation Directorates that are subdivided into 62 Inspectorates and about 206 Districts. The area of a district is between 20,000 and 60,000 feddan (this means some 40,000-100,000 farmers). Other organizational units relevant to irrigation include: feeder canal level (10,000-100,000 feddan, i.e. 15,000 – 150,000 farmers), branch canal level (1,000 – 12,000 feddan, i.e. 1,000 – 15,000 farmers), and mesqa level (10-100 feddan, i.e. less than 100 farmers) (MWRI, 2005).

Regarding drainage, the management is setup in a similar way with about the same number of Directorates, Inspectorates and 145 Districts. However, the organization was separate and as of 2001 the MWRI is in the process of integrating irrigation, drainage and groundwater management into Integrated Water Management Districts and introducing water resources management reform for which a dedicated unit at the MWRI has been established, i.e. the abovementioned IRU (MWRI, 2005).

Within reform, a portion of MWRI's management responsibilities are being decentralized and transferred to the lower administrative level. MWRI's Irrigation and Drainage District offices have consolidated to bring all water management responsibilities together in a single office called an Integrated Water Management District (IWMD). Further, to initiate a participatory management approach in the sector, Water Boards (operated at the district level) and Water Users Associations (operated at the branch canal and mesqa level) are being established. This, together with efforts to implement cost-sharing and cost-recovery mechanisms, aims to improve the existing water allocation and distribution system and enhance operation and maintenance. The deadline for implementation of reform is set for 2022.

In Egypt, irrigation and drainage are regulated by Law 12 originating in 1982 and Law 213 in 1994 regarding farmers' participation. Law 12 defines public properties related to irrigation and drainage; the use and maintenance of private canals and field drains; arrangements for the recovery of costs for drainage works; rules for water allocation and construction of water intakes along public properties; and the need for consultations with land owners before making any changes to water intakes. This law regulates the use of groundwater and drainage water as well as reclamation of new land (including price to be paid for its irrigation and drainage). Law 213 provided MWRI with a legal basis for enabling user organizations to play a role in the management of irrigation water at the levels of mesqa and above. It also established a fund to finance projects related to the development and maintenance of improved mesqa and to promote awareness with respect to water use (MWRI, 2005). Further, it enables the recovery of costs in case a landowner neglects their duties with respect to maintenance of the irrigation and drainage system.

Regarding the participation of other line ministries in the irrigation and drainage sector in Egypt, the role of the Ministry of Agriculture and Land Reclamation (MALR) should be emphasized. MALR is in charge of agricultural research and extension, land reclamation and agricultural, fisheries and animal wealth development. According to the latest National Water Resources Plan, MALR's objective is to improve food security and increase national agriculture production through maximizing the net return per unit of water. Key strategy elements to reach this objective include continuing the policy of liberalization and demand management, increasing the irrigation area in line with the availability of water, and increasing farmers' participation in the management of irrigation systems (MWRI, 2005).

8.4.2 Water Boards and Water Users Associations

As mentioned above, a fundamental institutional reform process of handing over water resources management responsibility from MWRI to lower tiers of administration was started in 2001 and will last until 2022. This reform aims at facilitating a greater involvement of water "end-users" and an increasingly multi-sectoral approach to water resources planning and control in the country. Within its framework Water Boards (WBs) and Water Users Associations (WUAs) are being established.

The results achieved up until May 2009 have been presented in the table below (MWRI, 2009). Although there is a continuous effort to establish new decentralized water bodies, the percentages as opposed to the final target still remain low. While most farmers recognize the importance of WUAs in the equitable distribution of available water, uneven water availability, either due to design shortcomings or to lax enforcement of rules against excess abstraction by front-end water users, has acted as a disincentive to the successful operation of WUAs in many instances. The successful progress of reform has been noted in those governorates which are characterized by a high unit of owned land (expressed in feddan per owner).

Organization Type	Final Target	Total Achieved (May 2009)	Percentage achieved compared to the target
Water Users Associations at mesqa level	80000	7000	8.75%

Water Users Associations at branch canal	4000	1000	25%
District Water Boards	204	4	1.96%

WBs assume the responsibility for integrated water management and are in charge of the operation and maintenance of water structures (pumps, canals, etc.) at the district level and are accountable to inspectors and water users. WBs also have the task of controlling unofficial reuse of drainage water and unauthorized pumping of groundwater. It has been planned that the setup of WBs will launch cost recovery for irrigation water by levying their own costs on their membership. This, however, is only a partial cost recovery since it does not take into consideration costs of the main system. Recovering the latter is a long-term process requiring further analyses of the real costs of the water service delivered, development of an adequate tariff setting mechanism and public-wide awareness campaigns.

Sub-units of WBs are responsible for water distribution (over the distributaries and the mesqa) and communication with stakeholders. The system foresees that daily intakes by individual mesqa is controlled by the number of hours that it is allowed to pump (depending on the size of the mesqa unit and the installed pump capacity).

Water Users Associations (WUAs) are legal entities governed by Law 213 benefitting from technical, managerial and financial autonomy (budget and irrigation tariff settings). WUAs have been designed to play an important role in water distribution between farmers at the branch canal and mesqa level. Farmers of one mesqa select representatives for the association's assembly and mesqas head regular meetings with authorities of the local water management district and local administration to address problems related to water distribution and determine issues related to construction, repair, and maintenance of the irrigation schemes and facilities (e.g. contracts conclusion, maintenance works planning) (EWA, 2007).

Over the past few years successful pilots have been carried out especially with the establishment of user organizations above the mesqa level (especially at the branch canal level; see the table above).

8.4.3 Advisory Panel Project on Water Management

The Advisory Panel Project on Water Management (APP) is a body that was established in Egypt in 1976 in the framework of the Egyptian and Dutch Bilateral Cooperation Programme. The APP was set up in response to the need for expertise in land drainage and irrigation following the construction of the Aswan High Dam and the corresponding large-scale drainage scheme in the Nile Valley and Delta. From the early years the APP, apart from providing such expertise and advice to the Egyptian Public Authority for Drainage Projects (EPADP) and MWRI's Drainage Research Institute (DRI), was supported by a number of projects aiming at developing new technologies tailor-made to country conditions. Over the years, the APP's focus has moved to other areas, e.g., groundwater management, water quality protection, and water policy development (including policy instruments and social aspects). Then, the APP evolved into an umbrella organisation encompassing all Egyptian-Dutch activities in the water sector, advising MWRI on more efficient and effective water management policy and taking an active role in policy development and implementation.

The APP is chaired by the Egyptian Minister of Water Resources and Irrigation. On the Egyptian side, it comprises directors from sectors and departments of the MWRI as well as MALR – this line ministry's representation was present from the beginning of APP's operation. Recently, an observer from the Ministry of Housing, Utilities and Urban Development has been added to reflect an integrated approach to water resources management. On the Dutch side, there is a representation of top officials from: the Ministry of Transport, Public Works and Water Management; the Ministry of Agriculture, Nature and Food Quality; Ministry for Economic Affairs; the Union of Water Boards. In addition, there is a financial expert representing the Dutch private sector and an independent co-chairman. The Ministry of Foreign Affairs has its observers. The APP is backed by a small, highly qualified Secretariat with a budget for supporting activities, such as workshops, meetings, consultancy services, field visits etc., financed by both countries.

The APP works using such tools as yearly Egyptian-Dutch panel meetings, workshops held at the national and regional levels, working group meetings, guided task forces, national and international consultant inputs (studies, reports, experts advise), field missions, capacity building seminars and trainings, coordination with Dutch financed development aid projects in other sectors. Lessons learned from the APP operation include knowledge and know how transfer (both from the Netherlands to Egypt but also from Egypt to the Netherlands, e.g., by employing experience gained in Egypt in other developing countries where the Dutch organizations and consultancies are present), creation of an irrigation and drainage equipment market for Dutch manufactures, source of technical assistance for water sector projects funded by development aid organizations, e.g., World Bank (APP 2009).

APP’s success factors include:

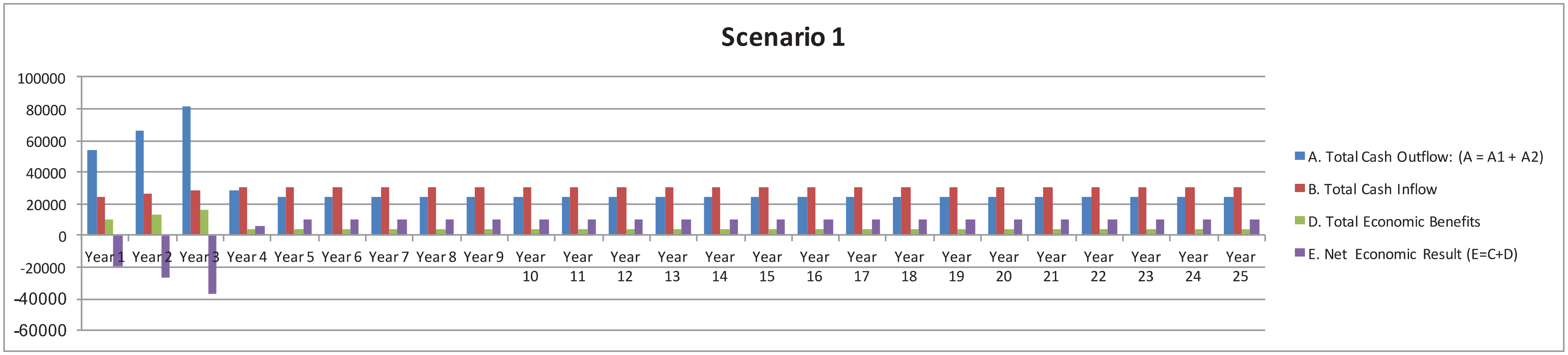
- Good preparatory discussions on relevant subjects supported by practical programmes and qualified professionals – both high-level public officials and private sector representatives
- Simple structure with a feedback and follow-up mechanism as well as an independent Secretariat
- Demand driven cooperation
- Financial commitment of both countries
- Cost-effectiveness – large spin-off effect and impact with a yearly budget of EUR 350,000
- Common understanding, trust and as a result equality of relations between panel members
- Willingness for continuous development and adaptation to changing circumstances and needs in the water sector in Egypt
- APP’s weaker points comprise:
- High dependency on political level and individual panel members’ commitment
- Sensitivity to experts fluctuation and little involvement of young specialist (especially on the Egyptian side)
- Insufficient use of modern communication channels (e.g., Internet) to disseminate results
- Less important role of international cooperation on the Dutch political agenda

8.5 Annex 5: Details of the Financial and Economic Analyses

8.5.1 *Scenario 1 – Details of the Calculations in ILS x 1,000*

Details			Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)											
A1. Capital Cost											
Investment cost at Farm level			4,695	4,695	4,695	4,695					
Training activities			2,000	1,000							
Recovery wells, tank and booster system			30,501	21,048							
Irrigation network				21,716	57,704						
A2. Operating Cost (Recurrent Expenses)											
Farmers pay off the investment						3742	3742	3742	3742	3742	3742
Cost at Farm level (including water tariff=	0.63	ILS/CM)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment	*152,751*										
A. Total Cash Outflow: (A= A1+ A2)	39,331		54,213	66,618	81,701	28,882	24,187	24,187	24,187	24,187	24,187
B. Benefit: Cash inflow: (ILS)											
Direct & indirect benefit											
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm *	1.0	ILS/CM	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657
Paid by Government/Donors											
Subsidies			0	0	0	0	0	0	0	0	0
B. Total Cash Inflow	55,466		24,625	26,651	28,678	30,705	30,705	30,705	30,705	30,705	30,705
C. Cash Flow Results: (C=B-A)	16,135		-29,588	-39,967	-53,022	1,823	6,519	6,519	6,519	6,519	6,519
Financial Internal Rate of Return	1.00%		FNPV@3%	**(24,024)**	BCR@3%	**0.956**					
Scenario 1 - full stage investment			FNPV@5%	**(39,976)**	BCR@5%	**0.913**					
			FNPV@7%	**(50,568)**	BCR@7%	**0.873**					
D. Economic Valuation											
Economic benefit											
Correction of labour cost from financial to economic			3,280	4,134	5,125	1,750	1,750	1,750	1,750	1,750	1,750
VAT Investment Adjustement			4,880	6,842	9,233						
VAT Revenues/Costs Adjustement			1,724	1,866	2,007	2,149	2,149	2,149	2,149	2,149	2,149
D. Total Economic Benefits			9,884	12,842	16,365	3,900	3,900	3,900	3,900	3,900	3,900
E. Net Economic Result (E=C+D)			-19,704	-27,125	-36,657	5,723	10,418	10,418	10,418	10,418	10,418
Economic Internal Rate of Return	9.57%		ENPV@3%	**69,527**	BCR@3%	**1.127**					
Scenario 1 - full stage investment			ENPV@5%	**39,563**	BCR@5%	**1.086**					
			ENPV@7%	**18,455**	BCR@7%	**1.046**					

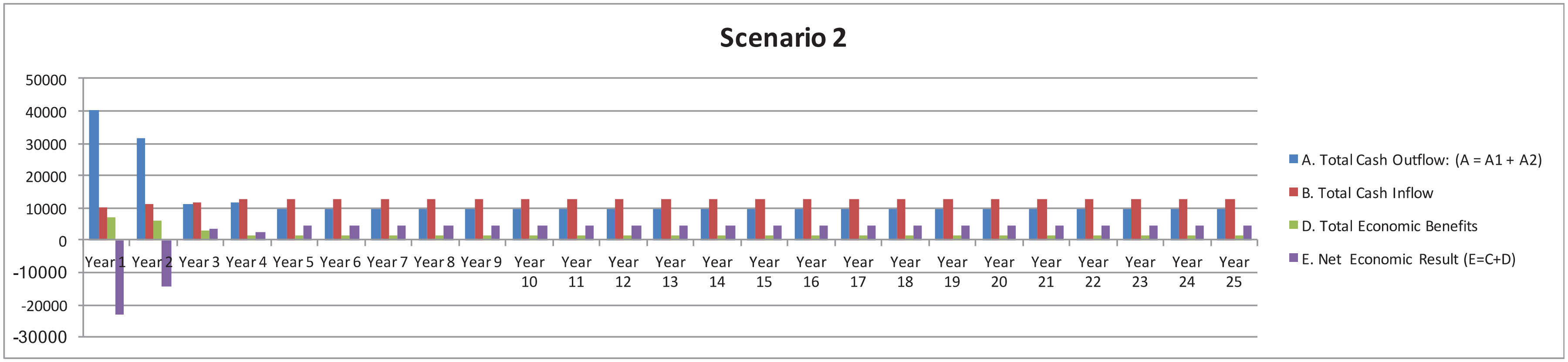
8.5.2 Scenario 1 – Cash Flow



8.5.3 Scenario 2 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				1,925	1,925	1,925	1,925					
Training activities				820	410							
Recovery wells - tank ans booster system				30,501								
Irrigation network					21,716							
A2. Operating Cost (Recurrent Expenses)												
Farmers pay off the investment						1492	1492	1492	1492	1492	1492	1492
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	6,977	7,445	7,914	8,382	8,382	8,382	8,382	8,382	8,382
Total investment	*61,148*											
A. Total Cash Outflow: (A = A1 + A2)	**302,209**			40,223	31,497	11,331	11,799	9,874	9,874	9,874	9,874	9,874
B. Benefit: Cash inflow: (ILS)												
Direct & indirect benefit												
Revenue at Farm level				9,798	10,629	11,460	12,291	12,291	12,291	12,291	12,291	12,291
Water tariff paid by industry 40,000 m³ *	1.0	ILS/CM		40	40	40	40	40	40	40	40	40
Time saved for non management of private wells				269	269	269	269	269	269	269	269	269
Paid by Government/Donors												
Subsidies				0	0	0	0	0	0	0	0	0
B. Total Cash Inflow	**310,023**			10,107	10,938	11,769	12,600	12,600	12,600	12,600	12,600	12,600
C. Cash Flow Results: (C=B-A)	**7,814**			-30,116	-20,558	439	801	2,726	2,726	2,726	2,726	2,726
Financial Internal Rate of Return	**1.10%**			FNPV@3%	**(10,167)**	BCR@3%	**0.955**					
Scenario 2 only Phase 1 investment				FNPV@5%	**(17,536)**	BCR@5%	**0.908**					
				FNPV@7%	**(22,598)**	BCR@7%	**0.863**					
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				1345	1695	2101	718	718	718	718	718	718
VAT Investment Adjustement				4880	3475	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				708	766	824	882	882	882	882	882	882
D. Total Economic Benefits				6,933	5,935	2,925	1,600	1,600	1,600	1,600	1,600	1,600
E. Net Economic Result (E=C+D)				-23,183	-14,623	3,364	2,401	4,326	4,326	4,326	4,326	4,326
Economic Internal Rate of Return	**8.72%**			ENPV@3%	**28,165**	BCR@3%	**1.125**					
Scenario 2 only Phase 1 investment				ENPV@5%	**15,166**	BCR@5%	**1.080**					
				ENPV@7%	**5,897**	BCR@7%	**1.036**					

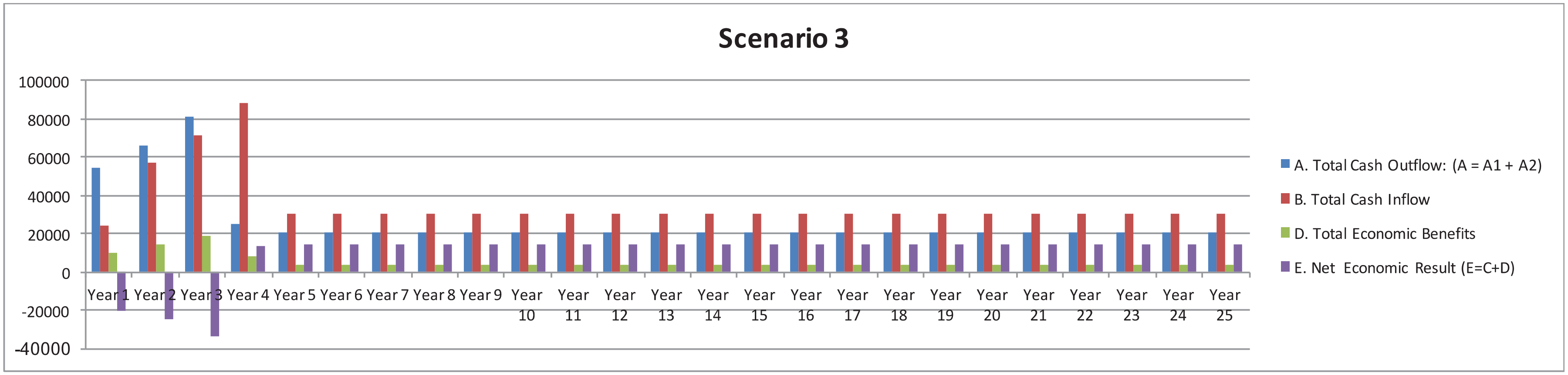
8.5.4 Scenario 2 – Cash Flow



8.5.5 Scenario 3 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				4,695	4,695	4,695	4,695					
Training activities				2,000	1,000							
Recovery wells, tank ans booster system				30,501	21,048							
Irrigation network					21,716	57,704						
A2. Operating Cost (Recurrent Expenses)												
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment		***152,751***										
A. Total Cash Outflow: (A= A1+ A2)		**657,007**		54,213	66,618	81,701	25,140	20,445	20,445	20,445	20,445	20,445
B. Benefit: Cash inflow: (NIS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm	*	1.0	ILS/cm	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors					30,501	42,764	57,704					
Subsidies												
B. Total Cash inflow		**886,435**		24,625	57,153	71,442	88,409	30,705	30,705	30,705	30,705	30,705
C. Cash Flow Results: (C=B-A)		**157,604**		-29,588	-9,465	-10,259	63,269	10,261	10,261	10,261	10,261	10,261
Financial Internal Rate of Return		**31.02%**		FNPV@3%	**149,706**	BCR@3%	**1.304**					
Scenario 3 : Capital cost payd by Government				FNPV@5%	**114,653**	BCR@5%	**1.274**					
				FNPV@7%	**88,791**	BCR@7%	**1.244**					
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				3280	4134	5125	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				4880	6842	9233	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1724	4001	5001	6189	2149	2149	2149	2149	2149
D. Total Economic Benefits				9,884	14,977	19,358	7,939	3,900	3,900	3,900	3,900	3,900
E. Net Economic Result (E=C+D)				-19,704	-24,990	-33,664	13,504	14,160	14,160	14,160	14,160	14,160
Economic Internal Rate of Return		**15.17%**		ENPV@3%	**132,443**	BCR@3%	**1.511**					
Scenario 3 : Capital cost payd by Government				ENPV@5%	**89,958**	BCR@5%	**1.482**					
				ENPV@7%	**59,633**	BCR@7%	**1.454**					

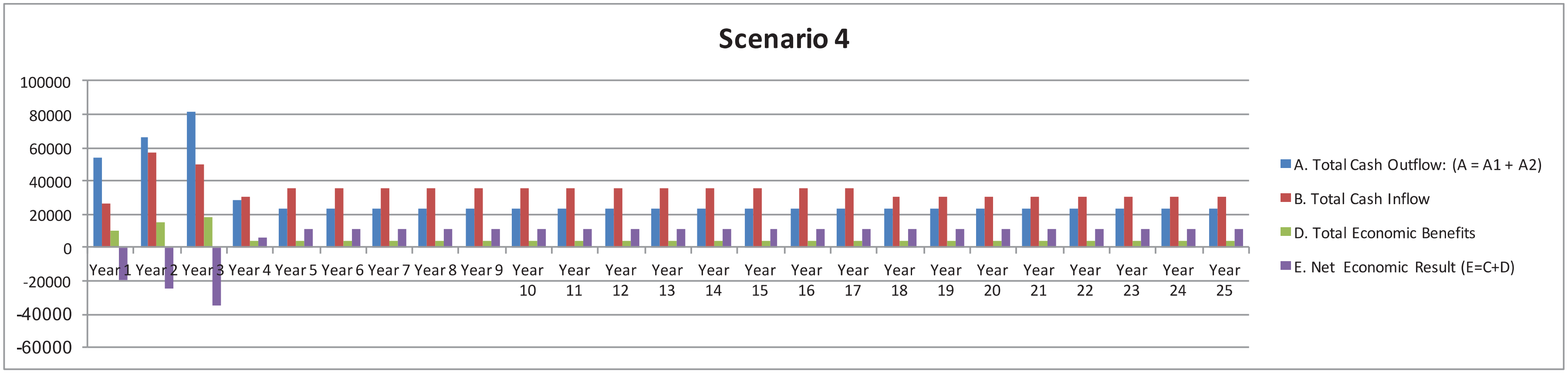
8.5.6 Scenario 3 – Cash Flow



8.5.7 Scenario 4 – Details of the Calculations in ILS x 1,000

Details	Total	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)										
A1. Capital Cost										
Investment cost at Farm level		4,695	4,695	4,695	4,695					
Training activities		2,000	1,000							
Recovery wells - tank ans booster system		30,501	21,048							
Irrigation network			21,716	57,704						
A2. Operating Cost (Recurrent Expenses)										
Farmers pay off the investment					3150	3150	3150	3150	3150	3150
Cost at Farm level (including water tariff= 0.63 ILS/CM)		17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment	*152,751*									
A. Total Cash Outflow: (A= A1 + A2)	**726,307**	54,213	66,618	81,701	28,290	23,595	23,595	23,595	23,595	23,595
B. Benefit: Cash inflow: (ILS)										
Direct & indirect benefit										
Revenue at Farm level		23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm * 1.0 ILS/CM		70	70	70	70	70	70	70	70	70
Time saved for non management of private wells		657	657	657	657	657	657	657	657	657
Paid by Government/Donors			30,501	21,716						
Subsidies		1,487	2,974	4,957	4,957	4,957	4,957	4,957		
B. Total Cash inflow	**873,609**	26,112	57,153	50,395	30,705	35,662	35,662	35,662	30,705	30,705
C. Cash Flow Results: (C=B-A)	**97,529**	-28,101	-9,465	-31,306	2,415	12,067	12,067	12,067	7,111	7,111
Financial Internal Rate of Return	**12.25%**	FNPV@3%	**81,515**	BCR@3%	**1.151**	investm. Phase II		8,751		
Scenario 4 Capital cost phase 1 paid by government - subsidies for 17 years to farmer payd capital cost phase 2		FNPV@5%	**52,904**	BCR@5%	**1.116**	subsidies		8,813		
		FNPV@7%	**32,140**	BCR@7%	**1.082**	17 year of subsidies				
D. Economic Valuation										
Economic benefit										
Correction of labour cost from financial to economic		3280	4134	5125	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement		4880	6842	9233	0	0	0	0	0	0
VAT Revenues/Costs Adjustement		1828	4001	3528	2149	2496	2496	2496	2149	2149
D. Total Economic Benefits		9,988	14,977	17,885	3,900	4,247	4,247	4,247	3,900	3,900
E. Net Economic Result (E=C+D)		-19,600	-24,990	-35,137	6,315	11,357	11,357	11,357	11,010	11,010
Economic Internal Rate of Return	**11.13%**	ENPV@3%	**84,944**	BCR@3%	**1.338**					
Scenario 4 Capital cost phase 1 paid by government - subsidies for 17 years to farmer payd capital cost phase 2		ENPV@5%	**52,325**	BCR@5%	**1.304**					
		ENPV@7%	**29,216**	BCR@7%	**1.272**					

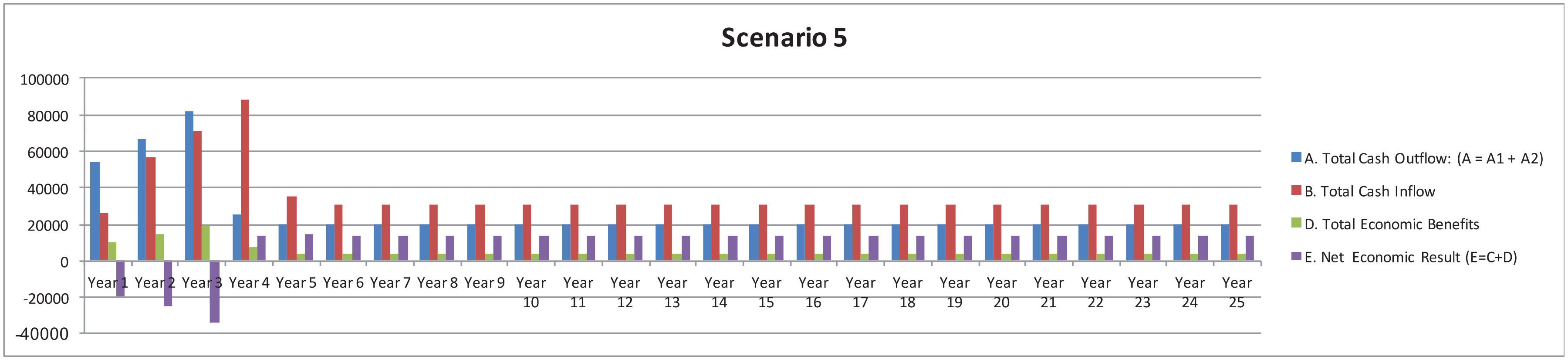
8.5.8 Scenario 4 – Cash Flow



8.5.9 Scenario 5 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				4,695	4,695	4,695	4,695					
Training activities				2,000	1,000							
Recovery wells, tanks ans booster system				30,501	21,048							
Irrigation network					21,716	57,704						
A2. Operating Cost (Recurrent Expenses)												
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment	***152,751***											
A. Total Cash Outflow: (A = A1 + A2)	**657,007**			54,213	66,618	81,701	25,140	20,445	20,445	20,445	20,445	20,445
B. Benefit: Cash inflow: (ILS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm	*	1.0	ILS/CM	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors					30,501	42,764	57,704					
Subsidies				1,487	2,974	4,957	4,957	4,957				
B. Total Cash Inflow	**892,879**			26,112	57,153	71,442	88,409	35,662	30,705	30,705	30,705	30,705
C. Cash Flow Results: (C=B-A)	**164,048**			-28,101	-9,465	-10,259	63,269	15,217	10,261	10,261	10,261	10,261
Financial Internal Rate of Return	**33.54%**			FNPV@3%	**155,425**	BCR@3%	**1.316**	investm. Fram level		18,782		
Scenario 5 Capital cost payd by government and and O&M patd by government util repayd invest				FNPV@5%	**119,953**	BCR@5%	**1.286**		subsidies	19,332		
				FNPV@7%	**93,715**	BCR@7%	**1.258**		5 year of subsidies			
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				3280	4134	5125	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				4880	6842	9233	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1828	4001	5001	6189	2496	2149	2149	2149	2149
D. Total Economic Benefits				9,988	14,977	19,358	7,939	4,247	3,900	3,900	3,900	3,900
E. Net Economic Result (E=C+D)				-19,600	-24,990	-33,664	13,504	14,507	14,160	14,160	14,160	14,160
Economic Internal Rate of Return	**15.24%**			ENPV@3%	**132,843**	BCR@3%	**1.523**					
Scenario 5 Capital cost payd by government and and O&M patd by government util repayd invest				ENPV@5%	**90,329**	BCR@5%	**1.496**					
				ENPV@7%	**69,978**	BCR@7%	**1.469**					

8.5.10 Scenario 5 – Cash Flow



8.6 Annex 6: Water Sector Capacity Development Programs of Donors and Financing Partners[9]

Many international governments provide financial assistance to the Palestinian Authority, and a significant portion of that goes to support the water sector. Many of these water programs have capacity development components, depending on the aims and policies of each government and the agreements they make with either the Palestinian Authority or the Palestinian Water Authority. Listed below, alphabetically, are the names of the funding and implementing agencies of different governments and a brief description of their contributions to capacity development in the Palestinian Water Sector.

Agence Française de Developpement (AFD) - Focuses on building capacities in water supply and sanitation as well as institutional support.

Austrian Representative Office- Supports the on-going Water Sector Reform process, capacity development in rural communities in wastewater, water supply and water quality, irrigation water capacity development and storm water management.

Czech Development Agency- Support began in 2011 with the planning and implementation of a water management system for the PWA.

European Union- The EU has been supporting the PWA in wastewater, sanitation and reuse, water governance, water policy and regional cooperation since 2006.

Formin Finland- Finland has been supporting the capacity of the PWA to manage projects since 1999. It focuses on institutional development and capacity development of the Joint Service Councils.

German Development Cooperation- Since 2006, the German government has been supporting the PWA in developing regulation capacities as well strengthening the technical, managerial and financial capacities of the Water Service Providers.

Italian Development Cooperation- Focuses on supporting other NGOS and the PWA in water service provision to the most vulnerable in Palestine.

Japan International Cooperation Agency (JICA)- Focuses building a new sewerage department in the Jericho Municipality through building capacities in O&M, financial management including setting tariffs and fees, and other technical trainings for the WWTP.

Kingdom of the Netherlands- Established a long term academic cooperation project between five Palestinian and five Dutch Universities to improve individual, organization and institutional capacity of the Palestinian higher education sector to improve the effectiveness of the Palestinian water sector regarding the development, provision and management of water resources and services.

Spanish Cooperation (AECID)- Conducts awareness raising activities to promote safe water management as well as capacity development in reuse of treated wastewater, water resources management, and access to sanitation. It also provides direct institutional support to the PWA.

[9] Taken from PWA Capacity Development Strategy, 2016

Swedish Development Cooperation- Beginning in 1998, Sweden has supported the PWA and the Palestinian Water Sector mostly in Gaza through storm water and wastewater management support.

World Bank- The World Bank has funded various Capacity Development projects in the Palestinian Water sector, most notably the “Water Sector Capacity Building Project” from 2011- 17, which is supporting the entire water sector reform process.

UNDP- Mostly working on improvement of governance, access to services and fostering regional cooperation. Previously the UNDP provided capacity support to the Costal Municipalities’ Water Utility for water supply monitoring. Currently the UNDP focuses on capacity development in wastewater treatment and management.

UNICEF- Beginning in the 1980’s, support from UNICEF to capacity development in the Palestinian Water Sector focuses on upgrading databases and information systems in the PWA and the Coastal Municipal Water Utilities in Gaza as well as awareness raising for hygiene.

UNRWA- One of the main overall service providers in Palestine, UNRWA is in charge of water quality assurance, vector control, solid waste disposal and sanitation inspections. It focuses only on refugee camp situations.

8.7 Annex 7: International Case Studies of Regulatory Systems for the Artificial Recharge of Aquifers with Treated Wastewater[10]

8.7.1 South Africa

Under the general framework of the National Water Policy for South Africa and the National Water Resources Strategy, an Artificial Recharge Strategy was finalised in 2007. "Artificial recharge (AR) is [defined as] the process whereby surface water is transferred underground to be stored in an aquifer". One of the management objectives of the strategy (legislation and regulation) is to "enable water management and water services institutions to adopt and regulate artificial recharge as part of Integrated Water Resources Management (IWRM)" (p. 119). South Africa has longstanding experience in artificial groundwater recharge. The city of Atlantis started recharging its aquifer with storm water and treated wastewater in 1979. At that time, the 1956 Water Act (No. 54 of 1956) was still in force, and artificial recharge and water recycling were not regulated under its provisions (DWAF, 2010).

Although there is still no consistent legal framework for AR, the current Atlantis Water Resources Management Scheme has to comply with the National Water Act (NWA) – No. 36 of 1998 – which explicitly regulates artificial groundwater recharge with treated or untreated wastewater. The Act arguably requires a licence for artificial groundwater recharge regardless of the source water when it identifies "storage of water" (art. 21(b)) among the 11 regulated water uses. Although at the time of drafting "storage of water" was intended for dams and canals, artificial groundwater recharge schemes may certainly be licensed under this use considering that the primary purpose of aquifers recharge is undoubtedly water storage (DWAF, 2007).

In addition, the Act requires a special authorization for "controlled activities", which include the "intentional recharging of an aquifer with any waste or water containing waste" (art. 21(e) and 37, NWA). The External Guidelines – Generic Water Use Authorisation Application Process of the Department of Water Affairs (DWA) state that, "if the proposed water uses comprise an integrated water use licence application, which combines both non-waste discharge and waste discharge-related water uses in a single application then a risk assessment must be undertaken for all the uses."

According to the 2007 AR Strategy, the procedure for the implementation of an artificial recharge project includes four stages, namely a pre-feasibility stage, a feasibility or testing stage, an implementation stage, and an operation, monitoring and maintenance stage. In order to identify suitable areas for artificial recharge, the checklist adopted for the first two stages includes 10 success criteria assessing: 1) demand (the need for an artificial recharge scheme); 2) supply (source water); 3) aquifer characteristics (aquifer hydraulics); 4) water quality; 5) applicable method (engineering issues); 6) environmental issues; 7) legal and regulatory issues; 8) economics; 9) technical capacity (management); and 10) institutional arrangements (Murray, 2009, as cited in Steinel, 2012, p. 43).

The pre-feasibility report is submitted to DWA, jointly with the licence application for testing, if required. DWA may convene an Artificial Recharge Authorities Committee Meeting, with other competent authorities, including Department of Environmental Affairs and Tourism and the relevant Catchment Management

[10] Taken from Study On The Legislative Framework Regulating The Recharge Of Aquifers With Adequately Treated Wastewater, Stefano Burchi, 2014.

Agencies. If an environmental authorisation is required for testing under the Environmental Impact Assessment (EIA) Regulations (2010) (Government Notice No.543 in Government Gazette No. 33306 of 18 June 2010), a Basic Assessment Report or a Scoping and Environmental Impact Report (S&EIR) should be added to the pre-feasibility file. At the second stage, testing is carried out upon authorisation, if required. The feasibility report is submitted to DWA, jointly with the licence application for the desired water use and the environmental authorisation, if required. At the third stage, implementation of the project may commence upon issuance of the licence. The fourth stage – operation and maintenance, or production – should include performance monitoring.

In South Africa, the main water authority is the Ministry of Water Affairs. The Minister is the custodian of water resources and has the ultimate responsibility to ensure that water is protected and allocated in the public interest. The DWA – formerly Department of Water Affairs and Forestry (DWAF) – is delegated by the Minister to administer the NWA. Its mandate focuses on developing the national water policy and water management regulations, and on supervising water-related activities of other institutions, including water users' associations. All water resource management institutions must function in accordance with the National Water Resource Strategy.

Catchment Management Agencies (CMAs) are being established in each of the 19 water management areas. DWA may delegate water licensing to the CMAs. The Department of Environmental Affairs and Tourism (DEAT) is involved in water management where an environmental authorisation is required, under the National Environmental Management Act (No. 107 of 1998) and the Environment Conservation Act (No. 73 of 1989). Water Services Authorities and Water Services Providers, including Water Boards, are in charge of drinking water supply under the Water Services Act (No. 108 of 1997).

The Waste Management Policy includes the Policy and Strategy for Groundwater Quality Management in South Africa (2000), according to which "National Government, acting through the Minister, is the public trustee of the country's water resources. Surface and groundwater quality management are both important parts of his responsibility". Among the functional strategies provided for, sewage treatment is a priority to be addressed through regulations, standards and guidelines. Aquifer management strategies regarding groundwater quality are only required "for large and continuous aquifers", whereas "localised and poorly defined aquifers" are generally part of a catchment management strategy (Groundwater Quality Policy, 2000).

8.7.2 Israel

Israel has been practising wastewater treatment and reuse since the '50s and '70s, including through groundwater recharge (Soil Aquifer Treatment – SAT) (Tal, 2013). The country has a 75% water reuse rate [Spain 12%; Australia 9%] (Mekorot, 2013). Artificial groundwater recharge serves a number of purposes in Israel, namely increasing water reserves for periods of high demand (primarily for irrigation), reducing hydrological deficits, preventing saline intrusion from peripheral areas and ensuring efficient utilisation of surplus water from Lake Kinneret (i.e. Lake Tiberias) (see Israel case study in DWAF, 2007).

Comprehensive water quality monitoring is normally carried out throughout all the stages of the recharge process. However, besides known problems related to clogging of recharge boreholes due to silt build-up and algae in the source water (Mekorot, 2013), health concerns have been raised lately, as endocrine disruptors, antibiotics and trace metals have been found in recycled water. In order to protect human health and groundwater quality, some experts are now calling for treatment to drinking water quality standards through desalination of treated sewage effluent by reverse osmosis (Tal, 2013).

The largest SAT facility in Israel is the Dan Region Wastewater Treatment Plant (Shafdan), where sewage water from the Tel Aviv region is treated. Wastewater treatment comprises four stages: pre- treatment, primary, secondary and tertiary treatment. Treatment methods include oxidation ponds, activated sludge and Mechanical Bio-Reactor (MBR). The Shafdan effluents are discharged into the soil for tertiary treatment and to recharge the aquifer. Water is then recovered and transported to the Negev for irrigation. The total effluent supplied for agricultural purposes is 216 million cubic meters per year (Mekorot, 2013).

The Israeli Water Law (No. 5719 of 1959) states that national water resources (including drainage and sewage water) are the property of the public. They are controlled by the State and are intended to fulfil the needs of the population and the development of the country (section 1). With a view to preventing water pollution in water facilities, the law establishes that anyone who has in his possession a facility for water production, supply, transport, storage or recharge to the subsoil must undertake every reasonable measure in order to prevent the facility or its operation from causing water pollution (s. 20C). In addition, anyone who is operating a polluting facility, which requires the disposal of sewage, must submit a sewage disposal plan to be approved by the Director of the National Authority for Water and Sewage (s. 20E).

National legislation regulating the use of wastewater for the specific purpose of artificially recharging aquifers includes the following (personal communication to the author):

a) National Plan No. 34 B/4 for Collecting Surface Water, Insertion, Recharge, and Protection of Groundwater. Part C of the plan identifies proposed recharge areas and areas meant for recharge projects. A building permit is required for any recharge project in an identified area. The permit will be issued with a detailed implementation plan, in accordance with the National Plan (s. 12). The detailed plan for a recharge site will include the area for spreading and recharge, pipes and equipment for water conveyance and service roads and access. It will also include the facilities for catching and diverting water, reservoirs, equipment for water conveyance including pumps, pipes, canals, dams, etc., and facilities for extraction of the recharge (s. 13). Given the fact that ponds and infiltration basins may attract birds, the plan must include measures to ensure flight safety over recharge areas in order to avoid bird strikes. The National Plan specifically includes the Shafdan sewage recharge facility in its scope of application (s. 15).

b) Public Health Regulations (Regulations for Sewage Quality and Rules for Treating Sewage), 2010, or "Sewage Regulations". Recycled sewage water that is used for recharge is mostly intended for irrigation purposes; hence the quality must meet the relevant specifications. Treatment plants are divided into "large" and "small" and, within each of these categories, quality values are established according to usage – unlimited agricultural usage, limited agricultural usage and release into streams (s. 4, appendix 1-3). The Sewage Regulations require permits for each usage/disposal method – irrigation, discharge into streams or other economic usage (s. 9). A plan for the control and monitoring of sewage quality is also required (s. 10).

c) Public Health Rules (Treating effluent for reuse in irrigation), 1981.Yearly permits are required from the regional engineer of the Ministry of Health for wastewater treatment systems intended for irrigation. Treated effluents may only be used for irrigating crops listed in the Public Health Rules8 and under specific conditions9, unless it has been treated to the level of "unlimited irrigation" purposes under the 2010 Public Health Regulations. In this latter case, treated water may be used for any type of crops. Farmers irrigating with treated effluents must apply for a permit and respect its terms and conditions. If a crop is not listed in the appendix to the Public Health Rules, a written permission of the Director General of the Ministry of Health is required for irrigation with treated effluents. For example, on 6 October 2013, 60 dunums (15 acres) of zucchini squash were destroyed in the central region, upon order of the local health authority. The order stated that the field was irrigated with effluents that did not meet the quality standards for this type of crop, and without a permit from the Ministry of Health.

The above-described framework establishes a web of interlocking regulatory requirements. The National Plan No. 34 B/4 regulates recharge projects and all aspects thereof, except the quality required of the wastewater being employed for recharge purposes, which is regulated by the 2010 Public Health Regulations. Treatment requirements vary depending on the intended end-use of the recharged aquifer water. The yearly (operating) permit requirements of the 1981 Public Health Rules with respect to wastewater treatment plants intended for irrigation use are additional to, and separate or independent from, the permit requirements of the National Plan. In other words, an aquifer recharge project involving the use of wastewater as source water for future irrigation use must secure a building permit under the National Plan, a recycled water use/disposal permit under the 2010 Public Health Regulations, plus a yearly operating permit of the wastewater treatment plant, under the 1981Public Health Rules.

8.7.3 Arizona (USA)

8.7.3.1 Applicable federal legislation

In the United States of America (USA), Aquifer Storage and Recovery (ASR) was first introduced in New Jersey in 1969 (Ward & Dillon, 2009). From a regulatory viewpoint, allocation of water rights is generally dealt with at the State level, as well as wastewater reuse regulation, although “much of the regulation of effluent quality takes place at the federal level” (Chapman, 2005). States with “well-developed, comprehensive water reclamation and reuse regulations” include Arizona, California, Florida, and Texas, where there is extensive reuse of water (Crook, 1994, as cited in Chapman, 2005). In Arizona, the MAR permit system is based on a statutory derivative of the prior appropriation doctrine, like in Colorado, New Mexico and Utah, among others. In California, there is a mixed system of the prior appropriation and the correlative rights doctrines. In Florida, the reasonable use doctrine is applied, whereas Texas has a system based on the absolute groundwater ownership doctrine (Wards & Dillon, 2009).

At federal level, the 1972 Clean Water Act (33 USC §§ 1251-138712), which is the main text on water pollution control, and the 1976 Resource Conservation and Recovery Act, which is the main federal law governing the disposal of solid waste and hazardous waste, only make provision for the protection of groundwater quality. They do not explicitly provide on artificial recharge of aquifers. Groundwater quality in relation to artificial recharge is regulated under federal drinking-water legislation. Under the 1974 Safe Drinking Water Act, the US Environmental Protection Agency (EPA) implements the Underground Injection Control (UIC) Program (42 USC §§ 300h-300h8 13). The Act authorizes EPA to regulate injection wells in order to protect underground sources of drinking water, but an amendment introduced by the 2005 Energy Policy Act has excluded hydraulic fracturing from EPA’s UIC Program (42 USC § 300h d) 1) B) ii) Underground injection defined) and has simplified federal requirements for State programmes involving this technique (42 USC § 300h-4 Optional demonstration by States relating to oil or natural gas).

8.7.3.2 Arizona State legislation

Arizona’s aquifer management legislation is based on two main laws: the 1980 Groundwater Management Act (Arizona Revised Statutes – ARS, Title 45 Water, Chapter 2 Groundwater Code) and the 1994 Underground Water Storage, Savings, and Replenishment (UWS) Act (ARS, Title 45 Water, Chapter 3.1 UWS), under which the UWS Program (Storage Program) operates15. Somebody wishing to store, save, replenish or recover water through the Storage Program must apply for permits through the Arizona Department of Water Resources (ADWR). Depending on the intended activity, up to three types of permits may be required:

a Facility Permit – Underground Storage Facility (USF) or Groundwater Savings Facility (GSF) Permit – for the operation of the storage facility, a Water Storage (WS) Permit to allow the holder to store water and a Recovery Well (RW) Permit for the recovery of stored water (or credits, in case of a GSF).

Firstly, USF Permit applicants must prove that legal access or the right to acquire legal access to the site (or to the storage space) has been obtained. Secondly, WS Permit applicants must prove their right to use the source water. In the case of effluents, the 1989 Arizona Supreme Court decision (Arizona Public Service Co. v. Long, 160 Ariz. 429, 773 p. 2d 988, as cited in the USF and WS Permit Application Guides of the ADWR) established that the entity generating the effluent (possibly the effluent discharge permit holder) has the right to put it to a beneficial use or convey it to another entity that will put it to a beneficial use. If the applicant did not generate the effluent, the legal right to the effluent must be "first in time, first in right". Permits are often required, by statute, in order to establish priority in use. Under the correlative rights doctrine, each user has an equal right to use of the groundwater regardless of who the first user was. If water is insufficient, users may be required, by the judiciary or by statute, to reduce their usage on a pro-rata basis until the overuse ends. (Bruggink, 1992, as cited in Ward & Dillon, 2009) proven through a contract or agreement with the effluent originator. In view of their contractual nature, the trade of effluents rights is "exempt from general water exchange permitting rules" (Chapman, 2005).

Thirdly, a RW Permit is required to recover water that was stored under a WS Permit. The right to withdraw stored water is linked to qualitative and quantitative variables: recharged water must meet the target quality levels for intended use before being recovered; water must be available at the time of withdrawal, considering pre-existing rights to withdraw water from the aquifer. In this regard, aquifer users in the area may withdraw from the recharged aquifer by accounting for it in the total amount of water allowed in their abstraction permit (Ward & Dillon, 2009). In fact, in most cases, no distinction seems to be possible in practice between existing (or "native") and recharged groundwater.

In addition, water storage projects (both from treated sewage/wastewater effluents and from surface water) require an Aquifer Protection Permit (APP) to be issued by the Arizona Department of Environmental Quality (ADEQ), prior to filing the USF Permit application. Moreover, a variety of wastewater treatment regulations and standards have been adopted for recycled water reuse for irrigation, for environmental purposes, for indirect potable use and for direct reuse (Chapman, 2005). These regulations may be applicable to either source water or to recovered water, or both, depending on the final use considered.

8.7.4 Western Australia (Australia)

8.7.4.1 Applicable national legislation

At the federal level, the definition of groundwater provided by the 2007 Water Act includes water that naturally occurs in aquifers, as well as "water occurring at a place below ground that has been pumped, diverted or released to that place for the purpose of being stored there; but does not include water held in underground tanks, pipes or other works" (art. 4). Australian Guidelines for Water Recycling are being prepared under the National Water Quality Management Strategy 18. Among these are the National MAR Guidelines, published in 2009 (Document No. 24), which focus "primarily on the protection of aquifers and the quality of the recovered water in managed aquifer recharge projects using all water sources including recycled water".

In Australia, the first successful MAR trials were made in the 1960s (e.g. Queensland) via infiltration basin for irrigation and in the 1980s (e.g. South Australia) via recharge wells. However, the first Unmanaged Aquifer Recharge (UAR) experiences go as far back as the 1830s and the 1880s (respectively in Perth and Mount

Gambier) where recharge occurred from roof run-off infiltration and drainage wells (Parsons et al., 2012). According to the 2009 MAR Guidelines, UAR is an "intentional water-related activity, known to increase aquifer recharge, but usually undertaken to dispose of water rather than recover it" (p. 21). To date, trials of storm water aquifer recharge and recovery have been made in a number of States, but MAR trials with recycled water have only been carried out in Western Australia and South Australia.

The implementation of MAR schemes generally falls under State legislation. However only three States have adopted a MAR policy so far, namely Western Australia, South Australia and Victoria, but no MAR trials with recycled water have been made in the last State so far. Following the Western Australia case below, a brief review of the MAR framework in the other two States is reported.

8.7.4.2 Western Australia State legislation

In Western Australia, the Department of Water (DoW) has issued an Operational Policy 1.01 – Managed Aquifer Recharge in Western Australia (DoW, 2011) that describes the procedures for the operation of a MAR scheme. Under the 1914 Rights in Water and Irrigation (RWI) Act, water that is infiltrated or injected into the natural groundwater system is vested in the Crown (section 5A). Proponents of MAR schemes must apply for a "licence to take water", under section 5C, which will define both the right to recharge and the right to recover groundwater. For the purpose of the Act, "'take' in relation to water means to remove water from, or reduce the flow of water in, a watercourse, wetland or underground water source [...] and includes storing water during, or ancillary to, any of those processes or activities". Moreover, to operate a MAR facility a "licence to construct bores" is required by section 26D.

According to Appendix A of the MAR Operational Policy, the issuance of the licence under section-5C – and the approval of the "banking (storage) and recovery of the recharge water" – requires the application of relevant national guidelines (e.g. for recycled water use), a hydrogeological assessment on a case-by-case basis, a previously-approved operating strategy, and relevant health-related documentation for drinking-water use. In this latter regard, a review of the Water Quality Protection Note No. 25: Land use compatibility in public drinking water source areas (2004) is under consideration, with a view to accounting for "infiltration or injection of wastewater into the ground" (DoW, 2011).

Lastly, recovery will only be allowed when recharge water is available and water quality requirements are met. If recharge and recovery are undertaken by different operators, the parties must reach an agreement to take water under the existing section-5C license, ensuring that enough water will be available for recovery during the period of the agreement. In view of the public-property nature of water resources in Australia, the agreement must be approved by the DoW (DoW, 2011).

The Groundwater Replenishment Project is a 3-year indirect MAR trial with highly-treated recycled water, and it is meant to investigate drinking-water-supply augmentation through a new climate- independent water source for Perth. The project is implemented by the government-owned Water Corporation, which is the main supplier of water, wastewater and drainage services in Western Australia. Before being recharged to the aquifer, water undergoes an advanced treatment process that uses three main technologies: ultra-filtration, reverse osmosis and ultra-violet filtration. Trials were carried out between November 2010 and December 2012, recharging a total of 2.533 billion litres of recycled water into groundwater. Trials aimed at providing a setting for regulators to develop health and environmental regulations and policies, and at feeding the public debate about groundwater replenishment.

8.7.4.3 Overview of South Australia and Victoria State legislation

In South Australia, under the 2004 Natural Resources Management Act (which repeals the 1997 Water Resources Act), the regional Natural Resources Management (NRM) boards are granted special powers to carry out works, including to "divert water to an underground aquifer, dispose of water to a lake, underground aquifer or the sea, or deal with water in any other manner". The SA Environmental Protection Agency (EPA) has issued a Code of Practice for Aquifer Storage and Recovery in January 2004. The State also has an Environment Protection (Water Quality) Policy, adopted in 2003.

In Victoria, the 1989 Water Act regulates the underground disposal of matter via bores (section 76), which seems to cover MAR. Water recharged in this manner is recoverable through a regular water abstraction licence (section 51). According to the Guidelines for MAR – Health and Environmental Risk Management, published by the Victoria EPA in 2009, MAR is generally regulated by Regional Water Corporations as a delegated responsibility (section 122b) (EPA, 2009). The Department of Sustainability and Environment (DSE) has issued a number of guidance documents on MAR, including the Policies for Managing Section 76 Approvals19 (DSE, 2010).

8.7.5 Spain

8.7.5.1 Applicable EU legislation

Under the European Union (EU)Water Framework Directive (No. 2000/60/EC of 23 October 2000) (art. 11), Member States must establish a programme of measures for each river basin district, or for the part of an international river basin district within its territory, in order to achieve the established environmental objectives (art. 4). The programme of measures must take into account the results of the required technical (hydrological and hydrogeological), social and economic analyses (art. 5), which include information on artificial recharge (Annex II, § 2 – Groundwater, on the characterization of groundwater bodies).

The programme of measures to achieve the environmental objectives should implement relevant EU directives by adopting 'basic measures' and, where necessary, 'supplementary measures' to be applied locally. If necessary, the programme of measures may refer to national legislation. Among the basic measures to be adopted by Member States, the directive mentions "controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies" (art. 11.3(f)). In addition, the source water used must not compromise the achievement of the environmental objectives established for the recharged body of groundwater. Artificial aquifer recharge is also mentioned among the supplementary measures that Member States may adopt to achieve the established management and quality objectives (Annex VI – Lists of measures to be included within the programmes of measures).

Artificial recharge of aquifers is more specifically regulated under EU legislation on groundwater pollution. In particular, Directive No. 80/68/CE of 17 December 1979 requires a special authorisation to be granted by Member States for the artificial recharge of aquifers under their jurisdiction (art. 6). Competent national authorities must ensure compliance with the terms and conditions of the authorization and avoid pollution of groundwater sources from wastewater.

On the other hand, Directive No. 2006/118/CE of 12 December 2006 (known as "Groundwater daughter Directive") establishes that all programmes of measures adopted by Member States should include measures to prevent or limit aquifer pollution. It then provides that the input of pollutants resulting from artificial groundwater recharge may be exempted from such measures, if so provided in the programme (art. 6.3). Such exemption is only applicable where efficient monitoring of the bodies of groundwater concerned is in place. In any case, under Directive No. 91/271/EEC of 21 May 1991 concerning urban wastewater treatment, the discharge of industrial waste water into collecting systems and urban waste water treatment plants is subject to a special authorisation (art. 11) and “treated wastewater may be reused whenever appropriate” (art. 12).

At the environmental end of the regulatory spectrum, according to Directive No. 85/337/CEE of 27 June 1985, the “artificial recharge of aquifers” is subject to EIA procedures where the annual volume of water extracted or recharged is equal to or greater than 10 million cubic meters. For smaller projects, competent national authorities may decide at their discretion, on a case-by-case basis, whether or not to require an EIA, according to parameters or criteria set by each Member State. Countries with experience in “managed aquifer recharge and subsurface storage” (NNC-IAH, 2003) in Europe include the Netherlands, Germany, Spain and Hungary. Below is a review of Spanish legislation on artificial groundwater recharge.

8.7.5.2 Spanish national legislation

The 2001 consolidated Spanish Water Law (Royal Decree No. 1/2001 of 20 July 2001 – Texto Refundido de la Ley de Aguas) requires an authorisation for treated effluent discharge (art. 101) and regulates the conditions for treated water reuse (reutilización de aguas depuradas) (art. 109). A concession is generally required for water reuse, but a simple authorisation shall suffice where the applicant is already authorised to discharge treated effluents. On the other hand, the holder of a water-reuse concession may acquire the relevant authorisation for treated effluent discharge via a contractual arrangement with the holder of said authorization, with the approval of the relevant Basin Authority.

Quality standards are defined according to the intended reuse. Royal Decree No. 1620/2007 of 7 December 2007 establishing the legal regime for treated water reuse (Real Decreto por el que se establece el regimen jurídico de la reutilización de las aguas depuradas) defines water quality parameters for different uses. For instance, Quality 5.2 is required for the recharge of aquifers through direct injection. Treated wastewater however cannot be reused for human consumption purposes (Steinel, 2012).

Under the 2001 Water Law, the regulation of water works– including underground water storage, aquifer recharge and wastewater treatment (art. 122)– indicates that new water works requiring a concession for a new water use may only commence after obtaining the prescribed concession. The institutional responsibility for water works is shared among the national water resources administration, the River Basin Organizations, the regional governments (“Autonomous Communities”) and the local governments, depending on the national or local relevance of the works, and on their funding (art. 123).

Guidelines for aquifer recharge are established in Royal Decree n. 907/2007of 6 July 2007 on hydrological planning regulations (Reglamento de la planificación hidrológica). Each hydrological plan shall include the areas of artificial recharge of groundwater bodies in order to determine the recharge objectives and the procedures to authorize the quantity and quality of water to be recharged. The source water may be recycled water, provided that environmental objectives and public health are not jeopardised (art. 53).

Government Order No. ARM/2656/2008 of 10 September 2008 approving instructions on hydrological planning (Orden por la que se aprueba la Instrucción de Planificación Hidrológica) requires each hydrological plan to identify different types of artificial recharge, including the recharge of aquifers with effluents (section 3.2.3.4(a)). For each type of recharge, the following shall be identified, where possible: (i) available source water, its origin, its temporary flow regime, its quality, its recharge rate and its chemical composition, (ii) indicators of the hydrogeological behaviour of the aquifer in order to assess its potential response to recharge, the procedures and facilities needed for the recharge operations (above or underground), as well as their lifespan, and (iii) number of artificial recharge points and evolution of recharge volumes in time for each groundwater body.

Some hydrological plans make provisions on artificial groundwater recharge, however most of them do not go into much detail and often refer to national legislation (Duero river basin Hydrological Plan, 2013, and Miño-Sil river basin Hydrological Plan, 2013). The 1998 Cuenca Sur basin Hydrological Plan is briefly reviewed below under the regional legislation of the Andalusia Autonomous Community.

8.7.5.3 Andalusian regional legislation

According to the 2010 Andalusian Water Law (Law No. 9/2010 of 30 July 2010), "artificial recharge" is a technique that allows programmed intervention and direct introduction of water in an aquifer, to increase the degree of water availability and to act on water quality; "underground storage" is defined as the temporary storage in a deep aquifer of liquids and gases through artificial recharge techniques (art. 4). In the Andalusia Autonomous Community, the Executive Council of Andalusia (Junta de Andalucía) is responsible for managed aquifer recharge (art. 8).

The artificial recharge of groundwater bodies or the temporary storage of groundwater is subject to an authorisation from the competent water authority (Consejería competente en materia de agua). The application must be accompanied by a hydrological report, the justification for the recharge, the volume of water to be recharged, the documentation proving availability and quality of the source water, as well as possible interaction with the aquifer, and the programme of recharge and recovery of stored groundwater. The competent water authority establishes the volume of recoverable water, in accordance with drought plans, if any, and taking into account water security concerns (art. 56).

Concerning recharge facilities and works, the Autonomous Community is competent for groundwater works that do not affect waters outside its jurisdiction, unless they are of general interest for the country (Royal Decree No. 2130/2004 of 29 October 2004 – Real Decreto sobre traspaso de funciones y servicios de la Administración del Estado a la Comunidad Autónoma de Andalucía en materia de recursos y aprovechamientos hidráulicos (Confederación Hidrográfica del Sur)). Carrying out artificial groundwater recharge operations without being duly authorised is considered a minor offence under the 2010 Water Law, except where human health risks are involved (art. 106).

The Cuenca Sur basin Hydrological Plan, adopted by Royal Decree No. 1664/1998 of 24 July 1998, identifies a number of artificial groundwater recharge areas, including with treated wastewater. Reportedly, however, there has been limited or no follow up on these Plan determinations (personal communication to the author).

State of Palestine

Palestinian Water Authority

دولة فلسطين

سلطة المياه الفلسطينية

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 4

DRAFT Complementary Feasibility Study

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Joint Venture ALMADINA-TIMESIS S.r.l.

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CMWU	Coastal Municipal Water Utility
CP	Cropping Pattern
EQA	Environment Quality Authority
FAO	Food and Agriculture Organization of the United Nations
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGEST	North Gaza Emergency Sewage Treatment
NWC	National Water Company
PWA	Palestinian Water Authority
ToR	Term of Reference
UAWC	Union of Agricultural Work Committees
WB	World Bank
WSRC	Water Sector Regulatory Council
WUA	Water User Association
WWTP	Waste Water Treatment Plant

1 Executive Summary

1.1 Key Results and Recommendations

Key results of this DRAFT Complementary Feasibility Study are as follows:

- By improving the original design of the water reuse (irrigation) scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern, it is possible to save nearly 3.2 Millions of Cubic Meter of water per year (MCM/year) or 21.5% less water than what was required by the original 2010 design. Less water requirements also leads to reduced energy needs for the recovery and water extracted from the aquifer. More precisely, the proposed changes will save 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation schedule that largely differs from the original by providing water to the entire irrigation project each day (instead of on a 6-day rotation with 12 lots irrigated 2 at a time once a week). The newly proposed irrigation schedule hinges on the idea of delivering a constant amount of water to the farm gate for 12 hours per day (10 hours per day during the coldest months of the year). Farms with different sizes will receive the necessary amount of water thanks to flow reducers that now come standard with many commercially available manholes. Furthermore, the possibility to pump water into the system on a constant rate through the day drastically reduces the complexity of managing the irrigation scheduling and eliminates the risk of overdrawing water from the storage tanks and stalling the system.
- Palestinian law restricting the use of treated wastewater in irrigation does not apply to the NGEST water reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that is allowed to be infiltrated into the aquifer: the quality must be either moderate (“C”), good (“B”), or high (“A”). Utilizing poor (“D”) wastewater for aquifer recharge is prohibited.
- If the proposed Cropping Pattern and Irrigation Methods are implemented, the construction of the water recovery and reuse (irrigation) scheme is feasible even if the entire investment (Phase I and Phase II) is paid by the farmers. Nevertheless, because developing a large investment in Gaza presents risks that are uncommon in other parts of the World, Scenario 3, where construction costs would be paid by the government and not charged back to the farmers, is presently being suggested. This scenario assumes that the capital investment necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmers.

Some of the key recommendations after reviewing the original design of the Irrigation Project are:

- Design drawings for the water reuse (irrigation) scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a precise cadastral survey has been provided.
- The design of the network could be revised to consider the reduced flows that come with the newly proposed Cropping Pattern. The need for such a revision should be discussed with PWA before making final recommendations.
- An Irrigation Advisory Service (IAS) should be established to manage and operate the recovery and reuse schemes, as well as to provide a platform for inter-ministerial and local communal cooperation for the project and provide technical and other assistance to farmers.
- Managing Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural

resource. Monitoring is an integral part of MAR management and should be robustly undertaken to both determine the effectiveness of the recharge scheme and to investigate the sustainability with respect to human and environmental health.

1.2 Project Background

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. Phase A of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

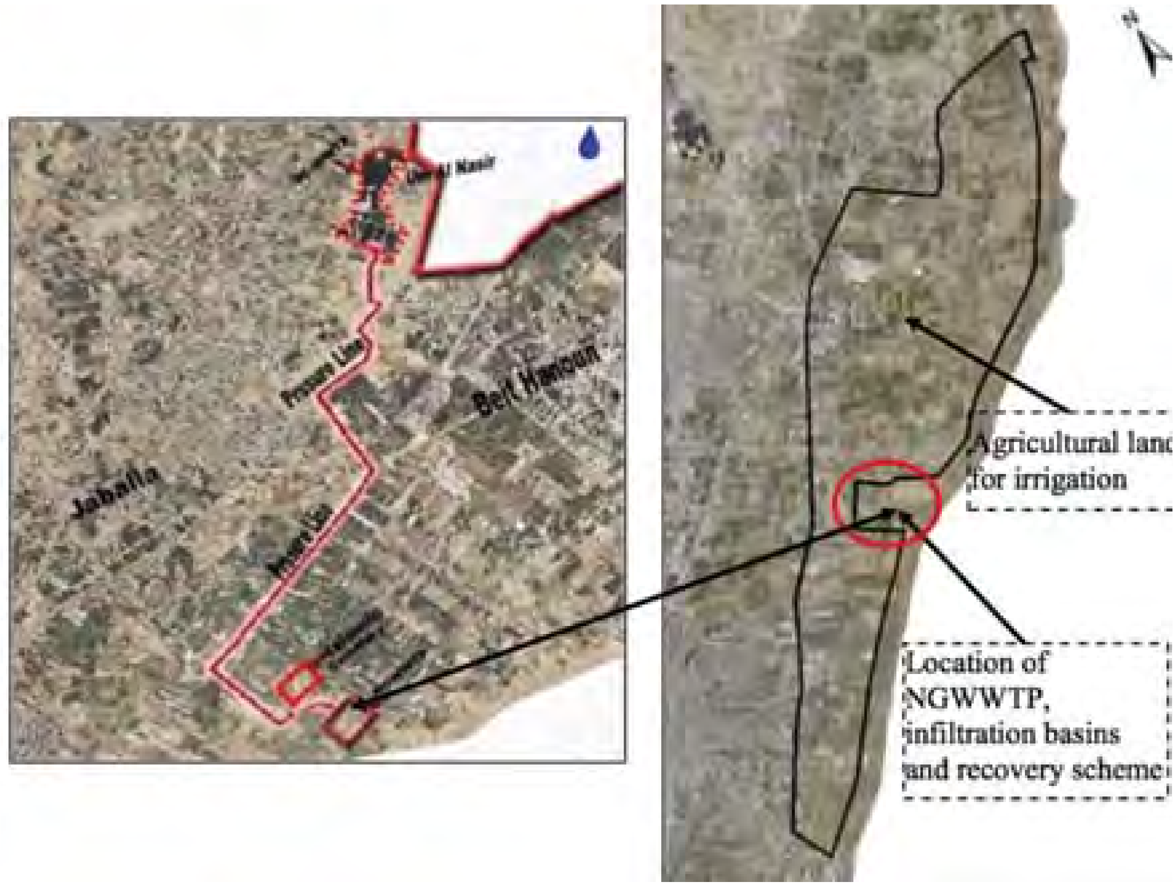


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

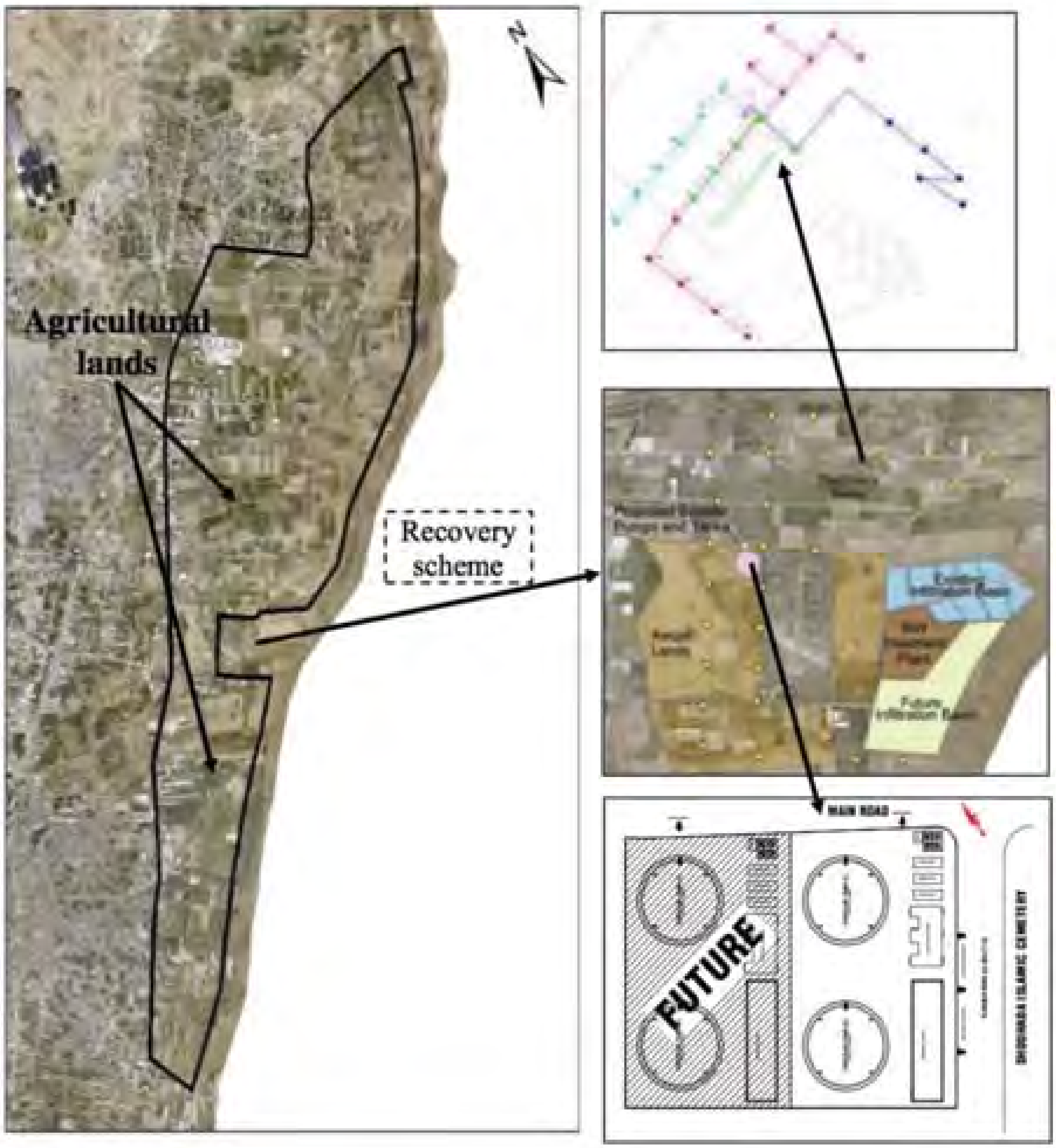


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, supplementary phase was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The treated sewage effluent will be disposed of into infiltration ponds, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 27 recovery wells, put into a storage reservoir, and distributed throughout the network for irrigated agriculture.

A gross agricultural area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit from the recovered water as well as the treated sewage sludge. This project component, known under the name of ‘Supplementary Project’, is subdivided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse (Irrigation) Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary phase has been subdivided into three stages:

The **first stage,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 15 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells - and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume from reaching agricultural and municipal wells located beyond the recovery wells.

The **second stage,** now scheduled for completion by the year 2018, would extend the recovery system by a second row of 12 supplementary wells (along with the previous 15 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated waste water infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank, booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **third stage**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

1.3 The Present Study

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare a Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and make the project feasible. To carry out its task, this project has drawn upon massive data collection, field visits, and state-of-the-art computer modeling in order to best understand the irrigation project’s hydraulics and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

1.4 Baseline Survey

1.4.1 Field Survey

The foundation of this baseline assessment and a primary tool for collecting first-hand current data, the field survey aimed to investigate the characteristics of the farming system in the project area. A questionnaire was developed and tested in coordination with PWA. The questions were focused on the farm cropping system, market channels, selling prices, and incomes. Special emphasis was given to the water issue, by inquiring about the current use of water on crops, irrigation methods and the source and cost of water. Specific questions were dedicated to understanding the farmers’ willingness to change/enlarge their cropping pattern and the role played by the farmers’ associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017 by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 3.

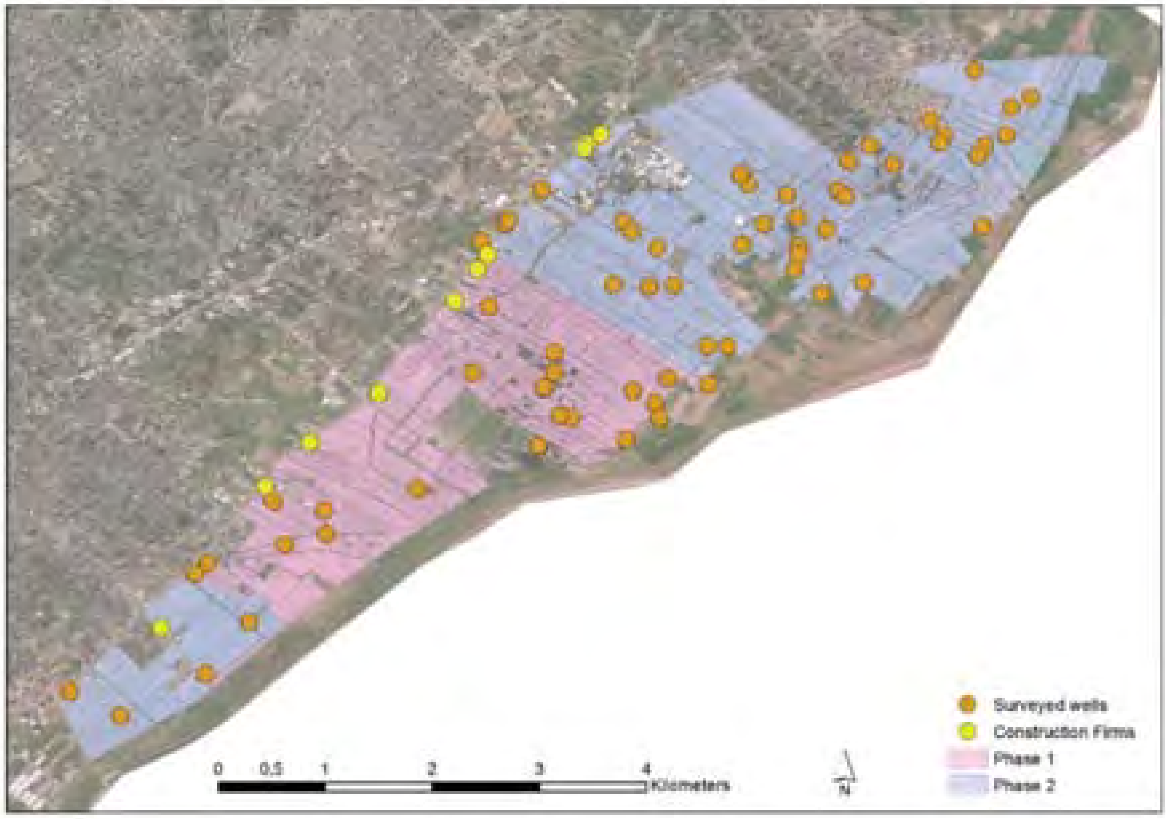


Figure 3: spatial location field survey

The survey resulted in the collection of 420 farm questionnaires, 9 farm inputs questionnaires, and 11 industries questionnaires. The paragraphs below summarize the results obtained from the analysis of the questionnaires.

1.4.2 Land Tenure and Cropping System

1.4.2.1 Farm size and land tenure

The Project area extends for 1,207 ha (12'068 du). As shown in Figure 4, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 du are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

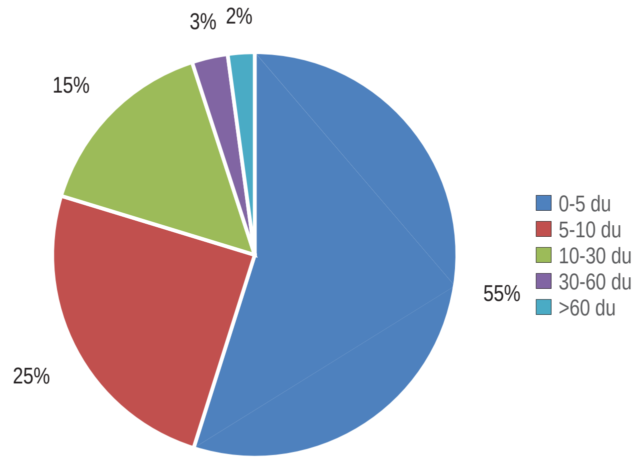


Figure 4. Distribution of farms by size.

1.4.2.2 Cropping System

The cropping pattern of the project area is shown in the following Figure 5.

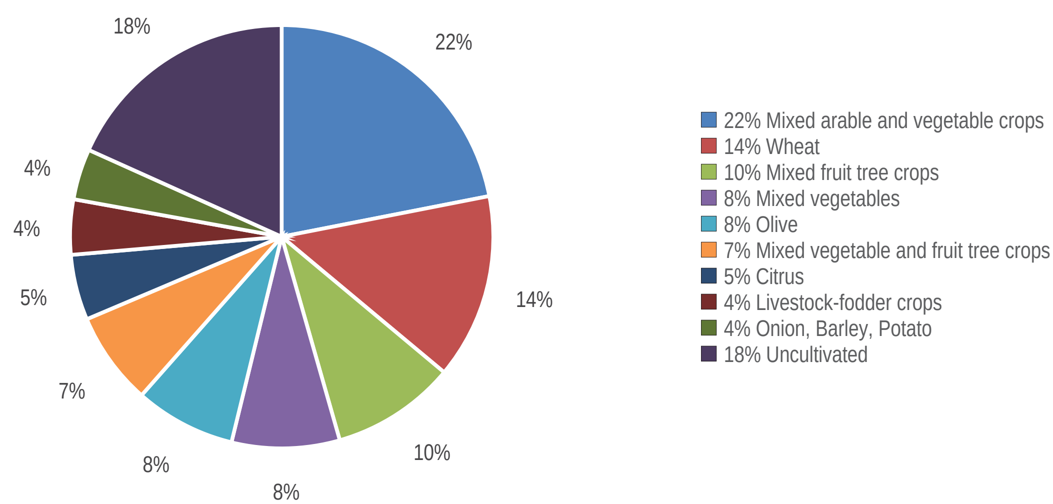


Figure 5. Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops; almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 7). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 7).

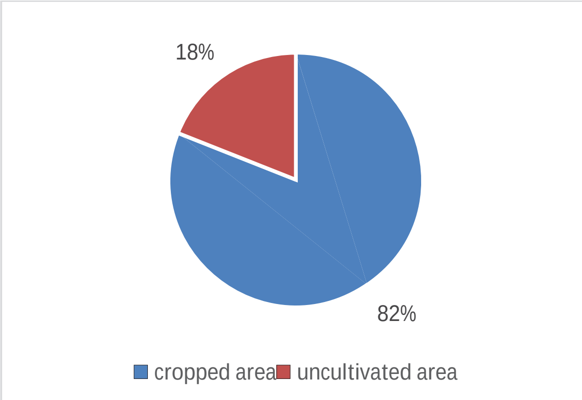


Figure 6. Cropped and uncultivated area.

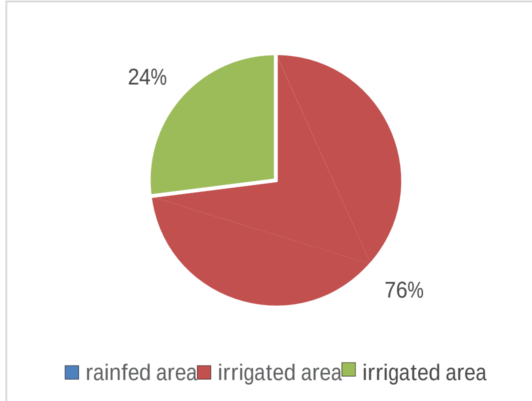


Figure 7. Irrigated and rainfed area.

1.4.3 Crop Water Requirements and Water Consumption in Agriculture

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well ("collective well") is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the "collective well" system owned by the remaining 8%.

Wells must be authorised by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also "non-legal" wells, estimated to be 5-6 times the number of the legal ones. The government does not close these wells but new unauthorised wells cannot be drilled.

The survey determined that water cost ranges from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

Figure 8 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

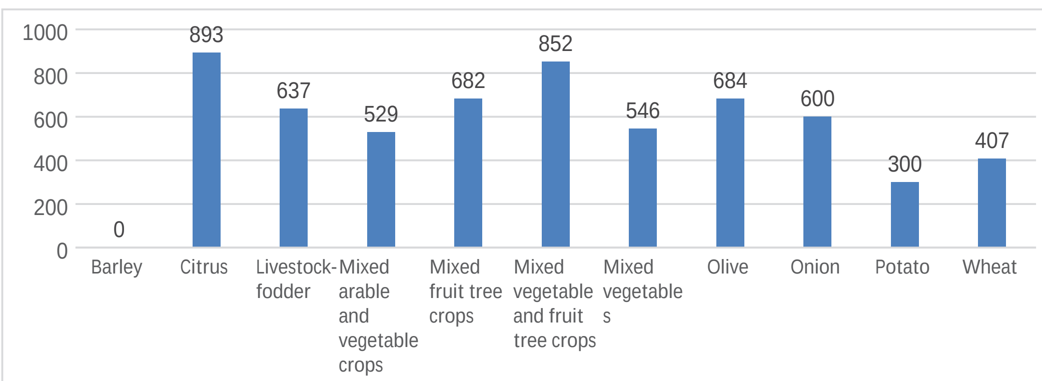


Figure 8. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m3/du); Barley is rainfed.

The **total crop water requirements** for the agriculture currently developed across the whole 15,000 du is estimated to be **5.8 Mm^3/year** with an **average daily water requirement of 15,990 m^3/day.**

1.4.4 Causes of the Present Land Abandonment

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is represented by the frequent **land invasions from the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, and periodically sprays herbicides to keep the field clear, which kill the crops and make the farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out the cropping operations (23%); and **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

1.4.5 Water Consumption in the Industries

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 3 their localisation): generally, most of them are small factories (less than 10 employees), operating only a few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%) of them is using private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

1.4.6 Value Chain

Gaza Strip, with its high population density and reduced connections to a production system because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

Interviews with the producers showed that the vast majority of the agricultural products are sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

The market chain of horticultural and fruit products is as follows:

farmers → traders or intermediary (middle man) → retailers → consumers.

Next table summarises revenues, costs and margins for the different crops.

Table 1. Summary of the single accounts cultivation statements of agricultural products

Farm/Crops	Revenues	Cost	Margin	Net margin per kg	Net margin + LH[1] per kg
Apple	1,000	2,495	-1,495	-2.99	-2.81
Barley	655	1,630	-975	-2.02	-0.36
Citrus	3,494	3,172	322	0.19	0.52
Lemon	1,400	2,048	-648	-0.65	-0.33
Livestock	1,582	2,310	-728	-	-
Melon	2,400	2,401	-1	0	0.17
Mixed arable and vegetable crops	3,226	2,267	959	0.36	0.59
Mixed fruit tree crops	2,487	2,472	15	0.02	0.34
Mixed vegetables and tree crops	3,444	1,667	1,777	0.81	0.92
Mixed vegetables	3,407	3,061	346	0.11	0.33
Olive	806	2,376	-1,570	-2.92	-2.05
Onion	675	1,837	-1,162	-2.58	-0.58

[1] LH: Labour Harvesting

Peach	1,000	1,055	-55	-0.11	0.07
Potato	2,500	1,656	844	0.34	0.50
Wheat	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

1.5 Assessment of the NGEST Recovery and Reuse (Irrigation) Schemes

1.5.1 Project Recovery Scheme

The recovery scheme comprises a system of 27 recovery wells and all related connection pipes as well as 10 monitoring wells. The following three sections provide a more detailed description of each component.

1.5.1.1 Recovery Wells

There are 27 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 zones (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 9. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

The recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October, which is equal to 50,885 m^3/day. The total number of wells is 27 where each should have a capacity of pumping between 150 m^3/hr to 200 m^3/hr. 25 out of the 27 wells are assumed to be operational always with a capacity of 170 m^3/hr. The two additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure.

According to the numerical modelling results, the exact location of the 27 wells was defined to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 9 shows the locations of the recovery wells.

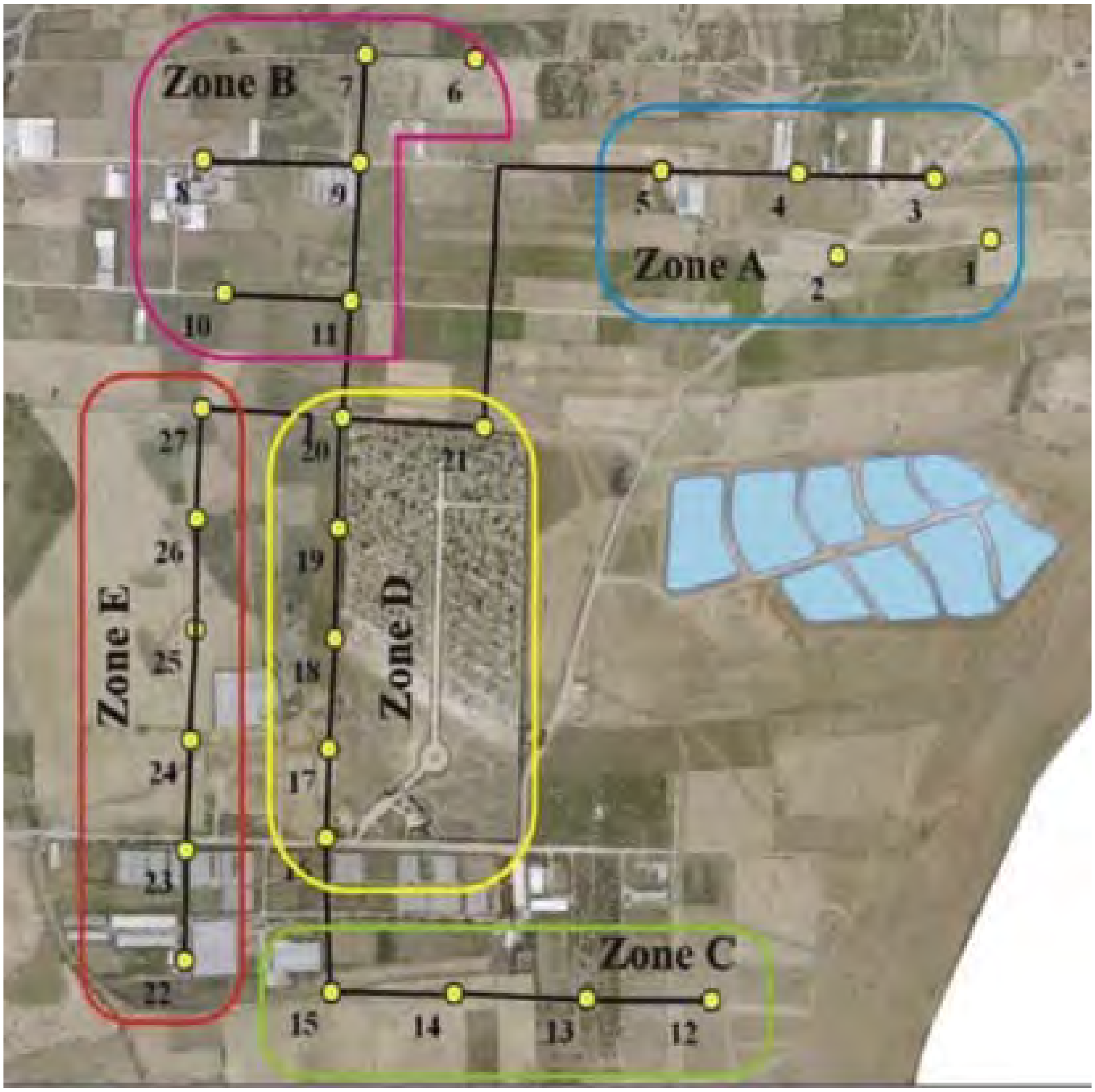


Figure 9: Location of the 27 Recovery Wells

1.5.1.2 Collection Pipes

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 10. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

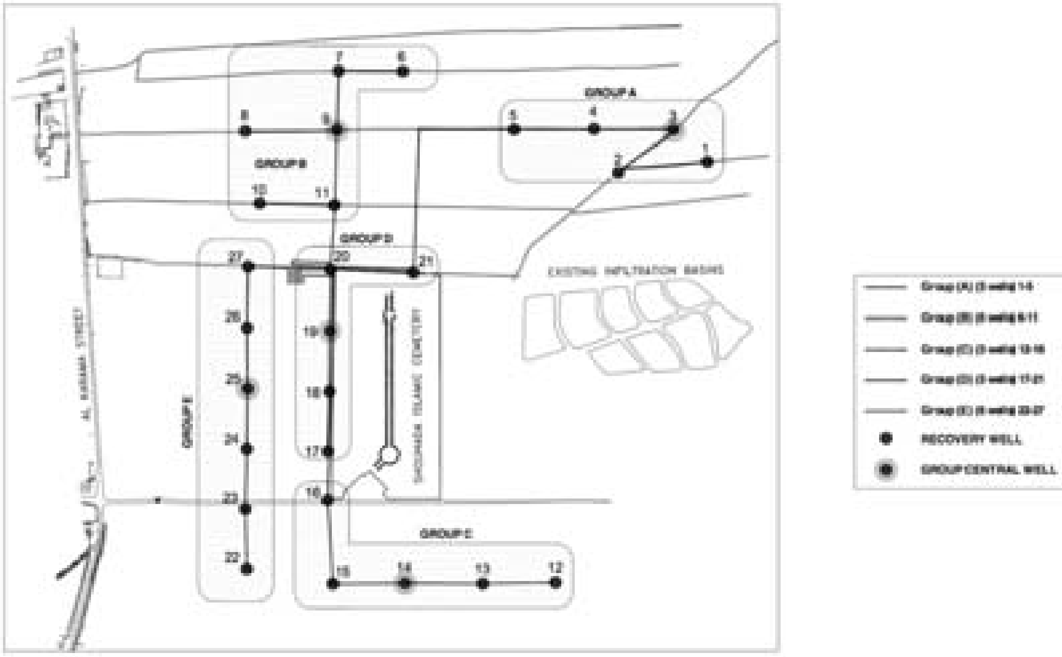


Figure 10: Wells grouping and Piping System

1.5.1.3 Monitoring Wells

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore be taken and analysed randomly at farm level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 42 monitoring wells will be implemented by using the 5 existing monitoring wells, the 27 newly built recovery wells and 10 new monitoring wells.

The location of the 42 monitoring wells is provided in the following Figure 11.

Figure 11: Location of the existing and newly proposed monitoring wells

1.5.2 Project Reuse (Irrigation) Scheme

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 12. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 13.

In accordance with irrigation requirements, irrigation was to be carried out on a six-days rotational basis over six zones of almost equal sizes, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F as shown in the following Figure 13. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 14.

Figure 12: Location of agricultural land

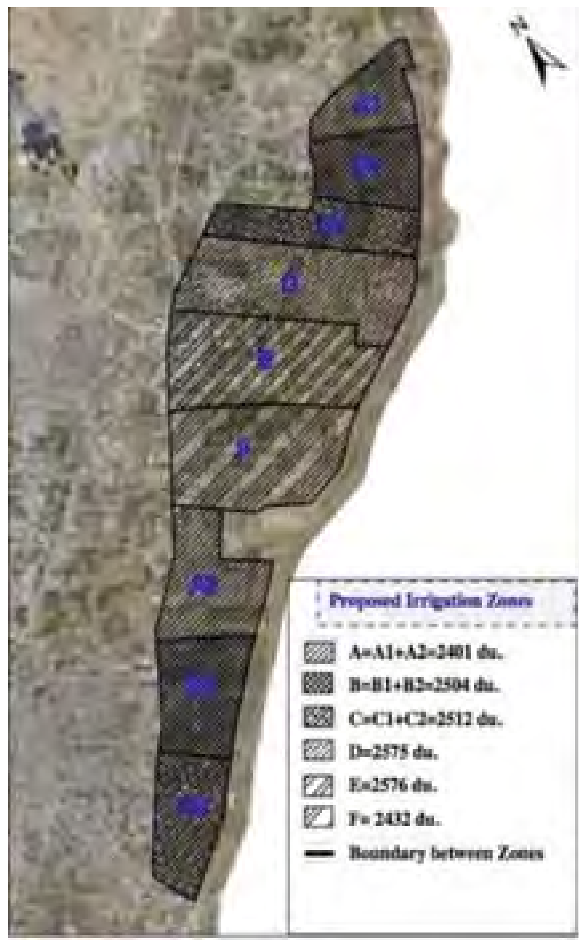


Figure 13: Proposed Irrigation Zones

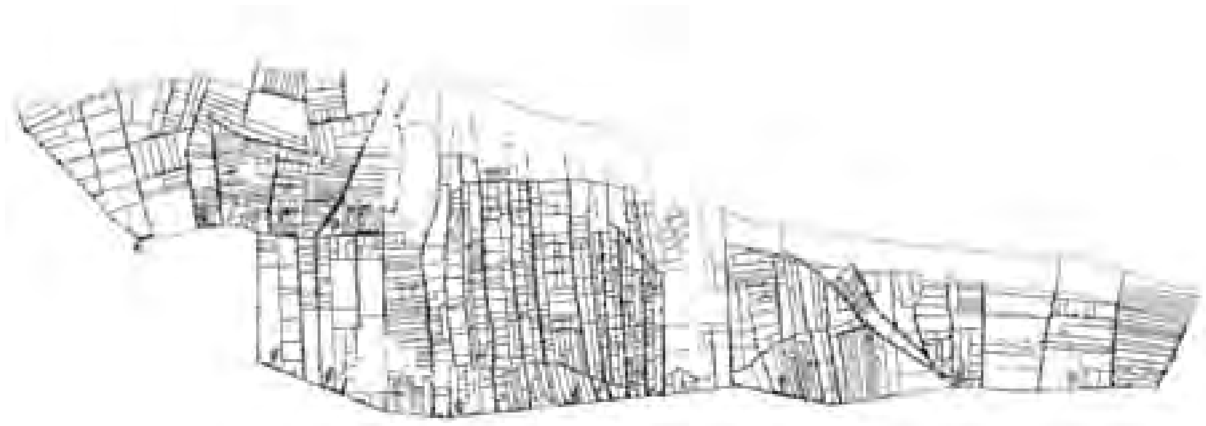


Figure 14: General Layout of the Originally Proposed Irrigation Network

1.5.3 Review of the Reuse (Irrigation) Scheme: additional findings and recommendation

1.5.3.1 Additional Findings

In addition to the key findings listed in Section 1.1 above, the following achievements were obtained while reviewing the original design of the Irrigation Project:

- A review of the original irrigation project layout that allowed to resolve some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gates (the original design failed to do so for a sizable number of farms);
- A review of the original design for the recovery scheme confirming its validity;
- A review of the original design for the reuse (irrigation) scheme confirming the selection of materials, the general layout and the selection of the pumping system;
- The overall cost for the construction of the water reuse (irrigation) scheme has significantly increased (nearly 40% increase) from its original estimation. Although this might be justifiable in the context of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%.

1.6 Project's Feasibility

1.6.1 Micro and Macro Economic Evaluation

A Cost-Benefit Analysis (CBA) has been conducted to assess the proposed investment from both a financial and an economic stand point. Costs and Revenues of the water recovery and reuse (irrigation) schemes have been estimated at a micro and macroeconomic level.

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

The newly proposed development plan assumes that the entire project area (Phase I + Phase II) will be able to adopt the design cropping pattern over a four-year period. The adoption of the new cropping pattern involves not only planting new crops but also all the necessary work required to modernize the farm and adapt it to the proposed irrigation method. The cost for the adoption of the cropping pattern and the modernization/development of the farms is expected to be 4.7 Million ILS (approximately 1.3 Million US$) per year for a period of four years.

Farmers will require intense training to be able to implement the proposed plan. Further to that, maximizing the output of the irrigation project will require the farmers to cooperate via Water User Associations (WUAs) and the irrigation scheme to be maintained and managed via an Irrigation Advisory Service (IAS). The Micro-Economic analysis assumes that WUAs will incur an initial cost of 3 Million ILS (approximately 0.8 Million US$) over a period of two years. Costs for operating and maintaining the IAS is assumed to be borne by the government and not charged to the farmers but this proposal needs further discussion with PWA's before it can be considered final.

Finally, operating and maintaining the system (on-farm and off-farm and including the water recovery and reuse schemes) will cost over 4.9 Million ILS (approximately 1.3 Million US$) per year including 0.3 Million ILS/year (approximately 80,000 US$) to account for the running costs of the WUA. Farmers will pay for the O&M and WUA costs through their water bills. Water consumed by each farm will be metered at the farm gate. Gross Irrigation water demand, excluding water needs for the Industries (estimated to be 70,000 m^3/year) but including all water losses and climate change, is estimated to be 11,110,000 m^3/year. The net irrigation water requirements (after all system losses are considered), is estimated to be 7,833,484 m^3. Farmers will be charged for the water delivered to their farms and this translates into a water tariff of 0.63 ILS/m^3 to pay for O&M and WUA costs.

On the other hand, the new cropping pattern and modernized irrigation methods will enable the irrigation project and the farmers to generate a stream of revenues that, after the first three years, should provide a steady income of over 30.7 Million ILS/year (over 8.5 Million US$/year).

From a macroeconomic perspective, several different investment scenarios were evaluated. Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

- (1) Capital Investment for the Water Recovery Scheme;
- (2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm's Gate;
- (3) O&M Cost for the Water Recovery Scheme;
- (4) O&M Costs for the Water Reuse (Irrigation) Scheme;
- (5) Capital Investments for Farm's Development.

The five scenarios are defined as follows:

- Scenario 1 - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under such scenario farmers would pay back the full cost for the construction of both the water recovery and the water reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- Scenario 2 - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built and paid by the farmers;
- Scenario 3 - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmer;
- Scenario 4 - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that farmers will have to pay back the cost for the construction of Phase II of both the recovery and the reuse scheme. Government/Donors would cover the cost for the construction of Phase I. Farmers would pay for the development and O&M of their

own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered by the Government/Donors for the number of years required for the farmers to pay back the construction of Phase II.

- Scenario 5 - Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for as many years as it takes for the farmers to be able to pay back for the improvement of their own farm. After that point, farmers will be responsible for paying O&M costs for the whole system.

1.6.2 Results of the Financial Analysis

The Government's ability to pay for the set up and operation of the NGEST Irrigation Project during the next 25 years (the so called 'Reference Period') is critical to the success of the investment and for achieving the overall objectives of this supplementary phase. From this perspective, the investment project should be financially sustainable without any difficulties regarding the fulfilment of its financial obligations during the reference period.

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

To determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

A discount rate of 5% was assumed for this project. Results with a discount rates of 3% and 7% were also calculated to test the sensitivity of the financial model.

The results of the financial analysis are presented in the following Table 2.

Table 2: Results for the financial indicators

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)	Note
	3%	5%	7%	3%	5%	7%		
1	30.551	2.574	-16.780	1,062	1,006	0,954	5,23%	
2	12.959	718	-7.908	1,064	1,004	0,947	5,14%	
3	149.706	114.653	88.791	1,304	1,274	1,244	31,02%	*Recommended Scenario
4	127.456	88.722	60.582	1,259	1,212	1,167	16,07%	17 years of subsidies to repay the phase II investment.
5	155.425	119.953	93.715	1,316	1,286	1,258	33,54%	5 years of subsidies to repay the investment at farm level

1.6.3 Results of the Economic Analysis

The economic analysis measures the project benefits depending on the following: the costs avoided due to project implementation and the external benefits arising from the implementation, which are not included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion (fiscal correction and labour cost correction from financial to economic) between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. Moreover, these externalities should have a monetary equivalent.

The main results of the economic cost benefit analysis are presented in the following Table 3.

Table 3: Main Results of the Economic Cost Benefit Analysis

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)
	3%	**5%**	**7%**	**3%**	**5%**	**7%**	
1	124.102	82.112	52.243	1,252	1,196	1,144	13,72%
2	51.291	33.420	20.586	1,254	1,194	1,137	12,62%
3	132.443	89.958	59.633	1,511	1,482	1,454	15,17%
4	130.885	88.143	57.658	1,462	1,416	1,371	14,64%
5	132.843	90.329	59.978	1,523	1,496	1,469	15,24%

As seen from this analysis, if the proposed Cropping Pattern and Irrigation Methods are implemented, the construction of the water recovery and reuse (irrigation) scheme is feasible even if the entire investment (Phase I and Phase II) is paid by the farmers. Nevertheless, because developing a large investment in Gaza presents risks that are uncommon in other parts of the World, Scenario 3, where construction costs would be paid by the government and not charged back to the farmers, is presently being suggested. This scenario assumes that the capital investment necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmers.

2 MANAGED AQUIFER RECHARGE

2.1 MAR in the NGEST Project

Managed aquifer recharge (MAR), also known as enhanced recharge, water banking and sustainable underground storage, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can be used to store water from various sources, such as stormwater, reclaimed water, mains water, desalinated seawater, rainwater or even groundwater from other aquifers. With appropriate pre-treatment before recharge and sometimes post-treatment on recovery of the water, it may be used for drinking water supplies, industrial water, irrigation, toilet flushing, and sustaining ecosystems. The figure below shows the basic MAR process for an unconfined aquifer.

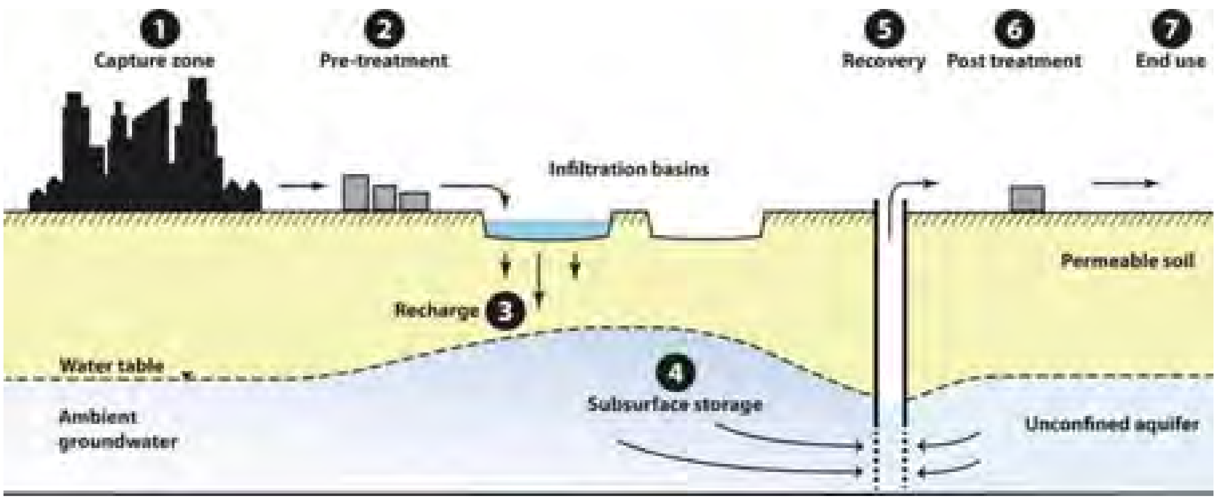


Figure 15: Schematization of Managed Aquifer Recharge System (Source: Dillon, 2009)

Several past documents describe the NGEST Project as if it is a treated-wastewater-for-irrigation project. It is not. Rather, it is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation. The difference is significant and has considerable implications for the feasibility and sustainability of the project. Outlined below are some of the central considerations and concerns for managing this segment of the project.

2.2 Regulatory Issues

The main objectives of MAR regulations should be the protection of groundwater from pollution and the assurance of public health. Topics covered in a regulatory framework often include technical issues, water quality requirements to protect groundwater and human health, regulations on the authorization to recharge and to recover water, and institutional arrangements (NRC, 2008). It is also important to determine at which point water should be submitted to regulations: at point of use, at the point of withdrawal from the aquifer or before recharge?

The quality of the water extracted from the aquifer should meet the most stringent standards related to the intended water use. The quality of the water of a recharged aquifer is a function of multiple factors, including:

- the quality of the recharge water;
- the recharge method used;
- the physical characteristics of the vadose zone and the aquifer layers;
- the water residence time;
- the amount of blending with other sources;
- the history of the recharge.

Setting requirements for indirect recharge is not an easy task. The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, thanks to retention and oxidation processes. These processes affect organic matter, nutrients, microorganisms, heavy metals and trace organic pollutants. However, though much is known about these processes (Bouwer, 1996; Drewes & Jekel, 1996), forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is complex. Performances depend on a number of factors such as depth of the unsaturated zone, physical and mineralogical characteristics of the soil layers, heterogeneity, hydraulic load, infiltration schedule and infiltrated water quality (Dillon, 2009).

Therefore, particularly when transfer through the vadose zone is part of the treatment intended to bring the water up to the required water quality, pollutant removal tests should be performed, at the laboratory and onsite, to ensure the water achieves the desired quality. The example of the Dan Project in Israel shows that submitting secondary effluents to a Soil Aquifer Treatment system in a dune sand aquifer can result in the production of a nearly potable water (Sack, Icekson-Tal & Cikurel, 2001).

The complexity of reactive transport processes in the unsaturated zone highlights two of the main stumbling blocks that must be taken into consideration if treated wastewater is being considered for MAR: one specific challenge is to have numerical models that can include all of the hydro-biogeochemical processes involved in reactive transport, while a second, more operational, is the need to have a complete biogeochemical and hydrogeological characterisation specific to each MAR site. These should be taken into consideration in assessing the capacity building needs of PWA, EQA and other stakeholders involved in managing the NGEST project.

Several countries (the United States and Australia, for example) have developed guidelines for the use of treated wastewater for recharge (USEPA 2004, 2012; WHO 2006a, b). These guidelines focus mainly on the health and environmental risks that result from the presence of pathogenic microorganisms, suspended solids and dissolved organic carbon in this water. There are few recommendations concerning trace element contents in water (e.g. USEPA 2012), except as concerns five trace metals. These are: (i) arsenic; (ii) nickel, which is only weakly toxic but which accumulates in plants; (iii) cadmium, which is considered to be the metallic pollutant of greatest concern due to its rapid accumulation in plants and its proven toxicity even at low concentrations (acceptable daily intake (ADI) 0.057 mg/day/individual); (iv) mercury, which can be highly mobile; and (v) lead, the injection of which, even at low doses, can cause neurotoxic and hepatotoxic disturbances (Dillon et al. 2009a).

Although these guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse. Land use planning and environmental impact assessment legislation add to the complexity of the regulatory frameworks currently available for MAR schemes. See Annex 7 for international case studies on regulating MAR systems.

2.2.1 Implications for the Application of Palestinian Wastewater Regulations

The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater. As has been discussed in past NGEST documents, the Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced. There has been some expressed concern whether this regulation applies to the NGEST irrigation scheme, which would significantly restrict the types of crops farmers could grow in the project area and, as a result, have severe implications for the financial sustainability of the project.

But the concern of whether the regulation applies to the irrigation scheme stems from the misunderstanding of the nature of this project highlighted at the beginning of this section. The NGEST project does not entail using treated wastewater for irrigation *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. The recovered water, therefore, is no longer “treated wastewater,” and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.

That being said, the regulation also covers the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A"). See the below Table 4 for the basic parameters for each category.

Table 4: Palestinian reuse standards (PS 742/2003)

Class	Quality	BOD mg/l	TSS mg/l	Feacal Coliform MPN/100ml
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000
D	Low	60	90	1,000

The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.

The project, therefore, is in complete compliance with the Palestinian regulation.

2.3 Operation and Maintenance

Clogging appears to be the most limiting technical problem in artificial recharge and can only be managed with regular maintenance and pretreatment. Clogging can be caused by various mechanisms like physical clogging by suspended solids, chemical clogging due to precipitation or clay dispersion, mechanical clogging due to entrapped air or biological clogging due to microbial growth (Pyne, 1995; Pérez-Paricio and Carrera, 2001; Bouwer, 2002). Clogging leads to the decrease in porosity and hydraulic conductivity and is experienced at the bottom of infiltration basins as well as around injection wells. There are two basic principles for the management of clogging: (a) pretreatment of recharge water and (b) redevelopment (Brown et al., 2006).

Apart from maintenance related to clogging, regular inspections of the facility are needed to assess if any repair works or cleaning is needed. This could include the cleaning of any screens, change of batteries, lubrication or replacement for equipment prone to wear and tear, repair of damage done by natural forces or vandalism. If mechanical or electrical parts are involved their proper functioning needs to be tested.

2.4 Monitoring Program and Data Collection

Monitoring is an integral part of MAR management and should be undertaken to both determine the effectiveness of the recharge scheme and to investigate the sustainability with respect to human and environmental health. The minimum monitoring requirements should guarantee that no groundwater contamination occurs or at least can be detected early. Minimum parameters should be TSS, TDS, nitrate and E.coli. Depending on the hazards present in the catchment further parameters like organic contaminants (pesticides, oil, MTBE, etc) should be added.

Monitoring starts with baseline monitoring i.e. the investigation of the current situation before the MAR scheme is implemented and should cover spatial and temporal variability. Validation monitoring determines the actual performance of the MAR scheme and is essential if the natural attenuation processes are part of the treatment scheme. For quality monitoring, mean concentrations in source water rather than peak values are needed. If pathogens are of concern, E.coli, coliphage and clostridium spores (NRMMC-EPHC-NHMRC, 2009b) or rotavirus, Cryptosporidium parvum and

Campylobacter (WHO, 2004) could be measured as pathogenic indicators. Typical herbicide parameters could be simazine and chloripyrifos (Swierc et al., 2005). Conservative tracers in source and groundwater can help determine the amount of mixing.

Reliable predictions of groundwater flow are possible only if the aquifer system is well known, which means that sufficient data need to be available to work out well-calibrated hydrodynamic numerical models. Obtaining representative groundwater samples requires properly constructed wells, an appropriate pumping mechanism, proper flushing of the well and correct sample preparation, storage and preservation and should hence only be undertaken from skilled personnel. There are a number of guidelines outlining proper groundwater sampling techniques (Schuller et al., 1981; Barcelona et al., 1985; Johnston, 2007; Sundaram et al., 2009).

2.4.1 Monitoring Strategy and Plans

Before preparing a groundwater monitoring plan, the overall strategy of the groundwater monitoring program should be defined to guide the development of the plan. In this sense, "strategy" refers to the manner in which a hypothetical release from a regulated unit will be detected or measured. Examples of issues that should be addressed when developing a monitoring strategy include:

- The type of monitoring data needed;
- The locations (both horizontal and vertical) from which the samples are to be collected (i.e., definition of "target monitoring zones");
- The manner in which the samples will be obtained; and
- The ability of the monitoring features to rapidly detect a change in groundwater quality.

Development of a groundwater monitoring strategy is illustrated in Figure 16 and Figure 17. As shown in these figures, the potential sources of contamination and the aquifer of concern should be characterized before developing a groundwater monitoring strategy because selection of target monitoring zones cannot be made until the source and the aquifer have been evaluated, usually through a detailed hydrogeological evaluation of the site. When evaluating the ability of a monitoring system to rapidly detect a release from a potential source, the impact of preferential flow paths and vertical gradients should be carefully evaluated; a two-dimensional analysis of groundwater elevation may not reveal actual upgradient or down gradient locations of groundwater flow. The presence of vertical gradients may significantly effect the selection of monitoring locations.

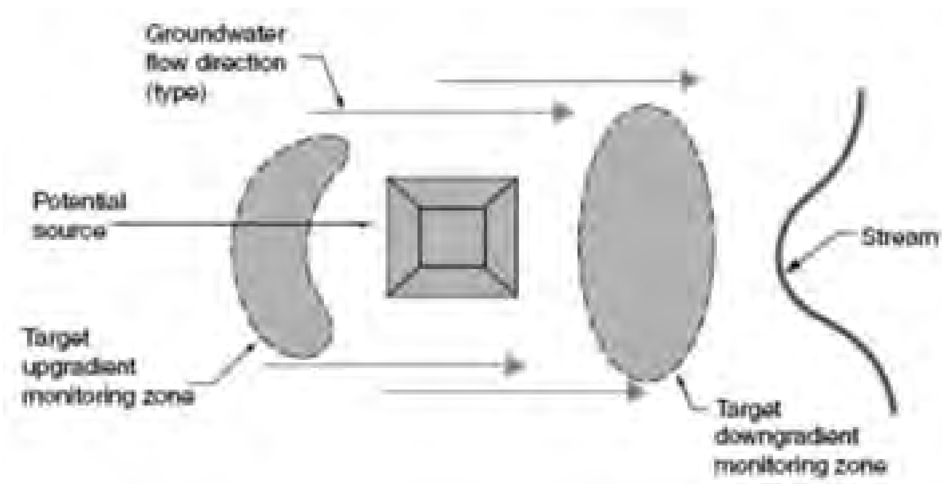


Figure 16: Plan view of typical unconfined aquifer groundwater monitoring system

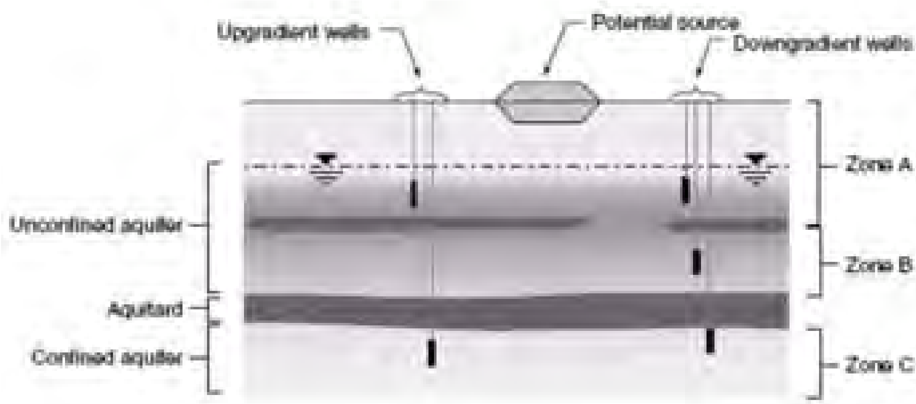


Figure 17: Vertical cross section of target monitoring zones.

2.4.2 *Monitoring Locations and Parameters*

Locating the appropriate monitoring point locations is essential in designing a monitoring network capable of providing data of adequate quality. Selected monitoring locations should provide the most reliable data needed to detect or assess a groundwater contaminant plume. To verify that the monitoring network can accomplish this goal, target monitoring zones must be selected based on the site hydrogeologic conditions and anticipated contaminant pathways. Figure 18 shows the recommended locations of the monitoring wells which was set up based on the location of the recovery wells.

The groundwater monitoring program in the NGEST Project is designed to evaluate the status of the groundwater quality after infiltration of partially treated and treated wastewater. The monitoring wells are distributed in two rows: around 400 to 500 m from the infiltration basin and the second row will be of 1100 to 1200 m from the basin. The first monitoring well row should be located before the first row of the recovery wells in the direction of the infiltration basin, and the second row of the monitoring wells should be located after the second row of the recovery wells to check the quality of groundwater outside the recovery wells areas. The monitoring network will also use the existing 5 monitoring wells constructed recently by PWA and used to monitor the infiltration basin. In addition, the recovery wells will be part of the monitoring network as shown in Figure 18.

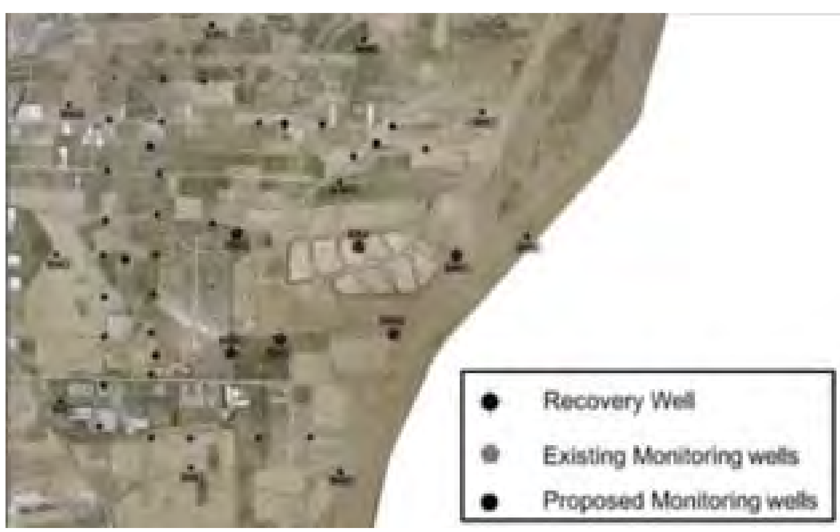


Figure 18: Monitoring wells location

The main objective of monitoring is to check the groundwater quality after infiltration and check the operation of SAT process. The consultant made extensive reviews of similar projects such Gosh Dan Project where several parameters are monitored. Among these parameters, the consultant proposed in Table 5 some parameters which would reflect the status of groundwater after infiltration and could be analysed in Gaza Strip laboratories.

Table 5: Monitored Parameters and Frequency of Monitoring

Parameter	Frequency of Monitoring
Water Level	Monthly
pH	Four Times a year
TDS	Four Times a year
BOD	Four Times a year
COD	Four Times a year
DOC	Four Times a year
TC	Four Times a year
Ammonia as N	Four Times a year
NO_3	Four Times a year
NO_2	Four Times a year
T.N	Four Times a year
Cl	Four Times a year
Detergent	Four Times a year
F.C	Four Times a year
Phosphorus	Four Times a year
Heavy Metals	Four Times a year
O_2	Four Times a year
Nitrogen and Oxygen Isotopes	Four Times a year
Mg	Four Times a year

Samples will be collected from the monitoring wells to characterize the geochemistry of groundwater. The nitrogen and oxygen isotopes of groundwater nitrate will be used in conjunction with other geochemical data to place constraints on potential nitrate sources.

2.5 Recommendations

2.5.1 Regulating Extraction

MAR is one of the measures that can be implemented to secure water supply, compensate for some effects of climate change and, more generally, handle the quantity and quality of groundwater bodies. It is not, however, a substitute for groundwater management based on decreasing abstraction and adapting withdrawal to resource availability.

There are a number of private wells in the Gaza Strip, only some of which are officially registered. Thousands of wells are estimated to have been drilled without authorization, which has contributed to more rapid deterioration of the aquifer. (UNEP, 2014) To protect the aquifer and for the success of the NGEST project, both the authorized and unauthorized agricultural wells should cease operation.

In order to do that, PWA, which is the institution responsible for issuing and renewing licenses for agricultural wells, plans to include a new clause in the next annual renewal of licenses that specifies that the operation of an agricultural well should be stopped when reuse water is available. At the same time, the voluntary adhesion to the new irrigation scheme shall be pursued.

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

2.5.2 MAR Training

There are various institutes within the Gaza Strip that currently provide training regarding water and wastewater management. These institutes should be encouraged to establish short courses for MAR operators and regulators. These could also help ensure risk management plans are designed and implemented effectively and management issues are understood and addressed.

More is said on the needs of MAR training in the section on Institutional Capacity Building.

2.5.3 Aquifer Protection

Enforcement measures against illegal use, abuse and deteriorating groundwater conditions should also be introduced as well as legislation to create water resources protection zones for drinking water resources. It is recommended to develop a holistic MAR strategy and to implement transparent and comprehensive regulations specifying maintenance, monitoring and reporting requirements. Regulations should also address water allocation, ownership issues and demand management.

3 INSTITUTIONAL FRAMEWORK

3.1 Overview

The institutions most likely to be involved in the implementation and oversight of the NGEST irrigation system consist of the following:

- PWA and MoAg will cooperate to set up WUAs. Both PWA and MoAg will monitor the project's implementation.
- IAS will manage the NGEST recovery and reuse schemes and be responsible for O&M of the network. WUAs will be part of the IAS so that they are fully involved with the project management. Until the IAS and WUAs are created, CMWU should operate and manage the network.
- EQA will monitor the work to ensure it does not cause environmental harm and will cooperate with PWU in setting any water quality/use standards.
- MoLG will coordinate with municipalities, the CMWU, the WUAs and other stakeholders in the water distribution system.
- MoH will monitor the work to ensure it does not cause harm to human health and will cooperate with PWU in setting any water quality/use standards.

3.2 Institutional Framework Under the New Water Law

The water sector reform process currently underway in Palestine began in earnest in 2009, with the endorsement of the "Action Plan for Reform" by the Cabinet of Ministers, which led to the definition and implementation of a comprehensive program of institutional and legislative reforms, culminating in the passage of a new water law in 2014. The new law "aims to develop and manage the Water Resources in Palestine, to increase their capacity, to improve their quality, to preserve and protect them from pollution and depletion, and to improve the level of water services through the implementation of integrated and sustainable water resources management principles". Of particular importance, the law identifies the roles and relations among the various water sector institutions.

Perhaps the most significant institutional change brought about by the new water law is that the Palestinian Water Authority's (PWA) role of regulating service providers has been given to a new independent entity, the Water Sector Regulatory Council (WSRC), which was established in late 2014. Its objective, as defined by the law, is to "monitor all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management, with the aim of ensuring water and waste water service quality and efficiency to consumers in Palestine at affordable prices."

In addition to measuring the efficiency and performance of the service providers, WSRC is mandated with economic regulations regarding tariffs and cost of development and supply of water, including:

- Approval of water prices, costs of supply networks and other services required for the delivery of water and waste water services;
- Issuance of licenses to Regional Water Utilities and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of wastewater, and the levying of license fees;
- Monitoring operation processes related to the production, transport, and distribution of water and operational processes of wastewater management; and
- Monitoring the compliance of the National Water Company and Service Providers with the adopted standards for the provision of water and sanitation services. Monitoring water supply agreements.

Furthermore, WSRC can conduct inquiries, investigations and inspections, but does not impose fines or other financial sanctions. The powers of WSRC to enforce compliance with regulation (for instance enforcing the water quality standards) are not defined in its mandate.

Another major institution created by the new water law is the National Water Company (NWC). The existing West Bank Water Department (WBWD) will undergo a transitional period of financial and management upgrade to be followed by the establishment of the NWC, which will be a publically owned water company to cover the Gaza Strip and the West Bank.

The NWC will oversee supply and sale of bulk water to water undertakings, local authorities, joint water councils and associations. It extracts or develops any resource and transmits it in bulk based on a license issued by PWA. Points of delivery of the bulk water are Regional Utilities for all water users (other than for irrigation) and Water Users Associations (WUA) for irrigation water.

The water sector is centralised in terms of strategy, policies, project development and identification of bulk water supply, yet decentralised to the point of fragmentation among municipalities in the provision of services. Customer water services are currently provided by 300 water service operators across the country. Most of them (> 90%) are not independent water companies, but rather small technical branches of municipalities (PWA, 2003). Many of these municipal branches have very low levels of financial autonomy and suffer from both a lack of technical skills and political interference.

In order to improve efficiency in the provision of services and achieve economies of scale, the new water law seeks the creation of Regional Utilities and WUAs for water distribution. Individual water departments in the municipalities will first consolidate to form Joint Services Councils and eventually amalgamate even more to form the Regional Utilities (RU), ideally four: three in North, Center, and South of the West Bank; and the fourth in Gaza. The Gaza structure is nearly completed as the Coastal Municipal Water Utility (CMWU). Irrigation water services will be administered through Water User Associations (WUA), which are to be established according to a regulation that will be proposed jointly between the PWA and the Ministry of Agriculture (MoAG). According to the Water Sector Reform Plan 2016-2018 and confirmed by representatives of PWA in May 2017, a by-law on WUAs is currently under review by the Cabinet of Ministers.

The figures below depict the institutional framework before and after the law. Table 6 and Table 7 identify the new roles and inter-related responsibilities of the various entities. Annex 1 further elaborates on these relationships.

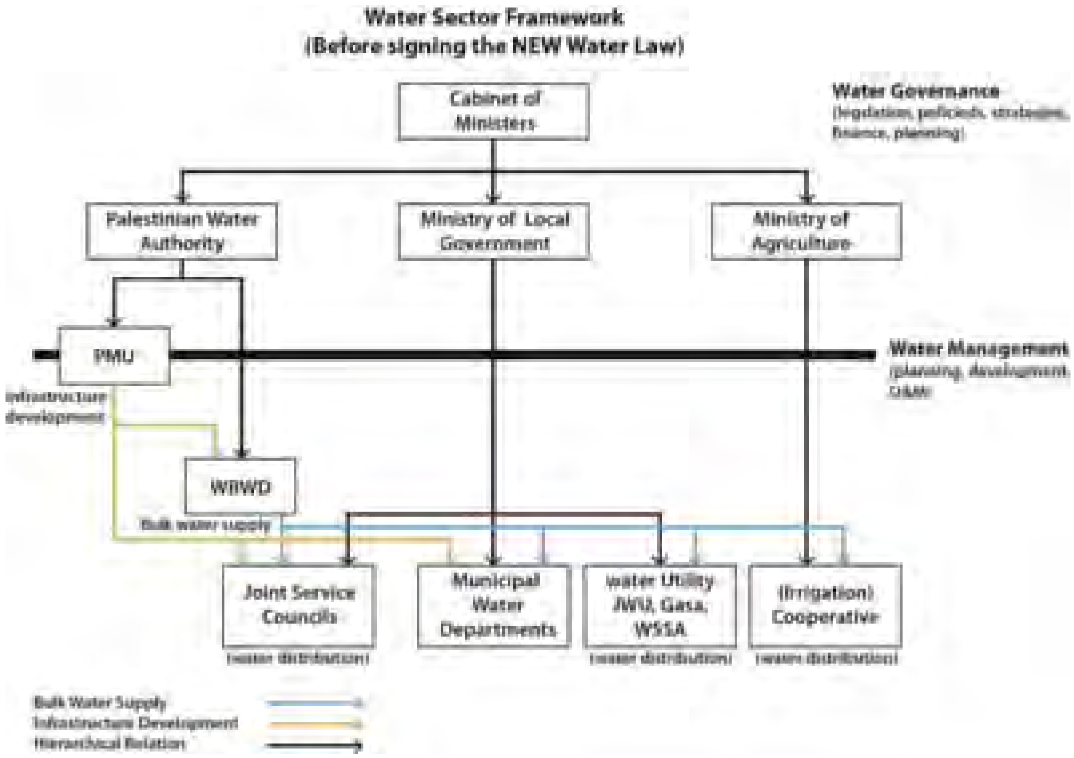


Figure 19: Institutional Framework before signing the law (Source: Water Governance, 2015)

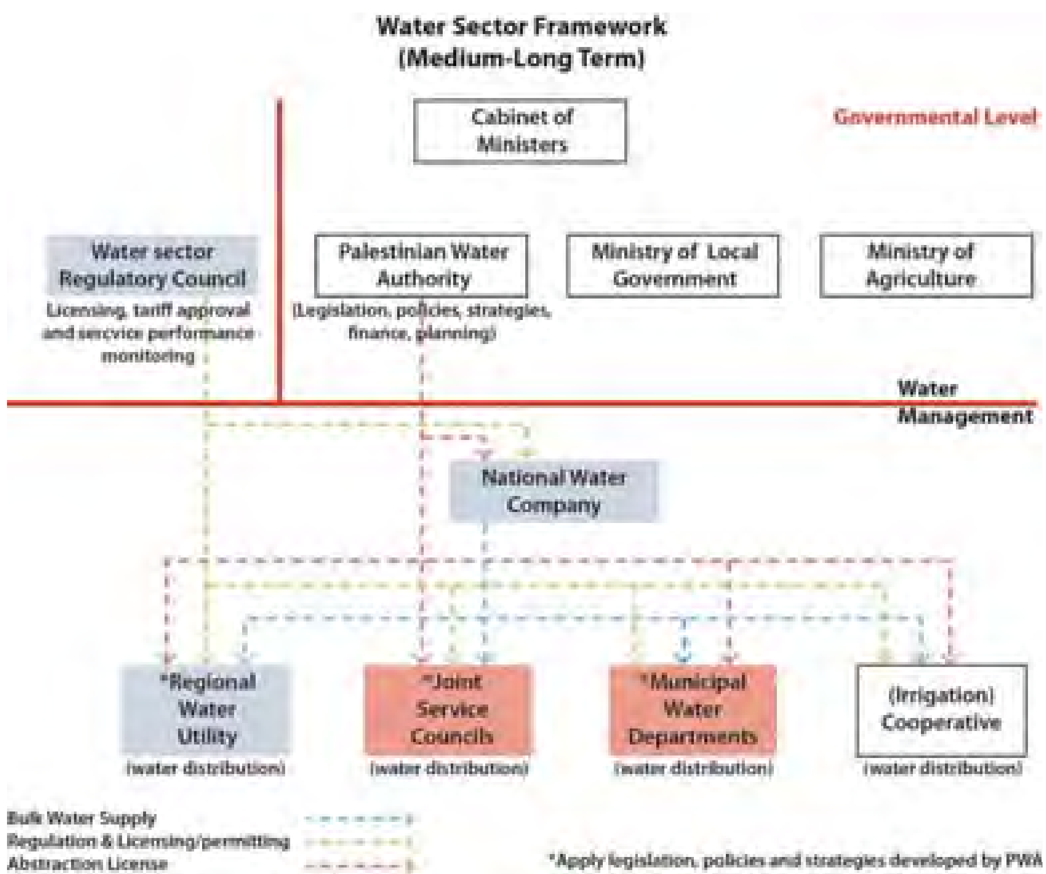


Figure 20: Institutional Framework after signing the law (Source: Water Governance, 2015)

Table 6: Institutional mapping of roles and responsibilities in the water sector at central government level according to the new water law. *Allocation of roles across ministries and public agencies*

AREA	WATER RESOURCES	WATER SUPPLY			Wastewater Treatment
		Domestic	Agriculture	Industry	
Strategy, priority setting and planning, including infrastructure	PWA	PWA	PWA	PWA	PWA, MOH, EQA
Policy Making	PWA	PWA	PWA	PWA	PWA, EQA, MOH
Information, monitoring and evalutation	PWA EQA, envt condition MOH, health qlty	WSRC EQA MOH	WSRC EQA MOH	WSRC EQA MOH	PWA, EQA, WRSC, MOH
Stakeholders engagement, citizen's awareness	PWA EQA MOLG MOH	PWA MOLG MOH	PWA MOA MOH	PWA MOH	PWA EQA MOH

Table 7: Institutional mapping of roles and responsibilities in the water sector at central government level according to the new water law. *Institutional mapping for quality standards and regulation*

AREA	WATER RESOURCES	WATER SUPPLY			Wastewater Treatment
		Domestic	Agriculture	Industry	
Allocation of uses	PWA	PWA	PWA	PWA	PWA, MOH, EQA
Quality standards	PWA, MOH	PWA, MOH	PWA, MOH, MOA	PWA, MOH	PWA, EQA, MOH, MOA
Compilance of service deliverys	WSRC	WSRC	WSRC	WSRC	WSRC
Economic regulations (tariffs)	PWA	PWA	PWA	PWA	PWA
Environmental regulation	PWA, EQA	PWA, EQA	PWA, EQA, MOA	PWA, EQA	PWA, EQA

The above list is not comprehensive as it does not include, for example, the Ministry of Finance.[2] It is also important to note that the Water Law of 2002 called for the establishment of the National Water Council, to be made up of representatives from several ministries. Though established, the Council was never effective.[3] The new Law of 2014 does not refer to the Council so it is presumably defunct.

[2] The list would also normally include the Ministry of Planning but it was apparently dissolved by Hamas in October 2016.

[3] The NWC has not held a single meeting since its establishment.

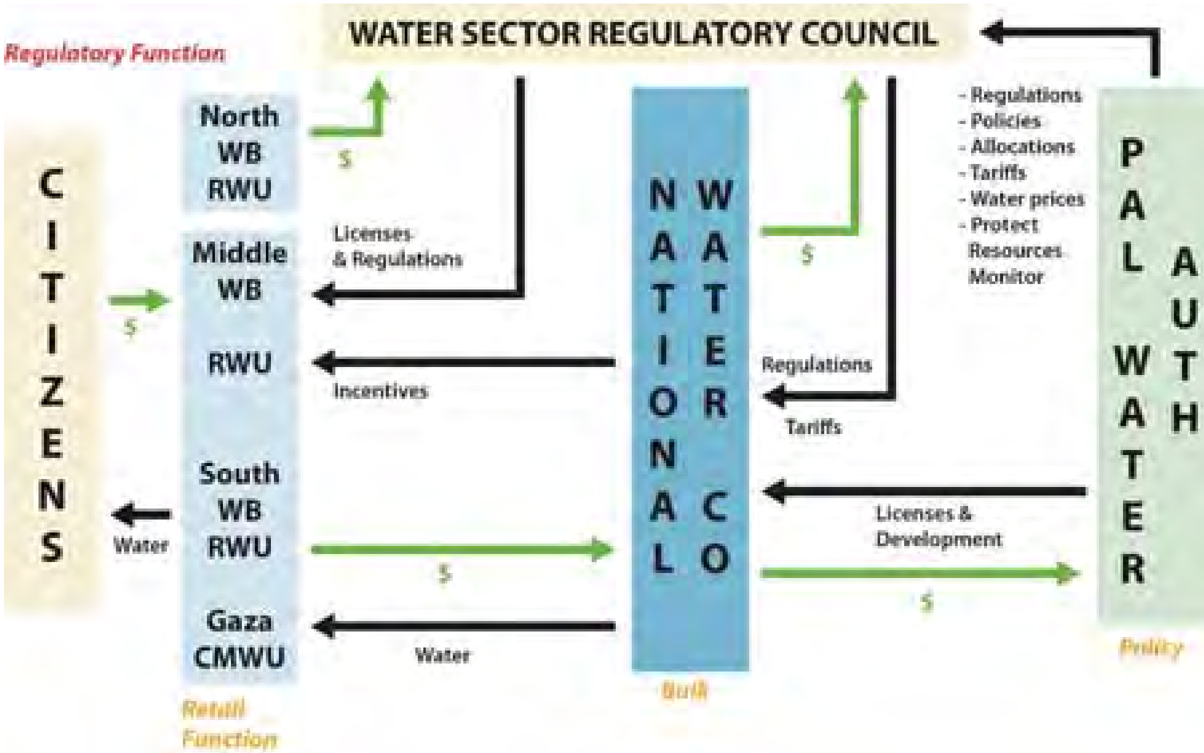


Figure 21: Water Sector Regulatory Council Functional Structure

The figure above illustrates the functional structure of the water sector entities according the 2014 Water Law. Arrows in black are functions whereas arrows in green show the direction of flow of funds. As seen, the consumers (citizens) pay the respective retail unit (CMWU, for example) for the water delivered. The retail unit then pays both the bulk supplier for the water supplied and the regulator for its services such as license fees, whereas the bulk supplier pays the PWA for licenses granted to exploit and develop the supply sources.

3.3 Key Institutions for the NGEST Irrigation Scheme

Various Palestinian institutions will be directly involved with the recovery and reuse scheme of the NGEST Project: PWA; MoAG; CMWU; WSRC; and WUAs. Indirectly, several other ministries are also implicated, including the Environmental Quality Authority (EQA), Ministry of Local Government (MoLG), and Ministry of Health (MoH). Each is briefly considered in turn below.

PWA and MoAG will need to cooperate with one another in multiple areas for the NGEST irrigation scheme. First, they must work to create WUAs through WUA-specific legislation. Establishing WUAs on the basis of specific legislation means that their purpose can be clearly specified from the outset as can the manner in which they are to be established and operated. It also means that the legislation can take account of the specific nature of WUAs through, for example, the provision of suitable and appropriate governance structures that are designed to promote transparency and effective rule making. There is allegedly a draft by-law on WUAs at the Cabinet. Its contents are unknown to the Consultant.[4]

Additionally, PWA and MoAG will need to jointly monitor the project's implementation, and provide farmers in the project area with support. MoAg will need to closely supervise farmers' activities, irrigation methods and application rates as well as collect sampling and do testing of crops and soils. Local WUAs should also be involved with the system's management and water distribution. PWA, MoAg, and the WUAs efforts may best be organized through an Irrigation

[4] The draft by-law as well as several other documents were requested but not received.

Advisory Service (IAS) recommended by this *Report*. The IAS would provide a platform for multi-stakeholder communication and gather the requisite expertise for running the project in one office. Given the multiple ministries responsible for monitoring, the IAS may also serve as the gathering point for monitoring data.

Because the IAS and WUAs do not yet exist, the CMWU is best positioned to run the irrigation scheme in the meantime. The CMWU, as the water utility in the Gaza Strip, currently handles municipal water supply as well as sewerage and WWTPs, including house connections and operation and maintenance, so it already has experience in this area. The existing sewerage fee is charged by the CMUW, so any additional wastewater fee could potentially be added to the same bill of water.

While it manages the system, CMWU would be responsible for the establishment of the conveyance system, metering of farm off-take points, contracting with farmers and tariff collection. It would also be responsible for recharge of the surplus effluent. Until the IAS and WUAs are established, CMWU will be responsible for control of water demand and should work with MoAg to coordinate with farmers to ensure equitable and suitable distribution of recovered water according to crop requirements.

Whatever entity is managing the irrigation network – either CMWU or IAS – that entity will be responsible for the recovered water quality and be subject to audits and check sampling by EQA. EQA will monitor the work to ensure it does not cause environmental harm and will cooperate with PWU in setting any water quality/use standards. Additionally, MoH should be involved in monitoring to ensure the application of recovered water does not cause harm to human health and should cooperate with PWU in setting any water quality/use standards. Finally, MoLG will coordinate with Local Government Units (LGU), municipalities, CMWU, WUAs and other stakeholders in the water distribution system.

In Annex 2, 3 and 4 are presented several case studies of successful institutional set-up (including water users involvement) in irrigation and drainage in developing countries.

3.4 Institutional Capacity Assessment

There are a number of particular skills that need to be developed for the successful implementation of the NGEST project, including management of MAR and sludge as well as the design, operation and maintenance of modern irrigation technologies. There are also a range of specialized technologies that must be mastered, including groundwater modelling and GIS remote sensing. Communication and cooperative approaches should also be fostered through trainings on developing the IAS or community awareness raising to bolster support for the project.

In order to adequately assess the specific capacity development needs for each aspect of the project, this *Report* has interwoven capacity building throughout each section: Managed Aquifer Recharge; Farmer Assistance; IAS; WUAs; and Operation and Maintenance of the Irrigation System. Therefore, although there are recommendations below for Institutional Capacity Building, overall capacity development should be viewed through the context of the entire *Report*.

3.5 Recommendations

A capacity development system for the Water Sector already exists and a substantial amount of resources are being invested to enhance capacities in the water sector in Palestine. (PWA, 2016) Compared to other countries, where capacity development efforts have to be developed from scratch, Palestine boasts a substantial foundation of sufficiently developed institutions and high number of human resources investments. Palestinian Universities, polytechnics, industrial secondary schools and vocational training schools produce a constant inflow of trained professionals for the water sector, and international donors have expended considerable sums for training of water sector stakeholders. See Annex 6 for a list of current capacity development initiatives.

However, there needs to be a better coordination of capacity development initiatives with policies and strategies so that there is a more efficient utilization of resources and the training better meets the needs of the sector. In particular, PWA, WSRC as well as the NWC, RU and WUAs need targeted capacity building to implement the water law, to make effective and efficient use of increased investments, and to maintain the existing and new infrastructure.

In addition to supporting the reform process through capacity development, work needs to be done to create an environment in which skill and knowledge acquisition can take place, including, for example, fostering a professional atmosphere in which technical growth is rewarded and there are incentives for participation, allocating a sufficient budget for on-going development, and ensuring monitoring and follow-up of capacity development efforts.

Below is a truncated list of institutional capacity building recommendations. As mentioned above, for a more detailed analysis of capacity development needs, see the other relevant sections of this *Report*.

- Capacity Development Coordination

There is a need for sector-wide monitoring and evaluation of capacity development interventions. The current lack of the monitoring and evaluation is directly correlated with the need for coordination, but also lends itself to the mismanagement of limited resources, decline in performance and loss of value for money spent. It is expected that the newly created Capacity Development Directorate of PWA will lead this coordination as well as execute the recommendations contained in PWA's Water Sector Capacity Development Policy and Strategy of 2016.

- Focus on Practical Skills

There should be increased focus on the development of practical knowledge and competencies to address existing and emerging water sector challenges, for example negotiation with the Joint Water Committee, and how to build, manage, repair and renew a technical irrigation system.

- Encourage On-going Capacity Development

Water professionals need to refresh and expand their knowledge base in a number of training days each year to be able to excel in their work. Organizational Capacity Development (action) plans, covering a 3-5 year period, should be prepared by the relevant units and persons within the respective organizations. These plans should be approved by the organization itself, endorsed at national level, and updates should be made annually.

- Help Prepare CMWU

Because CMWU will likely handle the operation and management of the NGEST irrigation scheme until the creation of the IAS and WUAs, the capacity of CMWU should be expanded to provide this service. Additionally, there may be the need to modify the current mandate of the CMWU to reflect this change.

- Sludge Management

Training is needed that tackles sludge collection, treatment, or dumping and sludge management. Sludge represents a completely new sector, which should be organized and well regulated in order to benefit from it.

- MAR Training

A simplistic view that treating water to near drinking standards before recharge will protect the aquifer and recovered water is incorrect. For example chlorination, to remove pathogens that would be removed in the aquifer anyway can result in water recovered from some aquifers containing excessive chloroform. In some locations, drinking water injected into potable aquifers has resulted in excessive arsenic concentrations on recovery due to reactions between injected water and pyrite containing arsenic. Source water that has been desalinated to a high purity dissolves more minerals within the aquifer than water that has been less treated.

Hence the ministries responsible for the MAR scheme need to understand how this aquifer will interact with the recharged water. More specifically, they should have hydrogeological and geotechnical knowledge, as well as knowledge on water storage and treatment design, water quality management, hydrology and modelling, monitoring and reporting. They need to understand d pathogen inactivation and biodegradation. The response of an aquifer to any water quality hazard depends on specific conditions within the aquifer, including temperature, presence of oxygen, nitrate, organic carbon and other nutrients and minerals, and prior exposure to the hazard, so the ministries should receive adequate training on these subjects.

Additionally, EQA and PWA (and any other ministry that will regulate the MAR scheme) should acquire basic stratigraphic and hydrogeological information for each well drilled. This information should be stored in departmental data bases, which would ideally be publically accessible on the web.

- Create a MAR Unit

The human resources at PWA are limited as the number of staff is already not sufficient to perform all needed tasks (e.g. data evaluation, quality control) let alone to fulfil new tasks related to MAR. If MAR activities are to be pursued, it is highly recommended to create a MAR unit with competent staff to be able to perform the additional work load either within PWA, EQA, or as a sub-committee within the IAS. It is recommended that strategic planning and the development of a regulatory framework as well as the oversight of MAR activities should be undertaken by the PWA/EQA. Any future technical cooperation on MAR should clearly define responsibilities and objectives of both partners and allow sufficient time for a successful cooperation.

4 Farmer Assistance

4.1 Present Farmers' Organisations

The Union of Agricultural Work Committees (UAWC) is the main organisation[5] active in the project area, already working with a few farmers. UAWC is a non-profit organisation founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union aims to help Palestinian farmers to market their produce and provides agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions.

Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors, in the West Bank and Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in different Palestinian rural areas. UAWC receives funding from numerous western governments and aid organisations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organisations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like MoAg is also established with international development agencies, like FAO.

The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, including: land reclamation; building greenhouses; products quality enhancement and new crops introduction. Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistical and financial support for exporting goods such as strawberries and medical herbs, which usually ensure a good revenue.

4.2 Improving Farmers Technical Skills

The farmers interviewed during the baseline survey stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.

According to the outcomes of the baseline survey and the agronomic characteristics of the new proposed irrigated cropping system, the following training and technical assistance needs have been identified for the farmers:

- Training on appropriate use of irrigation

So far, the irrigation practice has been left in the domain of individual farmers without any technical assistance. Underground water is being managed without considering the actual water requirements of crops, after computing the water balance of the area. Without an appropriate approach to irrigation, the amount of water supplied to crops is often under- or overestimated hence causing low yields and problems of uncontrollable pests and diseases on the cultivated crops. The envisaged training program has the objective to make the farmers fully capable to design an irrigation plan suitable for their cropping pattern for various irrigation methods (e.g. surface, sprinkle or drip irrigation).

- Training on integrated pest management (IPM)

[5] Other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

It has been observed that use of pesticides on crops is often high in north Gaza, although these products are quite expensive since imported from Israel. Pests outbreaks are common in the target area, probably because of irrigation misuse (see above). However, farmers lack specific knowledge on effective methods for preventing pests and diseases, which should allow them to drastically reduce the amount of sprayed pesticides, so saving money and making the farming environment healthier. The IPM method has been conceived in the '70. It is a pest control strategy that uses a variety of complementary strategies including: mechanical devices, physical devices, genetic, biological, cultural management, and chemical management. These methods are done in three stages: prevention, observation, and intervention. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. IPM practices have been so far successfully implemented on vegetables and fruit tree crops which represent 65% of the new cropping pattern proposed for the project.

- Training on Integrated Plant Nutrient Management (IPNM)

This methodology has been devised by the Food and Agriculture Organization of the UN (FAO, 2006). It allows to match crop nutrient needs with sufficient accuracy to prevent surplus of fertilization. This in turn limits soil and water chemical pollution which usually is a consequence of the use of mineral fertilizers. The purpose is to maintain or enhance soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients, including biological nitrogen fixation. IPNM focuses first on the seasonal or annual cropping system (namely, the entire crop rotation applied by a farm), rather than on an individual crop; secondly, on the management of plant nutrients in the whole farming system; and, thirdly, on the concept of village or community areas rather than individual fields. The proper application of IPNM, among others, allows to minimize the use of mineral fertilizers which are particularly costly in Gaza, because imported and from Israel.

- Farming field schools (FFS) for effective training on IPM and IPNM

The Farmer Field School (SUSTAINET, 2010)is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It was initially developed to help farmers tailor their IPM practices to diverse and dynamic ecological conditions, but subsequently the method has embraced also other relevant topics for improving farmers' technical skills. In regular sessions from planting till harvest, groups of neighboring farmers observe and discuss dynamics of the crop's ecosystem, under the guidance of a facilitator (usually an agricultural extensionist, well trained on running a FFS). Simple experimentation helps farmers further improve their understanding of functional relationships within the agro-ecosystem (e.g. pests-natural enemy population dynamics and crop damage-yield relationships). In this cyclical learning process, farmers develop the expertise that enables them to make their own crop management decisions. Special group activities encourage learning from peers, and strengthen communicative skills and group building.

4.3 Building Farmers' Capacity Along the Value Chain

- Supporting farmers in establishing organizations

Collective action can create a more effective market chain that is more stable and can produce the products required at the time needed and of the quality wanted. As a group, producers can provide a more stable and higher quality supply of raw material, which also improves the economic efficiency of the value chain. The higher bargaining power and improved access to markets for group members are made possible by creating a link with other actors along the chain (retailers, traders and processors). However, a farmer organisation cannot be simply created by a top-down approach from the government (for example, by providing strong subsidies to farmers if they join an organisation; or providing inputs for free). Many worldwide experiences clearly show that farmers organisations (under the shape of cooperatives, associations, etc.) fail when members are not fully convinced that collective action is really an opportunity for them to grow and improve their lives. Farmer organisations also fail when their members do not firmly aim at economic independence, but rather rely on external aid. The survey carried out in the project area highlighted that farmers work on individual basis. Even when they share collectively the same private well, everybody keeps on working on his own. It is also noted that only one organisation is existing in the project area, joining a small number of farmers.

To cope with this reluctance toward cooperation, farmers should be invited - through a tailored training programme - to progressively share their activities. For instance, an initial stage of farmer collective action may be started just by purchasing the farming inputs together, which will allow a discount from the seller. Then, farmer collective action can further evolve in growing crops together, according to a cropping plan that has been specifically designed to meet the market needs in a certain period of the year. When collective crop production is finally carried out relationships with the merchants (wholesalers, traders at any level of the supply chain) can be strengthened and options of contract farming may become feasible. Furthermore, associated farmers may start processing the raw materials and their marketing action will become more targeted and complex. By following this progressive process, the farmers' organisation purchasing power and its share of added value along the supply chain will increase.

- Training on post-harvest operations and food processing and establishing suitable physical structures.

This training programme requires high investments and well established farmer's organisations, which will handle the operations and run the post-harvest and processing structures. The survey carried out by the consultant highlighted that in northern Gaza the existing food industries do not buy raw food materials from the local farmers but they rather import it from Israel, probably because the industry cannot find the required amounts according to its needs. While this specific demand from the industry could be properly satisfied by an organised group of farmers (see above), on the other hand organised and well trained farmers could start simple post-harvest processing activities, such as sorting and packing fresh fruit and vegetables; preparing plant preserves, purée, jams, etc. Another option would be processing dairy products, considering the good milk production from cows, sheep and goats which are being reared in the project area.

All the above-mentioned activities will improve products quality and introduce new products into the local market which will increase the farmers' earnings.

However most of the farmers seem they cannot afford the cost of the initial investment (e.g. purchasing a refrigerator unit, packaging materials, other equipment for processing), nor bank loans seem available in north Gaza. Therefore, external aid should be foreseen together with sound training sessions.

5 Operation and Maintenance of the Irrigation System

5.1 Background

Irrigated agriculture, accounting for some 85% of total water use, is by far the largest consumer of the resource is Gaza. However, the water use is inefficient and agriculture has a low productivity and yield. This situation is not only due to a lack of appropriate irrigation infrastructure and maintenance, but also due to uncoordinated actions among institutions responsible for policy making, planning, and implementation.

Traditional irrigation management in Palestine is community-based and informally organized around private wells in Gaza or springs in West Bank. Whereas in the Gaza strip a small group of farmers share the operation and costs of a private irrigation well and organize the supply of water among themselves on a rotational basis, in the West bank, common irrigation schemes can supply up to a few hundred farmers and thousands of dunums, depending on the size of the spring. The organizational level is thus quite elaborate in West Bank, dealing with O&M, billing, and scheduling for hundreds of farmers in some cases. Still it is mainly informal, the number of WUAs in the Palestinian territories is very limited and the registered ones are very few. Institutional involvement in irrigation, therefore, has been very weak and limited to the licensing of agricultural wells.

5.2 Management Structure

As discussed above, the new Palestinian water law mandates that irrigation water supply be managed by Water User Associations (WUAs). It is envisioned, therefore, that a significant portion of the management of the NGEST irrigation system will be by WUAs in the project area. Given the scale and complexity of the project infrastructure, however, it is suggested that, overall management is handled by the IAS, with members of WUAs as part of the IAS. This way, WUAs can be fully involved but not given the impossible task of starting from scratch with such a sophisticated system.

Because neither the IAS nor WUAs exist yet, it is recommended that CMWU manages it temporarily.

The time of transition while the IAS and WUAs are created is an opportunity: an opportunity to put the necessary legal, institutional, and infrastructural mechanisms in place to ensure effective and sustainable organizations. The information and recommendations contained in this *Report* are aimed at aiding in that endeavour.

5.2.1 WUAs in Gaza

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – a “collective well”. Namely, a farmer owns one well and other neighbouring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The survey shows that 92% of the farmers depend on the “collective well” system, owned by the remaining 8%.

Usually, the farmers using a collective well do not sign any formal agreement, neither are they linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmers do not pay his share in due time, thus undermining the efficient operation of the well.

The few existing WUAs in Gaza are generally small and loosely organized. This low level of organization makes it difficult to initiate joint actions. They are also faced with harsh economic and financial circumstances, including a very limited access to the international market for agricultural products. Nevertheless, it is expected that WUAs will become platforms for stakeholders’ engagement, as they are designed with that purpose in mind.

5.2.2 Common Tasks of WUAs

The main tasks and activities commonly found in WUAs include:

- Choose and specify the joint water source and take part in the planning, designing and implementation.
- Define the roles and responsibilities to manage, operate and maintain the joint water source and its structures.
- Solve conflicts among water users by achieving a fair water distribution among the users.
- By mutual control and increased sense of ownership and responsibility, reduce violations over water.
- Take part in the tasks and functions for the management of I&D projects.
- Help to develop irrigation efficiency at a field and network level, also by facilitating the spreading of modern irrigation techniques.

5.2.3 Training Needs and Capacity Building

In order to ensure a sound, grass-root establishment of WUAs, a capacity building program should be carried out to create awareness among farmers on the advantages of operating together. Moreover, farmers will learn how to work as a group, sharing duties and rights, in a such a way that water will be equally distributed according to the planned irrigation schedule, which in turn will prevent disputes among users. The farmers will also acquire how to solve possible conflicts arising within the association.

On-farm technical assistance and training on I&D topics, in conjunction with best agricultural practice, shall be assured by the local IAS (Table 8).

Table 8: WUA capacity building and training needs; estimated costs for 20 farmers

TOPIC	DURATION (Days)	ESTIMATED COST (US$)
Capacity building and awareness	10	80,000 US$
Operation and maintenance of traditional irrigation schemes	10	80,000 US$
Operation and maintenance of modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc.	10	80,000 US$
Operation and maintenance of on-farm drainage systems	5	40,000 US$
Field application the agro-meteo recommendations	5	100,000 US$
	Total	380,000 US$

5.2.4 Economic sustainability of WUAs and Costs

While they may be entitled to claim subsidies or state assistance, WUAs are usually largely self-financing, the bulk of their income being provided by their participants. It is presumed that in the first 3 to 5 years, farmers will cover only those costs which are related to a WUA's management (financial and administrative affairs) and are necessary to run the organization's basic activities (e.g. office rent, administration staff salaries etc.). At a later date, farmers could pay a variable quota related to covering I&D operation costs. This could be done by paying member fees charged on an annual or monthly basis, or calculated in proportion to farm size.

In the initial period, costs related to I&D infrastructure maintenance and possible extension and/or modernization should be incurred by CMWU, not the farmers. Nevertheless, it is envisaged that in parallel with the process of WUAs becoming fully operational, their members contribution to such costs will increase gradually with the final objective of ensuring associations' financial independence (i.e. covering own costs of operating and maintaining infrastructure under their authority).

It should be noted that, because they are non-profit, WUA-specific legislation could confer powers on WUAs to take and impose compulsory measures. These can include: the right to impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; the right to make binding operational rules concerning, for example, the use and allocation of irrigation water; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts (FAO, 2007).

Table 9 shows an estimated cost breakdown for the establishment and operation of a WUA (gathering approximately 20 farmers) in the area of the NGEST Water Reuse Scheme.

Table 9: Estimated costs for the establishment and operation of one WUA, for 1 year

ITEM	UNIT	COST (USD)
4x4 car	1	25,000 USD
Office automation equipment for administrative affairs	Forfeit	25,000 USD
Salary for administrative staff	1	30,000 USD
Capacity building and Training for WUA	380,000 US$ (see Table 8)	
Running costs	Forfeit	20,000 USD
	Total	480,000 US$

5.3 Cost Sharing Mechanisms

Typically, WUA costs include some, or all, of the following (FAO, 2003):

- The cost of obtaining a permit to abstract and use water and/or to drain water or to dispose of wastewater together with any water use and wastewater disposal charges payable pursuant to such permit;
- Charges in respect of water supplied to the WUA on a contractual basis by a state agency (such as an irrigation agency) or some other bulk water supplier;
- The WUA's own costs of operating and maintaining the infrastructure under its authority which may include staff salaries, office expenses (including the costs of rent, utilities and communication), operation costs including the costs of electricity if pumps are used, system maintenance including routine and annual maintenance, the maintenance of an emergency reserve fund, small replacement fund, transport expenses, purchase of equipment, social charges and taxes; and
- Investment costs for the construction, rehabilitation or reconstruction of infrastructure.

As mentioned above, a key feature of WUAs across the world is that they are usually self-funding, at least as far as operating costs are concerned. The typical sources of WUAs finance include fees and charges for services provided by WUAs to its participants (in majority of cases this is the main part of WUAs income; such fees and charges include WUAs administrative costs), borrowing, grants and subsidies, income from assets or capital owned by WUAs, and fines from participants who have breached its operating rules.

Fees and charges can include:

- Irrigation water supply charges;
- Drainage charges;
- Annual membership fee; and

- Any other charges levied by WUAs.

The way in which the level of fees is determined can be left up to WUAs or specified in the relevant legislation. The amounts payable by individual WUA participants are assessed based on e.g. the volume of water supplied (if the main WUA service is water provision), flat rate charged per hectare of land (in case of a range of different and not easily measurable services provided by WUA), or value of possessed agricultural land. At this stage, a proposal is made to charge water to the farmers based on the water delivered to their farms and in order to recover costs for O&M and WUAs. The proposed tariff is 0.63 ILS/m^3 of water.

In case farmers are unable to pay charges until after the irrigation season is over and they have harvested their crops, a range of methods is applied to overcome the problem, such as: participants paying deposits in respect of the service to be provided, WUAs borrowing money by way of a loan or bank overdraft or issuing bonds, or finally, WUAs receiving governmental or other grants.

It is recommendable that a WUA fund can be established to provide cost sharing bases for matching grants to assist the establishment and start up of WUAs (having an initial capital of US$ 1 million). This is deemed important otherwise WUAs may fail due to low membership dues from the majority of small farmers.

5.4 Coordination Between WUAs, Farmers, and Ministries

In order to lay the ground for an improved administrative structure for irrigation and drainage in the future, it is advisable to establish a body that will work towards better inter-agency coordination between different ministries, particularly between PWA, CMWU and MoAg and is able to include local farmers in the decision-making process. The agency should have an overall objective of working towards improved efficiency of water use in the irrigation sector and overall increased efficiency of the agricultural production. At the beginning, the agency could operate on a pilot scale, e.g. focus on implementing on-farm modernized irrigation system in the NGEST Project area and/or implementation of modernisation programme for off-farm irrigation and drainage facilities. The agency recommended to fill this role is the Irrigation Advisory Service (IAS).

5.5 Irrigation Advisory Service (IAS)

Often introduction of more effective irrigation technologies and techniques as well as rehabilitation of irrigation and drainage facilities *per se*, does not improve significantly the efficiency of water use and overall agricultural production. The key is to help users (farmers) in applying and adopting new methods into/onto their fields and limit the problems resulting from insufficient know-how and inadequate handling. Experience of countries with irrigated agriculture shows that introduction of Irrigation Advisory Service (IAS), which assists farmers, helps to address these problems. The typical scope of IAS services includes:

- Crop water management and scheduling services;
- Irrigation performance analysis services;
- Advice on design, installation, of irrigation equipment;
- Irrigation management support services (from both administrative and technical perspective);
- Advice on environmental and, in particular, water quality aspects;
- Agricultural advisory services; and
- Training of farmers.

IAS can be provided by several different bodies - private, public or co-operative - each with their specific capabilities, resources and mandate. Those can include irrigation agencies, agricultural agencies, extension services, NGOs and irrigation equipment producers or consultants. Two aspects, critical for the success of IAS, should be highlighted, these are:

- Providing a suitable legal framework and institutional setting for IAS functioning; and
- Ensuring IAS financial sustainability (paramount especially in developing countries where often insufficient or no resources are made available for such purpose).

Some examples of institutional set-ups concerning IAS in developing countries are presented in Annex 2. The Nigerien case study has been presented in more detail due to significant gains made in the country's irrigation sector thanks to the active role of IAS and application of inexpensive technologies.

The NGEST Water Reuse Scheme would greatly benefit from hosting its own resident IAS.

5.5.1 IAS structure and Composition

The IAS should have a nimble structure, with one director managing a multi-disciplinary technical team: in total, 14 people from the CMWU, MoAg and representatives from local WUAs. Table 10 illustrates the proposed IAS composition.

The IAS shall be assisted for field activities by the existing local staff of the CMWU and MoAg, and act as coordination unit for related on-farm initiatives. The IAS shall be directly linked with the future WUAs that will be established to manage irrigation water distribution. Furthermore, efforts shall be made to link IAS with the private sector as well. For instance, when a group of farmers will be willing to upgrade the on-farm irrigation scheme, the IAS shall make the technical designs as well as support the farmers to identify a reliable retailer, by also checking whether the quality of the goods matches the required quality standard.

Table 10: IAS Staff Composition

NO.	AREA OF EXPERTISE	INSTITUTION	QUALIFICATION
1	I&D	CMWU	PhD, Director
2	On farm irrigation technology	CMWU	Eng.
3	On farm drainage	CMWU	Eng.
4	Land reclamation	CMWU	Eng.
5	Water distribution	CMWU	Eng.
6	Information Technology	CMWU	Eng.
7	Relationships with WUAs	PWA	Eng.
8	Plant Production and Soil Fertility	MoAg	MSc
9	Plant Protection	MoAg	MSc
10	Agro-meteorology	MoAg	MSc
11	Rural Extension	MoAg	MSc
12	Research & Development - Water Engineering	PWA	PhD
13	Research & Development - Irrigation & Drainage	PWA	PhD
14	Administration		

5.5.2 Typology of Delivered Services

The IAS is expected to deliver extension and technical advice to the farmers under its jurisdiction, such as:

- Operation and Maintenance of the Recovery Scheme
- Operation and Maintenance of the Irrigation/Reuse Scheme

- Good practice on land levelling;
- Identification of good on-farm irrigation methods, tailored to soil characteristics and cropping system;
- Irrigation scheduling and water amount according to crop needs over the growing season;
- Fertilization plan, according to water actually available over season and irrigation schedule;
- Good practice of operation and maintenance of the irrigation system;
- Agro-meteo information to support decision-making on pests and diseases control strategies, following the method of the Integrated Pest Management (IPM);
- Advice, capacity building and training support to the local WUAs for their set up and operation;
- Mediation with retailers about the procurement for farmers of irrigation equipment and materials.

5.5.3 Training Needs

An effective implementation of reforms in the irrigation and drainage sector depends to a large extent on prolonged training of irrigation agencies/irrigation advisory service staff. This means that training and related activities should not constitute a short-term effort but become part of a long-term program that eventually evolves into a consultative, problem-solving process that encompasses ongoing technical guidance and consultation between irrigation advisory staff and other I&D stakeholders (WUAs, farmers organizations etc.)

From this perspective, training should cover a broad range of areas and address both technical requirements (e.g. related to engineering, agriculture, and socio-economy) and management needs (i.e. financial, administrative, auditing and monitoring aspects), but above all, develop skills in assisting stakeholders to build their knowledge and experience.

In addition, training should set up the conditions to allow technicians and researchers, coming from different areas of expertise, to work together to cooperate with farmers, as individuals and/or united in WUAs. In other words, training should aim at establishing a real multidisciplinary work team.

The following training needs for a potential IAS team have been identified (see Table 11).

Table 11: Capacity building and Training needs; participants and estimated costs for IAS team

TOPIC	NO. PARTICIPANTS	DURATION (Days)	ESTIMATED COST (US$)
Facilitation and training skills	14	30	168,000 USD
Design, operation and maintenance of modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc. Basic level.	7	15	42,000 USD
Design, operation and maintenance of modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc. Advanced level.	7	10	28,000 USD
Design, operation and maintenance of modern on-farm surface irrigation systems.	7	5	14,000 USD
Design, operation and maintenance of on-farm drainage systems.	8	7	22,000 USD
On farm drainage, drainage water removal and conveyance out of the irrigation areas towards the drainage outfalls	8	10	32,000 USD
Soil pedology, salt leaching, land reclamation	7	5	14,000 USD
Computer models application in I&D	7	5	14,000 USD
GIS and remote sensing application for improved water management in I&D	11	5	22,000 USD

I&D management transfer (including participatory irrigation management/WUAs formation process and backstopping)	11	15	66,000 USD
Study tour to abroad (to be selected)	11	7	77,000 USD
Use of the agro-meteo stations network. Interpretation of weather forecasting and recommendation for farmers	11	15	165,000 USD
Irrigation methods and schedule for effective pest and disease control	11	7	30,000 USD
Basic training to CMWU and MoAg local team on the scope and organization of IAS	40	4	64,000 USD
		Total	758,000 USD

5.5.4 *Economic Sustainability of IAS and costs*

The cost of the salaries of the IAS members will be covered by the concerned ministries: an extra allowance of 30% of the basic salary shall be considered in order to provide an incentive to work on the proposed IAS.

Table 12 shows the breakdown of costs for the establishment and operation of one IAS. While the items to be considered as intrinsic costs for the ministry were not identified, the additional services costs are here listed.

Table 12: Estimated costs for the establishment and operation of one IAS, for 1 year

ITEM	UNIT	COST (USD)
Two-storey building (400 m^2) for IAS office, training room, equipment, etc., including furniture	1	350,000 USD
4x4 car	2	50,000 USD
Tractor trailer	1	70,000 USD
Small Backhoe/Loader tractor	1	40,000 USD
Office automation (PC desktops; laptops; printers, internet, etc.)	Lump Sum	50,000 USD
Field equipment: automatic levels and staff gauges, simple hand held GPS equipment, Digital Cameras," Idrometers", 3 inch hand augers to take soil samples, water quality comparator hand held kits, flow measurement devices such as 6 inch Parshal Flumes, hand tools for canal maintenance	Lump Sum	100,000 USD
Salaries for IAS staff members (+ 30%)	14	Ministry intrinsic cost
Capacity building and Training for IAS Staff	758,000 USD (see Table 11)	
Dissemination and communication activities	Lump Sum	Ministry intrinsic cost
Running costs	Lump Sum	Ministry intrinsic cost

5.6 Recommendations

- Create an Irrigation Advisory Service

The establishment of an Irrigation Advisory Service is proposed as highly strategic in view of the NGEST Water Reuse Scheme in Northern Gaza and as a pilot for the rest of Gaza.

IAS shall manage the NGEST reuse scheme, in cooperation with MoAg and WUAs. It will have the shape of a public inter-ministry agency and the capacity and skills to advise farmers about on-farm Irrigation and Drainage (I&D) and appropriate water-saving crop management; in addition, the Service shall recommend the best irrigation schedule as a function of rain and pests and diseases probability.

The IAS shall have a nimble structure, with one director managing a multi-disciplinary technical team: in total, 14 people from CMWU, MoAg, and WUAs.

Training has to be considered as part of a long-term program that eventually evolves into a consultative, problem-solving process that encompasses ongoing technical guidance and consultation between irrigation advisory staff and other I&D stakeholders.

- Immediately pass enabling legislation for the creation of WUAs

There should be specific WUA legislation addressing the establishment and operation of a WUA. Although there is no "blueprint" for the design of WUAs (just as each irrigation system is different so it is likely that each individual WUA will be different), common themes in WUA legislation across the world offer guidance. In particular, the role of an effective WUA law is to set out the basic parameters within which the design of each individual WUA can be crafted. At the same time, such a law must set out minimum criteria necessary to ensure transparency and robust governance structures while conferring substantive legal rights and duties on WUA members.

One of those substantive legal rights is the long term right to abstract water from a natural source or, more commonly, a long term contractual right with a bulk water supplier (e.g. the new National Water Company). Annual contracts with no legislative backing offer little in the way of water security. What if there is a dispute? How can a WUA be sure that the supplier will enter into a new contract the following year? Ideally such contractual arrangements should be backed up with legislation that should also specify that within their service area WUAs are to have an exclusive right to supply irrigation water.

Additionally, WUAs will very often need to have express legal rights to use publicly owned irrigation infrastructure. If WUAs do not have such rights or if they are weak or vague then very quickly problems regarding responsibility for maintenance can arise with no-one willing to undertake this. (FAO, 2003)

According to the Water Sector Reform Plan 2016-2018 and confirmed by representatives of PWA in May 2017, a by-law on WUAs is currently under review by the Cabinet of Ministers. Its contents are unknown to the Consultant, so it is unclear whether these issues have been addressed.

6 Project Economics and Financial Sustainability

6.1 Micro-Economic Conditions

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

This section of the *Report* assesses what the net income for farmers would be with and without the project and assesses the availability in the farmers' budget to pay for water.

6.1.1 Evolution of the Cropping Pattern

The analysis assumes that famers will be able to fully implement the proposed cropping pattern and irrigation methods over a period of four years. These changes, changing the existing land use and planting trees and vegetables, are expected to increase land productivity.

The analysis of the value chain has shown that some crops such as fresh fruit (peaches, apricots, plums) are scarcely produced and often imported goods. Olive, as a crop to produce olive oil, is often sold at a low price and profitability might be improved by nearly 50% if olives, especially the better-preserved ones of the right variety, are processed into eatable olives. The new cropping pattern also includes almond as a profitable and long-lasting, easy to preserve, type of crop.

The newly proposed cropping pattern cannot produce the desired increase in production and profits unless farmers are extensively trained (see above for specific recommendations on capacity building for water user associations and farmers). Furthermore, It would be desirable for farmers to unite in associations or cooperatives to jointly handle the supply chain through the use, for example, of refrigeration storage facilities that allow the consumption of perishable products over a longer period of time.

Table 13: Evolution of the Cropping Pattern

					Land Development Over Time [Years]			
	BEFORE		**AFTER**		**Y1**	**Y2**	**Y3**	**Y4**
Crops and crop groups[6]	**%**	**du**	**%**	**du**	du	du	du	du
Citrus	5	603	22	2,655	1,116	1,629	2,142	2,655
Olive	8	930	23	2,776	1,392	1,853	2,314	2,776
Almond	2	272	10	1,207	506	739	973	1,207
Peaches	5	587	7	845	652	716	780	845
Other fruit tree crops	5	544	3	362	499	453	408	362
Grains*	31	3.684	12	1,448	3,125	2,566	2,007	1,448
Winter vegs	13	1.603	4	483	1,323	1,043	763	483
Winter vegs (tomato in greenhouse)	1	121	3	362	181	241	302	362
Summer vegs	8	1.009	6	724	938	867	795	724
Alfalfa (green fodder)	4	509	10	1,207	684	858	1,032	1,207

6 Crops marked in red are those that, in future conditions, will occupy less land if compared to present conditions

Uncultivated	18	2.205	0	0	1,654	1,102	551	-
Total	**100**	**12.068**	**100**	**12,068**	**12,068**	**12,068**	**12,068**	**12,068**
* grains: wheat + barley								

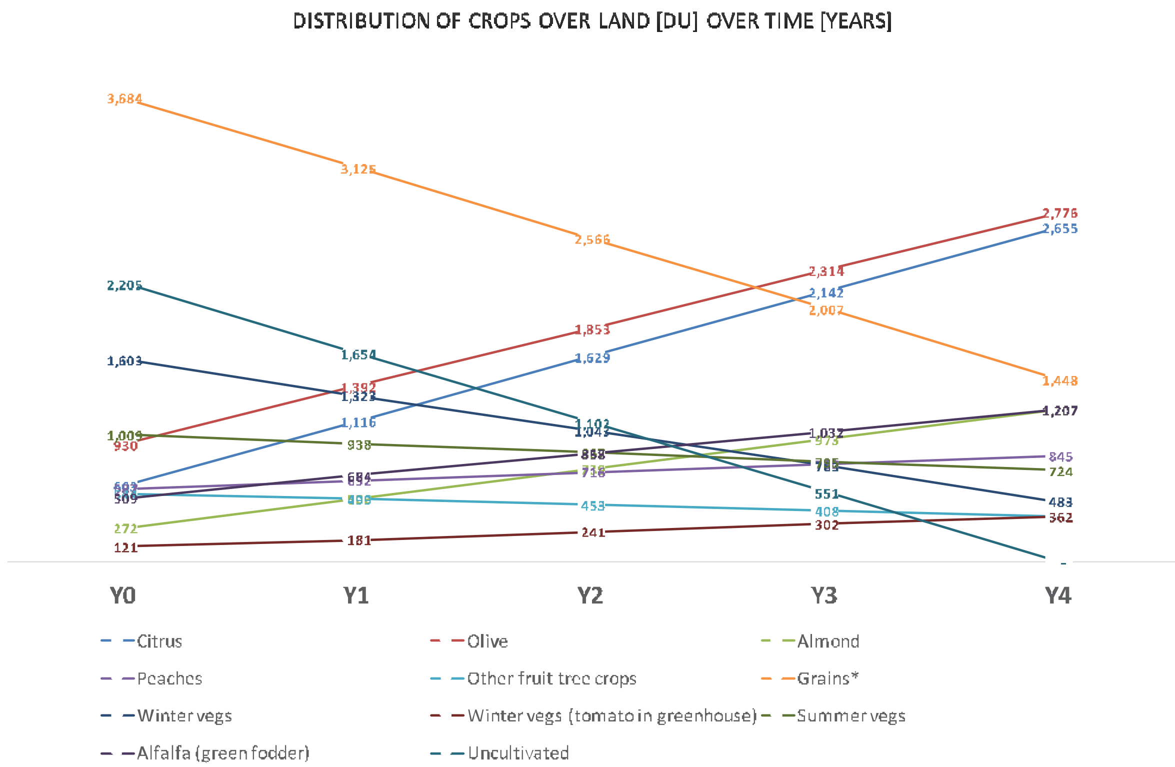


Figure 22: Evolution of the cropping pattern over land [du] over time [years]

6.1.2 Farm-Level Investments

Investments at the farm level would be largely spent on an increase in tree plantations and greenhouses placed in areas located away from the border with Israel.

The following table summarizes investments, expressed in Israeli New Shekel (ILS) per dunum (du) by type of crop and by type of material / activity required to produce such crop.

Table 14: Farm-level Investment [ILS] per dunum [du]

	Farm-level Investment [ILS/du]						
Crops and crop groups	*Green house*	*Trees*	*Irrigation grid*	*Labour*	*Machinery*	*Inputs*	*Total*
Citrus		400	380	400	0	200	1.380
Olive		800	380	400	0	200	1.780
Almond		1.200	380	400	0	200	2.180
Peaches		1.000	380	400	0	200	1.980

Other fruit tree crops							-
Grains*							-
Winter vegs							-
Winter vegs (tomato in greenhouse)	37,500		492				37,992
Summer vegs							-
Alfalfa (green fodder)			1,080	80	0	200	1,360
Uncultivated							

Considering the evolution of the cropping pattern, total investments at farm level are provided in the following Table 15.

Table 15: Farm-level investments evolution during four years of full stage

	Farm-level Investment at (ILS x 1,000)			
Crops and crop groups	Y1	Y2	Y3	Y4
Citrus	708	708	708	708
Olive	821	821	821	821
Almond	509	509	509	509
Peach	128	128	128	128
Other fruit tree crops				
Grains*				
Winter vegs				
Winter vegs (tomato in greenhouse)	2,292	2,292	2,292	2,292
Summer vegs				
Alfalfa (green fodder)	237	237	237	237
Total ILS x 1,000	**4,695**	**4,695**	**4,695**	**4,695**

Based on the new cropping pattern, balance sheet statements have been re-calculated by considering:

- a new cultural organization;
- more modern and efficient farming practices due to training activities and better extensions services;
- better and more effective phytosanitary defence;
- a more rational distribution of the irrigation network of the farm;
- a sizable reduction in net irrigation water demand;
- a higher production, especially of the tree plants due to increased attention to thinning, correct ripening and fruit calibration;
- a water tariff based on the 0,63 ILS/m^3.

6.1.3 Water Tariff

The water tariff has been prudently calculated including the effect of climate change, system losses, unexpected events due to pipe breaks, possible defects and/or breaks of the water metering system, possible reading errors of the water metering system and considering a margin of tariff increase of about 40%.

The balance sheet was calculated on the basis of a ILS/m^3 fee of 0.63 derived from the following calculation:

Annual Cost for O&M and WUAs/IAS [ILS/year]	Gross Water Requirements [m^3/year]	Net Irrigation Water Requirements [m^3/year]	Tariff ILS/m^3
4,956,799.90[7]	11,110,000	7,833,484	0,63

The details of the number presented above are given in the following Table 16:

Table 16: Gross and Net Irrigation Water Requirements at farm level and excluding industries

Type of Crop	Net Irrigation Water Demand	Gross Irrigation Water Demand
Crop	m^3/year	m^3/year
Citrus	2,196,183	3,114,835
Olive	1,957,104	2,775,750
Peaches	531,016	753,138
Grains	448,785	636,509
Other fruit	225,297	319,538
Summer vegetables	470,724	667,626
Winter vegetables	141,871	201,216
winter tomato greenhouses	51,337	72,811
Almond p	750,992	1,065,128
alpha-alpha p	1,060,174	1,503,639
Total m^3/year	7,833,484	11,110,191

6.1.4 Breakeven Point of Water Tariff

In order to better qualify how the balance sheet of each individual crop changes by changing the water tariff, the break-even point between costs and revenues was estimated for each crop. The results, displayed in the following table, show that a large part of the crops have the costs and revenues balance between a tariff of 0,90 ILS/$m^3$and of 2,49 ILS/m^3.

Water price sensitivity is lower in summer and winter vegetables, while only vegetables grown in the greenhouse can withstand a high cost per cubic meter of water.

Table 17: Water tariff that involve zero net margin

Crops	olive	citrus	peaches	grain	other fruit crop	summer vegetable	winter vegetables	winter greenhouses	almond	alpha alpha
water tariff ILS/m^3	**1.00**	**1.63**	**2.49**	**-0.89**	**1.76**	**3.31**	**6.56**	**42.51**	**0.90**	**1.14**

[7] The annual cost of the WUAs is assumed to be 300,000 ILS and added to the O&M costs.

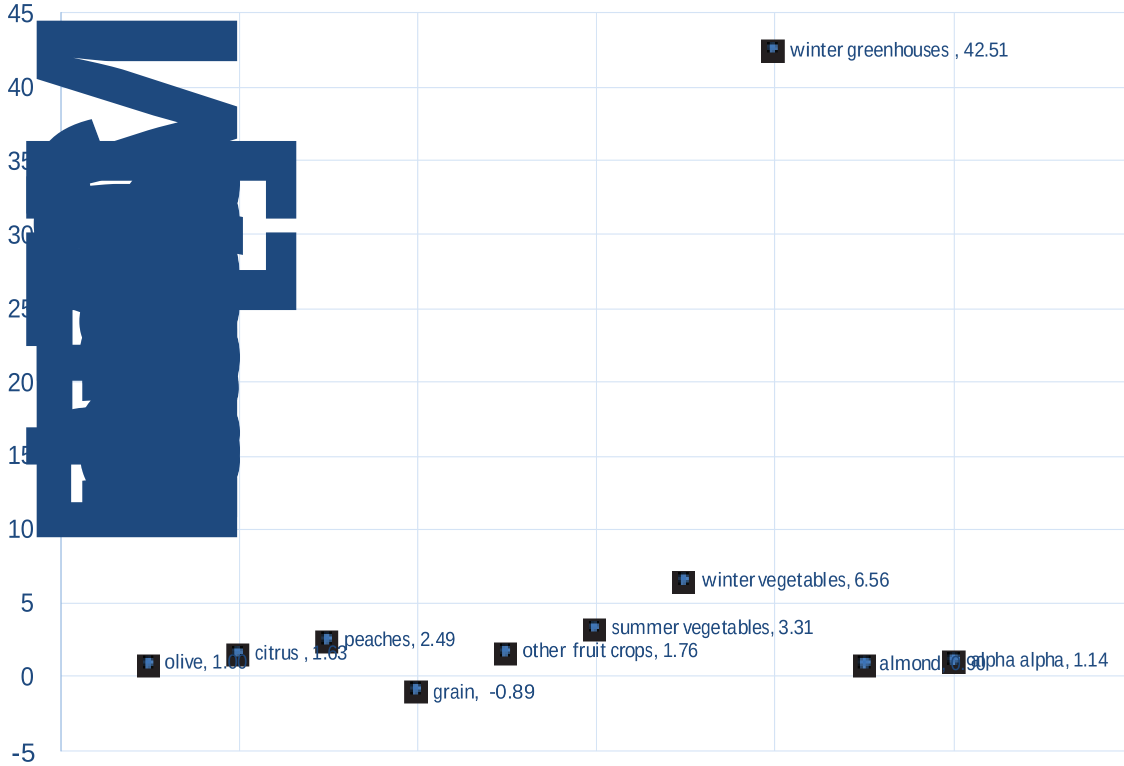


Figure 23: Water tariff that involve zero net margin

It is assumed that the following costs will be paid by the farmers: the Operation & Maintenance (O&M) costs of the irrigation network inside the farms; and the costs for training and operation of the Irrigation Advisory Services (IAS) and Water User Associations (WUA). The farmers would be charged based on the actual water they consume. Water consumption is measured by a water meter installed at the manhole located at the farm gate.

6.1.5 Balance Sheet for the Cropping Pattern

A summary and detailed analysis for both costs and revenues associated with each crop as suggested by the newly proposed cropping pattern is provided in the following series of tables.

Table 18 Summary of the Financial Costs [ILS x 1,000]

Crops	Y1	Y2	Y3	Y4
Citrus	2,493	3,639	4,784	5,930
Olive	2,253	2,999	3,746	4,493
Peaches	995	1,094	1,192	1,291
Grains	3,584	2,943	2,302	1,661
Other fruit crops	857	779	701	622
Summer vegetables	2,118	1,957	1,796	1,635
Winter vegetables	2,854	2,250	1,646	1,042
winter tomato greenhouses	486	648	810	972
Almond	599	875	1,152	1,429
alpha-alpha	777	975	1,173	1,371
Total for the Financial Costs [ILS x 1,000]	**17,016**	**18,159**	**19,302**	**20,445**

Table 19: Summary of the Financial Revenues [ILS x 1,000]

	Y1	Y2	Y3	Y4

Citrus	3,456	5,044	6,632	8,220
Olive	2,672	3,558	4,444	5,329
Peaches	1,792	1,969	2,146	2,323
Grains	2,109	1,732	1,355	978
Other fruit crops	1,253	1,139	1,024	910
Summer vegetables	3,751	3,466	3,181	2,896
Winter vegetables	5,158	4,066	2,975	1,883
winter tomato greenhouses	1,901	2,534	3,168	3,801
Almond	728	1,065	1,401	1,738
alpha-alpha	1,077	1,351	1,626	1,901
Total for the Financial Revenues [ILS x 1,000]	**23,898**	**25,924**	**27,951**	**29,978**

The detailed balance sheet for each crop are provided as follows:

Table 20: Balance sheet for Citrus

	Revenues	**Q.ty** kg/du	**ILS/kg**	**ILS/du**	*Margin*
		1,800.00	1.72	*3,096.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	80.00	5.00	400.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.			-	
Plant Protection*	kg.	4.00	100.00	400.00	
irrigation	m3	827.20	0.63	523.43	
Harvesting - Labour	dd	14.00	40.00	560.00	
Harvesting - machinery	h			-	
Depreciation of the plant	**1,380**	duration years	35.00	39.43	
TOTAL				*2,272.86*	*823.14*
Labour & Enterprise					1,383.14
**aver. q.ty*aver. Prices*					

Table 21: Balance sheet for Olive

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
olive oil 50%		45.00	16.00		
tables olive %		300.00	4.00	*1,920.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	450.00	0.50	225.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	3.00	40.00	120.00	

irrigation	m3	705.10	0.63	446.17	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h	5.00	6.00	30.00	
Olive's milling	kg.	45.00	3.50	157.50	
Depreciation of the plant	**1,780**	duration yrs	40.00	44.50	
TOTAL				*1,663.17*	*256.83*
Labour & Enterprise					576.83

Table 22: Balance sheet for Peaches

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		1,100.00	2.50	*2,750.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	628.60	0.63	397.76	
Harvesting - Labour	dd	4.00	40.00	160.00	
Harvesting - machinery	h			-	
Depreciation of the plant	1,980.00	duration yrs	35.00	56.57	
TOTAL				*1,584.33*	*1,165.67*
Labour & Enterprise					*1,325.67*

Table 23: Balance sheet for Grains

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		450.00	1.50	*675.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.33	60.00	79.80	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	100.00	0.50	50.00	
Irrigation pipes (/5 y)	ml	1400.00	0.70	196.00	
Plant Protection	kg.	4.00	15.00	60.00	
irrigation	m3	309.90	0.63	196.10	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h			-	

Seedings	kg.	20.00	2.25	45.00	
TOTAL				*1,146.90*	*(471.90)*
Labour & Enterprise					*(151.90)*

Table 24: Balance sheet for Other fruit crop

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		750.00	3.35	*2,512.50*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.50	60.00	150.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	250.00	0.50	125.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	622.30	0.63	393.77	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h	5.00	6.00	30.00	
Depreciation of the plant	1,800.00	duration yrs	20.00	90.00	
TOTAL				*1,808.77*	**703.73**
Labour & Enterprise					**1,023.73**

Table 25: Balance sheet for Summer vegetables

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		5,000.00	0.80	*4,000.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	500.00	0.50	250.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	15.00	25.00	375.00	
irrigation	m3	650.10	0.63	411.36	
Harvesting - Labour	dd	15.00	40.00	600.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				*2,258.36*	*1,741.64*
Labour & Enterprise					*2,341.64*

Table 26: Balance sheet for winter vegetables

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		3,000.00	1.30	*3,900.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	50.00	5.00	250.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	12.00	25.00	300.00	
irrigation	kg.	293.90	0.63	185.97	
Harvesting - Labour	dd	20.00	40.00	800.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				*2,157.97*	*1,742.03*
Labour & Enterprise					2,542.03

Table 27: Balance sheet for *winter tomato greenhouses*

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		7,000.00	1.50	*10,500.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	25.00	25.00	625.00	
irrigation	m3	141.80	0.63	89.73	
Harvesting - Labour	dd	30.00	40.00	1,200.00	
Harvesting - machinery	h			-	
Seedings	kg.	0.02	8,000.00	120.00	
Depreciation of greenhouse	mq	750.00	50.00	1,875.00	** 20 year*
TOTAL				*4,559.73*	*5,940.27*
Labour & Enterprise					7,140.27

Table 28: Balance sheet for *Almond*

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*

		180.00	8.00	*1,440.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	8.00	25.00	200.00	
irrigation	m3	622.30	0.63	393.77	
Harvesting - Labour	dd	3.00	40.00	120.00	
Harvesting - machinery	h			-	
Depreciation of the plant	2,180.00	duration yrs	25.00	87.20	
TOTAL				*1,270.97*	*169.03*
Labour & Enterprise					289.03

Table 29: Balance sheet for *Alpha alpha*

	Revenues	Q.ty kg/du	ILS/kg	ILS/du	*Margin*
		4,500.00	0.35	*1,575.00*	
	Costs	**Q,ty/du**	**ILS/unit.**	**ILS/dun**	
Tillage	n.	0.00	100.00	-	
Chemical Fertilizers	kg.	0.00	5.00	-	
Organic Fertilizers	kg.	0.00	0.50	-	
Soil Disinfection	kg.			-	
Plant Protection	kg.	0.00	25.00	-	
irrigation	m3	878.50	0.63	555.89	
Harvesting - Labour	dd	6.00	40.00	240.00	
Harvesting - machinery	h			-	
Depreciation of the plant	1,360.00	duration yrs	4.00	340.00	
TOTAL				*1,135.89*	*439.11*
Labour & Enterprise					679.11

6.2 Macro-Economic Conditions

6.2.1 Methodology

Cost-benefit analysis (CBA) is a formal analysis technique used in public and private investment projects (Rakhra, 1991) as well as in programs and policies (Stoica, 2005) in order to make a comparative assessment of all the benefits and costs anticipated. It also represents an attempt to measure the costs endured and gains earned by a community or a private company after the project is implemented.

CBA proves its usefulness in feasibility studies (from an economic, environmental, social or technological perspective) by selecting the optimal option for investment projects (Hanley and Spash, 1993). The purpose of using CBA in a sector is to set up pragmatic administrative rules in order to *allocate resources efficiently*.

The use of cost-benefit analysis contributes to determining the financial sustainability as well as profitability of the NGEST water reuse scheme. It also:

a) highlights the economic and financial viability of the NGEST water reuse scheme for different scenarios;
b) enables the identification of possible errors in the design or implementation phase (incorrect information, unrealistic hypotheses, etc.); and
c) enables the correction needed to properly conduct the NGEST water reuse scheme.

6.2.2 General Project Assumptions

Within the CBA, costs are presented in terms of capital investments and operation and maintenance (O&M); the first being a one-time cost and the second being a recurring, yearly, cost.

The entire water recovery and re-use scheme requires capital investments to be implemented over time to provide water in two separate areas (Phase I for 500 ha and Phase II for 1,000 ha). The implementation of each phase has been subdivided into two separate tendering packages. The details are provided in the following Table 30.

Table 30: Investment required for the implementation of the recovery and irrigation schemes

Phase	Package	Description	Cost US$	Cost ILS x 1,000
I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$8,449,164	30,518
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)	$6,015,625	21,728
II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$5,830,333	21,059
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)	$15,984,375	57,736
			$36,279,497	**131,042**

A distribution of the capital investments over time for each phase and for each tender package is provided in the following Table 31 where costs are expressed in ILS per 1,000.

Table 31: Phase I e Phase II implementation stage

Phase	Package	Description	Phase 1	Phase 2	Y1	Y2	Y3
			ILS x 1,000		*ILS x 1,000*		

I	**1**	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	30.518		30.518		
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		21.728		21.728	
II	**1**	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	21.059			21.059	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)		57.736			57.736
		TOTAL [ILS x 1,000]	**51.578**	**79.464**	**30.518**	**42.788**	**57.736**

The O&M cost are provided in the following Table 32.

Table 32: Annual O&M costs (US$)

Operation and Maintenance Cost		Phase I	Phase II
Description	USD	USD	USD
Manpower	150,000	90,000.00	60,000.00
Power consumption	978,953	326,317.56	652,635.11
Maintenance and repair works	83,345	27,781.67	55,563.33
Consumables & Miscellaneous	76,960	25,653.33	51,306.67
Total O&M cost USD/year	1,289,258	469,752.56	819,505.11

Table 33: Annual O&M costs (ILS)

Operation and Maintenance Cost		Phase I	Phase II
Description	ILS	ILS	ILS
Manpower	541,800.00	325,080.00	216,720.00
Power consumption	3,535,977.04	1,178,659.01	2,357,318.03
Maintenance and repair works	301,042.14	100,347.38	200,694.76
Consumables & Miscellaneous	277,979.52	92,659.84	185,319.68
Total O&M cost USD/year	4,656,798.70	1,696,746.23	2,960,052.47

Other costs that are included in this CBA are the water tariff, assumed to be 0.63 ILS/m^3, and the investments required at the farm level to support the introduction of the proposed cropping pattern as detailed in the Micro-Economic Conditions section.

Costs for supporting and training the Irrigation Advisory Services (IAS) and Water User Association (WUA) are assumed to cost 3,000,000 ILS, divided in 2,000,000 ILS for the first year and 1,000,000 ILS for the second year.

6.2.3 Financial Analysis

The financial analysis indicates whether the project will generate a positive net cash flow during the evaluation period (profitability) and whether the cumulative cash flow from the start of investment until the final prediction is negative (sustainability).

The analysis of the investment project's cash flow includes both the evaluation of the cash outflows (investment costs as well as and costs at farm level) and cash inflows (revenues at farm level, industries, grant and subsidies). As opposed to the economic analysis, in the financial analysis the cash flow does not include amortization, reserves and other accounting items.

From this perspective, the financial analysis was conducted with the following steps:

1. Estimating revenues and costs of the NGEST area farms and assessing the implications of these parameters on cash flow;
2. Defining the financing sources of investment and analysing the financial profitability.
3. Determining the funding gap in achieving the investment project and identifying the best mechanisms to attract funding;
4. Checking whether the estimated cash flow could ensure the proper operation of the NGEST project. The investment project is financially sustainable if there is no risk of running out of cash during the operation.

For the financial analysis, the following costs and revenues were taken into account:

Cash Outflows (Costs)

- Capital cost – recovery wells, farm investment
- Costs related to the IAS and WUA operation and training
- Operation Costs at farm level including water tariff

Cash Inflows (Revenues)

- Revenues at farm level derived from the new cropping pattern
- Water tariff paid by Industry based on 1 ILS/m^3 per 70,000 m^3 /year
- Reduction of time spent in management of private wells
- Investments paid by Government/Donors
- Public Subsidies based on farm water tariff of 0.63 ILS/m^3

The financial analysis carried out as part of the project's CBA uses market prices (which include VAT and indirect taxes) to check the balance of the investment and the sustainability of the project.

The cash flows accumulated in different years during the evaluation period (25 years) require a fair discount rate. The financial discount rate allows to account for the influence of time on the value of money and reflects the opportunity cost of the investor's capital.

In general, it is recommended to use a discount rate of 5%, but the model also used 2 more points (7%) and less (3%) to evaluate the sensitivity of the net present value.

6.2.3.1 Scenarios

Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

- (1) Capital Investment for the Water Recovery Scheme;
- (2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm's Gate;
- (3) O&M Cost for the Water Recovery Scheme;
- (4) O&M Costs for the Water Reuse (irrigation) Scheme;
- (5) Capital Investments for Farm's Development.

The five scenarios are defined as follows

- **Scenario 1 -** Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under such scenario farmers would pay back the full cost for the construction of both the water recovery and the water reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- **Scenario 2 -** Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built and paid by the farmers;
- **Scenario 3 -** Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the water recovery and water reuse schemes would be paid by the government or by a donor whereas every other cost would be paid by the farmer;
- **Scenario 4 -** Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that farmers will have to pay back the cost for the construction of Phase II of both the recovery and the reuse scheme. Government/Donors would cover the cost for the construction of Phase I. Farmers would pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered by the Government/Donors for the number of years required for the farmers to pay back the construction of Phase II.
- **Scenario 5 -** Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for as many years as it takes for the farmers to be able to pay back for the improvement of their own farm. After that point, farmers will be responsible for paying O&M costs for the whole system.

A schematic representation of the five scenarios is provided in the following Table 34.

Table 34: Project Scenarios

Scenario	Description	Cost Paid by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investments for Farm's Development	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Government and not charged to the Farmers		x	x	x	Paid by the Government and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Government until Farmers have paid back the Construction of Phase II	x	x	Paid by the Government and not charged to Farmers	x
5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5).	Paid by the Government and not charged to the Farmers		Subsidized by Donors/Government until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)		x	Paid by the Government and not charged to Farmers	

6.2.3.2 Financial Sustainability of the Investment Project

The Government's ability to paid for the set up and operation of the NGEST Irrigation Project during the next 25 years (the so called 'Reference Period') is critical to the success of the investment and for achieving the overall objectives of this supplementary phase. From this perspective, the investment project should be financially sustainable without any difficulties regarding the fulfilment of its financial obligations during the reference period.

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

In order to determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

FNPV represents the amount calculated when the estimated investments and operating costs of the project are deducted from the present value of the projected revenues. The investment project is profitable in the financial sense if FNPV has a positive value.

FIRR represents the discount rate for which FNPV is zero or which equals the present value of the financial cash flows projected for the reference period. If this indicator is less than the cost of the capital, the project is not profitable. When it is higher than the cost of capital, the project is acceptable because it will generate a positive FNPV.

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

6.2.4 Main Results of Financial Analysis

Table 35: Main Results of the Financial Analysis

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)	Note
	3%	**5%**	**7%**	**3%**	**5%**	**7%**		
1	30.551	2.574	-16.780	1,062	1,006	0,954	5,23%	
2	12.959	718	-7.908	1,064	1,004	0,947	5,14%	
3	149.706	114.653	88.791	1,304	1,274	1,244	31,02%	
4	127.456	88.722	60.582	1,259	1,212	1,167	16,07%	17 years of subsidies to repay the phase II investment.
5	155.425	119.953	93.715	1,316	1,286	1,258	33,54%	5 years of subsidies to repay the investment at farm level

6.2.5 Economic Analysis

An economic analysis for major investment projects determines if the project contributes significantly to total economic welfare. It measures the project benefits depending on the following: the costs avoided due to project implementation and the external benefits arising from the implementation, which are not included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. These externalities should be given a monetary equivalent.

In the economic CBA, some cost/benefits cannot be expressed in monetary units but only in qualitative terms. These costs/benefits are:

- Preservation and improvement of the quality of space for human life, as in the case of water pollution when human settlements located near water lose their basic quality.
- Prevention of flora and fauna destruction.
- Maintenance of natural system which will have a positive effect on people, like better mental condition and richer intellectual activities.

Benefits that cannot be expressed in monetary value are also called “intangible” benefits. Those benefits have been ignored in the cost-benefit analysis of the project. The reason is that these benefits cannot be assessed, and their detailed qualitative effects can be better described in an environmental impact assessment.

In the economic cost-benefit analysis the costs are expressed in accounting prices, and are measured in terms of 'resource' cost or 'opportunity' costs.

The economic analysis could be briefly described with the following steps:

- Conversion of market prices into accounting prices;
- Update the estimated costs and benefits;
- Calculation of economic performance indicators (Economic Net Present Value, Economic Rate of Return, benefit/cost ratio).

The corrections to be considered in the economic analysis are the following:

Fiscal Corrections. Fiscal Corrections are necessary because some transfers from one agent to another should be seen as pure transfers, without having an economic impact. For example, the subsidies provided by the government to those who want to invest in the NGEST Irrigation Project represent a pure transfer offering advantages to the beneficiaries, but not creating economic value. The fiscal corrections are made for indirect taxes (VAT), subsidies and pure transfer payments (employer's obligation to pay social security contributions) which are generally included in the eligible costs and/or operating or maintenance costs. However, the prices should also include direct taxes. In addition, if certain indirect taxes/subsidies are aimed at correcting externalities, then they will be included in the analysis. In order to assess the project's economic impact, information on the tax system in the West Bank and Gaza, as calculated by World Bank, was used as presented in the following Table 36.

Table 36: Direct and indirect taxation in Gaza and West Bank

Tax or Mandatory Contribution	**Payment** (number)	**Notes on** Payments	**Time** (hours)	**Statutory** Tax Rate	**Tax Base**	**Total Tax Rate** (% of Profit)	**Notes** on TTR
Corporate Income Tax	2		18	15% - 20%	Taxable Profit	14.23	
Capital Gain Tax	1			15% - 20%	Capital Gains	0.76	
Municipal Business Tax	1			17%	Rental Value of Building	0.28	

Employee Paid - Personal Income Tax	12		96	5% - 20%	Taxable Salaries	0	withheld
Irrecoverable VAT (on fuel)	0			15%	Fuel Consumption	0	
Value Added Tax (VAT)	12		48	16%	Value Added	0	not included
Totals	28		48			15.27	

Correction of labour cost from financial to economic. The correction of financial costs to economic costs of the price of labour has been made. The coefficient used to correct the financial value was 0.3 to consider taxation and social charges.

To carry out a neutral evaluation, positive and negative externalities of the project were not considered.

Based on the consideration presented above, the main results of the economic cost benefit analysis are presented in the following Table 37.

Table 37: Main Results of the Economic Cost Benefit Analysis

Scenario discounted rate	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)
	3%	**5%**	**7%**	**3%**	**5%**	**7%**	
1	124.102	82.112	52.243	1,252	1,196	1,144	13,72%
2	51.291	33.420	20.586	1,254	1,194	1,137	12,62%
3	132.443	89.958	59.633	1,511	1,482	1,454	15,17%
4	130.885	88.143	57.658	1,462	1,416	1,371	14,64%
5	132.843	90.329	59.978	1,523	1,496	1,469	15,24%

6.3 General Aspects

6.3.1 Financing Mechanisms

The sources of funding provided by the various scenarios of the project are:

- government financial sources
- financial sources of international cooperation
- private financial sources

While government finance and international cooperation does not have direct impacts on the financial market system, it is necessary to provide support and guarantees to a private financing system. As we know the banking system requires, turning on a loan, guarantees and payment of the price of money (interest).

Farmers will need to have access to a banking system and most of them do not have enough income or capital to finance investment in farms or parts of the project, so it is necessary to provide them with support tools.

- First, the government must provide for a national guarantee fund supporting the banking system for when, due to personal problems or because of adverse meteorological conditions or distortions in market prices, the farmer is unable to repay the annual instalment of the loan.
- The second important thing is government or donor support for bank interest payments, given the high price of money locally. Farmers can repay the loan principal, but hardly the interest portion.

6.3.2 Job Impacts

The project in its full version creates new employment, the estimate of the level of direct employment is about 150 new employees and the job security for current employees.

Table 38: Job Created

Job created			days/year
job days created at Farm level			23.741
job days created WUAs			4.400
Job days created O&M			4.840
total job days created			32.981
Incremental labour	dd	32981	+ 34%
	n.people	150	

The government may provide for subsidies for young farmers who undertake to work on the farm in order to reduce youth unemployment.

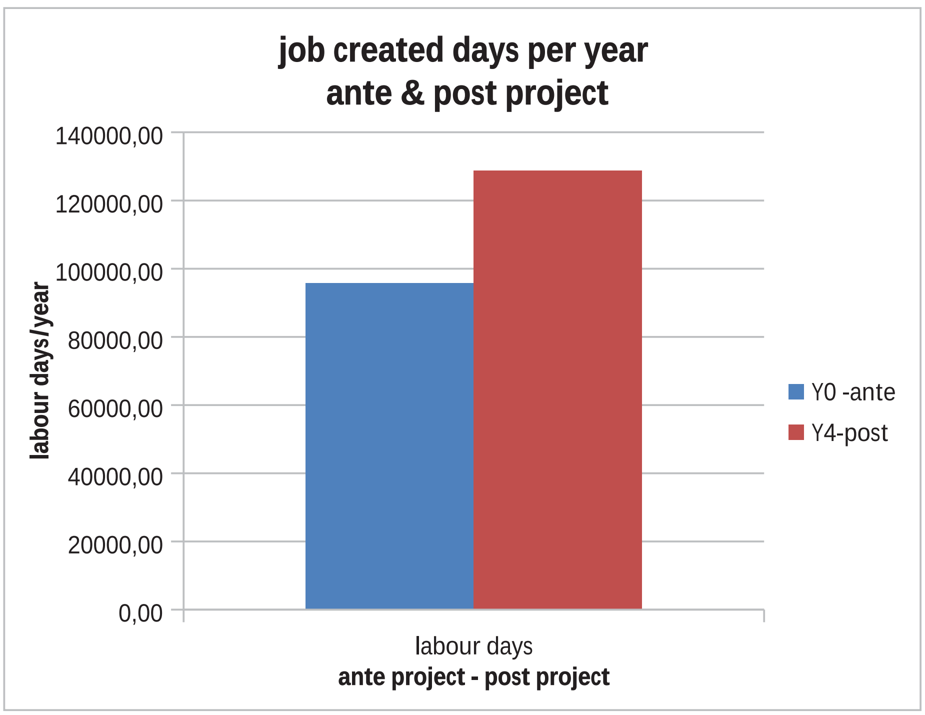


Figure 24: Job created per year before and after the project is implemented

7 CONCLUSION

This *DRAFT Complementary Feasibility Report* brings mostly good news. By reworking the original design, the project can save 21.5% of the water use while using 15% less energy, and can operate with a less complex irrigation schedule. It was determined that the project is in full compliance with Palestinian law, and should be financially sustainable by farmers. The review resulted in a new cropping pattern and design network, and offered innovative solutions to project O&M through a new IAS agency.

This *Report* also confirmed the validity of the original design for the recovery scheme and of the original design for the reuse (irrigation) scheme, confirming the selection of materials, the general layout and the selection of the pumping system. The newly proposed system fixes design inconsistencies of the original so that a minimum water pressure of 2.5 bars is provided to every farm gate.

The good news, however, is contingent. The water and energy savings, simplified irrigation schedule, and farmer profitability are contingent on improving the original design of the reuse scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern. The project's compliance with Palestinian law is contingent on a minimum level quality of water coming from the WWTP and being disposed of in the infiltration basins. And the project's feasibility and success overall are contingent on carrying out robust capacity building for ministerial and farmer stakeholders, and of adequately monitoring the Managed Aquifer Recharge component of the project.

8 ANNEXES

8.1 Annex 1: Roles and Responsibilities of Water Sector Entities as Defined By The Palestinian Water Law Of 2014[8]

FUNCTION	BY	OVERSEERS/PARTIES
Allocation of water resources	PWA	Other official and relevant authorities
Preparing general water policies, strategies and plans, seeking approval thereof, and ensuring their implementation	PWA	Relevant parties, as well as the Cabinet of Ministers
Protection zones to prevent pollution	PWA	In cooperation and coordination with relevant authorities
Licensing and development of Water Resources and utilization	PWA	In cooperation and coordination with the relevant authorities
Measures and plans as required to establish and develop the National Water Company and the Regional Water Utilities	PWA	In coordination with the relevant authorities
Supervising the organization of awareness raising campaigns in the sphere of water and wastewater and promoting the use of water saving fixtures	PWA	In coordination and cooperation with the relevant authorities
The development of plans and programs for capacity building, training and qualification of technical staff working in the water sector and supervising their implementation with the aim of improving the management of water resources	PWA	In cooperation and coordination with the relevant authorities
Equitable distribution and optimal use of water to ensure the sustainability of ground and surface Water Resources	PWA	In cooperation and coordination with the relevant parties
Developing solutions and suitable alternatives in cases of emergency and contingency to ensure the continuity of water provision services	PWA	In coordination with Service Providers and relevant parties
Scientific research and studies related to water and wastewater	PWA	Specialized and relevant authorities
Partake in the development of approved standards of water quality for various uses	PWA	In coordination and cooperation with the competent authorities

[8] Taken from Water Governance In Palestine: Sector Reform To Include Private Sector Participation, 2015.

FUNCTION	BY	OVERSEERS/PARTIES
All revenues collected	PWA	Deposit in the account of the Public Treasury
Accounts of the Authority and its records and all its financial affairs shall be regulated and audited	PWA	Ministry of Finance and Planning
Head of PWA appointment	PWA	Presidential Decree upon the recommendation of the Cabinet of Ministers
Deputy Head	PWA	Decision of the Cabinet upon a recommendation from the Head of PWA
Preparation of budget and financial reports	Head of PWA	Cabinet of Ministers for approval
Signing local and international water agreements on behalf of the Government	Head of PWA	Prior authorization from the competent and relevant authorities
Preparation of periodic reports concerning the activities of PWA and quality of performance, and the proposal of solutions for overcoming obstacles that hinder the progress of work	Head of PWA	To the Cabinet of Ministers
Establishment	WSRC	Decision of the Cabinet of Ministers
Regulating WSRC	WSRC	Be pursuant to this law
Reporting	WSRC	Cabinet of Ministers
Appointing Board of Directors	WSRC	Presidential decree , Cabinet recommends
Board Remuneration	WSRC	Regulation by Cabinet
Performance incentives	WSRC	Regulation by Cabinet
Internal regulations	WSRC Board	Approve and submit to Cabinet
Annual budget submittal	WSRC Board	Approve and submit to Cabinet
Audited financial reports submittal	WSRC	Relevant authorities
Audit and review of finances	WSRC	Official monitoring authorities
Regulating staff	WSRC	Board recommends to Cabinet
Issuing licenses and fees	PWA	Regulation from Cabinet
Terms of license stipulate prior approval	PWA	Competent authorities
Domestic harvesting	PH and Environ standards	Relevant official authorities
Prior use rights of Springs/wells and fees	PWA	Cabinet of Ministers
Licensing and registry and payments of fees	PWA	Right for public access to information
Water and wastewater tariffs	PWA	Regulation from Cabinet
Unified Bulk Water tariff	PWA	Regulation from Cabinet
Water prices	Service Providers	WSRC approves based on tariff regulations
- Regulation to create environment that would encourage private sector investment in water	PWA	Cabinet of Ministers

FUNCTION	BY	OVERSEERS/PARTIES
Capital of National Water Company	PWA	Decision by Cabinet
Financial affairs of National Water Company	PWA and MoF	Regulation from Cabinet
Water supply tariff and related services proposal	PWA	WSRC
Develop Unified Water Tariff Regulation	PWA	
Board of National Water Company	PWA	Cabinet decision
Quarterly and annual reports	NWC	WSRC and Cabinet
Establishing Regional Water Authorities	PWA	in coordination and cooperation with the relevant competent authorities
All matters	RWAs	Regulation from Cabinet
Provision of water and wastewater services	RWAs	Regulation from Cabinet
Establishing Water Users Association, joint recommendation	PWA jointly with MoAg	Regulation from Cabinet
Protect water resources and facilities and prevent their pollution by partaking proactively	PWA	Environmental Law and in coordination and cooperation with the authorities specialized in the protection of water resources and the prevention of their pollution
Regulation for protection of Water Resources and facilities	PWA	PWA recommends and Cabinet issues
Consideration of Water Resource Protection Zone and publication of notice	PWA	In coordination with other relevant parties and a regulation from Cabinet
Provide alternative resource to protected zone	PWA	As may be available, or compensate for damage as per existing laws
Applying penalties to specific offences	PWA	
Exercising current responsibilities	Existing institutions	Till RWAs and WUAs are established
Rehabilitate facilities of West Bank Water Department and in the transition period	PWA	Movable and immovable assets to PWA, powers and responsibilities to the National Water Company
West Bank Water Department final status	PWA	All assets, powers and responsibilities to the National Water Company
Regulations to implementation the Law	PWA	Cabinet issues regulations recommended by PWA

8.2 Annex 2: Example of Irrigation Advisory Services in Other Countries

8.2.1 NIGER

In Niger the government, apart from large scale irrigation schemes, supported also small- to medium-scale irrigation cooperatives (located on the perimeter of the large-scale projects) by providing them with technical extension support through the National Office of Hydro-Agricultural Perimeters. However, due to insufficient budget and incentives for efficient service provision, this technical support was weak. As a result farmers lacked knowledge and availability of irrigation technologies and maintenance service and lacked finance. These problems were addressed through the World Bank financed Pilot Private Irrigation Project that focused primarily on the poorest farmers and on selected private commercial irrigators. A private irrigation advisory body called the Nigerien Association for Promotion of Private Irrigation (Association Nigérienne de Promotion de l'IrrigationPrivée, ANPIP) became the implementing agency for the project. It took care of the promotion of small-scale irrigation technologies through information and assistance to farmers to access the technical and financial resources required for their adoption. ANPIP carried out promotional campaigns in support of the government's private irrigation development strategy; facilitated small farmers' access to legal and administrative assistance for obtaining tenurial security; and provided assistance, upon demand, in preparation of irrigation projects and in establishing economic interest groups. Tasks contracted out to consulting firms included testing and evaluating technologies, promoting grassroots savings and credit schemes (by an NGO), and project related evaluation studies and periodic audits.

The project has strongly supported the national agricultural strategy to increase productivity. Significant gains made in Niger's irrigation sector included:

- ANPIP grew gradually from a small group of 10 people to 19 decentralized committees constituting 13,500 farmers;
- An information campaign about the new national irrigation policy (through printed booklets, a prospectus, and radio and TV commercials) reached 2,000 representatives of farmers, and administration and traditional authorities. Following this campaign, over 1,500 economic interest groups were established with membership of over 15,000 farmers;
- The training component included 382 training sessions covering 4,150 participants, and it was complemented by radio, television, newspaper, a printed handbook, and demonstrations in the local market;
- The project introduced the treadle pump and promoted the tubular borehole, submerged pumps, motor pumps, and irrigation via buried pipes as components of comprehensive on-farm water systems. Farmers pay the full cost of the technologies;
- Cultivated area increased by about 63 percent, and yields of major crops increased by 27 to 32 percent (onion and sweet pepper, respectively).

The implementation of the Pilot Private Irrigation Project encompassed the following lessons learned:

- The shift of project administration from government to a private agency (ANPIP) enabled a private sector management style, and the legal and administrative flexibility to execute the project;
- Promotion of private ownership of treadle pumps and improved irrigation technologies, with incentives for good operation and maintenance, was undertaken. In relying on genuine demand in deciding the location of local pump manufacture, the project increased the chances that the nascent treadle pump market would be sustained in the long run;
- Giving farmers a menu of technology options allowed them to choose the level of technology and investment appropriate to their farming conditions;

- Making available simple, locally made, and affordable technologies, and training local craftspeople to manufacture and repair treadle pumps, kept the supply chain between farmer and manufacturer as short as possible, ensuring that pump parts and repair expertise would be locally available. Adaptations to irrigation technologies reduced their prices; and
- Linking these basic technical changes with other changes, such as a sound irrigation policy, available credit, land tenure security procedures, and effective monitoring of project success, facilitated adoption and contributed to the program's success.

(Agriculture Investment Sourcebook, World Bank, 2006)

8.2.2 PHILIPPINES

In the Philippines water resources management is a responsibility of the national Government. In 1963 a government-owned and controlled corporation primarily responsible for irrigation development called National Irrigation Administration (NIA) was established. In particular, NIA plans, designs, constructs and rehabilitates all types of irrigation structures in the country. It operates, maintains and administers all national-scale, major irrigation infrastructure. In case of communal irrigation systems (secondary canals and on-farm facilities) it supervises their operation and maintenance delegating their partial or full management to organized associations and cooperatives (irrigation associations) who can count on its technical assistance and managerial training. NIA also charges and collects fees for water use for irrigation and promotes private sector participation in irrigation and drainage.

8.2.3 TUNISIA

In Tunisia the central government through the Ministry of Agriculture is the main player providing the lead and support for irrigation development and its management. However, the main advisory services are in support of agricultural inputs rather than water. Still training in irrigation is organised for farmers and there is extensive use of TV and radio (both judged as a very successful way of getting information to the extensive rural areas).

8.2.4 JORDAN

Jordan has a small irrigation area confined mainly to the Jordan valley, which comes under the jurisdiction of the Jordan Valley Authority (JVA) for water management. Most farms are privately owned but the JVA has set up an Irrigation Advisory Unit which offers design and on-farm management support and has introduced participatory management approaches. The Ministry of Agriculture has the responsibility for providing agriculture extension services.

8.2.5 CYPRUS

Cyprus has a relatively small irrigated area (40,000ha). IAS is free of charge to farmers and include on-farm irrigation, which is provided by the Water Use Section (WUS), a branch of the Department of Agriculture. WUS employs less than 50 technical staff and provides planning and design services as well as scheduling information and farmer training as of 1965.

8.3 Annex 3: Example of Water User Associations in Other Countries

8.3.1 INDIA

Rajasthan is the largest state of India (supporting about 50 million people) with 10% of the national area and only 1% of the country's water resources. Agriculture accounts for 83% of the total water use. Water resources management in Rajasthan has been affected by weak capacity and uncoordinated effort among water sector departments, a weak regulatory framework, poor management practices and unsustainable use of resources, and high recurrent cost of water delivery. Problems are inherent in past approaches based entirely on public sector resource management, with a lack of beneficiary participation in scheme management and financing.

In order to support Rajasthan in ensuring long-term, sustainable use of increasingly scarce water resources and in improving the water use efficiency for agriculture, the World Bank launched The Rajasthan Water Sector Restructuring Project (RWSRP). The project seeks to achieve the above-mentioned objectives through increase in:

(a) system efficiency by downsizing and improved coordination and rationalization of public sector agencies;

(b) involvement of users and the private sector in design and management of systems; and

(c) cost recovery from users.

Specifically, RWSRP finances:

- Water sector institutional restructuring and capacity building through creation of a state water planning department, modernization of the water sector department, and piloting a community-driven institution for groundwater management;
- Improving irrigation system performance through the formation and fostering of 620 WUAs, rehabilitation of irrigation schemes, strengthening of agricultural extension, and enhancing safety of 16 dams supplying the project area;
- Capacity building for a project management unit to ensure the effective implementation and coordination of activities involving several government departments.

The WUAs, over time and in close coordination with the Irrigation Department, are expected to take over the operation and management (O&M) of surface irrigation systems up to the distribution level. The Government of Rajasthan has committed to moving toward full cost recovery of O&M costs. The rehabilitation of irrigation schemes (about 90 major, medium, and minor schemes) also involves participation of WUAs, which contribute 15 percent of the rehabilitation costs.

The project would support at least three pilot schemes for a community-driven approach to groundwater management. This would involve the establishment of groundwater conservation districts (GCDs) covering identified aquifer areas with water depletion and quality problems. The GCDs would include an elected body of stakeholder representatives (rural and urban communities, farmers, industry, state agencies, and local government) empowered to develop and implement groundwater management plans, involving both supply- and demand-side approaches for groundwater management. The plans would be prepared at the village level by the Groundwater Management Associations and integrated at the community level by the Gram Panchayat Level Committees, with assistance from NGOs and technical support groups.

The project includes a pilot scheme on “commercialization of irrigation services” in a distributory command, which would develop a farmer-owned and -managed utility for the management of a larger command area on a commercial basis. The core function of this entity is to provide water to farmers and other users, and to manage and maintain the water supply assets, including irrigation and drainage facilities. The farmer company would develop into an autonomous entity that would operate on commercial lines and have a bulk water entitlement from the Irrigation Department.

The implementation RWSRP brought the following lessons learned:

- A strong government commitment to fiscal and institutional reform at the highest level, and a sound legal framework, is critical to the successful formation and operation of WUAs. WUAs can effectively and efficiently implement rehabilitation, if they are empowered early in the process;
- Agricultural demonstration programs for application technology should focus on a few high-quality demonstrations that can be replicated with good results;
- Minimizing the turnover of senior staff will improve the effectiveness and timeliness of the implementation of project activities;
- Funding from increased water charges can make funds available for O&M, improving the state's overall recurrent budget situation; and
- Hybrid policy and multisectoral, statewide investment projects are complex. Investments are better concentrated on a few critical issues. This lesson is reflected in the design of this project, which has limited project period objectives but is set in a longer-term context.

(Agriculture Investment Sourcebook, World Bank, 2006)

8.3.2 MALI

The Office du Niger in Mali was created during colonial times to produce cotton, but in the 1950s cotton cultivation was abandoned because of waterlogging, and rice became the dominant crop. In the early 1980s, financing agencies stimulated reform gradually by promoting small steps of change, such as establishment of village-level WUAs that could implement maintenance at secondary and tertiary canal levels. The Office du Niger agreed to allow tenant farmers to have long-term rights to remain on their plots. By 1984, the financing agencies had obtained the agreement of the government to grant farmers freedom to market their grains. They promoted successful distribution of small threshers and hullers, which broke the dependence of farmers on the Office du Niger for threshers and hullers. In 1987, financing agencies promoted adoption of a new farming license that gave farmers permanent tenure if they agreed to cultivate rice intensively and pay the water charge.

Adoption of participatory irrigation management occurred in Mali in the mid-1990s with an act of parliament and policy declarations by the prime minister. This reform granted partial authority of WUAs over operation and maintenance and dispute resolution and full responsibility to pay for operation and maintenance. Staff of the Office du Niger were made responsible to elected farmer representatives through joint management committees at secondary and main canal levels. Elected farmers represented half of the membership of these committees, each covering about 5,000 to 8,000 hectares. Farmers prioritized maintenance works and arranged three-year operation and maintenance contracts, which are now signed between government, farmers and the Office du Niger.

Market liberalization and better land tenure gave farmers the incentives to improve production, and rice yields increased from 2 tons/ha in 1982 to 6 tons/ha in 1996. This gave farmers sufficient confidence in scheme management that they agreed to a 50-percent increase in the water charge. The experience of the Office du Niger suggests that a series of modest infrastructure improvements and reform steps worked better than if financing agencies had refused to provide assistance unless the Government agreed to a comprehensive reform all at once. This approach matches the capacity level of the farmers and may be a suitable model for other low-income countries with a low level of literacy (Irrigation Management Transfer, FAO, 2007).

8.3.3 ALBANIA

In 1994, Albania adopted irrigation management transfer after a period of civil unrest that followed collapse of the central government in the early 1990s. By 1994, most of the irrigation infrastructure was badly deteriorated or damaged. At first, the irrigation agency resisted management transfer. Farmers lacked money to pay the cost of operation and management. However, the Government and the World Bank agreed on a programme to transfer management to WUAs and rehabilitate irrigation systems. The WUAs played a key role in planning, supervising rehabilitation, collecting water charges, and paying part of the cost of rehabilitation. This participatory role helped to generate a new feeling of ownership of the systems by farmers. Extensive training was given to farmers in technical, financial, administrative and agricultural topics. Agency staff were trained and reassigned. By 2001, Albania had 404 WUAs and 22 WUA federations, serving a total area of 169 550 ha (Irrigation Management Transfer, FAO, 2007).

8.4 Annex 4: Case Study - Irrigation and Drainage in Egypt

8.4.1 Background

In Egypt, similar to Palestine, over 90% of water use is in agriculture that at the same time is the lowest yielding and least efficient user of water.

The Egyptian Ministry of Water Resources and Irrigation (MWRI) plays a strategic and operational role in the irrigation and drainage sector. The first comprises the leading role in national planning and policy making.

Egypt's main water and irrigation strategy focuses on the development and conservation of water resources. This is achieved through adopting water rotation for irrigation canals, limiting the rice growing areas, lining irrigation canals in sandy areas and prohibiting surface irrigation in the new developed areas outside the Nile basin.

Egypt's recent water resources policies include different structural and several non-structural measures. Structural measures include: irrigation structures rehabilitation; improvement of the irrigation system; installation of water level monitoring devices linked to the telemetry system; and expansion of the tile drainage system. Non-structural measures include: expansion of water user associations (WUAs) for irrigation ditches; establishment of water boards at district levels; promotion of public awareness programmes; and involvement of stakeholders (FAO, 2005).

Regarding the MWRI's operational role, currently the Ministry is undergoing gradual handing over of responsibilities to the lower administrative tiers (see the following sections) but still includes tasks both at the national (e.g. implementation and operation of the Nile related infrastructure, the irrigation and drainage canals and the coastal lakes) and the district level. The Ministry includes various departments and sectors. From the irrigation and drainage perspective the most important units include (MWRI, 2005):

- Irrigation Department (composed of the following sectors: Irrigation, Groundwater, Horizontal Expansion Projects, Irrigation Improvement, and the Nile Protection Bureau);
- Egyptian Public Authority for High Dam and Aswan Dam;
- Egyptian Public Authority for Drainage Projects;
- Mechanical and Electrical Department; and
- Institutional Reform Unit (IRU) that has been established to guide the process of the development of the MWRI's vision and strategy as well as initiate and coordinate the implementation of the institutional reform of water resources management in Egypt.

At the lower administrative tiers, the MWRI has 22 Irrigation Directorates that are subdivided into 62 Inspectorates and about 206 Districts. The area of a district is between 20,000 and 60,000 feddan (this means some 40,000-100,000 farmers). Other organizational units relevant to irrigation include: feeder canal level (10,000-100,000 feddan, i.e. 15,000 – 150,000 farmers), branch canal level (1,000 – 12,000 feddan, i.e. 1,000 – 15,000 farmers), and mesqa level (10-100 feddan, i.e. less than 100 farmers) (MWRI, 2005).

Regarding drainage, the management is setup in a similar way with about the same number of Directorates, Inspectorates and 145 Districts. However, the organization was separate and as of 2001 the MWRI is in the process of integrating irrigation, drainage and groundwater management into Integrated Water Management Districts and introducing water resources management reform for which a dedicated unit at the MWRI has been established, i.e. the abovementioned IRU (MWRI, 2005).

Within reform, a portion of MWRI's management responsibilities are being decentralized and transferred to the lower administrative level. MWRI's Irrigation and Drainage District offices have consolidated to bring all water management responsibilities together in a single office called an Integrated Water Management District (IWMD). Further, to initiate a participatory management approach in the sector, Water Boards (operated at the district level) and Water Users

Associations (operated at the branch canal and mesqa level) are being established. This, together with efforts to implement cost-sharing and cost-recovery mechanisms, aims to improve the existing water allocation and distribution system and enhance operation and maintenance. The deadline for implementation of reform is set for 2022.

In Egypt, irrigation and drainage are regulated by Law 12 originating in 1982 and Law 213 in 1994 regarding farmers' participation. Law 12 defines public properties related to irrigation and drainage; the use and maintenance of private canals and field drains; arrangements for the recovery of costs for drainage works; rules for water allocation and construction of water intakes along public properties; and the need for consultations with land owners before making any changes to water intakes. This law regulates the use of groundwater and drainage water as well as reclamation of new land (including price to be paid for its irrigation and drainage). Law 213 provided MWRI with a legal basis for enabling user organizations to play a role in the management of irrigation water at the levels of mesqa and above. It also established a fund to finance projects related to the development and maintenance of improved mesqa and to promote awareness with respect to water use (MWRI, 2005). Further, it enables the recovery of costs in case a landowner neglects their duties with respect to maintenance of the irrigation and drainage system.

Regarding the participation of other line ministries in the irrigation and drainage sector in Egypt, the role of the Ministry of Agriculture and Land Reclamation (MALR) should be emphasized. MALR is in charge of agricultural research and extension, land reclamation and agricultural, fisheries and animal wealth development. According to the latest National Water Resources Plan, MALR's objective is to improve food security and increase national agriculture production through maximizing the net return per unit of water. Key strategy elements to reach this objective include continuing the policy of liberalization and demand management, increasing the irrigation area in line with the availability of water, and increasing farmers' participation in the management of irrigation systems (MWRI, 2005).

8.4.2 Water Boards and Water Users Associations

As mentioned above, a fundamental institutional reform process of handing over water resources management responsibility from MWRI to lower tiers of administration was started in 2001 and will last until 2022. This reform aims at facilitating a greater involvement of water "end-users" and an increasingly multi-sectoral approach to water resources planning and control in the country. Within its framework Water Boards (WBs) and Water Users Associations (WUAs) are being established.

The results achieved up until May 2009 have been presented in the table below (MWRI, 2009). Although there is a continuous effort to establish new decentralized water bodies, the percentages as opposed to the final target still remain low. While most farmers recognize the importance of WUAs in the equitable distribution of available water, uneven water availability, either due to design shortcomings or to lax enforcement of rules against excess abstraction by front-end water users, has acted as a disincentive to the successful operation of WUAs in many instances. The successful progress of reform has been noted in those governorates which are characterized by a high unit of owned land (expressed in feddan per owner).

Organization Type	Final Target	Total Achieved (May 2009)	Percentage achieved compared to the target
Water Users Associations at mesqa level	80000	7000	8.75%
Water Users Associations at branch canal	4000	1000	25%
District Water Boards	204	4	1.96%

WBs assume the responsibility for integrated water management and are in charge of the operation and maintenance of water structures (pumps, canals, etc.) at the district level and are accountable to inspectors and water users. WBs also have the task of controlling unofficial reuse of drainage water and unauthorized pumping of groundwater. It has been planned that the setup of WBs will launch cost recovery for irrigation water by levying their own costs on their membership. This, however, is only a partial cost recovery since it does not take into consideration costs of the main system. Recovering the latter is a long-term process requiring further analyses of the real costs of the water service delivered, development of an adequate tariff setting mechanism and public-wide awareness campaigns.

Sub-units of WBs are responsible for water distribution (over the distributaries and the mesqa) and communication with stakeholders. The system foresees that daily intakes by individual mesqa is controlled by the number of hours that it is allowed to pump (depending on the size of the mesqa unit and the installed pump capacity).

Water Users Associations (WUAs) are legal entities governed by Law 213 benefitting from technical, managerial and financial autonomy (budget and irrigation tariff settings). WUAs have been designed to play an important role in water distribution between farmers at the branch canal and mesqa level. Farmers of one mesqa select representatives for the association's assembly and mesqas head regular meetings with authorities of the local water management district and local administration to address problems related to water distribution and determine issues related to construction, repair, and maintenance of the irrigation schemes and facilities (e.g. contracts conclusion, maintenance works planning) (EWA, 2007).

Over the past few years successful pilots have been carried out especially with the establishment of user organizations above the mesqa level (especially at the branch canal level; see the table above).

8.4.3 Advisory Panel Project on Water Management

The Advisory Panel Project on Water Management (APP) is a body that was established in Egypt in 1976 in the framework of the Egyptian and Dutch Bilateral Cooperation Programme. The APP was set up in response to the need for expertise in land drainage and irrigation following the construction of the Aswan High Dam and the corresponding large-scale drainage scheme in the Nile Valley and Delta. From the early years the APP, apart from providing such expertise and advice to the Egyptian Public Authority for Drainage Projects (EPADP) and MWRI's Drainage Research Institute (DRI), was supported by a number of projects aiming at developing new technologies tailor-made to country conditions. Over the years, the APP's focus has moved to other areas, e.g., groundwater management, water quality protection, and water policy development (including policy instruments and social aspects). Then, the APP evolved into an umbrella organisation encompassing all Egyptian-Dutch activities in the water sector, advising MWRI on more efficient and effective water management policy and taking an active role in policy development and implementation.

The APP is chaired by the Egyptian Minister of Water Resources and Irrigation. On the Egyptian side, it comprises directors from sectors and departments of the MWRI as well as MALR – this line ministry's representation was present from the beginning of APP's operation. Recently, an observer from the Ministry of Housing, Utilities and Urban Development has been added to reflect an integrated approach to water resources management. On the Dutch side, there is a representation of top officials from: the Ministry of Transport, Public Works and Water Management; the Ministry of Agriculture, Nature and Food Quality; Ministry for Economic Affairs; the Union of Water Boards. In addition, there is a financial expert representing the Dutch private sector and an independent co-chairman. The Ministry of Foreign Affairs has its observers. The APP is backed by a small, highly qualified Secretariat with a budget for supporting activities, such as workshops, meetings, consultancy services, field visits etc., financed by both countries.

The APP works using such tools as yearly Egyptian-Dutch panel meetings, workshops held at the national and regional levels, working group meetings, guided task forces, national and international consultant inputs (studies, reports, experts advise), field missions, capacity building seminars and trainings, coordination with Dutch financed development aid projects in other sectors. Lessons learned from the APP operation include knowledge and know how transfer (both from the Netherlands to Egypt but also from Egypt to the Netherlands, e.g., by employing experience gained in Egypt in other developing countries where the Dutch organizations and consultancies are present), creation of an irrigation and drainage equipment market for Dutch manufactures, source of technical assistance for water sector projects funded by development aid organizations, e.g., World Bank (APP 2009).

APP's success factors include:

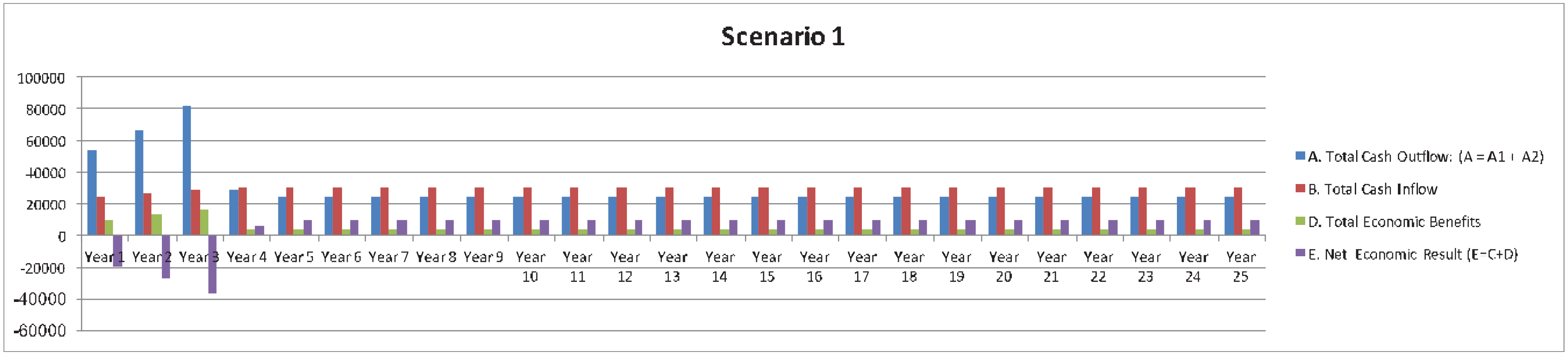
- Good preparatory discussions on relevant subjects supported by practical programmes and qualified professionals – both high-level public officials and private sector representatives
- Simple structure with a feedback and follow-up mechanism as well as an independent Secretariat
- Demand driven cooperation
- Financial commitment of both countries
- Cost-effectiveness – large spin-off effect and impact with a yearly budget of EUR 350,000
- Common understanding, trust and as a result equality of relations between panel members
- Willingness for continuous development and adaptation to changing circumstances and needs in the water sector in Egypt
- APP’s weaker points comprise:
- High dependency on political level and individual panel members’ commitment
- Sensitivity to experts fluctuation and little involvement of young specialist (especially on the Egyptian side)
- Insufficient use of modern communication channels (e.g., Internet) to disseminate results
- Less important role of international cooperation on the Dutch political agenda

8.5 Annex 5: Details of the Financial and Economic Analyses

8.5.1 Scenario 1 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				4,695	4,695	4,695	4,695					
Training activities				2,000	1,000							
Recovery wells - tank and booster system				30,501	21,048							
Irrigation network					21,716	57,704						
A2. Operating Cost (Recurrent Expenses)												
Farmers pay off the investment							3742	3742	3742	3742	3742	3742
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment		*152,751*										
A. Total Cash Outflow: (A = A1 + A2)		**739,331**		54,213	66,618	81,701	28,882	24,187	24,187	24,187	24,187	24,187
B. Benefit: Cash inflow: (ILS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm	*	1.0	ILS/CM	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors												
Subsidies				0	0	0	0	0	0	0	0	0
B. Total Cash Inflow		**755,466**		24,625	26,651	28,678	30,705	30,705	30,705	30,705	30,705	30,705
C. Cash Flow Results: (C=B-A)		**16,135**		-29,588	-39,967	-53,022	1,823	6,519	6,519	6,519	6,519	6,519
Financial Internal Rate of Return		**1.00%**		FNPV@3%	**(24,024)**	BCR@3%	**0.956**					
Scenario 1 - full stage investment				FNPV@5%	**(39,976)**	BCR@5%	**0.913**					
				FNPV@7%	**(50,568)**	BCR@7%	**0.873**					
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				3,280	4,134	5,125	1,750	1,750	1,750	1,750	1,750	1,750
VAT Investment Adjustement				4,880	6,842	9,233	-	-	-	-	-	-
VAT Revenues/Costs Adjustement				1,724	1,866	2,007	2,149	2,149	2,149	2,149	2,149	2,149
D. Total Economic Benefits				9,884	12,842	16,365	3,900	3,900	3,900	3,900	3,900	3,900
E. Net Economic Result (E=C+D)				-19,704	-27,125	-36,657	5,723	10,418	10,418	10,418	10,418	10,418
Economic Internal Rate of Return		**9.57%**		ENPV@3%	**69,527**	BCR@3%	**1.127**					
Scenario 1 - full stage investment				ENPV@5%	**39,563**	BCR@5%	**1.086**					
				ENPV@7%	**18,455**	BCR@7%	**1.046**					

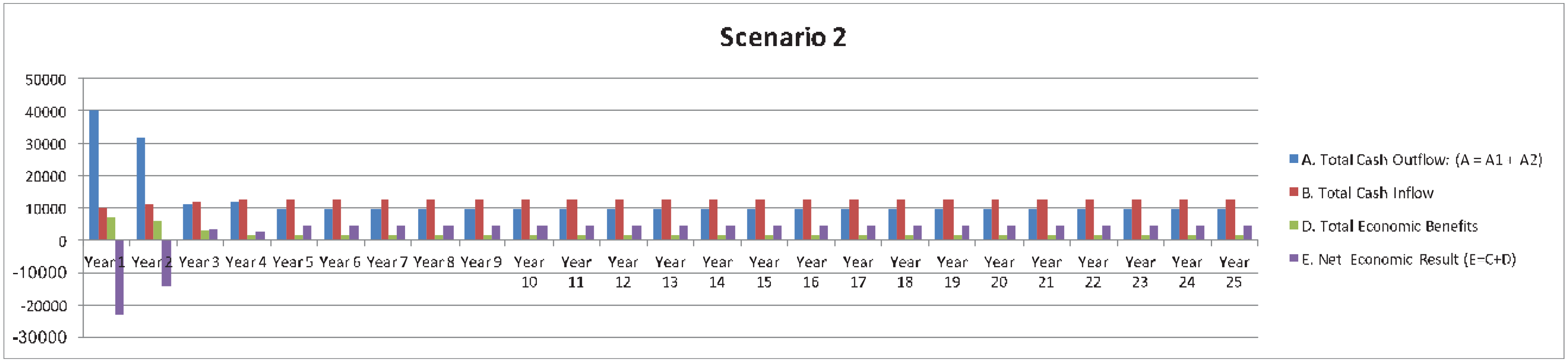
8.5.2 Scenario 1 – Cash Flow



8.5.3 Scenario 2 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				1,925	1,925	1,925	1,925					
Training activities				820	410							
Recovery wells - tank ans booster system				30,501								
Irrigation network					21,716							
A2. Operating Cost (Recurrent Expenses)												
Farmers pay off the investment						1492	1492	1492	1492	1492	1492	1492
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	6,977	7,445	7,914	8,382	8,382	8,382	8,382	8,382	8,382
Total investment		*61,148*										
A. Total Cash Outflow: (A = A1 + A2)		**302,209**		40,223	31,497	11,331	11,799	9,874	9,874	9,874	9,874	9,874
B. Benefit: Cash inflow: (ILS)												
Direct & indirect benefit												
Revenue at Farm level				9,798	10,629	11,460	12,291	12,291	12,291	12,291	12,291	12,291
Water tariff paid by Industry 40,000 cm	*	1.0	ILS/CM	40	40	40	40	40	40	40	40	40
Time saved for non management of private wells				269	269	269	269	269	269	269	269	269
Paid by Government/Donors												
Subsidies				0	0	0	0	0	0	0	0	0
B. Total Cash Inflow		**310,023**		10,107	10,938	11,769	12,600	12,600	12,600	12,600	12,600	12,600
C. Cash Flow Results: (C=B-A)		**7,814**		-30,116	-20,558	439	801	2,726	2,726	2,726	2,726	2,726
Financial Internal Rate of Return		**1.10%**		FNPV@3%	**(10,167)**	BCR@3%	**0.955**					
Scenario 2 -only Phase I investment				FNPV@5%	**(17,536)**	BCR@5%	**0.908**					
				FNPV@7%	**(22,598)**	BCR@7%	**0.863**					
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				1345	1695	2101	718	718	718	718	718	718
VAT Investment Adjustement				4880	3475	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				708	766	824	882	882	882	882	882	882
D. Total Economic Benefits				6,933	5,935	2,925	1,600	1,600	1,600	1,600	1,600	1,600
E. Net Economic Result (E=C+D)				-23,183	-14,623	3,364	2,401	4,326	4,326	4,326	4,326	4,326
Economic Internal Rate of Return		**8.72%**		ENPV@3%	**28,165**	BCR@3%	**1.125**					
Scenario 2 -only Phase I investment				ENPV@5%	**15,166**	BCR@5%	**1.080**					
				ENPV@7%	**5,897**	BCR@7%	**1.036**					

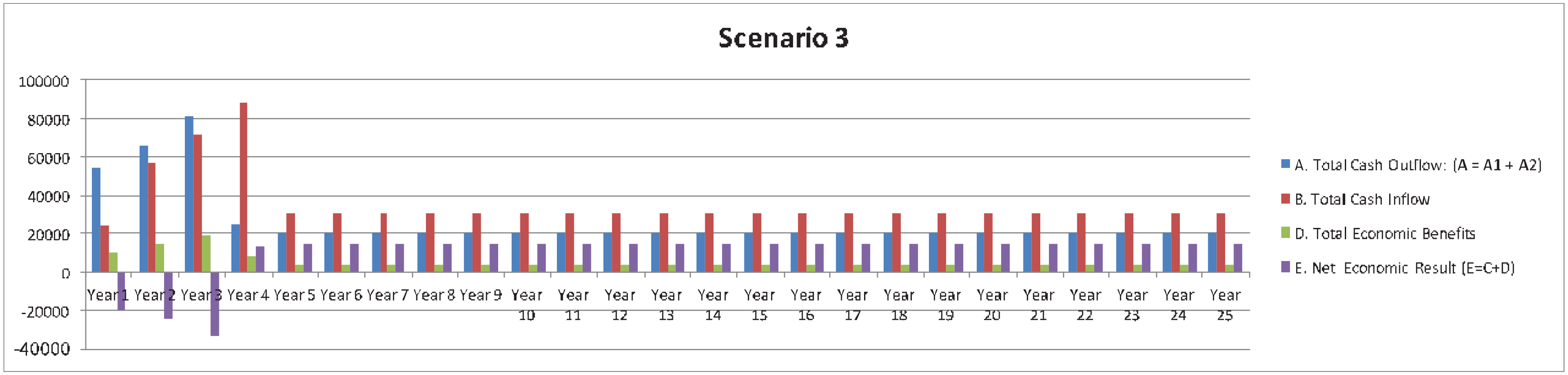
8.5.4 Scenario 2 – Cash Flow



8.5.5 Scenario 3 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				4,695	4,695	4,695	4,695					
Training activities				2,000	1,000							
Recovery wells - tank ans booster system				30,501	21,048							
Irrigation network					21,716	57,704						
A2. Operating Cost (Recurrent Expenses)												
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment		*152,751*										
A. Total Cash Outflow: (A = A1 + A2)		**657,007**		54,213	66,618	81,701	25,140	20,445	20,445	20,445	20,445	20,445
B. Benefit: Cash inflow: (NIS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm	*	1.0	ILS/cm	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors					30,501	42,764	57,704					
Subsidies												
B. Total Cash Inflow		**886,435**		24,625	57,153	71,442	88,409	30,705	30,705	30,705	30,705	30,705
C. Cash Flow Results: (C=B-A)		**157,604**		-29,588	-9,465	-10,259	63,269	10,261	10,261	10,261	10,261	10,261
Financial Internal Rate of Return		**31.02%**		FNPV@3%	**149,706**	BCR@3%	**1.304**					
Scenario 3 - Capital cost payd by Government				FNPV@5%	**114,653**	BCR@5%	**1.274**					
				FNPV@7%	**88,791**	BCR@7%	**1.244**					
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				3280	4134	5125	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				4880	6842	9233	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1724	4001	5001	6189	2149	2149	2149	2149	2149
D. Total Economic Benefits				9,884	14,977	19,358	7,939	3,900	3,900	3,900	3,900	3,900
E. Net Economic Result (E=C+D)				-19,704	-24,990	-33,664	13,504	14,160	14,160	14,160	14,160	14,160
Economic Internal Rate of Return		**15.17%**		ENPV@3%	**132,443**	BCR@3%	**1.511**					
Scenario 3 - Capital cost payd by Government				ENPV@5%	**89,958**	BCR@5%	**1.482**					
				ENPV@7%	**59,633**	BCR@7%	**1.454**					

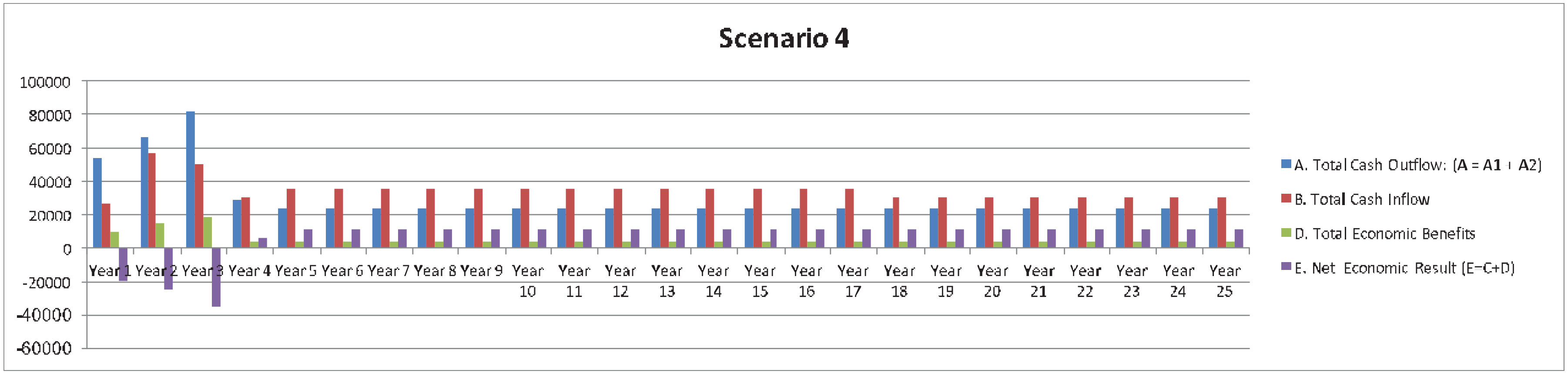
8.5.6 Scenario 3 – Cash Flow



8.5.7 Scenario 4 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				4,695	4,695	4,695	4,695					
Training activities				2,000	1,000							
Recovery wells - tank ans booster system				30,501	21,048							
Irrigation network					21,716	57,704						
A2. Operating Cost (Recurrent Expenses)												
Farmers pay off the investment							3150	3150	3150	3150	3150	3150
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment		*152,751*										
A. Total Cash Outflow: (A = A1 + A2)		**726,307**		54,213	66,618	81,701	28,290	23,595	23,595	23,595	23,595	23,595
B. Benefit: Cash inflow: (ILS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm	*	1.0	ILS/CM	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors					30,501	21,716						
Subsidies				1,487	2,974	4,957	4,957	4,957	4,957	4,957		
B. Total Cash Inflow		**873,609**		26,112	57,153	50,395	30,705	35,662	35,662	35,662	30,705	30,705
C. Cash Flow Results: (C=B-A)		**97,529**		-28,101	-9,465	-31,306	2,415	12,067	12,067	12,067	7,111	7,111
Financial Internal Rate of Return		**12.25%**		FNPV@3%	**81,515**	BCR@3%	**1.151**	investm. Phase II		78,751		
Scenario 4 Capital cost phase 1 paid by government - subsidies for 17 years to farmer payd capital cost phase 2				FNPV@5%	**52,904**	BCR@5%	**1.116**	subsidies		78,813		
				FNPV@7%	**32,140**	BCR@7%	**1.082**	17 year of subsidies				
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				3280	4134	5125	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				4880	6842	9233	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1828	4001	3528	2149	2496	2496	2496	2149	2149
D. Total Economic Benefits				9,988	14,977	17,885	3,900	4,247	4,247	4,247	3,900	3,900
E. Net Economic Result (E=C+D)				-19,600	-24,990	-35,137	6,315	11,357	11,357	11,357	11,010	11,010
Economic Internal Rate of Return		**11.13%**		ENPV@3%	**84,944**	BCR@3%	**1.338**					
Scenario 4 Capital cost phase 1 paid by government - subsidies for 17 years to farmer payd capital cost phase 2				ENPV@5%	**52,325**	BCR@5%	**1.304**					
				ENPV@7%	**29,216**	BCR@7%	**1.272**					

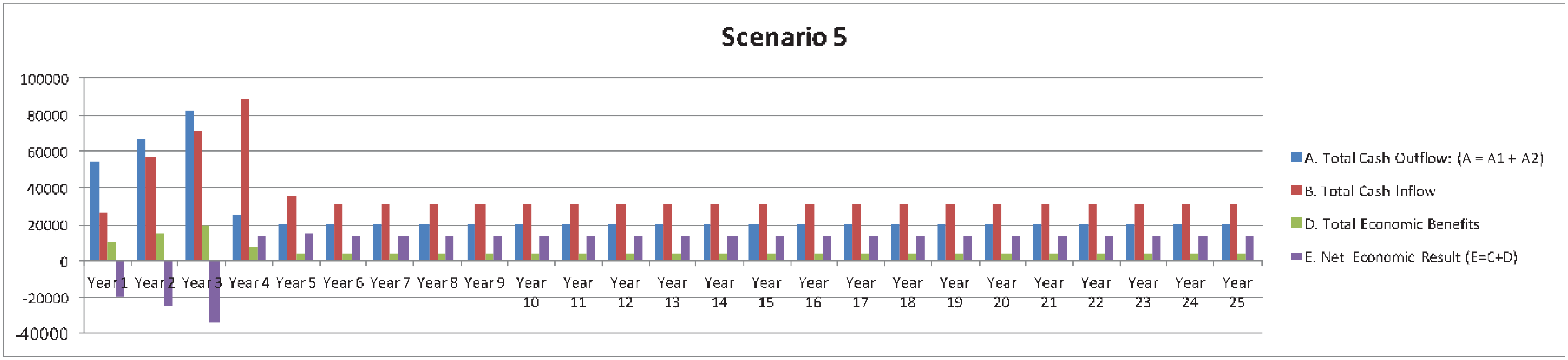
8.5.8 Scenario 4 – Cash Flow



8.5.9 Scenario 5 – Details of the Calculations in ILS x 1,000

Details				Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 24	Year 25
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level				4,695	4,695	4,695	4,695					
Training activities				2,000	1,000							
Recovery wells - tank ans booster system				30,501	21,048							
Irrigation network					21,716	57,704						
A2. Operating Cost (Recurrent Expenses)												
Cost at Farm level (including water tariff=	0.63	ILS/CM	)	17,016	18,159	19,302	20,445	20,445	20,445	20,445	20,445	20,445
Total investment		*152,751*										
A. Total Cash Outflow: (A = A1 + A2)		**657,007**		54,213	66,618	81,701	25,140	20,445	20,445	20,445	20,445	20,445
B. Benefit: Cash inflow: (ILS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm	*	1.0	ILS/CM	70	70	70	70	70	70	70	70	70
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors					30,501	42,764	57,704					
Subsidies				1,487	2,974	4,957	4,957	4,957				
B. Total Cash Inflow		**892,879**		26,112	57,153	71,442	88,409	35,662	30,705	30,705	30,705	30,705
C. Cash Flow Results: (C=B-A)		**164,048**		-28,101	-9,465	-10,259	63,269	15,217	10,261	10,261	10,261	10,261
Financial Internal Rate of Return		**33.54%**		FNPV@3%	**155,425**	BCR@3%	**1.316**	investm. Fram level		18,782		
Scenario 5 Capital cost payd by government and and O&M patd by government util repayd inves				FNPV@5%	**119,953**	BCR@5%	**1.286**		subsidies	19,332		
				FNPV@7%	**93,715**	BCR@7%	**1.258**	5 year of subsidies				
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				3280	4134	5125	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				4880	6842	9233	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1828	4001	5001	6189	2496	2149	2149	2149	2149
D. Total Economic Benefits				9,988	14,977	19,358	7,939	4,247	3,900	3,900	3,900	3,900
E. Net Economic Result (E=C+D)				-19,600	-24,990	-33,664	13,504	14,507	14,160	14,160	14,160	14,160
Economic Internal Rate of Return		**15.24%**		ENPV@3%	**132,843**	BCR@3%	**1.523**					
Scenario 5 Capital cost payd by government and and O&M patd by government util repayd inves				ENPV@5%	**90,329**	BCR@5%	**1.496**					
				ENPV@7%	**59,978**	BCR@7%	**1.469**					

8.5.10 Scenario 5 – Cash Flow



8.6 Annex 6: Water Sector Capacity Development Programs of Donors and Financing Partners[9]

Many international governments provide financial assistance to the Palestinian Authority, and a significant portion of that goes to support the water sector. Many of these water programs have capacity development components, depending on the aims and policies of each government and the agreements they make with either the Palestinian Authority or the Palestinian Water Authority. Listed below, alphabetically, are the names of the funding and implementing agencies of different governments and a brief description of their contributions to capacity development in the Palestinian Water Sector.

Agence Française de Developpement (AFD) - Focuses on building capacities in water supply and sanitation as well as institutional support.

Austrian Representative Office- Supports the on-going Water Sector Reform process, capacity development in rural communities in wastewater, water supply and water quality, irrigation water capacity development and storm water management.

Czech Development Agency- Support began in 2011 with the planning and implementation of a water management system for the PWA.

European Union- The EU has been supporting the PWA in wastewater, sanitation and reuse, water governance, water policy and regional cooperation since 2006.

Formin Finland- Finland has been supporting the capacity of the PWA to manage projects since 1999. It focuses on institutional development and capacity development of the Joint Service Councils.

German Development Cooperation- Since 2006, the German government has been supporting the PWA in developing regulation capacities as well strengthening the technical, managerial and financial capacities of the Water Service Providers.

Italian Development Cooperation- Focuses on supporting other NGOS and the PWA in water service provision to the most vulnerable in Palestine.

Japan International Cooperation Agency (JICA)- Focuses building a new sewerage department in the Jericho Municipality through building capacities in O&M, financial management including setting tariffs and fees, and other technical trainings for the WWTP.

Kingdom of the Netherlands- Established a long term academic cooperation project between five Palestinian and five Dutch Universities to improve individual, organization and institutional capacity of the Palestinian higher education sector to improve the effectiveness of the Palestinian water sector regarding the development, provision and management of water resources and services.

Spanish Cooperation (AECID)- Conducts awareness raising activities to promote safe water management as well as capacity development in reuse of treated wastewater, water resources management, and access to sanitation. It also provides direct institutional support to the PWA.

Swedish Development Cooperation- Beginning in 1998, Sweden has supported the PWA and the Palestinian Water Sector mostly in Gaza through storm water and wastewater management support.

World Bank- The World Bank has funded various Capacity Development projects in the Palestinian Water sector, most notably the “Water Sector Capacity Building Project” from 2011- 17, which is supporting the entire water sector reform process.

[9] Taken from PWA Capacity Development Strategy, 2016

UNDP- Mostly working on improvement of governance, access to services and fostering regional cooperation. Previously the UNDP provided capacity support to the Costal Municipalities' Water Utility for water supply monitoring. Currently the UNDP focuses on capacity development in wastewater treatment and management.

UNICEF- Beginning in the 1980's, support from UNICEF to capacity development in the Palestinian Water Sector focuses on upgrading databases and information systems in the PWA and the Coastal Municipal Water Utilities in Gaza as well as awareness raising for hygiene.

UNRWA- One of the main overall service providers in Palestine, UNRWA is in charge of water quality assurance, vector control, solid waste disposal and sanitation inspections. It focuses only on refugee camp situations.

8.7 Annex 7: International Case Studies of Regulatory Systems for the Artificial Recharge of Aquifers with Treated Wastewater[10]

8.7.1 South Africa

Under the general framework of the National Water Policy for South Africa and the National Water Resources Strategy, an Artificial Recharge Strategy was finalised in 2007. "Artificial recharge (AR) is [defined as] the process whereby surface water is transferred underground to be stored in an aquifer". One of the management objectives of the strategy (legislation and regulation) is to "enable water management and water services institutions to adopt and regulate artificial recharge as part of Integrated Water Resources Management (IWRM)" (p. 119). South Africa has longstanding experience in artificial groundwater recharge. The city of Atlantis started recharging its aquifer with storm water and treated wastewater in 1979. At that time, the 1956 Water Act (No. 54 of 1956) was still in force, and artificial recharge and water recycling were not regulated under its provisions (DWAF, 2010).

Although there is still no consistent legal framework for AR, the current Atlantis Water Resources Management Scheme has to comply with the National Water Act (NWA) – No. 36 of 1998 – which explicitly regulates artificial groundwater recharge with treated or untreated wastewater. The Act arguably requires a licence for artificial groundwater recharge regardless of the source water when it identifies "storage of water" (art. 21(b)) among the 11 regulated water uses. Although at the time of drafting "storage of water" was intended for dams and canals, artificial groundwater recharge schemes may certainly be licensed under this use considering that the primary purpose of aquifers recharge is undoubtedly water storage (DWAF, 2007).

In addition, the Act requires a special authorization for "controlled activities", which include the "intentional recharging of an aquifer with any waste or water containing waste" (art. 21(e) and 37, NWA). The External Guidelines – Generic Water Use Authorisation Application Process of the Department of Water Affairs (DWA) state that, "if the proposed water uses comprise an integrated water use licence application, which combines both non-waste discharge and waste discharge-related water uses in a single application then a risk assessment must be undertaken for all the uses."

According to the 2007 AR Strategy, the procedure for the implementation of an artificial recharge project includes four stages, namely a pre-feasibility stage, a feasibility or testing stage, an implementation stage, and an operation, monitoring and maintenance stage. In order to identify suitable areas for artificial recharge, the checklist adopted for the first two stages includes 10 success criteria assessing: 1) demand (the need for an artificial recharge scheme); 2) supply (source water); 3) aquifer characteristics (aquifer hydraulics); 4) water quality; 5) applicable method (engineering issues); 6) environmental issues; 7) legal and regulatory issues; 8) economics; 9) technical capacity (management); and 10) institutional arrangements (Murray, 2009, as cited in Steinel, 2012, p. 43).

The pre-feasibility report is submitted to DWA, jointly with the licence application for testing, if required. DWA may convene an Artificial Recharge Authorities Committee Meeting, with other competent authorities, including Department of Environmental Affairs and Tourism and the relevant Catchment Management Agencies. If an environmental authorisation is required for testing under the Environmental Impact Assessment (EIA) Regulations (2010) (Government Notice No.543 in Government Gazette No. 33306 of 18 June 2010), a Basic Assessment Report or a Scoping and Environmental Impact Report (S&EIR) should be added to the pre-feasibility file. At the second stage, testing is carried out upon authorisation, if required. The feasibility report is submitted to DWA, jointly with the licence application for the desired water use and the environmental authorisation, if required. At the third stage, implementation of the project may commence upon issuance of the licence. The fourth stage – operation and maintenance, or production – should include performance monitoring.

[10] Taken from Study On The Legislative Framework Regulating The Recharge Of Aquifers With Adequately Treated Wastewater, Stefano Burchi, 2014.

In South Africa, the main water authority is the Ministry of Water Affairs. The Minister is the custodian of water resources and has the ultimate responsibility to ensure that water is protected and allocated in the public interest. The DWA – formerly Department of Water Affairs and Forestry (DWAF) – is delegated by the Minister to administer the NWA. Its mandate focuses on developing the national water policy and water management regulations, and on supervising water-related activities of other institutions, including water users' associations. All water resource management institutions must function in accordance with the National Water Resource Strategy.

Catchment Management Agencies (CMAs) are being established in each of the 19 water management areas. DWA may delegate water licensing to the CMAs. The Department of Environmental Affairs and Tourism (DEAT) is involved in water management where an environmental authorisation is required, under the National Environmental Management Act (No. 107 of 1998) and the Environment Conservation Act (No. 73 of 1989). Water Services Authorities and Water Services Providers, including Water Boards, are in charge of drinking water supply under the Water Services Act (No. 108 of 1997).

The Waste Management Policy includes the Policy and Strategy for Groundwater Quality Management in South Africa (2000), according to which "National Government, acting through the Minister, is the public trustee of the country's water resources. Surface and groundwater quality management are both important parts of his responsibility". Among the functional strategies provided for, sewage treatment is a priority to be addressed through regulations, standards and guidelines. Aquifer management strategies regarding groundwater quality are only required "for large and continuous aquifers", whereas "localised and poorly defined aquifers" are generally part of a catchment management strategy (Groundwater Quality Policy, 2000).

8.7.2 Israel

Israel has been practising wastewater treatment and reuse since the '50s and '70s, including through groundwater recharge (Soil Aquifer Treatment – SAT) (Tal, 2013). The country has a 75% water reuse rate [Spain 12%; Australia 9%] (Mekorot, 2013). Artificial groundwater recharge serves a number of purposes in Israel, namely increasing water reserves for periods of high demand (primarily for irrigation), reducing hydrological deficits, preventing saline intrusion from peripheral areas and ensuring efficient utilisation of surplus water from Lake Kinneret (i.e. Lake Tiberias) (see Israel case study in DWAF, 2007).

Comprehensive water quality monitoring is normally carried out throughout all the stages of the recharge process. However, besides known problems related to clogging of recharge boreholes due to silt build-up and algae in the source water (Mekorot, 2013), health concerns have been raised lately, as endocrine disruptors, antibiotics and trace metals have been found in recycled water. In order to protect human health and groundwater quality, some experts are now calling for treatment to drinking water quality standards through desalination of treated sewage effluent by reverse osmosis (Tal, 2013).

The largest SAT facility in Israel is the Dan Region Wastewater Treatment Plant (Shafdan), where sewage water from the Tel Aviv region is treated. Wastewater treatment comprises four stages: pre- treatment, primary, secondary and tertiary treatment. Treatment methods include oxidation ponds, activated sludge and Mechanical Bio-Reactor (MBR). The Shafdan effluents are discharged into the soil for tertiary treatment and to recharge the aquifer. Water is then recovered and transported to the Negev for irrigation. The total effluent supplied for agricultural purposes is 216 million cubic meters per year (Mekorot, 2013).

The Israeli Water Law (No. 5719 of 1959) states that national water resources (including drainage and sewage water) are the property of the public. They are controlled by the State and are intended to fulfil the needs of the population and the development of the country (section 1). With a view to preventing water pollution in water facilities, the law establishes that anyone who has in his possession a facility for water production, supply, transport, storage or recharge to the subsoil must undertake every reasonable measure in order to prevent the facility or its operation from causing water pollution (s. 20C). In addition, anyone who is operating a polluting facility, which requires the disposal of sewage, must submit a sewage disposal plan to be approved by the Director of the National Authority for Water and Sewage (s. 20E).

National legislation regulating the use of wastewater for the specific purpose of artificially recharging aquifers includes the following (personal communication to the author):

a) National Plan No. 34 B/4 for Collecting Surface Water, Insertion, Recharge, and Protection of Groundwater. Part C of the plan identifies proposed recharge areas and areas meant for recharge projects. A building permit is required for any recharge project in an identified area. The permit will be issued with a detailed implementation plan, in accordance with the National Plan (s. 12). The detailed plan for a recharge site will include the area for spreading and recharge, pipes and equipment for water conveyance and service roads and access. It will also include the facilities for catching and diverting water, reservoirs, equipment for water conveyance including pumps, pipes, canals, dams, etc., and facilities for extraction of the recharge (s. 13). Given the fact that ponds and infiltration basins may attract birds, the plan must include measures to ensure flight safety over recharge areas in order to avoid bird strikes. The National Plan specifically includes the Shafdan sewage recharge facility in its scope of application (s. 15).

b) Public Health Regulations (Regulations for Sewage Quality and Rules for Treating Sewage), 2010, or "Sewage Regulations". Recycled sewage water that is used for recharge is mostly intended for irrigation purposes; hence the quality must meet the relevant specifications. Treatment plants are divided into "large" and "small" and, within each of these categories, quality values are established according to usage – unlimited agricultural usage, limited agricultural usage and release into streams (s. 4, appendix 1-3). The Sewage Regulations require permits for each usage/disposal method – irrigation, discharge into streams or other economic usage (s. 9). A plan for the control and monitoring of sewage quality is also required (s. 10).

c) Public Health Rules (Treating effluent for reuse in irrigation), 1981.Yearly permits are required from the regional engineer of the Ministry of Health for wastewater treatment systems intended for irrigation. Treated effluents may only be used for irrigating crops listed in the Public Health Rules8 and under specific conditions9, unless it has been treated to the level of "unlimited irrigation" purposes under the 2010 Public Health Regulations. In this latter case, treated water may be used for any type of crops. Farmers irrigating with treated effluents must apply for a permit and respect its terms and conditions. If a crop is not listed in the appendix to the Public Health Rules, a written permission of the Director General of the Ministry of Health is required for irrigation with treated effluents. For example, on 6 October 2013, 60 dunums (15 acres) of zucchini squash were destroyed in the central region, upon order of the local health authority. The order stated that the field was irrigated with effluents that did not meet the quality standards for this type of crop, and without a permit from the Ministry of Health.

The above-described framework establishes a web of interlocking regulatory requirements. The National Plan No. 34 B/4 regulates recharge projects and all aspects thereof, except the quality required of the wastewater being employed for recharge purposes, which is regulated by the 2010 Public Health Regulations. Treatment requirements vary depending on the intended end-use of the recharged aquifer water. The yearly (operating) permit requirements of the 1981 Public Health Rules with respect to wastewater treatment plants intended for irrigation use are additional to, and separate or independent from, the permit requirements of the National Plan. In other words, an aquifer recharge project involving the use of wastewater as source water for future irrigation use must secure a building permit under the National Plan, a recycled water use/disposal permit under the 2010 Public Health Regulations, plus a yearly operating permit of the wastewater treatment plant, under the 1981Public Health Rules.

8.7.3 Arizona (USA)

8.7.3.1 Applicable federal legislation

In the United States of America (USA), Aquifer Storage and Recovery (ASR) was first introduced in New Jersey in 1969 (Ward & Dillon, 2009). From a regulatory viewpoint, allocation of water rights is generally dealt with at the State level, as well as wastewater reuse regulation, although “much of the regulation of effluent quality takes place at the federal level” (Chapman, 2005). States with “well-developed, comprehensive water reclamation and reuse regulations” include Arizona, California, Florida, and Texas, where there is extensive reuse of water (Crook, 1994, as cited in Chapman, 2005). In Arizona, the MAR permit system is based on a statutory derivative of the prior appropriation doctrine, like in Colorado, New Mexico and Utah, among others. In California, there is a mixed system of the prior appropriation and the correlative rights doctrines. In Florida, the reasonable use doctrine is applied, whereas Texas has a system based on the absolute groundwater ownership doctrine (Wards & Dillon, 2009).

At federal level, the 1972 Clean Water Act (33 USC §§ 1251-138712), which is the main text on water pollution control, and the 1976 Resource Conservation and Recovery Act, which is the main federal law governing the disposal of solid waste and hazardous waste, only make provision for the protection of groundwater quality. They do not explicitly provide on artificial recharge of aquifers. Groundwater quality in relation to artificial recharge is regulated under federal drinking-water legislation. Under the 1974 Safe Drinking Water Act, the US Environmental Protection Agency (EPA) implements the Underground Injection Control (UIC) Program (42 USC §§ 300h-300h8 13). The Act authorizes EPA to regulate injection wells in order to protect underground sources of drinking water, but an amendment introduced by the 2005 Energy Policy Act has excluded hydraulic fracturing from EPA’s UIC Program (42 USC § 300h d) 1) B) ii) Underground injection defined) and has simplified federal requirements for State programmes involving this technique (42 USC § 300h-4 Optional demonstration by States relating to oil or natural gas).

8.7.3.2 Arizona State legislation

Arizona’s aquifer management legislation is based on two main laws: the 1980 Groundwater Management Act (Arizona Revised Statutes – ARS, Title 45 Water, Chapter 2 Groundwater Code) and the 1994 Underground Water Storage, Savings, and Replenishment (UWS) Act (ARS, Title 45 Water, Chapter 3.1 UWS), under which the UWS Program (Storage Program) operates15. Somebody wishing to store, save, replenish or recover water through the Storage Program must apply for permits through the Arizona Department of Water Resources (ADWR). Depending on the intended activity, up to three types of permits may be required: a Facility Permit – Underground Storage Facility (USF) or Groundwater Savings Facility (GSF) Permit – for the operation of the storage facility, a Water Storage (WS) Permit to allow the holder to store water and a Recovery Well (RW) Permit for the recovery of stored water (or credits, in case of a GSF).

Firstly, USF Permit applicants must prove that legal access or the right to acquire legal access to the site (or to the storage space) has been obtained. Secondly, WS Permit applicants must prove their right to use the source water. In the case of effluents, the 1989 Arizona Supreme Court decision (Arizona Public Service Co. v. Long, 160 Ariz. 429, 773 p. 2d 988, as cited in the USF and WS Permit Application Guides of the ADWR) established that the entity generating the effluent (possibly the effluent discharge permit holder) has the right to put it to a beneficial use or convey it to another entity that will put it to a beneficial use. If the applicant did not generate the effluent, the legal right to the effluent must be “first in time, first in right”. Permits are often required, by statute, in order to establish priority in use. Under the correlative rights doctrine, each user has an equal right to use of the groundwater regardless of who the first user was. If water is insufficient, users may be required, by the judiciary or by statute, to reduce their usage on a pro- rata basis until the overuse ends. (Bruggink, 1992, as cited in Ward & Dillon, 2009) proven through a contract or agreement with the effluent originator. In view of their contractual nature, the trade of effluents rights is “exempt from general water exchange permitting rules” (Chapman, 2005).

Thirdly, a RW Permit is required to recover water that was stored under a WS Permit. The right to withdraw stored water is linked to qualitative and quantitative variables: recharged water must meet the target quality levels for intended use before being recovered; water must be available at the time of withdrawal, considering pre-existing rights to withdraw water from the aquifer. In this regard, aquifer users in the area may withdraw from the recharged aquifer by accounting for it in the total amount of water allowed in their abstraction permit (Ward & Dillon, 2009). In fact, in most cases, no distinction seems to be possible in practice between existing (or “native”) and recharged groundwater.

In addition, water storage projects (both from treated sewage/wastewater effluents and from surface water) require an Aquifer Protection Permit (APP) to be issued by the Arizona Department of Environmental Quality (ADEQ), prior to filing the USF Permit application. Moreover, a variety of wastewater treatment regulations and standards have been adopted for recycled water reuse for irrigation, for environmental purposes, for indirect potable use and for direct reuse (Chapman, 2005). These regulations may be applicable to either source water or to recovered water, or both, depending on the final use considered.

8.7.4 Western Australia (Australia)

8.7.4.1 Applicable national legislation

At the federal level, the definition of groundwater provided by the 2007 Water Act includes water that naturally occurs in aquifers, as well as “water occurring at a place below ground that has been pumped, diverted or released to that place for the purpose of being stored there; but does not include water held in underground tanks, pipes or other works” (art. 4). Australian Guidelines for Water Recycling are being prepared under the National Water Quality Management Strategy 18. Among these are the National MAR Guidelines, published in 2009 (Document No. 24), which focus “primarily on the protection of aquifers and the quality of the recovered water in managed aquifer recharge projects using all water sources including recycled water”.

In Australia, the first successful MAR trials were made in the 1960s (e.g. Queensland) via infiltration basin for irrigation and in the 1980s (e.g. South Australia) via recharge wells. However, the first Unmanaged Aquifer Recharge (UAR) experiences go as far back as the 1830s and the 1880s (respectively in Perth and Mount Gambier) where recharge occurred from roof run-off infiltration and drainage wells (Parsons et al., 2012). According to the 2009 MAR Guidelines, UAR is an “intentional water-related activity, known to increase aquifer recharge, but usually undertaken to dispose of water rather than recover it” (p. 21). To date, trials of storm water aquifer recharge and recovery have been made in a number of States, but MAR trials with recycled water have only been carried out in Western Australia and South Australia.

The implementation of MAR schemes generally falls under State legislation. However only three States have adopted a MAR policy so far, namely Western Australia, South Australia and Victoria, but no MAR trials with recycled water have been made in the last State so far. Following the Western Australia case below, a brief review of the MAR framework in the other two States is reported.

8.7.4.2 Western Australia State legislation

In Western Australia, the Department of Water (DoW) has issued an Operational Policy 1.01 – Managed Aquifer Recharge in Western Australia (DoW, 2011) that describes the procedures for the operation of a MAR scheme. Under the 1914 Rights in Water and Irrigation (RWI) Act, water that is infiltrated or injected into the natural groundwater system is vested in the Crown (section 5A). Proponents of MAR schemes must apply for a “licence to take water”, under section 5C, which will define both the right to recharge and the right to recover groundwater. For the purpose of the Act, “‘take’ in relation to water means to remove water from, or reduce the flow of water in, a watercourse, wetland or underground water source [...] and includes storing water during, or ancillary to, any of those processes or activities”. Moreover, to operate a MAR facility a “licence to construct bores” is required by section 26D.

According to Appendix A of the MAR Operational Policy, the issuance of the licence under section-5C – and the approval of the “banking (storage) and recovery of the recharge water” – requires the application of relevant national guidelines (e.g. for recycled water use), a hydrogeological assessment on a case-by-case basis, a previously-approved operating strategy, and relevant health-related documentation for drinking-water use. In this latter regard, a review of the Water

Quality Protection Note No. 25: Land use compatibility in public drinking water source areas (2004) is under consideration, with a view to accounting for “infiltration or injection of wastewater into the ground” (DoW, 2011).

Lastly, recovery will only be allowed when recharge water is available and water quality requirements are met. If recharge and recovery are undertaken by different operators, the parties must reach an agreement to take water under the existing section-5C license, ensuring that enough water will be available for recovery during the period of the agreement. In view of the public-property nature of water resources in Australia, the agreement must be approved by the DoW (DoW, 2011).

The Groundwater Replenishment Project is a 3-year indirect MAR trial with highly-treated recycled water, and it is meant to investigate drinking-water-supply augmentation through a new climate- independent water source for Perth. The project is implemented by the government-owned Water Corporation, which is the main supplier of water, wastewater and drainage services in Western Australia. Before being recharged to the aquifer, water undergoes an advanced treatment process that uses three main technologies: ultra-filtration, reverse osmosis and ultra-violet filtration. Trials were carried out between November 2010 and December 2012, recharging a total of 2.533 billion litres of recycled water into groundwater. Trials aimed at providing a setting for regulators to develop health and environmental regulations and policies, and at feeding the public debate about groundwater replenishment.

8.7.4.3 Overview of South Australia and Victoria State legislation

In South Australia, under the 2004 Natural Resources Management Act (which repeals the 1997 Water Resources Act), the regional Natural Resources Management (NRM) boards are granted special powers to carry out works, including to “divert water to an underground aquifer, dispose of water to a lake, underground aquifer or the sea, or deal with water in any other manner”. The SA Environmental Protection Agency (EPA) has issued a Code of Practice for Aquifer Storage and Recovery in January 2004. The State also has an Environment Protection (Water Quality) Policy, adopted in 2003.

In Victoria, the 1989 Water Act regulates the underground disposal of matter via bores (section 76), which seems to cover MAR. Water recharged in this manner is recoverable through a regular water abstraction licence (section 51). According to the Guidelines for MAR – Health and Environmental Risk Management, published by the Victoria EPA in 2009, MAR is generally regulated by Regional Water Corporations as a delegated responsibility (section 122b) (EPA, 2009). The Department of Sustainability and Environment (DSE) has issued a number of guidance documents on MAR, including the Policies for Managing Section 76 Approvals19 (DSE, 2010).

8.7.5 Spain

8.7.5.1 Applicable EU legislation

Under the European Union (EU)Water Framework Directive (No. 2000/60/EC of 23 October 2000) (art. 11), Member States must establish a programme of measures for each river basin district, or for the part of an international river basin district within its territory, in order to achieve the established environmental objectives (art. 4). The programme of measures must take into account the results of the required technical (hydrological and hydrogeological), social and economic analyses (art. 5), which include information on artificial recharge (Annex II, § 2 – Groundwater, on the characterization of groundwater bodies).

The programme of measures to achieve the environmental objectives should implement relevant EU directives by adopting ‘basic measures’ and, where necessary, ‘supplementary measures’ to be applied locally. If necessary, the programme of measures may refer to national legislation. Among the basic measures to be adopted by Member States, the directive mentions “controls, including a requirement for prior authorisation of artificial recharge or augmentation of groundwater bodies” (art. 11.3(f)). In addition, the source water used must not compromise the achievement of the environmental objectives established for the recharged body of groundwater. Artificial aquifer recharge is also mentioned among the supplementary measures that Member States may adopt to achieve the established management and quality objectives (Annex VI – Lists of measures to be included within the programmes of measures).

Artificial recharge of aquifers is more specifically regulated under EU legislation on groundwater pollution. In particular, Directive No. 80/68/CE of 17 December 1979 requires a special authorisation to be granted by Member States for the artificial recharge of aquifers under their jurisdiction (art. 6). Competent national authorities must ensure compliance with the terms and conditions of the authorization and avoid pollution of groundwater sources from wastewater.

On the other hand, Directive No. 2006/118/CE of 12 December 2006 (known as "Groundwater daughter Directive") establishes that all programmes of measures adopted by Member States should include measures to prevent or limit aquifer pollution. It then provides that the input of pollutants resulting from artificial groundwater recharge may be exempted from such measures, if so provided in the programme (art. 6.3). Such exemption is only applicable where efficient monitoring of the bodies of groundwater concerned is in place. In any case, under Directive No. 91/271/EEC of 21 May 1991 concerning urban wastewater treatment, the discharge of industrial waste water into collecting systems and urban waste water treatment plants is subject to a special authorisation (art. 11) and "treated wastewater may be reused whenever appropriate" (art. 12).

At the environmental end of the regulatory spectrum, according to Directive No. 85/337/CEE of 27 June 1985, the "artificial recharge of aquifers" is subject to EIA procedures where the annual volume of water extracted or recharged is equal to or greater than 10 million cubic meters. For smaller projects, competent national authorities may decide at their discretion, on a case-by-case basis, whether or not to require an EIA, according to parameters or criteria set by each Member State. Countries with experience in "managed aquifer recharge and subsurface storage" (NNC-IAH, 2003) in Europe include the Netherlands, Germany, Spain and Hungary. Below is a review of Spanish legislation on artificial groundwater recharge.

8.7.5.2 Spanish national legislation

The 2001 consolidated Spanish Water Law (Royal Decree No. 1/2001 of 20 July 2001 – Texto Refundido de la Ley de Aguas) requires an authorisation for treated effluent discharge (art. 101) and regulates the conditions for treated water reuse (reutilización de aguas depuradas) (art. 109). A concession is generally required for water reuse, but a simple authorisation shall suffice where the applicant is already authorised to discharge treated effluents. On the other hand, the holder of a water-reuse concession may acquire the relevant authorisation for treated effluent discharge via a contractual arrangement with the holder of said authorization, with the approval of the relevant Basin Authority.

Quality standards are defined according to the intended reuse. Royal Decree No. 1620/2007 of 7 December 2007 establishing the legal regime for treated water reuse (Real Decreto por el que se establece el regimen juŕidico de la reutilización de las aguas depuradas) defines water quality parameters for different uses. For instance, Quality 5.2 is required for the recharge of aquifers through direct injection. Treated wastewater however cannot be reused for human consumption purposes (Steinel, 2012).

Under the 2001 Water Law, the regulation of water works– including underground water storage, aquifer recharge and wastewater treatment (art. 122)– indicates that new water works requiring a concession for a new water use may only commence after obtaining the prescribed concession. The institutional responsibility for water works is shared among the national water resources administration, the River Basin Organizations, the regional governments ("Autonomous Communities") and the local governments, depending on the national or local relevance of the works, and on their funding (art. 123).

Guidelines for aquifer recharge are established in Royal Decree n. 907/2007of 6 July 2007 on hydrological planning regulations (Reglamento de la planificación hidrológica). Each hydrological plan shall include the areas of artificial recharge of groundwater bodies in order to determine the recharge objectives and the procedures to authorize the quantity and quality of water to be recharged. The source water may be recycled water, provided that environmental objectives and public health are not jeopardised (art. 53).

Government Order No. ARM/2656/2008 of 10 September 2008 approving instructions on hydrological planning (Orden por la que se aprueba la Instrucción de Planificación Hidrológica) requires each hydrological plan to identify different types of artificial recharge, including the recharge of aquifers with effluents (section 3.2.3.4(a)). For each type of recharge, the following shall be identified, where possible: (i) available source water, its origin, its temporary flow regime, its quality, its recharge rate and its chemical composition, (ii) indicators of the hydrogeological behaviour of the aquifer in order to assess its potential response to recharge, the procedures and facilities needed for the recharge operations (above or underground), as well as their lifespan, and (iii) number of artificial recharge points and evolution of recharge volumes in time for each groundwater body.

Some hydrological plans make provisions on artificial groundwater recharge, however most of them do not go into much detail and often refer to national legislation (Duero river basin Hydrological Plan, 2013, and Miño-Sil river basin Hydrological Plan, 2013). The 1998 Cuenca Sur basin Hydrological Plan is briefly reviewed below under the regional legislation of the Andalusia Autonomous Community.

8.7.5.3 Andalusian regional legislation

According to the 2010 Andalusian Water Law (Law No. 9/2010 of 30 July 2010), “artificial recharge” is a technique that allows programmed intervention and direct introduction of water in an aquifer, to increase the degree of water availability and to act on water quality; “underground storage” is defined as the temporary storage in a deep aquifer of liquids and gases through artificial recharge techniques (art. 4). In the Andalusia Autonomous Community, the Executive Council of Andalusia (Junta de Andalućia) is responsible for managed aquifer recharge (art. 8).

The artificial recharge of groundwater bodies or the temporary storage of groundwater is subject to an authorisation from the competent water authority (Consejeŕia competente en materia de agua). The application must be accompanied by a hydrological report, the justification for the recharge, the volume of water to be recharged, the documentation proving availability and quality of the source water, as well as possible interaction with the aquifer, and the programme of recharge and recovery of stored groundwater. The competent water authority establishes the volume of recoverable water, in accordance with drought plans, if any, and taking into account water security concerns (art. 56).

Concerning recharge facilities and works, the Autonomous Community is competent for groundwater works that do not affect waters outside its jurisdiction, unless they are of general interest for the country (Royal Decree No. 2130/2004 of 29 October 2004 – Real Decreto sobre traspaso de funciones y servicios de la Administración del Estado a la Comunidad Autónoma de Andalućia en materia de recursos y aprovechamientos hidráulicos (Confederación Hidrográfica del Sur)). Carrying out artificial groundwater recharge operations without being duly authorised is considered a minor offence under the 2010 Water Law, except where human health risks are involved (art. 106).

The Cuenca Sur basin Hydrological Plan, adopted by Royal Decree No. 1664/1998 of 24 July 1998, identifies a number of artificial groundwater recharge areas, including with treated wastewater. Reportedly, however, there has been limited or no follow up on these Plan determinations (personal communication to the author).

Complementary Feasibility Study for Irrigation Project

Preliminary Results

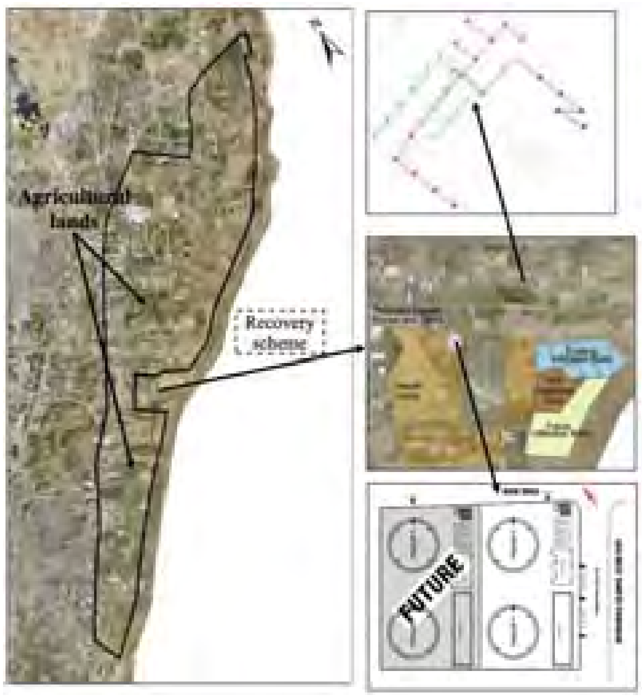
Presented by:
Andrea Cattarossi, P.E.
Gaza, May 31st 2017

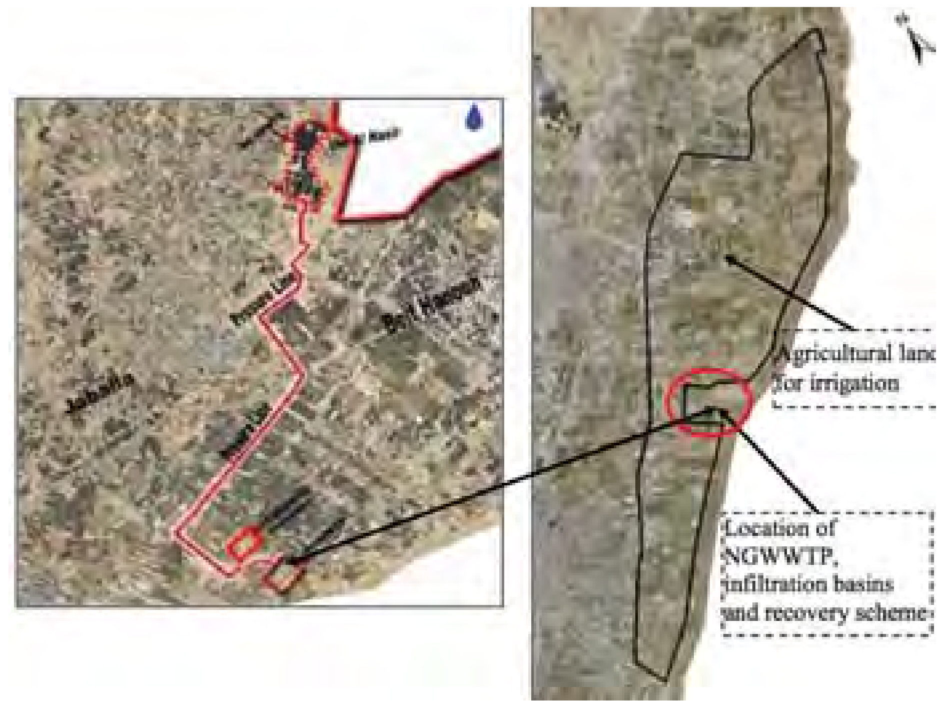
State of Palestine
Palestinian Water Authority

PROJECT RESULTS

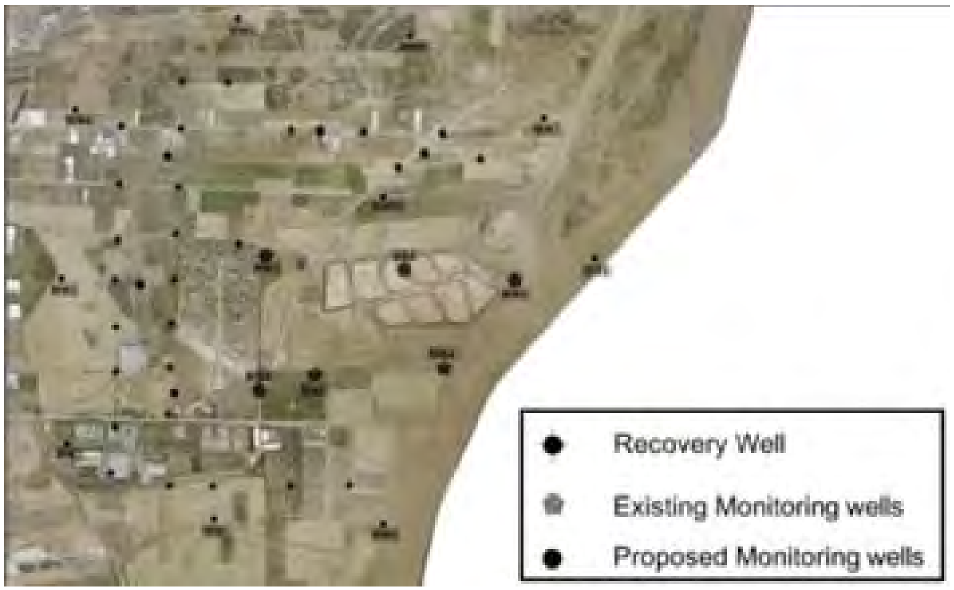
1. Baseline Survey and Assessment of Present Conditions:
   - Field Survey;
   - Land Tenure and Cropping System;
   - Crop Water Requirements and Water Consumption in Agriculture;
   - Key Financial Facts Under Present Conditions.
2. Assessment of the Recovery and Reuse (Irrigation) Schemes:
   - Proposed Cropping Pattern;
   - Proposed Irrigation Scheduling;
   - Review of the Network Design.
3. Draft Complementary Feasibility Study of the Irrigation Scheme:
   - Institutional and Legal Setups;
   - Crop Net Margins Under Future (Proposed) Conditions;
   - Project’s Feasibility.

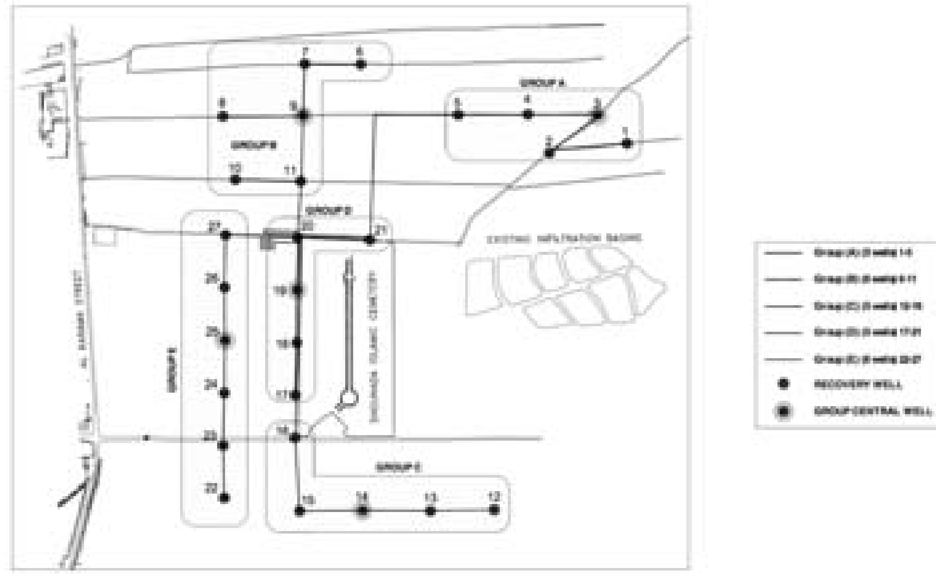
Project Background



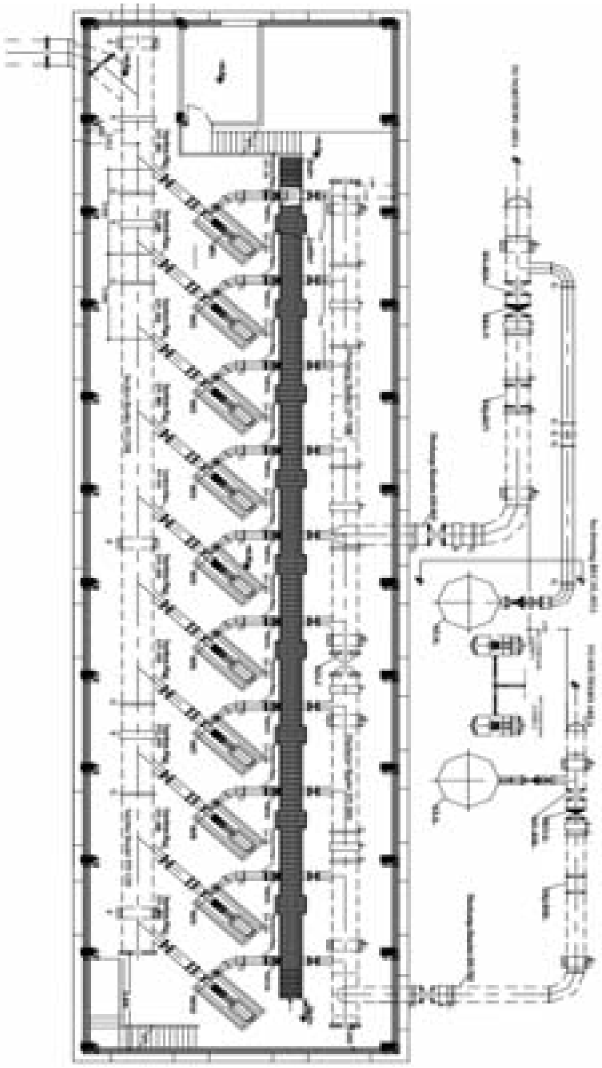


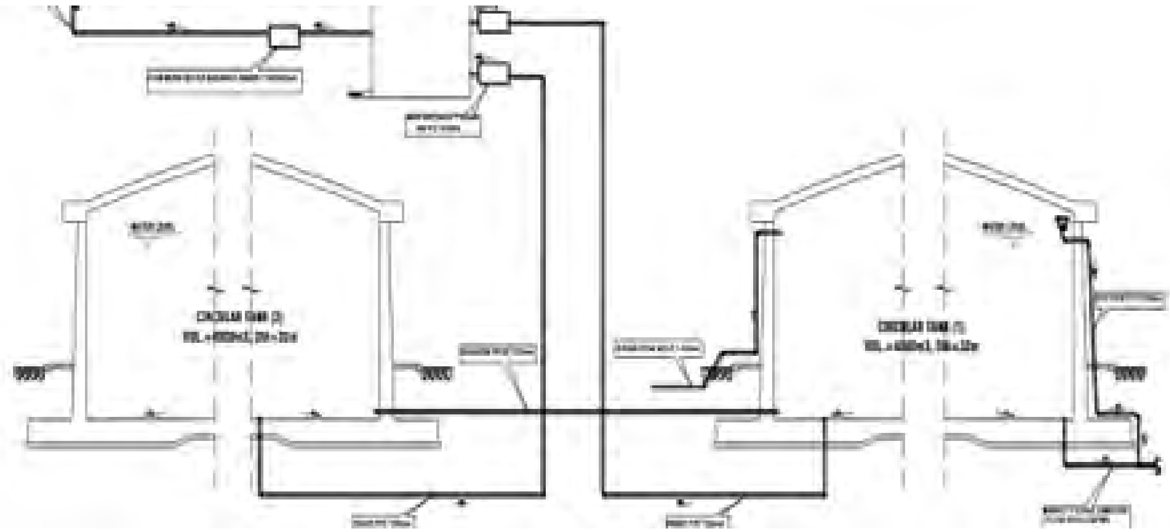
Water Recovery and Reuse (Irrigation) Schemes



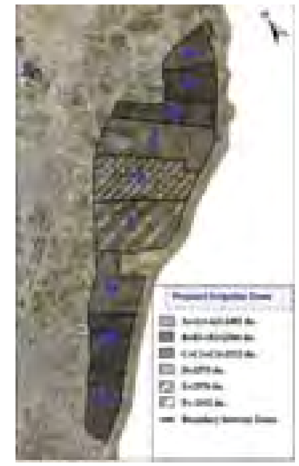


Recovery and Monitoring Wells





Storage Tanks and Booster Pumping Station



Irrigation Project Layout and Development Plan

CAPITAL INVESTMENTS

Implementation stage			Phase I	Phase II
Item No,	Description	Total Rate (USD)	US$	US$
1	General Items	$262,400.00	$131,200.00	$131,200.00
2	Circular Tank 4000 m^3 (2 Tanks)	$1,061,300.00	$530,650.00	$530,650.00
3	Booster Site (Civil)	$511,000.00	$511,000.00	
4	Mechanical Building	$2,285,150.00	$340,000.00	$1,945,150.00
5	Electrical Building	$1,060,000.00	$1,060,000.00	
6	Guard Room	$15,500.00	$15,500.00	
7	Recovery Wells (27 Wells)	$3,270,000.00	$1,816,666.67	$1,453,333.33
8	Monitoring Wells (10 Wells)	$260,000.00	$130,000.00	$130,000.00
9	Well Networks (approximately 6.7 km)	$707,000.00	$707,000.00	
10	Instrumentation & Automation SCADA System	$1,961,250.00	$1,321,250.00	$640,000.00
11	Electric Work	$2,885,897.00	$1,885,897.00	$1,000,000.00
12	Irrigation Network (approximately 128 km)	$22,000,000.00	$6,015,625.00	$15,984,375.00
	Grand total	**$36,279,497.00**	**$14,464,788.67**	**$21,814,708.33**

OPERATION AND MAINTENANCE COSTS

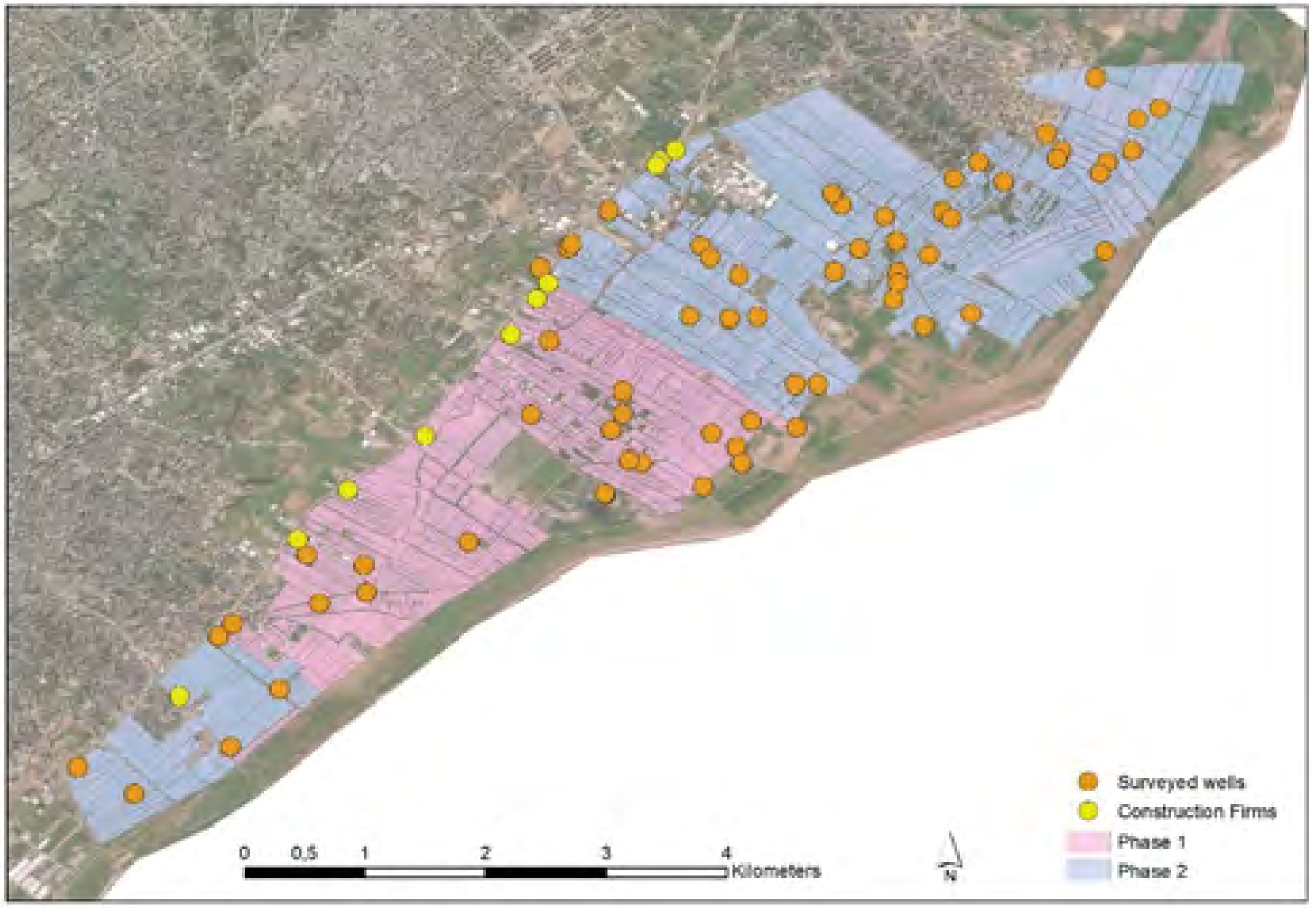
Operation and Maintenance Cost		Phase I	Phase II
Description	**Total [US$]**	**US$**	**US$**
Manpower	$150,000	$90,000	$60,000
Power Consumption	$2,014,711	$671,570	$1,343,141
Maintenance and Repair Work	$83,345	$27,782	$55,563
Consumables & Miscellaneous	$76,960	$25,653	$51,307
Total O&M cost USD/year	**$2,325,016**	**$815,005**	**$1,510,011**

TENDERING PHASES

ID	Phase	Package	Description	Cost [US$]
A	I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil work within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$8,449,163.67
B		2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)	$6,015,625.00
C	II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil work within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$5,830,333.33
D		2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)	$15,984,375.00
			TOTAL	$36,279,497.00

Baseline Survey and Assessment of Present Conditions

FIELD SURVEY

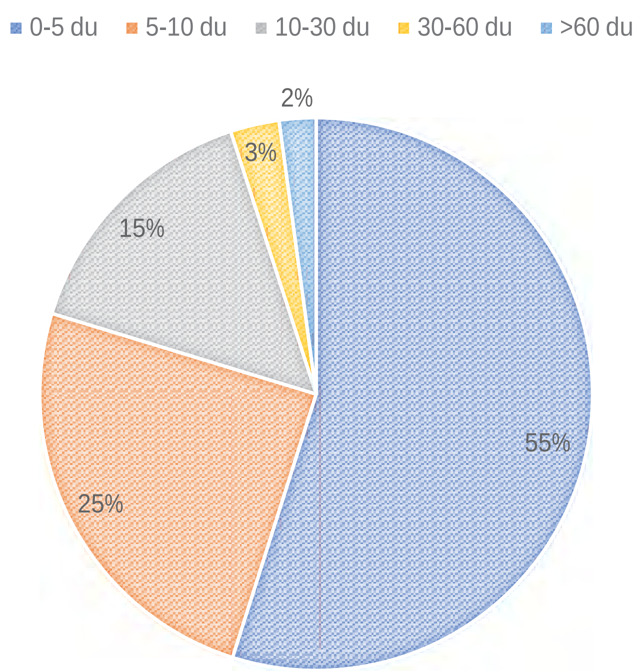


Methodology:
Field questionnaire and group interviews to farmers gathered around wells they use. Field visits and interviews were also performed at local markets and industries.

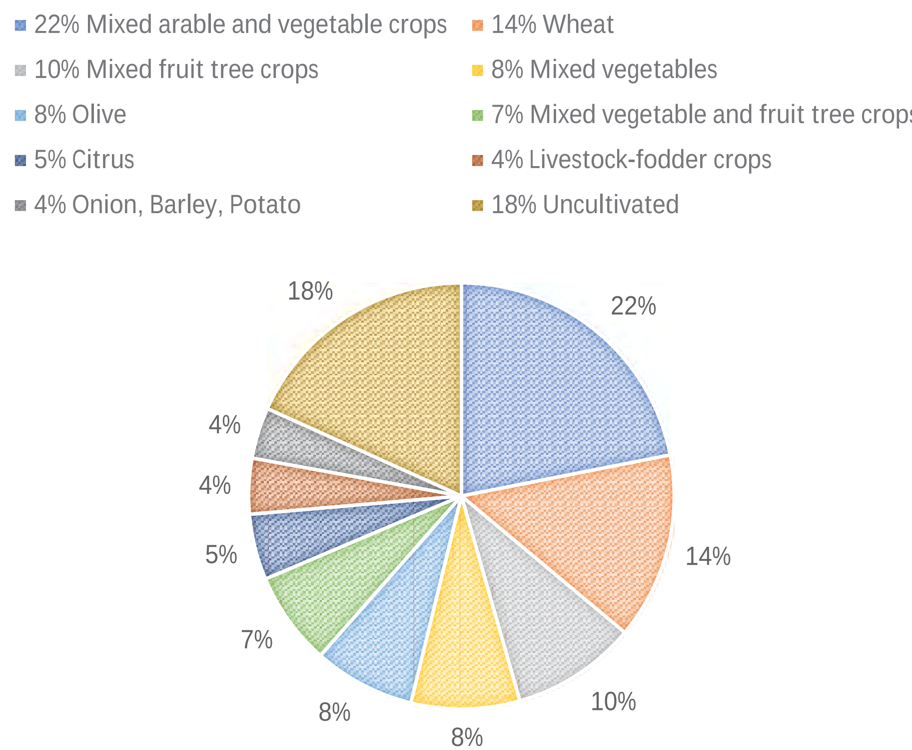
Date:
18th of February to the 28th of March 2017.

Results:
420 farms out of 650 were surveyed with the aid of 9 farm input questionnaires. 11 industries out of 14 were surveyed.

LAND TENURE AND CROPPING SYSTEM

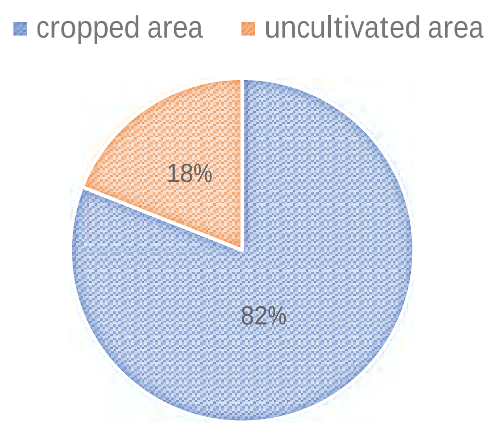


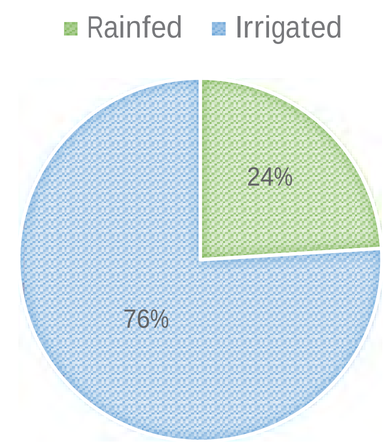
LAND TENURE



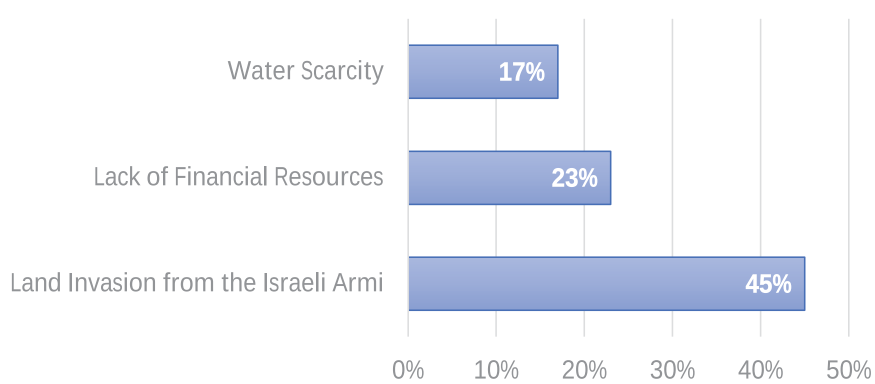
CROPPING SYSTEM

LAND TENURE

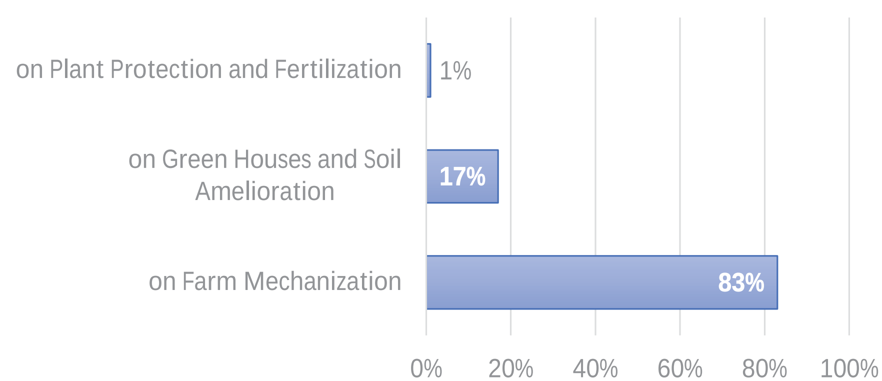




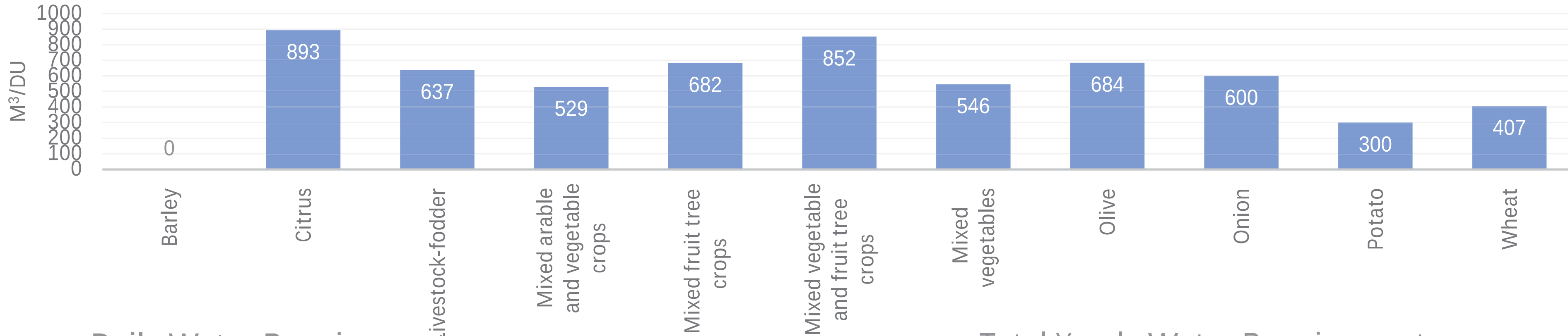
Main Reasons for Land Abandonment

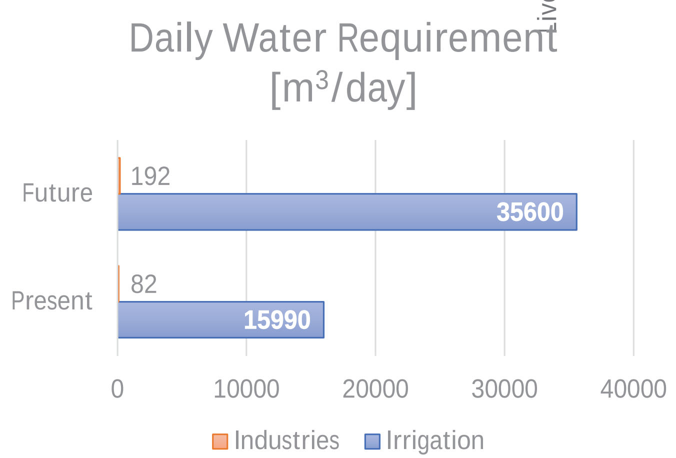


Needs for Technical Support and Training

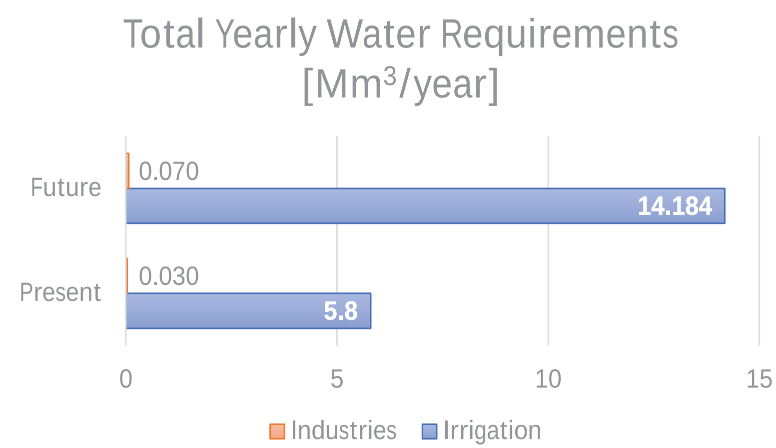


CROP WATER REQUIREMENTS AND WATER CONSUMPTION IN THE PROJECT AREA

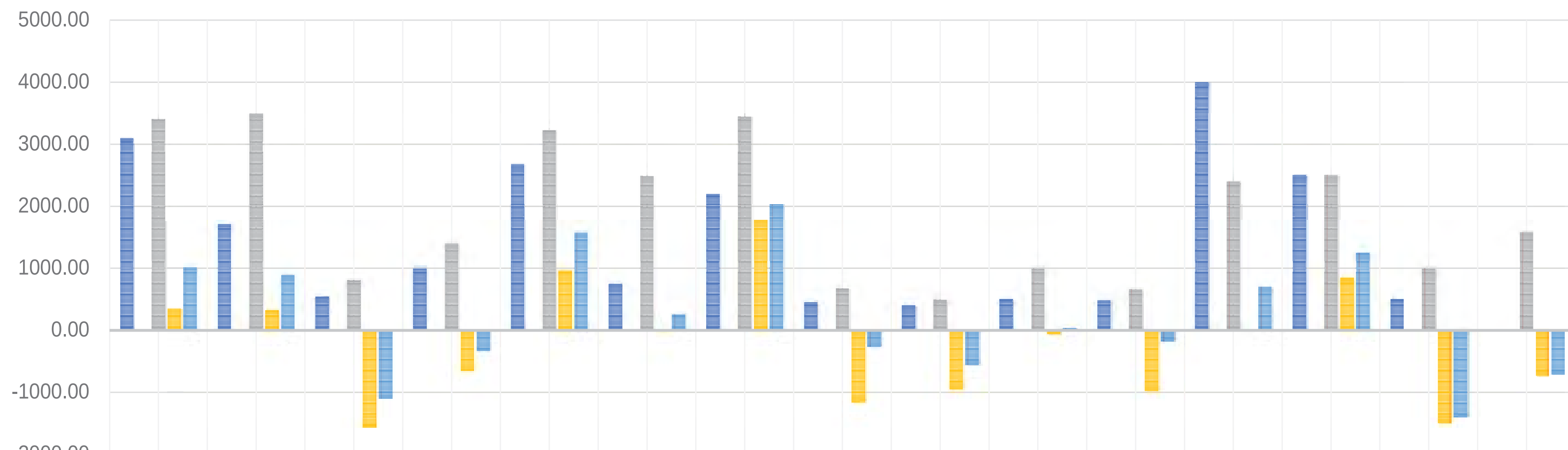




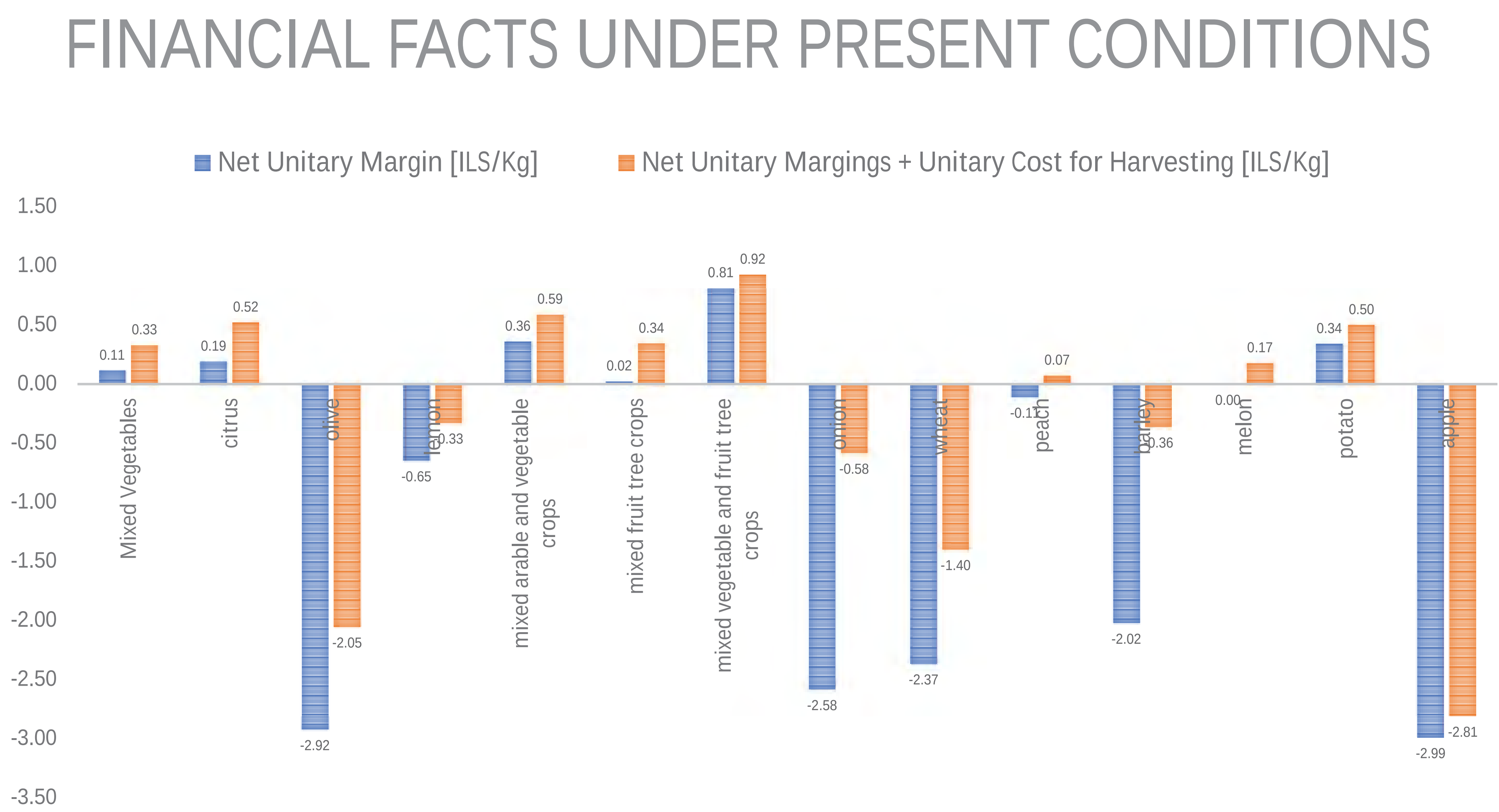
Cost for Extracting Water ranges between 1 and 1.5 ILS/m^3 for Irrigation and 0.4 to 4 ILS/m^3 for Industry



FINANCIAL FACTS UNDER PRESENT CONDITIONS



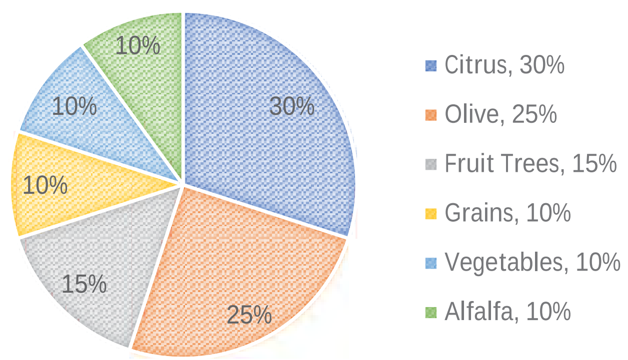
	Mixed Vegetables	citrus	olive	lemon	mixed arable and vegetable crops	mixed fruit tree crops	mixed vegetable and fruit tree crops	onion	wheat	peach	barley	melon	potato	apple	animal rearing - sheep
Quantity [kg/du]	3094.44	1709.43	537.43	1000.00	2677.41	746.48	2195.96	450.00	400.00	500.00	481.84	4000.00	2500.00	500.00	
Value [ILS/kg]	1.10	2.04	1.50	1.40	1.20	3.33	1.57	1.50	1.23	2.00	1.36	0.60	1.00	2.00	
Revenues [ILS]	3407.75	3494.34	806.15	1400.00	3226.02	2487.38	3444.70	675.00	492.00	1000.00	655.55	2400.00	2500.00	1000.00	1582.27
Net Margin [ILS]	346.61	321.55	-1570.73	-648.33	958.18	15.33	1776.76	-1162.70	-946.50	-55.00	-974.65	-1.50	844.00	-1495.00	-728.41
NM + LH [ILS]	1013.28	886.75	-1104.06	-328.33	1568.93	254.14	2029.26	-262.70	-559.83	35.00	-174.65	698.50	1244.00	-1405.00	-710.91


FINANCIAL FACTS UNDER PRESENT CONDITIONS
Net Unitary Margin [ILS/Kg]
Net Unitary Margings + Unitary Cost for Harvesting [ILS/Kg]
1.50
1.00
0.50
0.00
-0.50
-1.00
-1.50
-2.00
-2.50
-3.00
-3.50
Mixed Vegetables
0.11
0.33
citrus
0.19
0.52
olive
-2.92
-2.05
lemon
-0.65
-0.33
mixed arable and vegetable crops
0.36
0.59
mixed fruit tree crops
0.02
0.34
mixed vegetable and fruit tree crops
0.81
0.92
onion
-2.58
-0.58
wheat
-2.37
-1.40
peach
-0.11
0.07
barley
-2.02
-0.36
melon
0.00
0.17
potato
0.34
0.50
apple
-2.99
-2.81

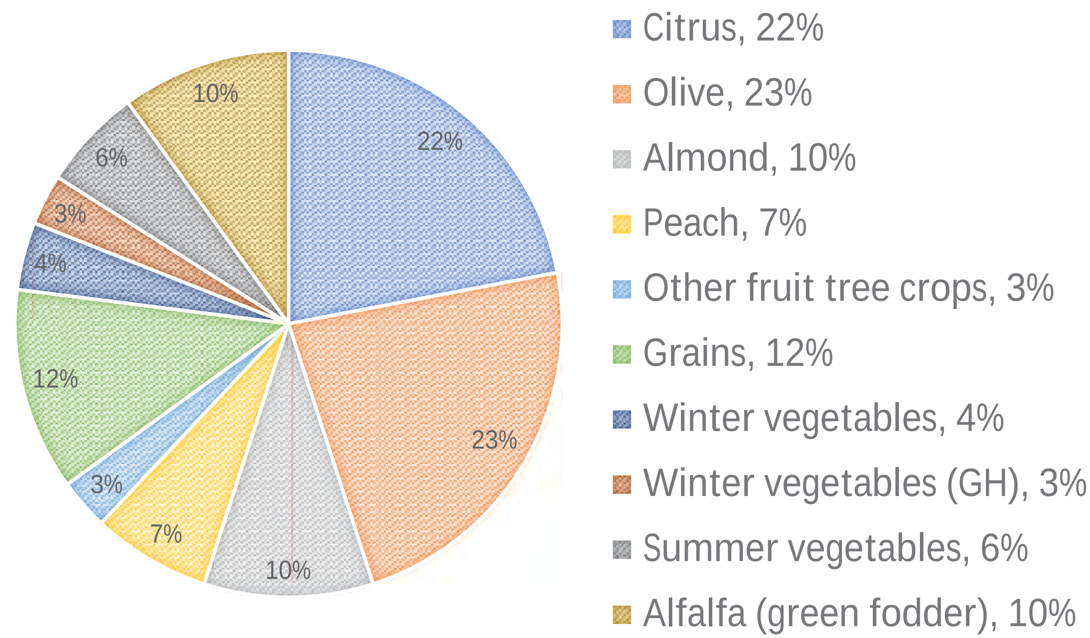
Assessment of the Recovery and Reuse (Irrigation) Schemes

PROPOSED CROPPING PATTERN (CP)

CROPPING PATTERN (2010 DESIGN)

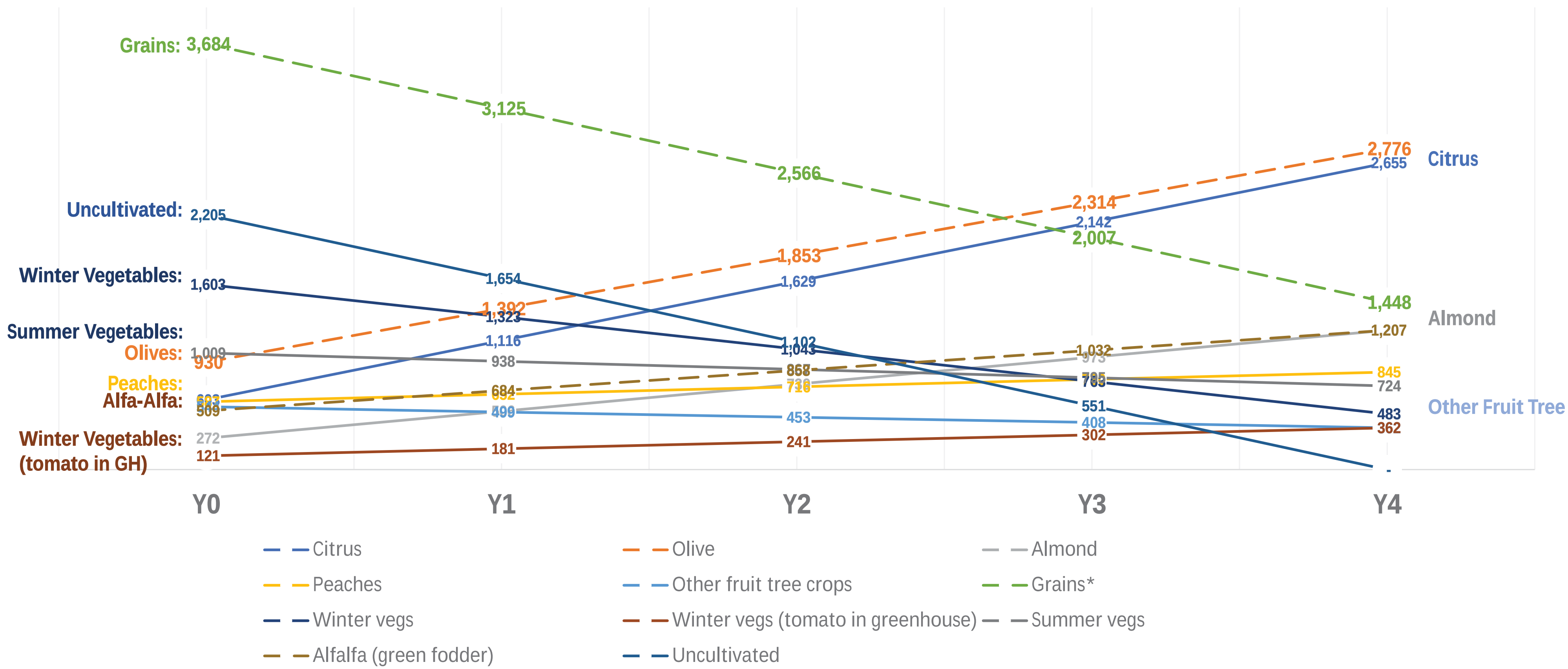


PROPOSED NEW CROPPING PATTERN



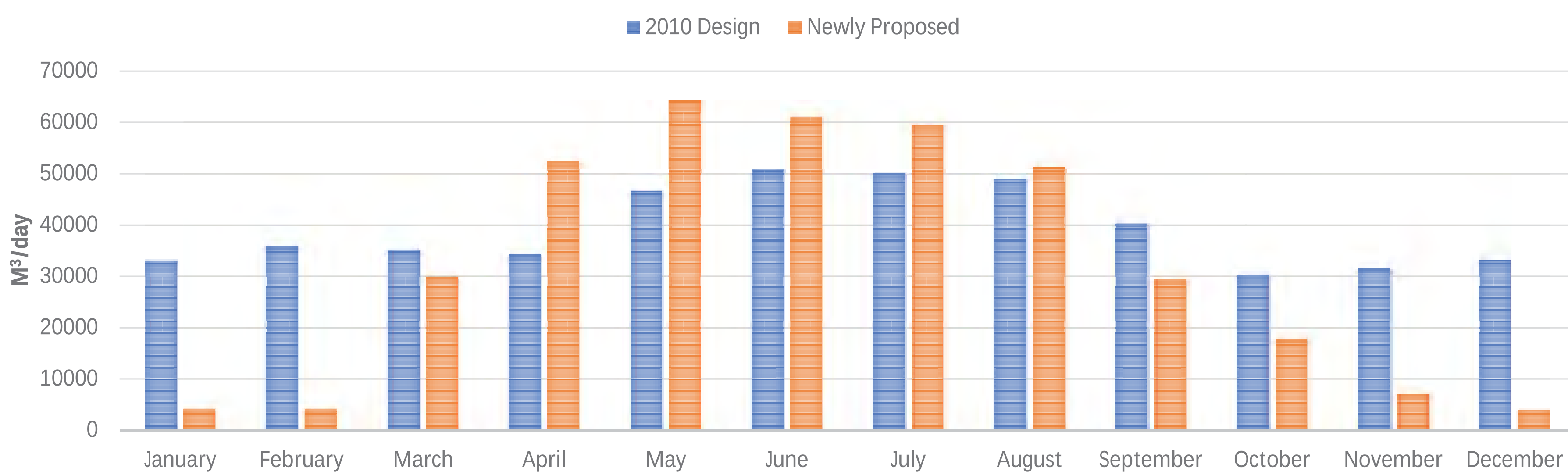
Note: the newly proposed Cropping Pattern (CP) has been approved by the MoAg and, according to the Baseline Survey, it is highly desirable from the farmers' point of view. The new CP gives more details and uniform distribution (across the project area) of winter and summer vegetables thus leading to a different distribution of the water requirements through the year.

DISTRIBUTION OF CROPS OVER LAND [DU] OVER TIME [YEARS]



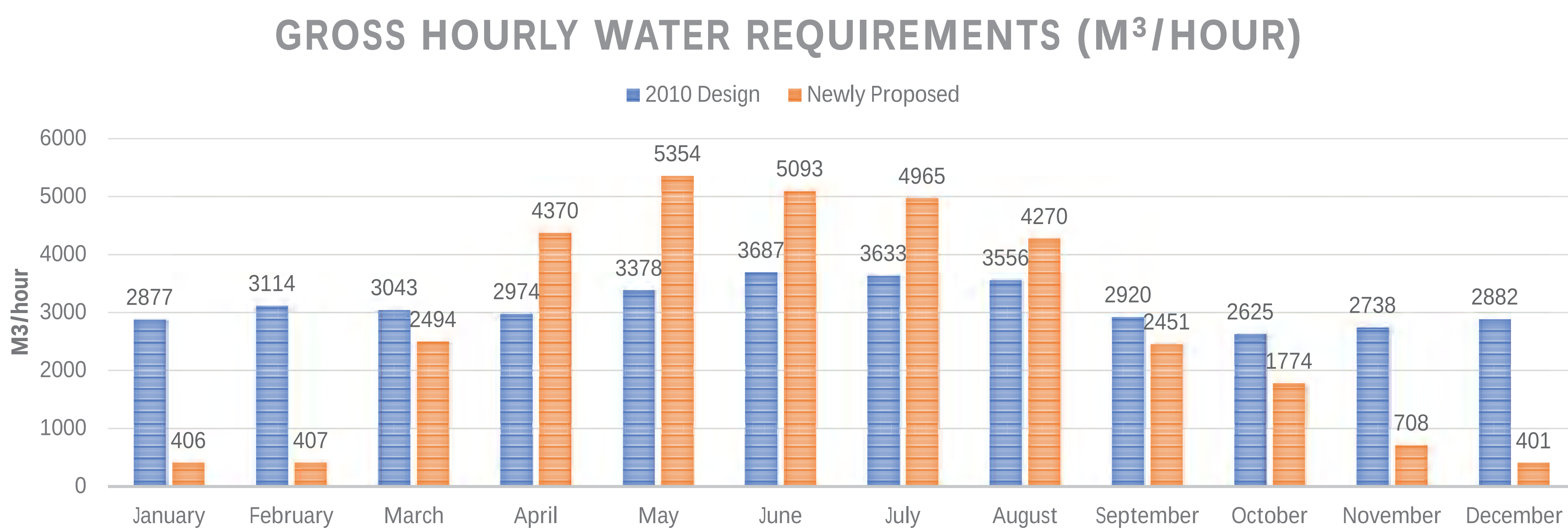
WATER REQUIREMENTS AND IRRIGATION SCHEDULING

GROSS DAILY WATER REQUIREMENTS [M^3/DAY]



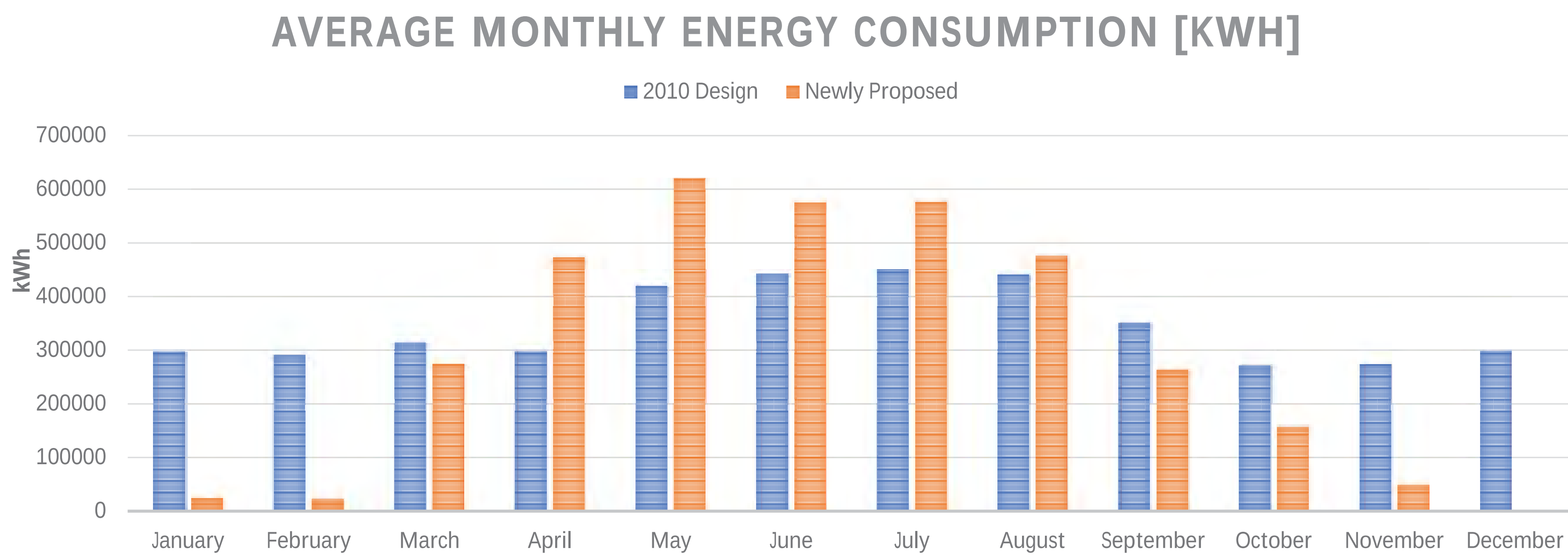
The chart compares the total water that needs to be extracted daily from the recovery wells under the newly proposed system and the original 2010 design. The total water extracted needs to account for water losses along the irrigation system, climate change, industrial needs and other water needs at farm level.

WATER REQUIREMENTS AND IRRIGATION SCHEDULING



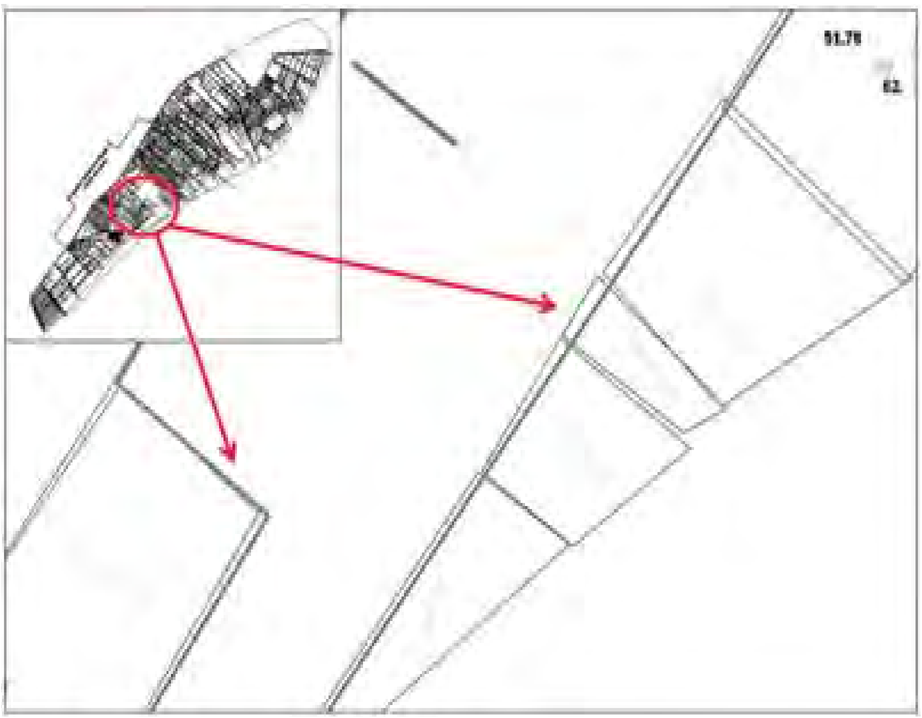
The newly proposed irrigation scheduling assumes that water is delivered at a constant rate during the day. Water is pumped for 12 hours/day during the months of March to September and 10 hours a day for the rest of the year.

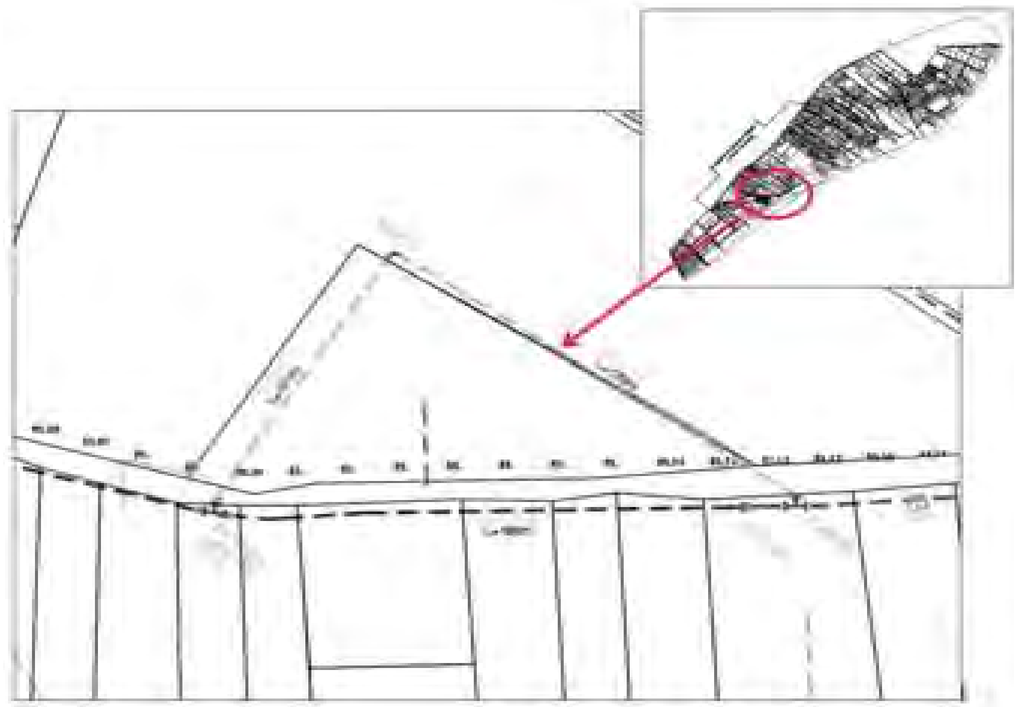
ENERGY REQUIREMENTS



Water is pumped into the system at a constant rate during the day. Less water is used overall during the year thus allowing for energy savings in the amount of 637 MWh.

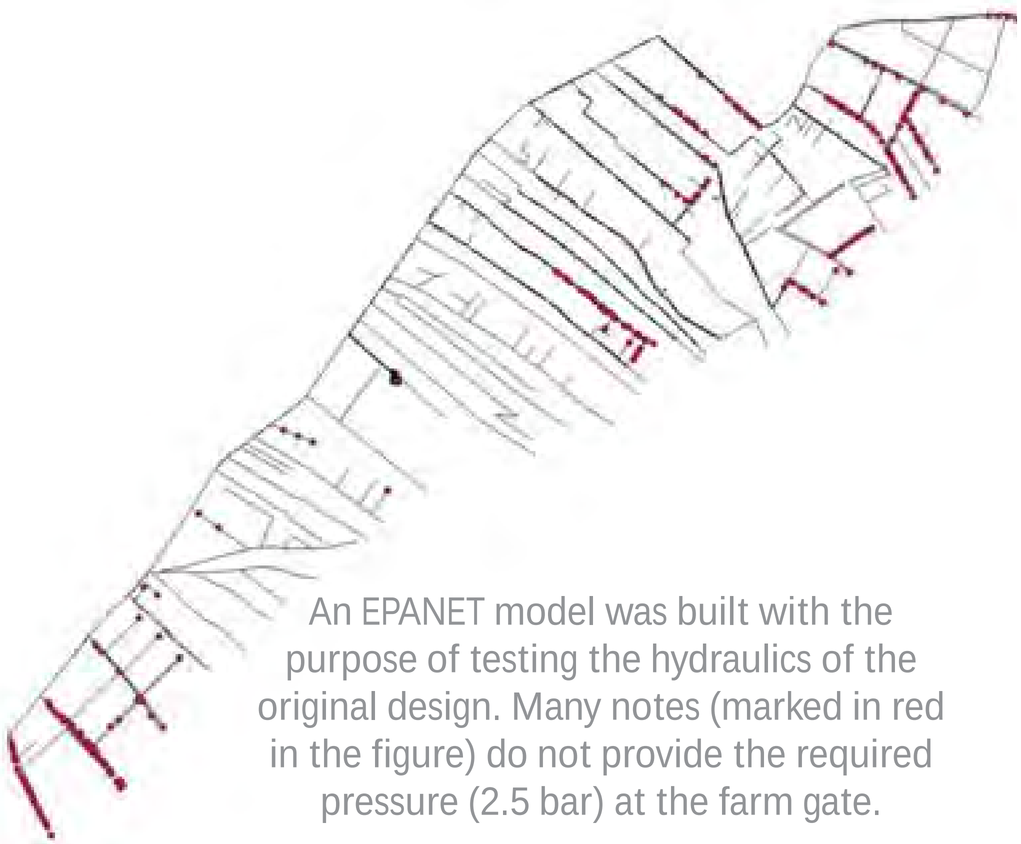
CONSISTENCY OF THE NETWORK DESIGN



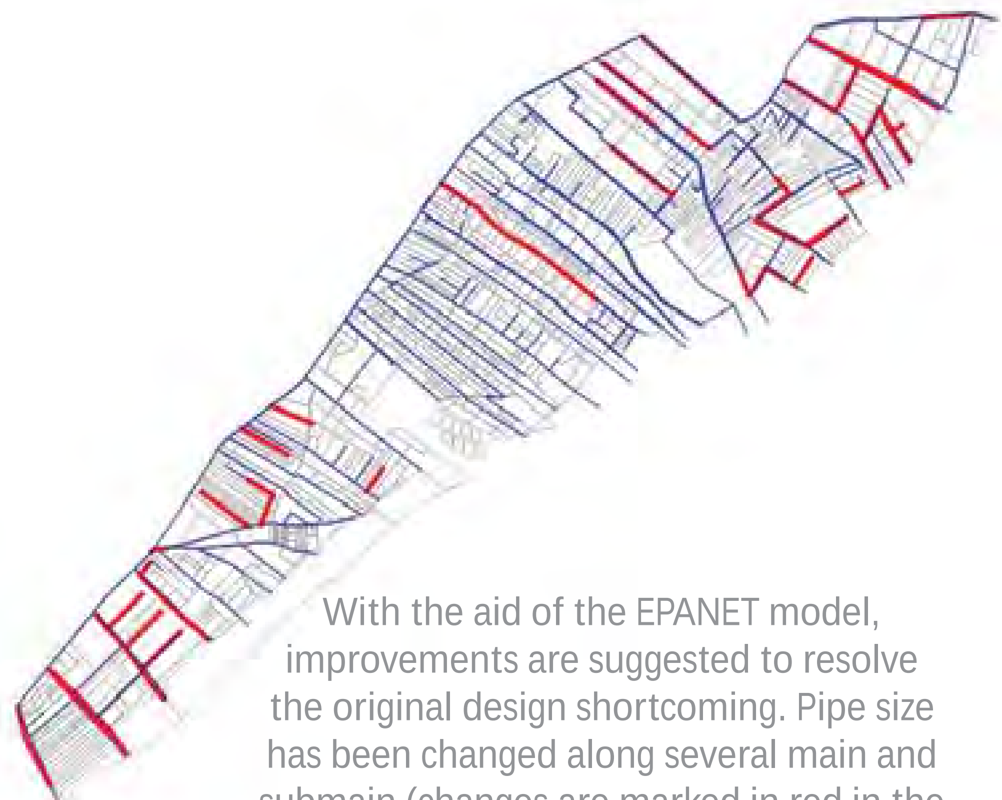


The original design is based on a low quality cadastral survey. Drawings are presented in various geographical projections making impossible to precisely overlay the proposed network with roads and property boundaries. Further to that, a number of main and submain alignments are introduced in the original design with no obvious technical justification.

NETWORK HYDRAULICS



An EPANET model was built with the purpose of testing the hydraulics of the original design. Many notes (marked in red in the figure) do not provide the required pressure (2.5 bar) at the farm gate.



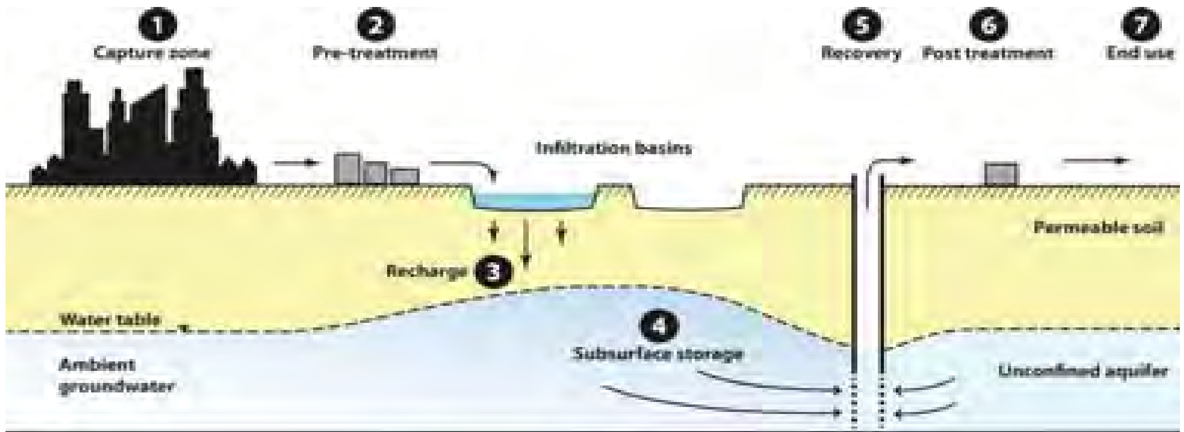
With the aid of the EPANET model, improvements are suggested to resolve the original design shortcoming. Pipe size has been changed along several main and submain (changes are marked in red in the figure above).

KEY FINDINGS AND RECOMMENDATIONS

1. The proposed changes could save nearly **3.2 Mm^3/year** (or 21.5% less water than what was required by the original 2010 design);
2. Less water requirements also leads to reduced energy needs for the recovery and reuse (irrigation) schemes. More precisely, the proposed changes will save **637 MWh**, a reduction in energy consumption of over 15%;
3. With the introduction of a new cropping pattern, water can be delivered via the originally designed water recovery and reuse (irrigation) schemes **on a constant rate** to the farms' gate for 12 hours per day (10 hr/day during the coldest months of the year);
4. The possibility to pump water into the system on a constant rate through the day **drastically reduces the complexity of managing the irrigation scheduling** and eliminates the risk of overdrawing water from the storage tanks and stalling the system;
5. Design drawings for the water reuse (irrigation) scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a **precise cadastral survey has been provided**;
6. The design of the network could be revised (thus leading to a **reduction on capital investments**) to account for the reduced flows that come with the newly proposed Cropping Pattern.

Draft Complementary Feasibility Study of the Irrigation Scheme

MANAGING AQUIFER RECHARGE (MAR)



- The NGEST Project is often mistaken for a treated-wastewater-for-irrigation project when, in reality, It is not.
- The NGEST Project is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation.
- The difference is significant and has considerable implications for the feasibility and sustainability of the project.
- Although guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse.

LEGISLATIVE CONSIDERATIONS

- The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater.
- The Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced.
- **The NGEST project does not entail using treated wastewater for irrigation** *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. **The recovered water, therefore, is no longer "treated wastewater,"** and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.
- The Palestinian Wastewater standards also cover the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A").
- The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.
- **The project**, therefore, is in **complete compliance with the Palestinian regulation.**

INSTITUTIONAL SET UP

The institutions most likely to be involved in the implementation and oversight of the NGEST irrigation system consist of the following:

- PWA and MoAg will cooperate to set up WUAs. Both PWA and MoAg will monitor the project's implementation.
- Irrigation Advisory Service (IAS) will manage the NGEST recovery and reuse schemes and be responsible for O&M of the network. WUAs will be part of the IAS so that they are fully involved with the project management. Until the IAS and WUAs are created, CMWU should operate and manage the network.
- EQA will monitor the work to ensure it does not cause environmental harm and will cooperate with PWA in setting any water quality/use standards.
- MoLG will coordinate with municipalities, the CMWU, the WUAs and other stakeholders in the water distribution system.
- MoH will monitor the work to ensure it does not cause harm to human health and will cooperate with PWA in setting any water quality/use standards.

CMWU	Coastal Management Water Utility	MoLG	Ministry of Local Government
EQA	Environmental Quality Agency	MoH	Ministry of Health
IAS	Irrigation Advisory Service	PWA	Palestinian Water Authority
MoAg	Ministry of Agriculture	WUA	Water Users Association

CAPACITY DEVELOPMENT ASSISTANCE

A capacity development system for the Water Sector already exists and a substantial amount of resources are being invested to enhance capacities in the water sector in Palestine. However, there needs to be a better coordination of capacity development initiatives with policies and strategies. This study provides specific recommendations on:

- Focus on Practical Skills
- Encourage on-going Capacity Development
- Help Prepare CMWU
- Sludge Management
- Managed Aquifer Recharge;
- Farmer Assistance;
- IAS;
- WUAs;
- and Operation and Maintenance of the Irrigation System

IRRIGATION ADVISORY SERVICE (IAS)

The creation of an IAS office is being recommended for the NGEST Project to serve as a platform for communication and cooperation between the various stakeholders of the project and to handle the O&M of the recovery and reuse systems. It should be composed of representatives from ministries directly involved with O&M of the system as well as WUAs.

The typical scope of IAS services includes:
- Crop water management and scheduling services;
- Irrigation performance analysis services;
- Advice on design, installation, of irrigation equipment;
- Irrigation management support services (from both administrative and technical perspective);
- Advice on environmental and, in particular, water quality aspects;
- Agricultural advisory services; and
- Training of farmers.

Two aspects, critical for the success of IAS, should be highlighted, these are:
- Providing a suitable legal framework and institutional setting for IAS functioning; and
- Ensuring IAS financial sustainability (paramount especially in developing countries where often insufficient or no resources are made available for such purpose).

FINANCIAL REQUIREMENTS

The Financial Requirements to support the WUAs are summarized as follows:

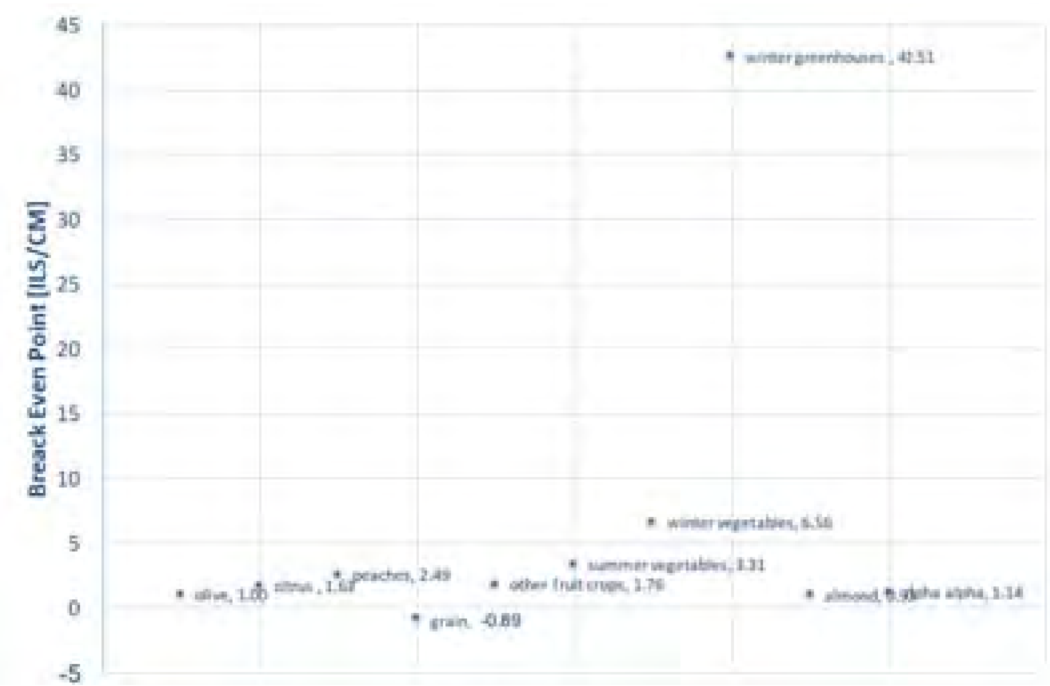
- Investment Costs: $50,000
- Recurring Costs: $50,000
- Capacity Building: $380,000

The Financial Requirements to support the IAS are summarized as follows:

- Investment Costs: $660,000
- Recurring Costs: Government Salaries (+30%) for 14 staff
- Capacity Building: $758,000

PROPOSED WATER TARIFF

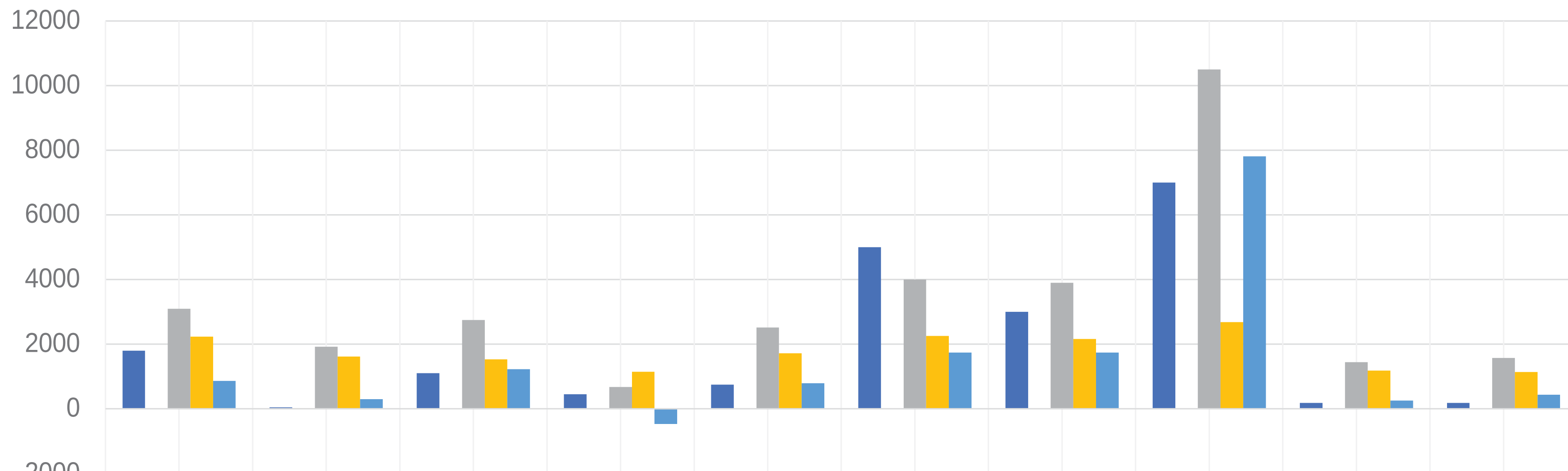
Annual Cost for O&M and WUAs/IAS [ILS/year]	Gross Water Requirements [m^3/year]	Net Irrigation Water Requirements [m^3/year]	Proposed Water Tariff [ILS/m^3]
4,956,799.9	11,110,000	7,833,484	0.63



Notes:

- Farmers today are paying from 1 and 1.5 ILS/m^3 to extract water from legal and illegal wells.
- The proposed water tariff is calculated assuming that farmers will be charged for the water delivered (and metered) at the farm gate. Water Tariff pays for O&M costs.
- The graph on the left shows the breakeven point for the water tariff for each type of crop.

CROP NET MARGINS UNDER FUTURE CONDITIONS



	Citrus	Olive	Peaches	Grains	Other fruit crops	Summer vegetables	Winter vegetables	winter tomato GH	Almond	alpha-alpha
Quantity [kg/du]	1800	45	1100	450	750	5000	3000	7000	180	180
Value [ILS/kg]	1.72	16	2.5	1.5	3.35	0.8	1.3	1.5	8	8
Revenues [ILS/du]	3096	1920	2750	675	2512.5	4000	3900	10500	1440	1575
Cost [ILS/du]	2233	1619	1528	1147	1719	2258	2158	2685	1184	1136
Net Margin [ILS/du]	863	301	1222	-472	794	1742	1742	7815	256	439

COST SHARING SCENARIOS

N	Description	Cost to be Born by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investment s for Farm's Developme nt	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Governament and not charged to the Farmers		x	x	x	Paid by the Governament and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Governament/Donors for a number of years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Governament until Farmers have paid back the Construction of Phase II	x	x	Paid by the Governament and not charged to Farmers	x
5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Governament until Farmers have paid back Cost (5).	Paid by the Governament and not charged to the Farmers		Subsidized by Donors/Governament until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)		x	Paid by the Government and not charged to Farmers	

FINANCIAL ANALYSIS - RESULTS

Scenario	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)	Note
	3%	5%	7%	3%	5%	7%		
1	30,551	2,574	-16,780	1.062	1.006	0.954	5.23%	
2	12,959	718	-7,908	1.064	1.004	0.947	5.14%	
3	149,706	114,653	88,791	1.304	1.274	1.244	31.02%	
4	127,456	88,722	60,582	1.259	1.212	1.167	16.07%	17 years of subsidies to repay the phase II investment.
5	155,425	119,953	93,715	1.316	1.286	1.258	33.54%	5 years of subsidies to repay the investment at farm level

ECONOMIC ANALYSIS - RESULTS

Scenario	Net Present Value (NPV) [ILS x 1,000]			Benefit Cost Ratio (BCR)			Internal Rate of Return (IRR)
	3%	5%	7%	3%	5%	7%	
1	124,102	82,112	52,243	1.252	1.196	1.144	13.72%
2	51,291	33,420	20,586	1.254	1.194	1.137	12.62%
3	132,443	89,958	59,633	1.511	1.482	1.454	15.17%
4	130,885	88,143	57,658	1.462	1.416	1.371	14.64%
5	132,843	90,329	59,978	1.523	1.496	1.469	15.24%

CONCLUSIONS

1. Palestinian law restricting the use of treated wastewater in irrigation does not apply to the NGEST water reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that is allowed to be infiltrated into the aquifer: the quality must be either moderate (“C”), good (“B”), or high (“A”). Utilizing poor (“D”) wastewater for aquifer recharge is prohibited.
2. An Irrigation Advisory Service (IAS) should be established to manage and operate the recovery and reuse schemes, as well as to provide a platform for inter-ministerial and local communal cooperation for the project and provide technical and other assistance to farmers.
3. Managing Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural resource. Monitoring is an integral part of MAR management and should be robustly undertaken to both determine the effectiveness of the recharge scheme and to investigate the sustainability with respect to human and environmental health.
4. If the proposed Cropping Pattern and Irrigation Methods are implemented, the construction of the water recovery and reuse (irrigation) scheme is feasible even if the entire investment (Phase I and Phase II) is paid by the farmers. Nevertheless, because developing a large investment in Gaza presents risks that are uncommon in other parts of the World, **Scenario 3,** where construction costs would be paid by the government and not charged back to the farmers, is presently being suggested.

State of Palestine
Palestinian Water Authority

دولة فلسطين
سلطة المياه
الفلسطينية

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 6

FINAL Complementary Feasibility Study

Final

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

July 2017

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Output 5 – Stakeholder Workshop Presentation

Output 6 – Final Complementary Feasibility Report

ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CAPEX	CAPital EXpenses
CMWU	Coastal Municipal Water Utility
CP	Cropping Pattern
EQA	Environment Quality Authority
FAO	Food and Agriculture Organization of the United Nations
MAR	Managed Aquifer Recharge
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGEST	North Gaza Emergency Sewage Treatment
NWC	National Water Company
OPEX	OPerational EXpenses
PIU	Project Implementation Unit
PWA	Palestinian Water Authority
ToR	Term of Reference
UAWC	Union of Agricultural Work Committees
WB	World Bank
WSRC	Water Sector Regulatory Council
WUA	Water User Association
WWTP	Waste Water Treatment Plant

RESULTS AND RECOMMENDATIONS

KEY RESULTS

- By improving the original design of the water reuse scheme, introducing modernized irrigation methods and a newly proposed cropping pattern, it is possible to save nearly 3.2 Million Cubic Meter of water per year (MCM/year) or 21.5% less water than what was required by the original 2010 design. Less water requirements also leads to reduced energy needs for the recovery of water from the aquifer. More precisely, the proposed changes will save 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation schedule that largely differs from the original by providing water to the entire irrigation project each day (instead of on a 6-day rotation with 12 lots irrigated 2 at a time once a week). Pumping water into the system on a constant rate drastically reduces the complexity of managing the irrigation scheduling and eliminates the risk of overdrawing water from the storage tanks and stalling the system.
- Palestinian law restricting the use of treated wastewater for irrigation does not apply to the NGEST reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that may be infiltrated into the aquifer: the quality must be either moderate ("C"), good ("B"), or high ("A"). Utilizing poor ("D") wastewater for aquifer recharge is prohibited.
- Three water tariffs options are suggested for covering the OPEX costs (including operating the WUA): farmers will be charged a flat rate of 0.9 or 1.2 or 1.461 ILS/m^3 for water delivered at the farm gate. The lowest rate is possible if all energy requirements are provided by the national grid; the highest fees are necessary to cover the costs in case 100% of electricity is produced by diesel generators. The median rate is possible if a 50/50 mix of energy production is achieved. Even if the operator of the system is charged the highest rate of 1.461 ILS/m^3, this would still be less than what farmers are paying, on average, today.

KEY ASSUMPTIONS

- The feasibility of the project is tested against the most conservative scenario of energy generation, with an assumption that 100% of electricity will be provided by diesel generators.
- The capital investment required for the construction of the irrigation network (and the O&M costs associated with a more complex and expensive network) is assumed to be much higher than previously estimated. The capital investments required for the construction of the irrigation network have seen a 75% increase from the original estimates made in 2010, when the network was designed. Some of this increase is justified by price changes in cost and material over the past 7 years but the largest increase is due to subsequent modifications of the original design which, this *Report* argues, could be streamlined for a better (and less expensive) design of the system.

KEY RECCOMENDATIONS

- The recommended Investment Scenario is for the capital investments (CAPEX) needed for the reuse and recovery scheme to be paid for by the government/donors and the operating costs (OPEX) to be paid for by the farmers. If the proposed cropping pattern and modern irrigation methods are implemented as suggested by this *Report*, this scenario is feasible and profitable for both phases of the project even if 100% of the energy required to operate the scheme is produced by diesel generators.
- The recommended Institutional Arrangement is for the operation of the irrigation system to be a combination of both governmental and non-governmental management. More specifically, the bulk water supplier (CMWU and then, when created, NWC) will own and operate the recovery and reuse infrastructure for the first 3 years. During that time, the WUA would receive intensive capacity building. After the first 3 years of the project, the WUA would assume operation and management of the recovery and reuse scheme, leasing the infrastructure from NWC. The WUA (the farmers) would pay for the OPEX from the start of the organization, as outlined in the Investment Scenario 3 above.
- Design drawings for the water reuse scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a precise cadastral and topographic survey have been provided.
- The design of the network should be revised to consider the reduced flows that come with the newly proposed Cropping Pattern. By revising the network design with updated cadastral and topographic data and streamlined flow requirements it is likely that the overall cost for constructing and maintaining the reuse system will be significantly reduced.
- Donors' engagement and government assistance to farmers is a critical component for the success of the project. Donors/Government must assist the WUA (and farmers) by providing intensive and continuous training and technical support. Such assistance program should last at least 3 years from the construction of the irrigation network. A provisional budget of $806,000 has been defined for training WUA.
- Managed Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural resource. Monitoring is an integral part of MAR management and should be robustly undertaken to determine the effectiveness of the recharge scheme, evaluate water quality and address clogging and other operational issues.

IMMEDIATE ACTIONS

After reviewing the project, this *Report* recommends the following **immediate actions**:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA;
- Contract UAWC to provide technical assistance to both the WUA staff and members;
- Hold the negotiations necessary to broker project agreements (*viz*., the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc);
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years;
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017;
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;
- Start the construction of Phase I of the reuse scheme by early 2018, and initiate the process for construction of Phase II by early 2019.

PROJECT BACKGROUND AND RATIONALE

PROJECT BACKGROUND

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

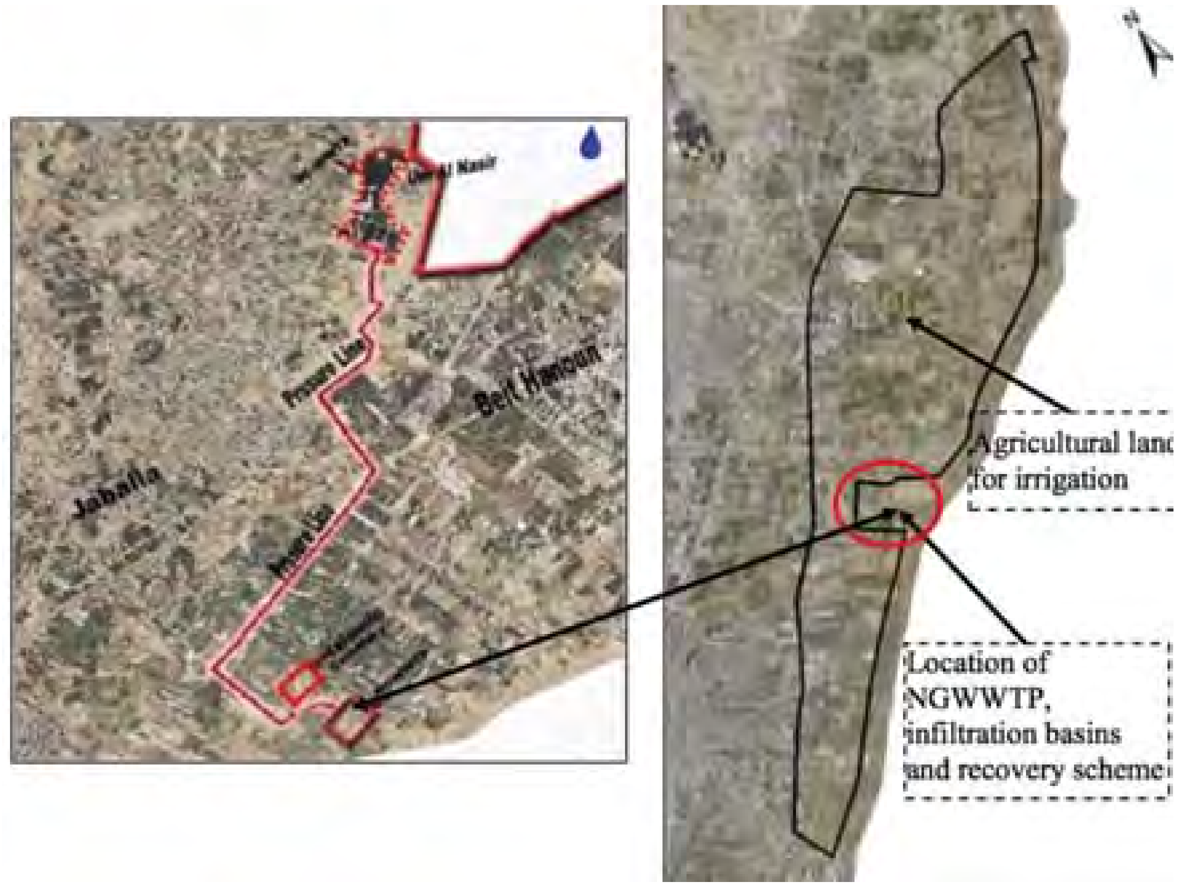


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

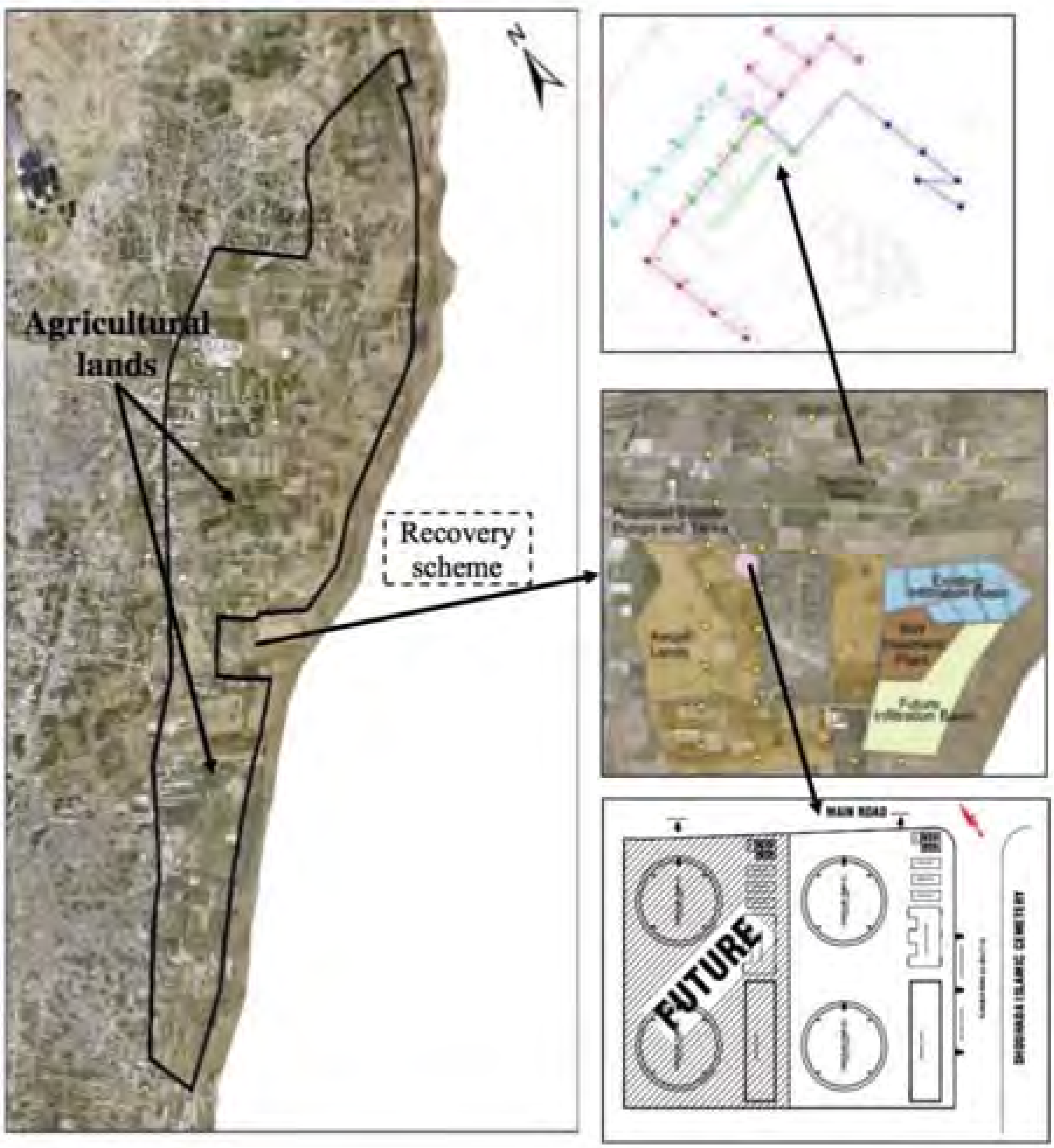


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, **supplementary phase** was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The treated sewage effluent will be disposed of into infiltration ponds, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 28 recovery wells, put into two storage reservoirs, and distributed throughout the network for irrigated agriculture.

THE PRESENT STUDY

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare this Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and making the project feasible. To carry out its task, this project has drawn upon data collection, field visits, and state-of-the-art computer modeling in order to best understand the irrigation project's hydraulics and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

COUNTRY AND SECTOR ISSUE AND POLICY

The activities of the NGEST project are in line with the policies and objectives of the National Water Policy (2012 – 2023), the Strategy for the Water and Wastewater Sector (2011-2013), the Draft Water Resources Management Strategy (1997), the National Water Policy (1995), Water Sector Strategy Planning Study (WSSPS, 2000), Water National Plan (NWP) 2000 and Coastal Aquifer Management Plan (CAMP) 1999-2004.

More specifically, this project puts into practice numerous water sector policy principles and statements, as set out in the National Water and Wastewater Strategy for Palestine, 2013, including:

Sustainable management of water resources:

- Water supply must be based on the sustainable development of all water resources (conventional and non-conventional, shared and endogenous).
- Develop additional quantities of water from non-conventional water resources without infringing upon Palestinian Water Rights.
- Recognize water users' associations (including farmers' associations) as formal entities entitled to negotiate and manage shared national water rights on behalf of their members.

Integrated water resources management:

- Agricultural, industrial, and other development and investments must be aligned to the water resource quantity available or to be developed.

Good Governance and Management:

- The responsibilities for water resources governance, being a regulatory function, and water services management, being an operational function, should be separated institutionally.
- Encourage the involvement of formal water users' associations to ensure optimal management of shared water resources (including wells, springs and treated wastewater) used for economic purposes (irrigation, industry, tourism).

Sustainable wastewater management:

- Treated wastewater effluent is considered a water resource and is added to the water balance.

Financial sustainability of water and wastewater utilities:

- Ensure that the abstraction, transmission and distribution of water, together with wastewater collection and treatment, is financially sustainable and that providers of these services can demonstrate their financial reliability as regards to the full recovery of operation, maintenance, capital investment and capital replacement costs.

Protecting the environment from pollution by wastewater:

- Treat all produced wastewater to a quality suitable for safe and productive reuse, in line with national standards, and support the distribution and productive reuse of treated wastewater.
- Priority shall be given to agricultural reuse of treated effluent. Blending of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.

PROJECT CHALLENGES

As described in the NGEST Assessment of Wastewater Treatment and Reuse Practices Report from 2011, there are several challenges and potential constraints to this project. A few of these challenges are outlined below.

Water Reuse Vision

An integrated vision for wastewater reuse issues in Palestine is still missing, which should include awareness-raising, targeted marketing, and a unified tariff. Greater effort should be devoted in producing good quality treated wastewater to be used for various purposes. Most of the treated wastewater (TWW) pilot projects have failed from the beginning, or only partially satisfied its objectives, mainly because:

- Some NGO's provide farmers of TWW with emergency subsidies, without a comprehensive system of follow up or sustainability.
- The absence of wastewater user associations to integrate and complete the role of donors and NGO's.
- The municipality was unable to operate the scheme because of lack of funds and lack of trained staff.
- The idea of reuse was not readily accepted by the farmers who had no incentive to use reclaimed wastewater.
- Some farmers could abstract fresh water from private wells at lower costs than the reclaimed wastewater.
- The effluent quality did not meet the standard required for reuse.

Political & Institutional Constraints

In Palestine, wastewater reuse projects face various political obstacles, in addition to financial, social, institutional, and technical ones. Although the reuse of reclaimed wastewater in Palestine is a priority confirmed in the Palestinian water policy and adopted in the strategies of the relevant institutions, the experience and promotion of water reuse is still in the early stages. The lack of coordination among stakeholders especially between governmental bodies and NGOs and the limited accessibility to data, information, and reports are hindering the scientific evaluation and the monitoring of implemented projects.

The installation of effective treatment systems to provide effluent that complies with water standards is a prerequisite for the success of this project. It is frequently the case that sewage treatment plants in Arab countries do not operate satisfactorily and, in most cases, treated wastewater discharges exceed the legal and/or hygienically acceptable maximum. This is usually due to interrupted power supply, poor infrastructure and the lack of adequately trained staff with the technical skills to operate these plants, as well as the lack of an adequate budget for plant maintenance and operation.

Farmer Adherence

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

Training

A lack of technical knowledge and skills can cause failure in project implementation and, in the case of TWW MAR projects, can potentially increase environmental and public health risks. Training programs should be an integral part of the project, and it should include technical, environmental, health and socio-economic aspects. The educational input must provide farmers with an understanding of the details of techniques and their associated hazards and precautions. Capacity building in these areas are discussed in each of the relevant sections of this *Report*.

RATIONALE FOR DONOR INVOLVEMENT

Gaza faces a severe water crisis. Gaza relies almost completely on a coastal aquifer as the sole source of freshwater. However, 95% of the aquifer's water is not safe for drinking without treatment (PWA, 2014). Years of over-abstraction have taken a heavy toll on Gaza's present and future water resources. Annual abstraction of water from the aquifer has been well above the recharge rate by over 100 million cubic meters, almost twice the sustainable rate. Consequently, groundwater levels have declined, seawater from the Mediterranean has infiltrated and salinity levels have increased, making the water unsafe for drinking according to WHO standards (World Bank, 2009).

The over-abstraction and scarcity of drinking water have been exacerbated by crumbling sanitation infrastructure, while the Israeli blockade creates chronic shortages of electricity and fuel, which in turn aggravate contamination and the water crisis. The damage of contamination and over-abstraction is such that the aquifer may become unusable and, if unaddressed, the UN has stated the damage may be "irreversible" by 2020 (UNRWA, 2015a).

As early as 2009, the United Nations Environment Programme (UNEP) emphasized that prolonged over-abstraction and pollution jeopardized the sustainability of Gaza's aquifer unless it was rested (UNEP, 2009). The best suggested solution was to cease abstraction and install a monitoring system to continuously assess recovery. Once the aquifer recovers, sustainable abstraction may be resumed at carefully calculated levels. In the meantime, alternative solutions to the water crisis should be introduced, such as desalination, reduction of the loss of water in the distribution network, and wastewater treatment. Presently the application of wastewater treatment is limited because of the high cost and technological complexity of conventional systems.

In 2014, the Gaza Strip endured the third conflict of full-scale military operations in six years, coming on top of eight years of economic blockade. Reconstruction efforts have been extremely slow relative to the magnitude of devastation, and Gaza's local economy has not had a chance to recover. Socioeconomic conditions are at their lowest point since 1967 (UNCTD, 2015).

Large scale investment in water, electricity and sanitation infrastructure was needed even before the damage inflicted by the military operation in 2014. The operation resulted in severe damage to Gaza's water and sanitation infrastructure, including water wells and networks, tanks, desalination units, wastewater networks and pump stations. The preliminary static value of the damage is estimated by the Palestinian Water Authority at more than $34 million. However, long-term repair of the accumulated damage and decay of the water and sanitation infrastructure will require $620 million (UNCTD, 2015).

If the Gaza Strip is to overcome its uniquely disadvantaged situation, it will need help. Although the international community has failed to prevent these crises in Gaza from taking place, it can still play a role in its reconstruction and survival. Besides the rather stark moral imperative, as this *Report* has shown, the project has the potential to be sustainable and even profitable, arguably making the investment worth the risk on multiple levels.

LESSONS LEARNED FROM SIMILAR PROJECTS IN THE REGION

As stressed elsewhere in this *Report*, the NGEST project is not a treated wastewater for irrigation project. Rather, it is a treated wastewater for managed aquifer recharge project (TWW MAR). This section briefly looks at some of the experiences with MAR and TWW MAR in the region.

MAR in the Middle East and North Africa

Given the water scarcity in many Middle East North African (MENA) countries and the water saving capabilities of MAR, several countries have at least experimented with the technology. Although MAR is conducted in many countries in the region, monitoring is often lacking or information is not published. As a result, the success of many of these schemes cannot be evaluated (Steinel, 2012). Below are brief descriptions of relevant projects.

Israel

Israel has been practicing wastewater treatment and reuse since the ‘50s, including through groundwater recharge (Soil Aquifer Treatment – SAT). The country has a 75% water reuse rate, which is much higher than most other countries [e.g. Spain 12%; Australia 9%] (Mekorot, 2013). Artificial groundwater recharge serves a number of purposes in Israel, such as increasing water reserves for periods of high demand (primarily for irrigation), reducing hydrological deficits, preventing saline intrusion from peripheral areas and ensuring efficient utilization of surplus water from Lake Kinneret (i.e. Lake Tiberias) (DWAF, 2007).

Comprehensive water quality monitoring is normally carried out throughout all stages of the recharge process. However, besides known problems related to clogging of recharge boreholes due to silt build-up and algae in the source water, health concerns have been raised lately, as endocrine disruptors, antibiotics and trace metals have been found in recycled water. In order to protect human health and groundwater quality, some experts are now calling for treatment to drinking water quality standards through desalination of treated sewage effluent by reverse osmosis (Tal, 2013).

The largest SAT facility in Israel is the Dan Region Wastewater Treatment Plant (Shafdan), where sewage water from the Tel Aviv region is treated. Wastewater treatment comprises four stages: pre-treatment, primary, secondary and tertiary treatment. Treatment methods include oxidation ponds, activated sludge and Mechanical Bio-Reactor (MBR). The Shafdan effluents are discharged into the soil for tertiary treatment and to recharge the aquifer. Water is then recovered and transported to the Negev for irrigation. The total effluent supplied for agricultural purposes is 216 million cubic meters per year (Mekorot, 2013).

Jordan

Jordanian law basically prohibits intentional recharge with reclaimed wastewater, as virtually all aquifers are also used for drinking water purposes. Yet as unintentional recharge of treated and untreated wastewater is taking place already through irrigational return flows and leaking sewage pipes, the standard is currently under review. The new standard is likely to loosen the restrictions to allow recharge of tertiary treated wastewater with near drinking water quality to all aquifers.

Jordan has one large recharge dam, Wala dam, where surface runoff is infiltrated via the side walls to recharge production wells downstream. Recently, sedimentation has decreased storage volume and infiltration rates considerably as no sedimentation dams are installed upstream, necessitating the use of recharge wells.

Documentation on recharge volumes, water quality, clogging problems, and resulting increase in groundwater table is not available.

The expenses for MAR dam construction in Jordan are commonly covered by international donors, while the maintenance has to be summoned up by the governmental budget. Hence, the government sees it as cheaper to build a new dam rather than maintain existing ones, which is a significant flaw in the system. An important lesson learned from Jordan is that international donors should ensure that part of the budget is set aside for long-term maintenance during finance negotiations.

Iran

Iran practices aquifer recharge via a cascade of basins including settling basins or floodwater spreading systems (Hashemi et al., 2012). Removal of accumulated sediments is vital for maintaining infiltration rates in the infiltration basins (Mousavi and Rezai, 1999). In the flood spreading systems the accumulation of sediments is used as improvement to the soil for agriculture.

Oman

Oman has 15 recharge release dams that capture runoff from the mountains in the plain with high sediment loads (5 - 6 % of runoff volume) and infiltrate runoff downstream to prevent seawater intrusion and for irrigational reuse. Socio-political reasons and a lack of regulations are the main limiting factors and the recharge scheme does not generate economic benefits for irrigational reuse (Prathapar, 2012).

Saudi Arabia

Saudi Arabia has constructed a number of recharge dams, which are experiencing clogging problems. Sediment removal or release to downstream infiltration basins or the downstream wadi channel need to be undertaken (Al-Muttair et al., 1994). There are investigations to use treated wastewater in fully engineered artificial recharge and recovery systems in alluvial wadi aquifers (Missimer et al., 2012).

Tunisia

Tunisia recharges surface water for agricultural and domestic purposes after retention in small earth dams via basins and recharge wells. In upland areas, the reservoir area with collected sediments is often used for farming and further retained water is hence used for irrigation and not for recharge. Profitability of the schemes is relevantly low (Ouessar et al., 2004). The release of captured flood water for downstream percolation in the wadi is also practiced (Ketata et al., 2011) and simulations showed much higher recharge rates especially when first flush release for silt removal was undertaken (Zammouri and Feki, 2005). In coastal regions seawater intrusions are controlled by recharge of reservoir water via wells (Bouri and Dhia, 2010). The infiltration of treated wastewater has also been investigated in coastal regions (Kallali et al., 2007).

Conclusion

MAR can only be successful if proper management plans and funding are in place and implemented. As seen in the region and around the world, clogging is a major issue, which can only be addressed with monitoring and proper maintenance. As seen in Jordan, international donors should be cautious in only funding the construction – and not also the maintenance – of MAR schemes. Lastly, water quality testing must evaluate not only regular parameters but also other emerging pollutants such as endocrine disruptors, antibiotics and trace metals, as shown in Israel’s experience.

PROJECT DETAILED DESCRIPTION

OVERALL DEVELOPMENT OBJECTIVE AND SPECIFIC OBJECTIVES

The overall project objective is to more sustainably utilize water resources in the Gaza Strip by seeking out alternative water sources for irrigation. Specifically, utilizing treated wastewater for managed aquifer recharge, which will then be recovered for irrigated agriculture throughout the Strip.

When completed the project will have:

- A WWTP capable of handling 35,600 m^3 of waste each day;
- Remediation of the Beit Lahia effluent lake;
- Nine infiltration basin
- 28 recovery wells and a network of 15 monitoring wells;
- 15,000 dunums of irrigated agricultural land.

More specific objectives related to the implementation of the Supplementary Phase of the project include:

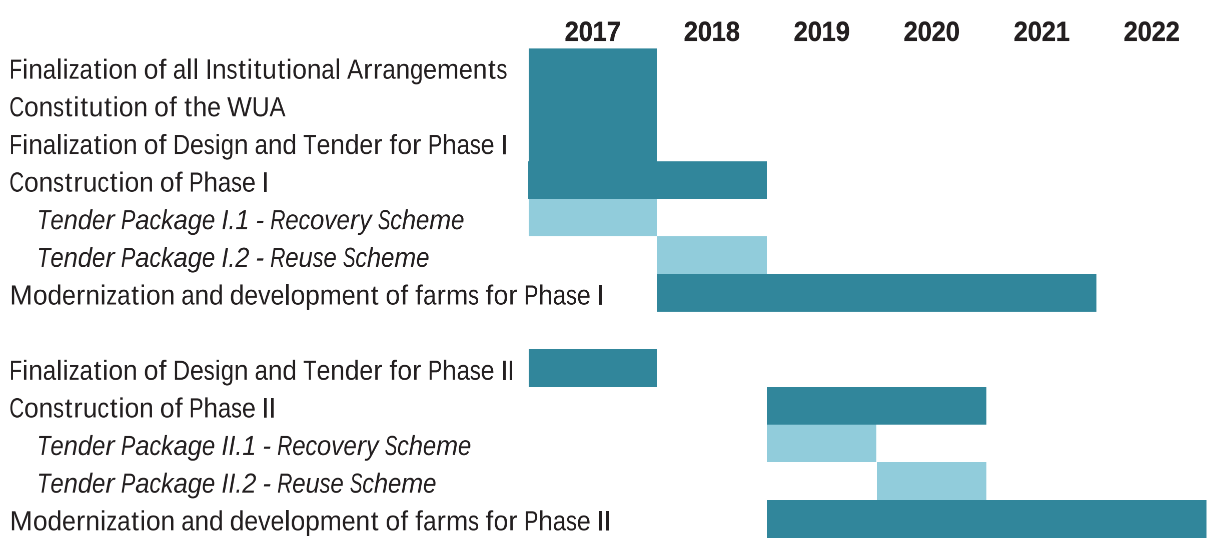
- Develop an irrigation project that assists local farmers to improve profitability and increase the value chain linked to agriculture;
- Test and promote MAR in Palestine;
- Improving groundwater health through introduction of higher quality water, and achieving more sustainable extraction practices;
- Promote the role of WUAs in managing and operating larger irrigation projects.

PROJECT COMPONENTS

LOGICAL FRAMEWORK

The logical framework and timetable for implementation is provided in the following Gantt chart. A detailed description of the various activities is provided in the following section.

Table 1: Project's Logical Framework



DETAILED ACTIVITIES

A gross agricultural area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit from the recovered water as well as the treated sewage sludge. This project component, known as the 'Supplementary Project', is divided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary component has been subdivided into three phases:

The **First Phase,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 14 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells – and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume from reaching agricultural and municipal wells located beyond the recovery wells.

The **Second Phase,** now scheduled for completion by the year 2020, would extend the recovery system by a second row of 14 supplementary wells (along with the previous 14 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated wastewater infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank, booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **Third Phase**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

Phase I and Phase II shall be implemented via four separate tendering procedures: two related to Phase I and two related to Phase II. The following table provides a summary of the various tendering packages and proposed implementation schedule.

Phase	Package	Description	2017	2018	2019	2020
I	1	Supply and install 14 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	X			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		X		
II	1	Supply and install 14 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells			X	

	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)				X

Construction of the various component of the recovery and reuse schemes for both phases represent only one side of the overall project. Additional, critically needed, activities are defined as follows:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA. This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Contract UAWC to provide technical assistance to both the WUA staff and members. Also this activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017 so that training can be activated in conjunction to the development of the first phase of the reuse scheme. Training activities would then be intensified during the first year and carried on for a period of three years.
- Hold the negotiations necessary to broker project agreements (*viz*., the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc). This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017. Such activities must be implemented before tendering procedures for Phase I of the reuse scheme are initiated. Updating the design and tendering documents for both Phases of the project (for the reuse part only) will require the acquisition of more detailed topographic survey and a precise cadastral survey. Considering the small scale of these tasks, it is likely that the entire process of acquiring additional field data and updating the design and tendering document can be completed before the end of the year 2017.
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years. The necessary procedures for the creation of such fund and identification of suitable financial tools to support farmers should be started during the present year 2017 and best completed before the completion of the first stage of the reuse scheme in 2018.
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;

ADDITIONAL TECHNICAL ASSISTANCE PACKAGES

The following Technical Assistance Packages are proposed:

1. Update topographic and cadastral survey of the project area;
2. Update detailed design and tendering documentation for Phase I and Phase II
3. Assistance for finalization of MoUs and Agreements and creation of the WUA;

A short description of each Technical Assistance (TA) Packages is provided below.

UPDATE TOPOGRAPHIC AND CADASTRAL SURVEY OF THE PROJECT AREA

Objectives: Update the existing topographic survey by expanding the survey area, collect additional survey points and provide a precise cadastral survey of the project area.

Level of Effort: 4 months/man to be divided between 1 senior topographer and supporting staff.

Deliverables: Revised topographic map and cadastral map

Tentative Budget: EUR 35,000

Proposed Timetable: The proposed program shall be implemented between the months of October and November 2017.

UPDATE DETAILED DESIGN AND TENDERING DOCUMENTATION FOR PHASE I AND PHASE II

Objectives: Prepare updated detail design and tendering document for both Phase I and Phase II of the project for the reuse scheme only.

Level of Effort: 4 months/man to be divided between 1 senior irrigation engineer, 1 junior irrigation engineer with the assistance of mechanical and electrical engineers

Deliverables: Revised detailed design for both Phase I and Phase II in addition to General and Detail Specifications and Tendering Documents. The update design shall be provided only for the irrigation (reuse) scheme as the existing design for the recovery scheme does not need modificaitons.

Tentative Budget: EUR 35,000

Proposed Timetable: The proposed program shall be implemented between the months of November and December 2017, and can be implemented only after updated topography and cadastral survey has been completed.

GOVERNAMENT ASSISTANCE PROGRAMS

Objectives: Assist parties in negotiating the necessary agreements for project implementation.

Level of Effort: 2 months/man of a senior legal advisor/mediator + local support staff

Deliverables: MoU[1] between CMWU and NWC (for CMWU to initially manage the system); a Contract between CMWU and the WUA (for CMWU to initially operate the system); a Water Supply Agreement between CMWU and the WUA (for bulk water supply); a Contract between the WUA and UAWC (for capacity building of the WUA); Lease agreement between whoever owns the system and whomever is going to operate it and collect fees (depending on the Scenario chosen).

Tentative Budget: EUR 25,000

Proposed Timetable: The proposed program shall be implemented between the months of October and November 2017.

[1] Because NWC and CMWU are both governmental entities, it is arguably more appropriate to have an MOU than a contract but this is open for discussion.

PROJECT APPRAISAL

BASELINE CONDITIONS

FIELD SURVEY

The foundation of this baseline assessment and a primary tool for collecting first-hand current data, the field survey aimed to **investigate the characteristics of the farming system** in the project area. A questionnaire was developed and tested in coordination with PWA. The questions were focused on the farm cropping system, market channels, selling prices, and incomes. Special emphasis was given to the water issue, by inquiring about the current use of water on crops, irrigation methods and the source and cost of water. Specific questions were dedicated to understanding the farmers' willingness to change/enlarge their cropping pattern and the role played by the farmers' associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017, by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 3.

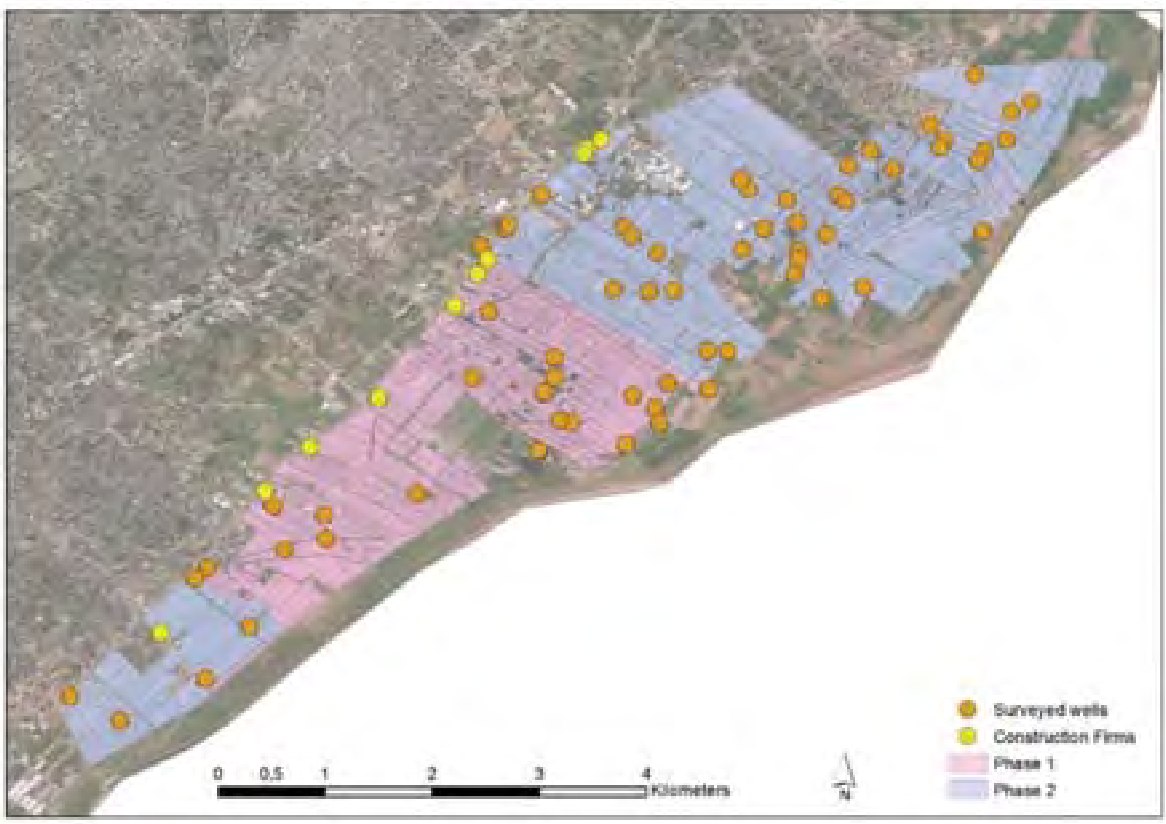


Figure 3: spatial location field survey

The survey resulted in the collection of **420 farm questionnaires**, **9 farm inputs questionnaires**, and **11 industry questionnaires**. The paragraphs below summarize the results obtained from the analysis of the questionnaires.

LAND TENURE AND CROPPING SYSTEM

FARM SIZE AND LAND TENURE

The Project area extends for 1,207 ha (12'068 du). As shown in Figure 4, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 du are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

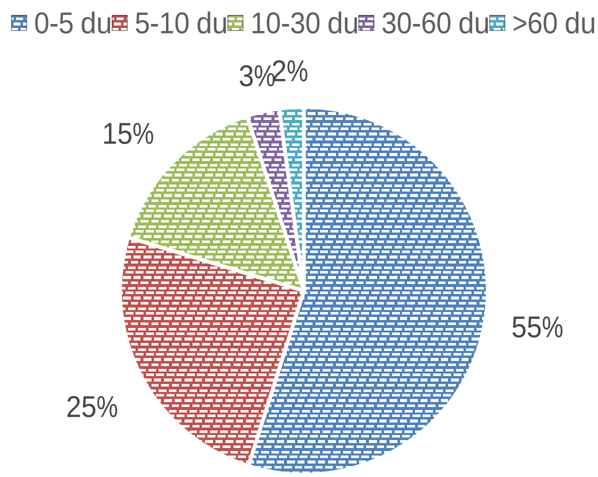


Figure 4. Distribution of farms by size.

CROPPING SYSTEM

The cropping pattern of the project area is shown in the following Figure 5.

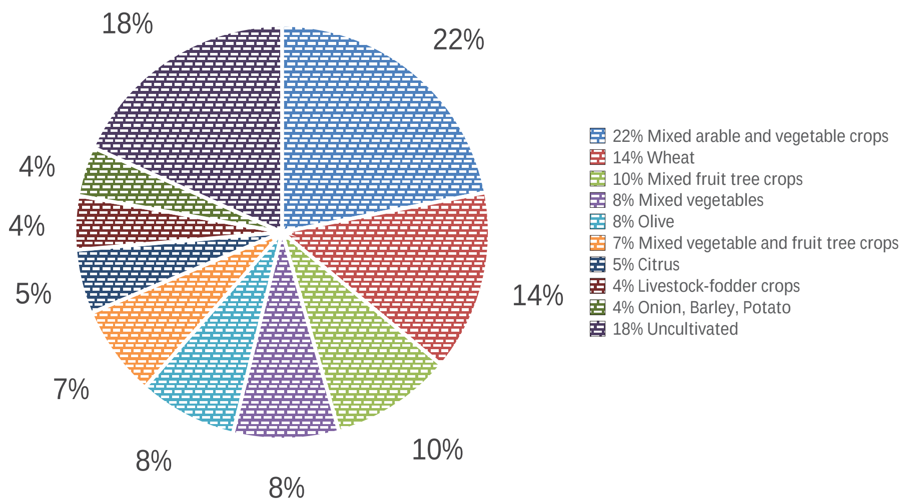


Figure 5: Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops. Almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 6). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 7).

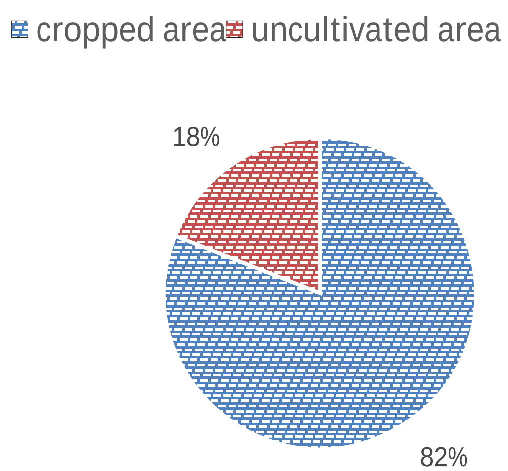


Figure 6. Cropped and Uncultivated Area

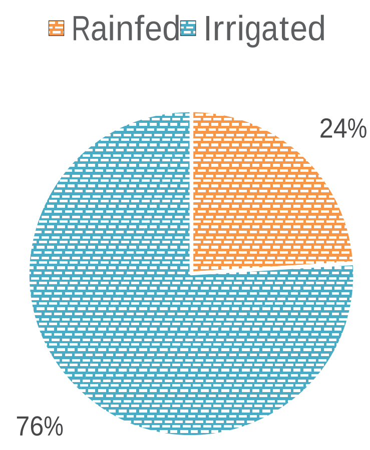


Figure 7: Irrigated and Rainfed Areas

CROP WATER REQUIREMENTS AND WATER CONSUMPTION IN AGRICULTURE

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well ("collective well") is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the "collective well" system owned by the remaining 8%.

Wells must be authorized by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also "non-legal" wells, estimated to be 3-4 times the number of the legal ones. The government does not close these wells but new unauthorized wells cannot be drilled.

The survey determined that water cost ranges[2] from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

Figure 8 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

[2] The value is the average among the ones provided by farmers during the field survey. During the filed survey, farmers provided the following rationale for their stated value for cost of water: a well's pump consumes 10 to 12 litters of diesel per hour to extract 40 to 60 m^3/hours at an average depth of 60 to 70 meters. The cost of diesel, on average, is between 6 and 7 ILS/litter. For that reason, the cost of water ranges from a minim of from 1 to a maximum of 2.1 ILS/m^3. On average, it is therefore approximately 1.5 ILS/m^3 or more.

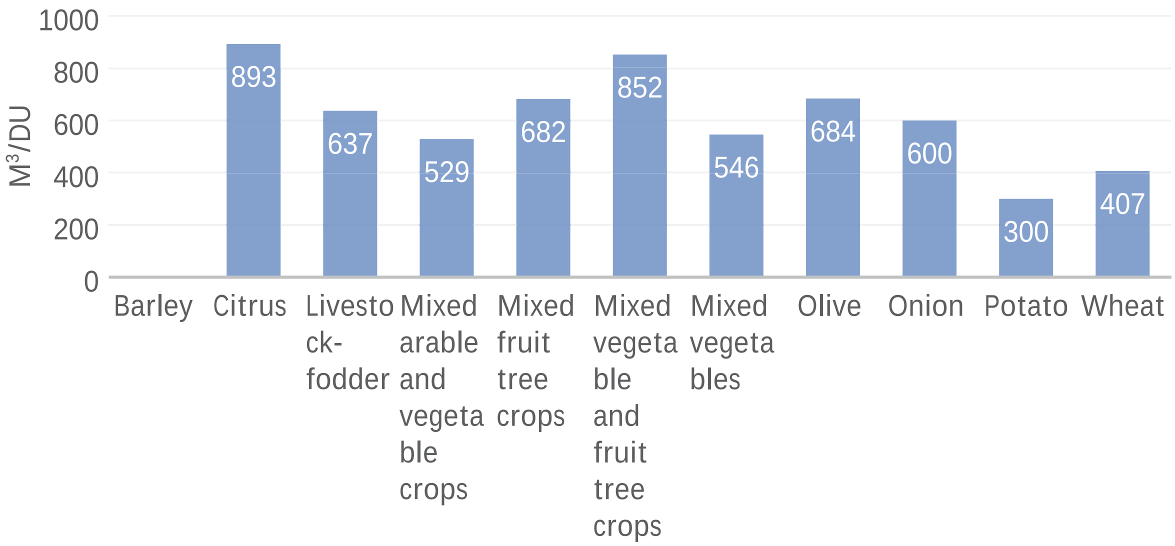


Figure 8. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m^3/du); Barley is rain fed.

The **total crop water requirements** for the agriculture currently developed across the whole 15,000 du is estimated to be **5.8 Mm^3/year** with an **average daily water requirement of 15,990 m^3/day**.

CAUSES OF THE PRESENT LAND ABANDONMENT

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is because of the frequent **land invasions by the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, as well as periodic herbicide sprays to keep the field clear, which kills the crops and makes farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out cropping operations (23%); and **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

WATER CONSUMPTION IN THE INDUSTRIES

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 3 their localization): generally, most of them are small factories (less than 10 employees), operating only a few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%) of them is using private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

VALUE CHAIN

Gaza Strip, with its high population density and reduced connections to a production system because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

Interviews with the producers showed that the vast majority of the agricultural products are sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

The market chain of horticultural and fruit products is as follows:

farmers → traders, wholesalers, middle men → retailers → consumers.

Next table summarizes revenues, costs and margins for the different crops expressed in the local currency.

Table 2. Summary of the single accounts cultivation statements of agricultural products

FARM/CROPS	REVENUES	COST	MARGIN	NET margin per kg	NET margin + LH[3] per kg
APPLE	1,000	2,495	-1,495	-2.99	-2.81
BARLEY	655	1,630	-975	-2.02	-0.36
CITRUS	3,494	3,172	322	0.19	0.52
LEMON	1,400	2,048	-648	-0.65	-0.33
LIVESTOCK	1,582	2,310	-728	-	-
MELON	2,400	2,401	-1	0	0.17
MIXED ARABLE AND VEGETABLE CROPS	3,226	2,267	959	0.36	0.59
MIXED FRUIT TREE CROPS	2,487	2,472	15	0.02	0.34
MIXED VEGETABLES AND TREE CROPS	3,444	1,667	1,777	0.81	0.92
MIXED VEGETABLES	3,407	3,061	346	0.11	0.33
OLIVE	806	2,376	-1,570	-2.92	-2.05
ONION	675	1,837	-1,162	-2.58	-0.58
PEACH	1,000	1,055	-55	-0.11	0.07
POTATO	2,500	1,656	844	0.34	0.50
WHEAT	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

ASSESSMENT OF THE NGEST RECOVERY AND REUSE SCHEMES

PROJECT RECOVERY SCHEME

The recovery scheme comprises a system of 28 recovery wells and all related connection pipes as well as 15 monitoring wells. The following three sections provide a more detailed description of each component.

RECOVERY WELLS

[3] LH: Labour Harvesting

There are 28 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 9. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

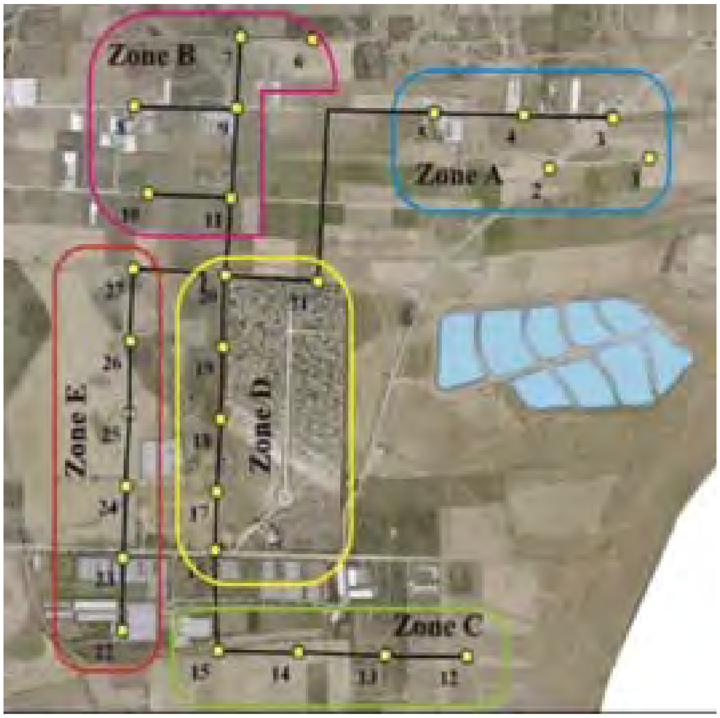


Figure 9: Location of the 27 Recovery Wells

The recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October, which is equal to 50,885 m^3/day. The total number of wells is 28 where each should have a capacity of pumping between 180 m^3/hr to 200 m^3/hr. 25 out of the 28 wells are assumed to be operational always with a capacity of 180 m^3/hr. The three additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure.

According to the numerical modelling results, the exact location of the 28 wells was selected to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 9 shows the locations of the recovery wells.

COLLECTION PIPES

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 10. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

MONITORING WELLS

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore be taken and analyzed randomly at farm level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 43 wells will be implemented by using the 5 existing monitoring wells, the 28 newly built recovery wells and 10 new monitoring wells.

The location of the 43 wells is provided in the following Figure 11.

Figure 11: Location of the existing and newly proposed monitoring wells

PROJECT REUSE SCHEME

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 12. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 13.

In accordance with irrigation requirements, irrigation was to be carried out on a six-day rotational basis over six zones of almost equal size, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F, as shown in the following Figure 13. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 14.

Figure 12: Location of agricultural land

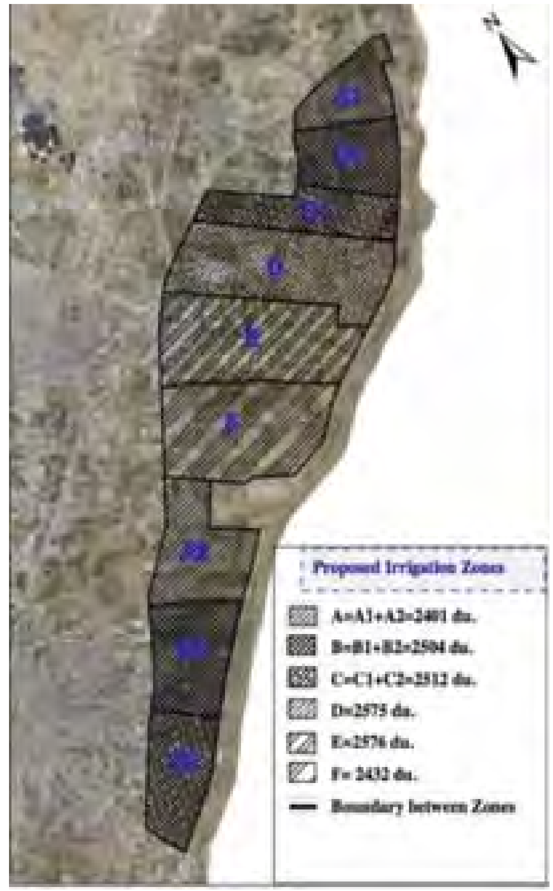


Figure 13: Proposed Irrigation Zones

Figure 14: General Layout of the Originally Proposed Irrigation Network

REVIEW OF REUSE SCHEME: ADDITIONAL FINDINGS AND RECOMMENDATIONS

In addition to the key findings listed in the Executive Summary above, the following achievements were obtained while reviewing the original design of the Irrigation Project:

- A review of the original irrigation project layout resolved some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gate (the original design failed to do so for a sizable number of farms);
- A review of the original design for the recovery scheme confirmed its validity;

- A review of the original design for the reuse scheme confirmed the selection of materials, the general layout and the selection of the pumping system;
- The overall cost for the construction of the water reuse scheme has significantly increased (nearly 75% increase) from its original estimation. Although this might be justifiable in the context of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%. Further to that, it is possible that a further reduction in the overall cost for the construction of the irrigation scheme might be achieved with the adoption of a optimized layout. Particularly, several trunk lines had to be doubled up (sometimes even tripled up) to guarantee that the right water pressure is delivered thought the network. These changes are driving the cost of the construction up and could be optimized with the aid of a proper topographic survey and a further refinement of the original design.

PROJECT ECONOMIC AND FINANCIAL SUSTAINABILITY

The newly proposed development plan assumes that the entire project area (Phase I + Phase II) will be able to adopt the proposed cropping pattern within four years from the completion of the irrigation scheme. The adoption of the new cropping pattern involves not only planting new crops but also modernizing the farm and adapting it to the proposed irrigation method. The cost for the adoption of the cropping pattern and the modernization/development of the farms is expected to be 4.695 Million ILS (approximately 1.3 Million US$) per year for a period of four years assuming that Phase I and II are developed one after the other over a period of two years.

Farmers will require intense training to be able to implement the proposed plan. Additionally, maximizing the output of the irrigation project will require the farmers to cooperate via one Water User Associations (WUA), which has yet to be created. The macro-economic analysis assumes that the WUA should immediately invest approximately 3 Million ILS (approximately 0.8 Million US$) in trainings.

Finally, operating and maintaining the system (on-farm and off-farm, including the water recovery and reuse scheme) will cost anywhere between 7.2 Million ILS (approximately 1.98 Million US$) and 11.4 Million ILS (approximately 3.17 Million US$) per year depending on the cost of energy. The O&M costs include 0.36 Million ILS/year (100,000 US$) for the running costs of the WUA. Farmers will pay for the O&M of the system through their water bills.

In order to track the amount used, water consumed by each farm will be metered at the farm gate. Gross Irrigation water demand, excluding water needs for Industries (estimated to be 70,000 m^3/year) but including all system losses[4] and climate change[5], is estimated to be 11,110,000 m^3/year. The net irrigation water requirements (after all system losses are considered), is estimated to be 7,833,484 m^3. Farmers will be charged for the water delivered to their farms. The tariff farmers will have to pay to cover O&M costs will vary from a minimum of 0.9 ILS/m^3 to a maximum of 1.5 ILS/m^3 depending on the cost of electricity (if entirely provided by the national grid or entirely generated by the stand-by diesel generators installed at the site).

Then, after the new cropping pattern and modernized irrigation methods have been implemented, the irrigation project should generate a stream of revenue that, after the first three years, would provide a steady income of approximately 30 Million ILS/year (approximately 8.3 Million US$/year).

MICRO-ECONOMIC CONDITIONS

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

This section of the *Report* assesses what the net income for farmers would be with and without the project and assesses the availability in the farmers' budget to pay for water.

EVOLUTION OF THE CROPPING PATTERN

[4] System losses includes both on farm and off farm losses.

[5] The estimates for water demand assumes that, due the rising of temperatures over the next decades, water requirements for irrigation will increase.

The analysis assumes that famers will be able to fully implement the proposed cropping pattern and irrigation methods over a period of four years after the construction of the irrigation network. These changes, changing the existing land use and planting trees and vegetables, are expected to increase land productivity.

The analysis of the value chain has shown that some crops such as fresh fruit (peaches, apricots, plums) are scarcely produced and often imported goods. Olive, as a crop to produce olive oil, is often sold at a low price and profitability might be improved by nearly 50% if olives, especially the better-preserved ones of the right variety, are processed into eatable olives. The new cropping pattern also includes almond as a profitable and long-lasting, easy to preserve, type of crop.

The newly proposed cropping pattern cannot produce the desired increase in production and profits unless farmers are extensively trained (see above for specific recommendations on capacity building for water user associations and farmers). Furthermore, It would be desirable for farmers to unite in associations or cooperatives to jointly handle the supply chain through the use, for example, of refrigeration storage facilities that allow the consumption of perishable products over a longer period of time.

Table 3: Evolution of the Cropping Pattern

LAND DEVELOPMENT OVER TIME [YEARS]

	BEFORE		AFTER		Y1	Y2	Y3	Y4
CROPS AND CROP GROUPS (**)	%	du	%	du	du	du	du	du
CITRUS	5	603	22	2,655	1,116	1,629	2,142	2,655
OLIVE	8	930	23	2,776	1,392	1,853	2,314	2,776
ALMOND	2	272	10	1,207	506	739	973	1,207
PEACHES	5	587	7	845	652	716	780	845
OTHER FRUIT TREE CROPS	5	544	3	362	499	453	408	362
GRAINS*	31	3.684	12	1,448	3,125	2,566	2,007	1,448
WINTER VEGS	13	1.603	4	483	1,323	1,043	763	483
WINTER VEGS (TOMATO IN GREENHOUSE)	1	121	3	362	181	241	302	362
SUMMER VEGS	8	1.009	6	724	938	867	795	724
ALFALFA (GREEN FODDER)	4	509	10	1,207	684	858	1,032	1,207
UNCULTIVATED	18	2.205	0	0	1,654	1,102	551	-
TOTAL	100	12.068	100	12,068	12,068	12,068	12,068	12,068

* GRAINS: WHEAT + BARLEY
** CROPS MARKED IN RED ARE THOSE THAT, IN FUTURE CONDITIONS, WILL OCCUPY LESS LAND IF COMPAR

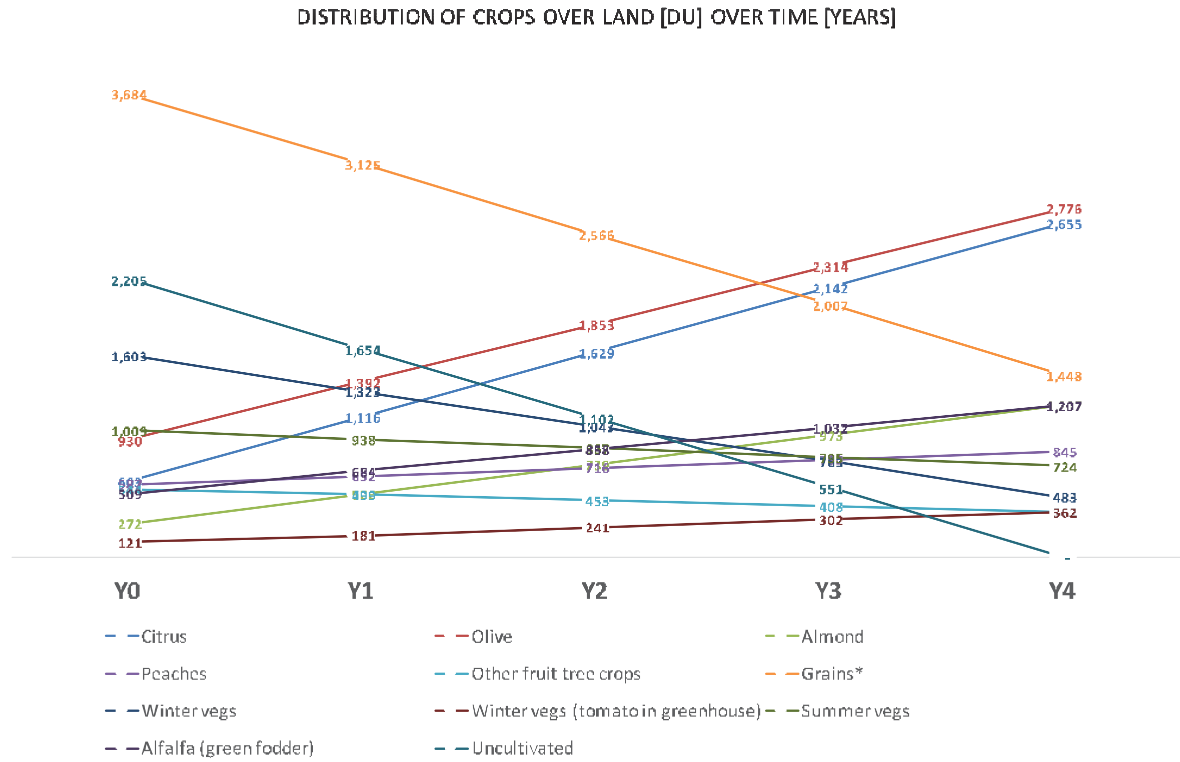


Figure 15: Evolution of the cropping pattern over land [du] over time [years]

FARM-LEVEL INVESTMENTS

Investments at the farm level would be largely spent on an increase in tree plantations and greenhouses placed in areas located away from the border with Israel.

The following table summarizes investments, expressed in Israeli New Shekel (ILS) per dunum (du) by type of crop and by type of material / activity required to produce such crop.

Table 4: Farm-level Investment [ILS] per dunum [du]

CROPS AND CROP GROUPS	*GREEN house*	*TREES*	*IRRIGATION GRID*	*LABOUR*	*MACHINERY*	*INPUTs*	*TOTAL*
CITRUS		400	380	400	0	200	1,380
OLIVE		800	380	400	0	200	1,780
ALMOND		1,200	380	400	0	200	2,180
PEACHES		1,000	380	400	0	200	1,980
OTHER FRUIT TREE CROPS							-
GRAINS							-
WINTER VEGS							-
WINTER VEGS (TOMATO IN GREENHOUSE)	37,500		492				37,992
SUMMER VEGS							-
ALFALFA (GREEN FODDER)			1,080	80	0	200	1,360
UNCULTIVATED							

Considering the evolution of the cropping pattern, total investments at farm level are provided in the following Table 5.

Table 5: Farm-level investments (ILS x 1,000) evolution during four years of full stage

CROPS AND CROP GROUPS	Y1	Y2	Y3	Y4
CITRUS	708	708	708	708
OLIVE	821	821	821	821
ALMOND	509	509	509	509
PEACH	128	128	128	128
OTHER FRUIT TREE CROPS				
GRAINS				
WINTER VEGS				
WINTER VEGS (TOMATO IN GREENHOUSE)	2,292	2,292	2,292	2,292
SUMMER VEGS				
ALFALFA (GREEN FODDER)	237	237	237	237
TOTAL ILS X 1,000	**4,695**	**4,695**	**4,695**	**4,695**

Based on the new cropping pattern, balance sheet statements have been re-calculated by considering:

- a new cultural organization;
- more modern and efficient farming practices due to training activities and better extensions services;
- better and more effective phytosanitary protection;
- a more rational distribution of the irrigation network of the farm;
- a sizable reduction in net irrigation water demand;
- a higher production, especially of the tree plants due to increased attention to thinning, correct ripening and fruit calibration;
- a water tariff based on the most conservative estimate of 1,461 ILS/m^3.

WATER TARIFF

The water tariff has been conservatively calculated including the effect of climate change, system losses, unexpected events due to pipe breaks, possible defects and/or breaks of the water metering system, possible reading errors of the water metering system and the assumption that 100% of the power requirements to run the recovery wells and the irrigation project will have to be generated by the stand-by generators and not by the national grid.

Ideally the water tariff should be able to cover all OPEX costs including those associated with running the Water User Association. Under these circumstances, farmers should be charged based on the actual amount of water they consumed at a rate of 1.461 ILS/m^3 if energy is provided entirely by the diesel generators, 1.188 ILS/m^3 if energy is provided 50% by the national grid and 50% by the diesel generators and 0.916 ILS/m^3 if energy is provided 100% by the national grid. The details of such estimates are provided in the following tables.

Table 6: Water Tariff based on different energy generation scenarios

SCENARIO	ANNUAL COST FOR O&M and WUAs [ILS/year]	GROSS WATER Requirements [m^3/year]	NET IRRIGATION WATER Requirements [m^3/year]	TARIFF ILS/M^3
100% DIESEL	11,443,430	11,110,000	7,833,484	**1.461**

50% DIESEL	9,308,435	**1.188**
100% NATIONAL Grid	7,173,439	**0.916**

The details of the number presented above are given in the following Table 7.

Table 7: Gross and Net Irrigation Water Requirements at farm level and excluding industries

TYPE OF CROP	NET IRRIGATION WATER DEMAND	GROSS IRRIGATION WATER DEMAN
CROP	**m^3/year**	**m^3/year**
CITRUS	2,196,183	3,114,835
OLIVE	1,957,104	2.775,750
PEACHES	531,016	753,138
GRAINS	448,785	636,509
OTHER FRUIT	225,297	319,538
SUMMER VEGETABLES	470,724	667,626
WINTER VEGETABLES	141,871	201,216
WINTER TOMATO GREENHOUSES	51,337	72,811
ALMOND P	750,992	1,065,128
ALPHA-ALPHA P	1,060,174	1,503,639
TOTAL M$^{3/}$year	**7,833,484**	**11,110,191**

BREAK-EVEN POINT FOR WATER TARIFF

In order to better qualify how the balance sheet of each individual crop changes by changing the water tariff, the break-even point between costs and revenues was estimated for each crop. The results, displayed in the following table, show that a large part of the crops has costs and revenues balance between a tariff of 0.90 ILS/m^3 and of 2.49 ILS/m^3.

Water price sensitivity is lower in summer and winter vegetables, while only vegetables grown in the greenhouse can withstand a high cost per cubic meter of water.

Table 8: Water tariff that involve zero net margin

CROPS	OLIVE	CITRUS	PEACHES	GRAIN	OTHER fruit crop	SUMMER vegetable	WINTER vegetables	WINTER greenhouses	ALMOND	ALPHA alpha
WATER TARIFF ILS/M^3	**1.00**	**1.63**	**2.49**	**-0.89**	**1.76**	**3.31**	**6.56**	**42.51**	**0.90**	**1.14**

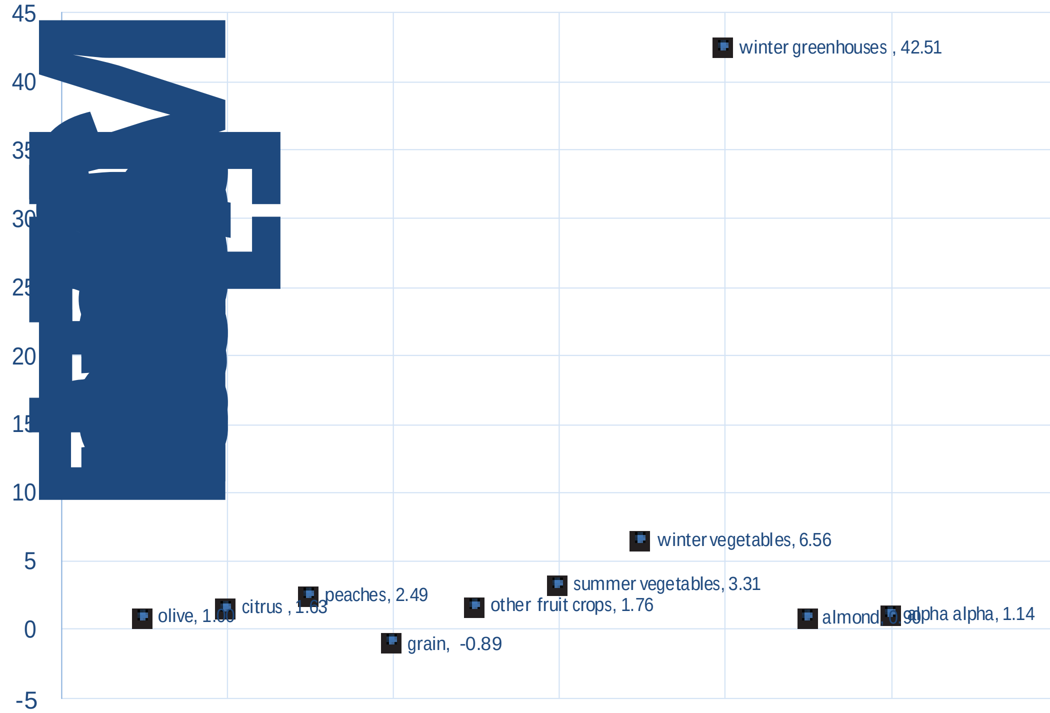


Figure 16: Water tariff that involve zero net margin

It is assumed that the following costs will be paid by the farmers: the Operation & Maintenance (O&M) costs of the recovery scheme, the reuse scheme and the irrigation network inside the farms, the costs for operating the Water User Associations (WUA). The farmers would be charged based on the actual water they consume. Water consumption is measured by a water meter installed at the manhole located at the farm gate.

BALANCE SHEET FOR THE CROPPING PATTERN

A summary and detailed analysis for both costs and revenues associated with each crop as suggested by the newly proposed cropping pattern is provided in the following series of tables.

Table 9 Summary of the Financial Costs [ILS x 1,000]

CROPS	Y1	Y2	Y3	Y4
CITRUS	2,493	3,639	4,784	5,930
OLIVE	2,253	2,999	3,746	4,493
PEACHES	995	1,094	1,192	1,291
GRAINS	3,584	2,943	2,302	1,661
OTHER FRUIT CROPS	857	779	701	622
SUMMER VEGETABLES	2,118	1,957	1,796	1,635
WINTER VEGETABLES	2,854	2,250	1,646	1,042
WINTER TOMATO GREENHOUSES	486	648	810	972
ALMOND	599	875	1,152	1,429
ALPHA-ALPHA	777	975	1,173	1,371
TOTAL FOR THE FINANCIAL COSTS [ILS X 1,000]	**17,016**	**18,159**	**19,302**	**20,445**

Table 10: Summary of the Financial Revenues [ILS x 1,000]

	Y1	Y2	Y3	Y4
CITRUS	3,456	5,044	6,632	8,220
OLIVE	2,672	3,558	4,444	5,329

PEACHES	1,792	1,969	2,146	2,323
GRAINS	2,109	1,732	1,355	978
OTHER FRUIT CROPS	1,253	1,139	1,024	910
SUMMER VEGETABLES	3,751	3,466	3,181	2,896
WINTER VEGETABLES	5,158	4,066	2,975	1,883
WINTER TOMATO GREENHOUSES	1,901	2,534	3,168	3,801
ALMOND	728	1,065	1,401	1,738
ALPHA-ALPHA	1,077	1,351	1,626	1,901
TOTAL FOR THE FINANCIAL REVENUES [ILS X 1,000]	**23,898**	**25,924**	**27,951**	**29,978**

The detailed balance sheet for each crop are provided in "Annex 5: Balance Sheet for Individual Crops".

MACRO-ECONOMIC CONDITIONS

METHODOLOGY

Cost-benefit analysis (CBA) is a formal analysis technique used in public and private investment projects (Rakhra, 1991) as well as in programs and policies (Stoica, 2005) in order to make a comparative assessment of all the benefits and costs anticipated. It also represents an attempt to measure the costs endured and gains earned by a community or a private company after the project is implemented.

CBA proves its usefulness in feasibility studies (from an economic, environmental, social or technological perspective) by selecting the optimal option for investment projects (Hanley and Spash, 1993). The purpose of using CBA in a sector is to set up pragmatic administrative rules in order to *allocate resources efficiently*.

The use of cost-benefit analysis contributes to determining the financial sustainability as well as profitability of the NGEST water reuse scheme. It also:

a) highlights the economic and financial viability of the NGEST water reuse scheme for different scenarios;
b) enables the identification of possible errors in the design or implementation phase (incorrect information, unrealistic hypotheses, etc.); and
c) enables the correction needed to properly conduct the NGEST water reuse scheme.

GENERAL PROJECT ASSUMPTIONS

Within the CBA, costs are presented in terms of capital investments and operation and maintenance (O&M); the first being a one-time cost and the second being a recurring, yearly, cost.

The entire water recovery and re-use scheme requires capital investments to be implemented over time to provide water in two separate areas (Phase I for 500 ha and Phase II for 1,000 ha). The implementation of each phase has been subdivided into two separate tendering packages. The details are provided in the following Table 11 including the implementation schedule.

Table 11: Tendering Packages and proposed timeframe for the implementation of Phase I and Phase II

		DESCRIPTION	2017	2018	2019	2020
I	**1**	Supply and install 14 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$10,970,996.40			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		$7,519,531		

II	**1**	Supply and install 14 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$13,421,602.00	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)		$11,178,400.00

The O&M cost are provided in the following tables assuming three possible scenarios of cost for electricity. The first scenario assumes that energy will be provided 100% by the national grid, the second scenario assumes that 50% of the energy requirements are provided by the national grid and the other 50% by the standby diesel generators installed onsite. The third and most conservative scenario assumes that 100% of the energy requirements are provided by the standby diesel generators.

Table 12: Annual O&M costs (US$ and ILS) assuming all energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (ONLY NATIONAL GRID)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$1,074,060	$358,020	$716,040
FROM THE GRID (100%)	*$1,074,060*	*$358,020*	*$716,040*
FROM THE DIESEL GENERATORS (0%)	*$0*	*$0*	*$0*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	$1,886,002	$724,235	$1,161,767
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS	**$ 1,986,002**	**$824,235**	**$1,261,767**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 7,173,439**	ILS 2,977,000	ILS 4,558,000
WATER TARIFF (ILS/M^3)	0.918		

Table 13: Annual O&M costs (US$ and ILS) assuming 50% of the energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (50/50)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$1,665,144	$555,048	$1,110,096
FROM THE GRID (50%)	*$537,030*	*$179,010*	*$358,020*
FROM THE DIESEL GENERATORS (50%)	*$1,128,114*	*$376,038*	*$752,076*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$2,477,086**	**$921,263**	**$1,555,823**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	$2,577,086	**$ 1,021,263**	**$1,655,823**
TOTAL MANAGEMENT COSTS (ILS	**ILS 9,308,435**	3,689,000	5,981,000
WATER TARIFF (ILS/M^3)	**1.188**		

Table 14: Annual O&M costs (US$ and ILS) assuming 100% of the energy is provided by the standby diesel generators

OPERATION AND MAINTENANCE COST (ONLY GENERATOR)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$2,256,228	$752,076	$1,504,152
FROM THE GRID (0%)	*$0*	*$0*	*$0*
FROM THE DIESEL GENERATORS (100%)	*$2,256,228*	*$752,076*	*$1,504,152*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$3,068,170**	**$1,118,291**	**$1,949,879**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	**$3,168,170**	**$1,218,291**	**$2,049,879**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 11,443,430**	**ILS 4,400,000**	**ILS 7,404,000**
WATER TARIFF (ILS/M^3)	**1.461**		

Other costs that are included in this CBA are the water tariff, assumed to be 1.461 ILS/m^3, and the investments required at the farm level to support the introduction of the proposed cropping pattern.

Costs for supporting and training the Water User Association (WUA) are assumed to cost 3,000,000 ILS (equivalent to $806,000), divided in 2,000,000 ILS for the first year and 1,000,000 ILS for the second year.

FINANCIAL ANALYSIS

The financial analysis indicates whether the project will generate a positive net cash flow during the evaluation period (profitability) and whether the cumulative cash flow from the start of investment until the final prediction is negative (sustainability).

The analysis of the investment project's cash flow includes both the evaluation of the cash outflows (investment costs as well as and costs at farm level) and cash inflows (revenues at farm level, industries, grant and subsidies). As opposed to the economic analysis, in the financial analysis the cash flow does not include amortization, reserves and other accounting items.

From this perspective, the financial analysis was conducted with the following steps:

1. Estimating revenues and costs of the NGEST area farms and assessing the implications of these parameters on cash flow;
2. Defining the financing sources of investment and analyzing the financial profitability.
3. Determining the funding gap in achieving the investment project and identifying the best mechanisms to attract funding;
4. Checking whether the estimated cash flow could ensure the proper operation of the NGEST project. The investment project is financially sustainable if there is no risk of running out of cash during the operation.

For the financial analysis, the following costs and revenues were taken into account:

Cash Outflows (Costs)

- Capital cost – recovery wells, farm investment
- Costs related to the WUA operation and training
- Operation Costs at farm level including water tariff

Cash Inflows (Revenues)

- Revenues at farm level derived from the new cropping pattern
- Water tariff paid by Industry based on 2 ILS/m^3 per 70,000 m^3 /year

- Reduction of time spent in management of private wells
- Investments paid by Government/Donors
- Public Subsidies based on farm water tariff of 1.461 ILS/m^3 (worse case scenario).

The financial analysis carried out as part of the project's CBA uses market prices (which include VAT and indirect taxes) to check the balance of the investment and the sustainability of the project.

The cash flows accumulated in different years during the evaluation period (25 years) require a fair discount rate. The financial discount rate allows to account for the influence of time on the value of money and reflects the opportunity cost of the investor’s capital.

In general, it is recommended to use a discount rate of 5%, but the model also used 2 more points (7%) and less (3%) to evaluate the sensitivity of the net present value.

SCENARIOS

Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

(1) Capital Investment for the Water Recovery Scheme;
(2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm’s Gate;
(3) O&M Cost for the Water Recovery Scheme;
(4) O&M Costs for the Water Reuse (irrigation) Scheme;
(5) Capital Investments for Farm's Development.

The five scenarios are defined as follows

- **Scenario 1** - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under this scenario, farmers would pay back the full cost for the construction of both the recovery and the reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- **Scenario 2** - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built;
- **Scenario 3** - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government/donors and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the recovery and reuse schemes would be paid by the government or by a donor and every other cost would be paid by the farmer;
- **Scenario 4** - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that the Government/Donors would cover the cost for the construction of Phase I, but that the farmers will pay back the cost for the construction of Phase II. Farmers would also pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered by the Government/Donors for the first 8 years (i.e. the time needed by the farmers to pay back the construction of Phase II). After that, the farmers will pay for the cost of O&M of the recovery and reuse schemes as well.
- **Scenario 5** - Capital and O&M Subsidies: considers costs (1) and (2) will be paid by the government/donors. Costs (3) and (4) would be subsidized by the Government only until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for the first 3 years (i.e. the time it takes for the farmers to be able to pay back for the improvement of their own farm). After that point, farmers will be responsible for paying O&M costs for the whole system.

A schematic representation of the five scenarios is provided in the following Table 15.

Table 15: Investment Scenarios

Scenario	Description	Cost Paid by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investments for Farm's Development	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Government and not charged to the Farmers		x	x	x	Paid by the Government and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Government until Farmers have paid back the Construction of Phase II	x	x	Paid by the Government and not charged to Farmers	x
5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5).	Paid by the Government and not charged to the Farmers		Subsidized by Donors/Government until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)		x	Paid by the Government and not charged to Farmers	

FINANCIAL SUSTAINABILITY OF THE INVESTMENT PROJECT

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

In order to determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

FNPV represents the amount calculated when the estimated investments and operating costs of the project are deducted from the present value of the projected revenues. The investment project is profitable in the financial sense if FNPV has a positive value.

FIRR represents the discount rate for which FNPV is zero or which equals the present value of the financial cash flows projected for the reference period. If this indicator is less than the cost of the capital, the project is not profitable. When it is higher than the cost of capital, the project is acceptable because it will generate a positive FNPV.

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

The main results of the financial analysis are summarized in the following table.

Table 16: Main Results of the Financial Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]			BENEFIT COST RATIO (BCR)			INTERNAL RATE OF Return (FIRR)
	3%	5%	7%	3%	5%	7%	
1	-155,002	-140,864	-130,096	0.772	0.750	0.728	NF
2	-61,389	-56,792	-53,353	0.778	0.753	0.728	NF
3	**17,400**	**12,152**	**7,405**	**1.028**	**1.023**	**1.017**	**10.82%**
4	-52,493	-48,408	-46,166	0.922	0.913	0.902	NF
5	17,400	12,152	7,405	1.028	1.023	1.017	10.82%

ECONOMIC ANALYSIS

An economic analysis for major investment projects determines if the project contributes significantly to total economic welfare. It measures the project benefits depending on the following: the costs avoided due to project implementation; and the external benefits arising from the implementation, neither of which are included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. These externalities should be given a monetary equivalent.

In the economic CBA, some cost/benefits cannot be expressed in monetary units but only in qualitative terms. These costs/benefits are:

- Preservation and improvement of the quality of space for human life, as in the case of water pollution when human settlements located near water lose their basic quality.
- Prevention of flora and fauna destruction.
- Maintenance of natural system which will have a positive effect on people, like better mental condition and richer intellectual activities.

Benefits that cannot be expressed in monetary value are also called “intangible” benefits. Those benefits have been ignored in the cost-benefit analysis of the project. The reason is that these benefits cannot be assessed, and their detailed qualitative effects can be better described in an environmental impact assessment.

In the economic cost-benefit analysis the costs are expressed in accounting prices, and are measured in terms of 'resource' cost or 'opportunity' costs.

The economic analysis could be briefly described with the following steps:

- Conversion of market prices into accounting prices;
- Update the estimated costs and benefits;
- Calculation of economic performance indicators (Economic Net Present Value, Economic Rate of Return, benefit/cost ratio).

The corrections to be considered in the economic analysis are the following:

Fiscal Corrections. Fiscal Corrections are necessary because some transfers from one agent to another should be seen as pure transfers, without having an economic impact. For example, the subsidies provided by the government to those who want to invest in the NGEST Irrigation Project represent a pure transfer offering advantages to the beneficiaries, but not creating economic value. The fiscal corrections are made for indirect taxes (VAT), subsidies and pure transfer payments (employer's obligation to pay social security contributions) which are generally included in the eligible costs and/or operating or maintenance costs. However, the prices should also include direct taxes. In addition, if certain indirect taxes/subsidies are aimed at correcting externalities, then they will be included in the analysis. In order to assess the project's economic impact, information on the tax system in the West Bank and Gaza, as calculated by World Bank, was used as presented in the following Table 17.

Table 17: Direct and indirect taxation in Gaza and West Bank

TAX OR MANDATORY Contribution	**PAYMENT** (number)	**NOTES ON** Payments	**TIME** (hours)	**STATUTORY** Tax Rate	**TAX BASE**	**TOTAL TAX RATE** (% of Profit)	**NOTES** on TTR
CORPORATE INCOME Tax	2		18	15% - 20%	Taxable Profit	14.23	
CAPITAL GAIN TAX	1			15% - 20%	Capital Gains	0.76	
MUNICIPAL BUSINESS Tax	1			17%	Rental Value of Building	0.28	
EMPLOYEE PAID - Personal Income Tax	12		96	5% - 20%	Taxable Salaries	0	withheld
IRRECOVERABLE VAT (on fuel)	0			15%	Fuel Consumption	0	
VALUE ADDED TAX (VAT)	12		48	16%	Value Added	0	not included

TOTALS	28	48	15.27

Correction of labour cost from financial to economic. The correction of financial costs to economic costs of the price of labour has been made. The coefficient used to correct the financial value was 0.3 to consider taxation and social charges.

To carry out a neutral evaluation, positive and negative externalities of the project were not considered.

Based on the consideration presented above, the main results of the economic cost benefit analysis are presented in the following Table 18

Table 18: Main Results of the Economic Cost Benefit Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]			BENEFIT COST RATIO (BCR)			INTERNAL RATE C Return (EIRR)
	3%	5%	7%	3%	5%	7%	
1	-61,667	-61,628	-61,454	0.909	0.891	0.871	NF
2	-23,386	-24,446	-25,237	0.915	0.894	0.871	NF
3	**118,983**	**99,119**	**83,307**	**1.190**	**1.190**	**1.188**	**61.68%**
4	47,413	36,828	27,978	1.071	1.066	1.059	18.55%
5	118,983	99,119	83,307	1.190	1.190	1.188	61.68%

GENERAL ASPECTS

FINANCING MECHANISMS

The sources of funding provided by the various scenarios of the project are:

- government financial sources
- financial sources of international cooperation
- private financial sources

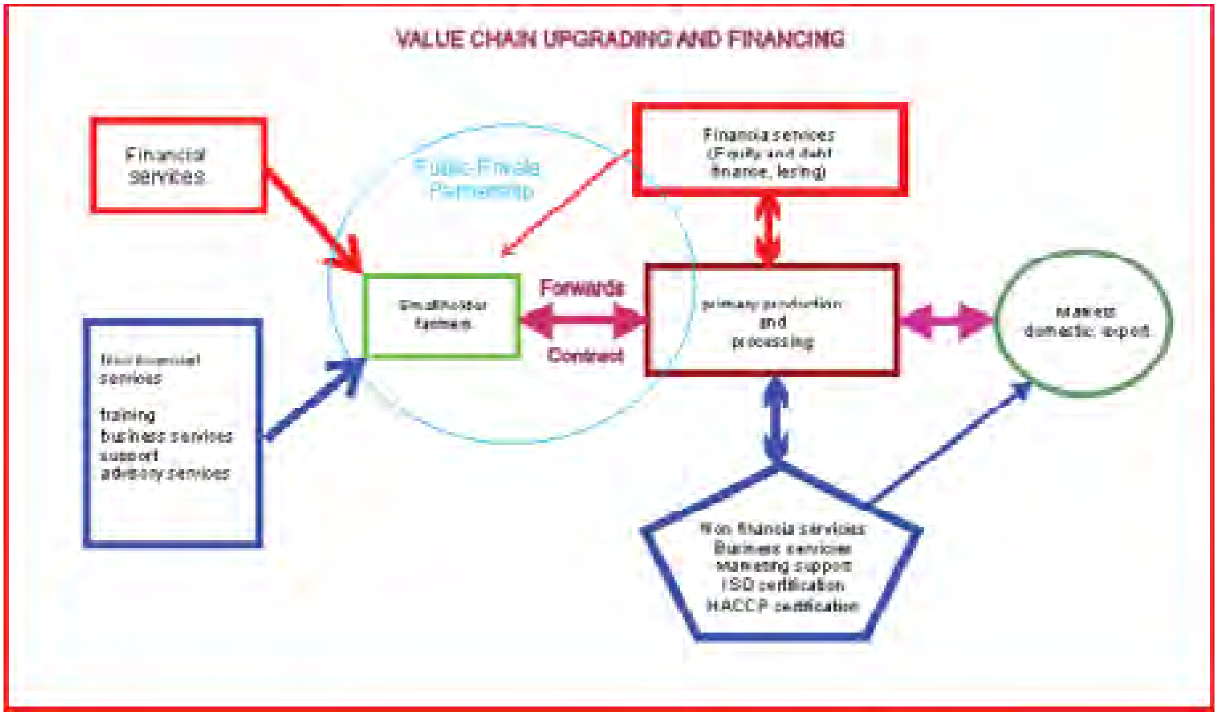
While government finance and international cooperation does not have direct impacts on the financial market system, it is necessary to provide support and guarantees to a private financing system. As we know the banking system requires, turning on a loan, guarantees and payment of the price of money (interest).

Farmers will need to have access to a banking system and most of them do not have enough income or capital to finance investment in farms or parts of the project, so it is necessary to provide them with support tools.

- First, the government must provide for a national guarantee fund supporting the banking system for when, due to personal problems or because of adverse meteorological conditions or distortions in market prices, the farmer is unable to repay the annual instalment of the loan.
- The second important thing is government or donor support for bank interest payments, given the high price of money locally. Farmers can repay the loan principal, but hardly the interest portion.

Farmers interested in the project are largely small companies (1 or 2 dunums) are heterogeneous and have different needs. It is important to identify the various sub-organizations of small owners and to evaluate their needs and constraints. In addition, small farmers do not only need credit for agricultural activities, but also need credit for other family / needs, savings, payment systems and insurance.

Clearly knowledge of the needs of small farmers makes it possible to identify the real needs, in particular regarding the guarantees for the banking system. On systemic risk, agricultural insurance, catastrophic risk programs, price coverage through exchanges of goods or value chains, banks can provide some innovative solutions.



Agriculture value chain development is strongly influenced by:

Financial services Financial services identify the possibility of providing credit easily to small farmers who can expand their business by investing in more profitable crops, plant and machinery, improving the quality of agricultural production and starting up with other farmers on processing products in order to increase the value added on the farm.

On this point, it is important to develop warranty services, such as a **national guarantee fund** that supports the banking system in lending.

Another example of financial services for farms is the establishment of a **national rotation fund** for investment financing for small farmers.

Agricultural insurance must support farmers with regard to the risks of climate change that pose the greatest risk to agriculture and food security. It is clearly necessary to ensure farmers also for losses due to the contingent difficulties of the neighbouring Israel.

Financing needs are not high and are comprised between 1,000-2,000 ILS/du for new tree plantations, so they do not represent important figures to guarantee - only greenhouse construction requires more important investments around 35,000 ILS/du. Other investments relate to corporate mechanization as possible support for company work for medium-sized farms.

Non-financial services: Non-financial services are fundamental to farmers' training for new technologies, low-impact farming practices and organic farming. In addition, credit counselling services and advisory services for the processing and marketing of the products of their own farm are required.

Public-Private Partnerships (PPPs): Another element that could support the development of new financial management models is based on public-private collaboration.

Public-private partnerships (PPPs) enable the involvement of the private sector in the implementation and development of a programme. Various forms of PPPs can be implemented within the program are:

- Partnership with the private sector for better access of small producers to markets and enhancement of quality of production at grassroots level;
- Partnership with the public sector to enforce the necessary legal framework and to develop the indispensable infrastructure;
- Partnership with financial institutions inclusive of commercial banks, microfinance institutions and leasing companies to finance the needs of different stakeholders within value chains and service providers to the value chains;
- Partnership with insurance companies to develop specific products aiming at mitigating risks for stakeholders and financiers;
- Partnership with communities to strengthen their capacities to gradually own and operate productive assets and/or specifically created companies;
- Partnership with local SMEs and entrepreneurs to develop services to value chain stakeholders like processing, storage facilities, transport, maintenance and repair, inputs supply.

JOB IMPACTS

The project in its full version creates new employment, the estimate of the level of direct employment is about 150 new employees and the job security for current employees.

Table 19: Job Created

JOB CREATED			DAYS/YEAR
JOB DAYS CREATED AT FARM LEVEL			**23.741**
JOB DAYS CREATED WUAS			**4.400**
JOB DAYS CREATED O&M			**4.840**
TOTAL JOB DAYS CREATED			**32.981**
INCREMENTAL labour	dd	**32981**	**+ 34%**
	n.people	150	

The government may provide subsidies for young farmers who undertake to work on the farm in order to reduce youth unemployment.

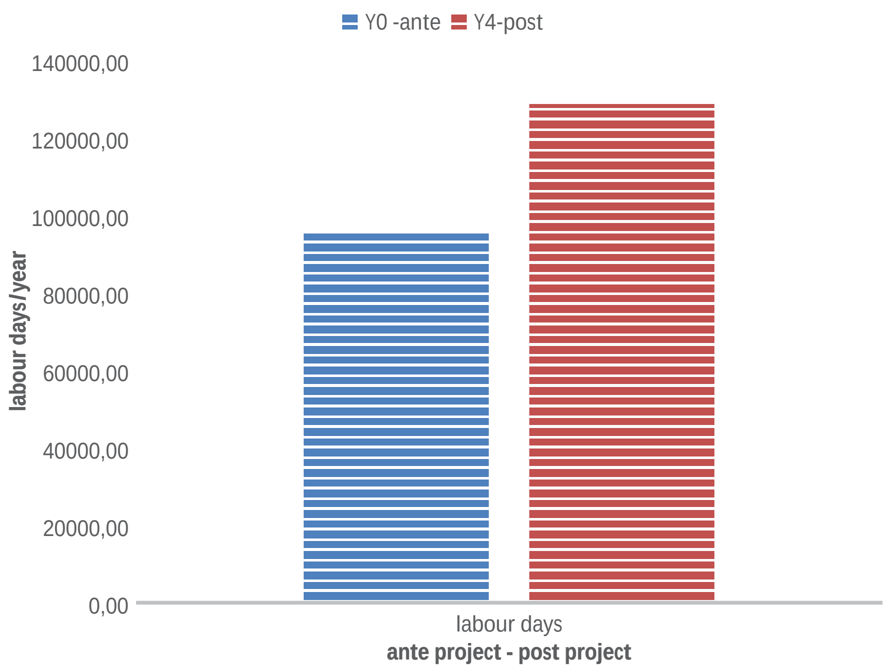


Figure 17: Job created per year before and after the project is implemented

PROJECT IMPLEMENTATION RECOMMENDATIONS

INSTITUTIONAL ARRANGEMENT

BACKGROUND

Traditional irrigation management in Palestine is community-based and informally organized around private wells in Gaza or springs in West Bank. Whereas in the Gaza Strip a small group of farmers share the operation and costs of a private irrigation well and organize the supply of water among themselves on a rotational basis, in the West bank, common irrigation schemes can supply up to a few hundred farmers and thousands of dunums, depending on the size of the spring. The organizational level is thus quite elaborate in West Bank, dealing with O&M, billing, and scheduling for hundreds of farmers in some cases. Still it is mainly informal, the number of WUAs in the Palestinian territories is very limited and the registered ones are very few. Governmental involvement in irrigation, therefore, has been very weak and limited to the licensing of agricultural wells.

INSTITUTIONAL OVERVIEW

Below is a summary of the responsibilities of the institutions that should be involved in the NGEST project, as outlined by the Water Law 2014 and the Draft Water User Association Regulation 2016.[6] It is important to note that the statements below are from the English translation of the laws. If there is a dispute as to the accuracy of a statement, the original Arabic version should be consulted.

As it pertains to this project, the PWA is responsible for (emphasis added):

- Setting a general policy for the planning and evaluation of water and wastewater projects in terms of their economic and social feasibility, setting design and quality control standards, technical specifications, and **monitoring their implementation**.
- Partake in the development of approved **standards of water quality** for various uses, in coordination and cooperation with the competent authorities, and ensure their implementation.
- The **establishment of advanced monitoring systems** to monitor precipitation, surface flows, groundwater levels, utilization quantities, and water quality, as well as analysis of data to determine the safe and sustainable yield of Water Resources and improve water resources planning;
- Issue **licenses** for the drilling, exploration, extraction or collection of groundwater;
- Set the general policies for determining the water and wastewater **tariff**;
- Order the suspension of water extraction or water supply in cases of a water source or supply system pollution.

The Water Sector Regulatory Council is responsible for monitoring all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management. It has the responsibility and power to:

[6] Because the WUA Regulation is a draft, its provisions (outlined here) may be different in the final version.

- Approve of **water prices**, costs of supply networks and other services required for the delivery of water and wastewater services, including setting a unified price for the provision of bulk water supply to Service Providers;
- Issue **licenses to Regional Water Utilities** and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of wastewater, and the levying of license fees;
- **Monitor operation processes** related to the production, transport, and distribution of water and operational processes of wastewater management;
- **Monitor water supply agreements**;
- Setting the basis for regulating the extent and percentage of **local authorities' participation** in the general assemblies of water utilities and ensuring implementation.

The National Water Company is responsible for the production and supply of bulk water at a national level. It is responsible for:

- The **supply and sale of bulk water** to water undertakings, local authorities, joint water councils and associations;
- The **extraction of water** from water resources, desalination of water, and **bulk water transmission** in accordance with a license issued by PWA for this purpose;
- The management, upgrade and development of any assets received from PWA;
- The provision of all the means necessary for the development of all activities and **infrastructure works related to the supply of bulk water**; and
- Propose a water supply tariff and submit to the WSRC for approval.

Service Providers include Regional Water Utilities and Water User Associations.

Regional Water Utilities provide water and wastewater services directly to the consumer, and are responsible for the provision of water and wastewater services within its specified administrative and geographical scope.

Water Users Associations are responsible for managing the service of supplying irrigation water at the local level. More specifically, it is responsible for:

- **Operation, maintenance and management of irrigation and drainage systems** in a fair, efficient and economical manner.
- **Produce or purchase water from its sources** at a certain rate and then redistribute it in a fair and timely manner to all farmers in the irrigation unit according to the criteria agreed with PWA;
- Determine the prices of water sold based on the tariff system in force;
- **Install, dismantle, repair and calibrate the means of measuring water** quantities used by water users.

To create a WUA, (at least) three people representing (at least) twenty farmers owning (at least) 100 dunums may submit an application to the Ministry of Agriculture. The application should contain basic information about the members, including the names and identity cards of the founding members, and the land owned or used by all members along with its agricultural pattern and water usage needs. The application should also include information about the Association, including its address, scope of work, and the water source to be used.

The Ministry of Agriculture will study the application and will then forward it to PWA, which in turn decides whether to grant a license to use the water source. If PWA approves the granting of a license, the Minister of Agriculture shall issue a decision to establish the Association. The application shall then be referred to the WSRC for approval to issue the license.

A WUA will be terminated if its approval to use a water source by PWA is cancelled.

The Ministry of Agriculture shall work with PWA and others in training WUAs on the following subjects:

- General training on participation in associations.
- Specialized training in the fields of financial, administrative and technical affairs necessary for the operation of the Association in accordance with the plans and programs established by PWA;
- Develop the operational plan, management and water distribution operations;
- Develop a maintenance plan for waterways, sockets and pumping mechanisms;
- Directly implement operation and maintenance plans; and
- Evaluation and follow-up.

During the transitionary period while the NWC, WUAs, and other new institutions are created, the relevant governmental authorities, official institutions, civil society organizations, and local authorities should continue to exercise their existing responsibilities and powers.

PUTTING IT ALL TOGETHER

Although it is clear which institutions should be involved in the various aspects of this project, what is not clear is where that authority exactly starts and stops. For example, it is stated that WUAs are responsible for "supplying irrigation water at the local level." But reasonable people may disagree with where that management should start in this project. Does it start at the recovery wells? At the booster station? Or somewhere else?

The main ambiguity, however, is regarding the responsibilities of NWC and the WUA. NWC is responsible for the extraction of water and bulk water transmission. Yet the WUA may "purchase ***or produce***" water, suggesting that the WUA may also be able to extract water itself without purchasing it from NWC. In the new Water Law, NWC is given the responsibility to sell to "associations", including WUAs. That statement alone, however, does not logically necessitate that associations *must* buy from NWC.

Moreover, the WUA is responsible for the irrigation system, which in the case of the NGEST project, coincides with the bulk water transmission system. In other words, the recovery wells extracting water and the pipes bringing the water to the farm gate can be characterized in one of two ways: 1) as bulk water supply (and therefore under the purview of NWC) or 2) as an irrigation system (and therefore under the purview of the WUA), or some combination thereof.

Below are three scenarios for O&M, which are meant to provide a starting point for discussions by Palestinian stakeholders on how best to run the project.

TERMS

Before introducing the scenarios, there should be some clarification of terms:

"**Recovery System**" includes the 28 recovery wells and 15 monitoring wells.

"**Reuse System**" includes all connecting pipes, two 4,000 m^3 water storage tanks, a booster station with 10 pumps, and an irrigation network of 126km of pipelines, which transports the water from the recovery wells to the farm gate and the water metering system.

"**On-Farm System**" is the infrastructure on each individual farm, including the tertiary pipe network to bring the water from the farm gate to the crops.

INSTITUTIONAL SCENARIOS

For the management of irrigation systems, world experience has generally followed three basic arrangements:

1) the government officials continue to manage the systems after completion;
2) the government turns the systems over to farmers to manage them; or

3) the government and farmers manage the systems jointly, meaning some parts of the physical system (generally the larger elements) are managed by governmental agencies while the smaller ones are the farmers' responsibility.

These scenarios are put into the NGEST context and discussed below.

It should be noted that during this transitionary period, neither NWC nor the WUA exist. It is envisioned, therefore, that CMWU will handle the responsibilities of NWC until it is created and able to function. The WUA, which should be created as soon as practicable, will also be assisted by CMWU until it is ready.

Scenario 1 – Governmental Management

1. In this scenario, the Recovery and Reuse Systems would be owned and operated by the NWC.
2. This would mean:
   a. NWC will own and operate the Recovery System;
   b. NWC will own and operate the Reuse System;
   c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it is a simple, straightforward arrangement, whereby the governmental body that specializes in water distribution handles the supply.

The main detriments of this scenario are that it seems to contradict the spirit (if not the letter) of the law, which envisions a greater role for the WUA, and may perpetuate some of the problems with a centralized, governmental approach.

Countries have historically entrusted the management of their irrigation systems to government agencies, on the assumption that they will have the capacity and motivation to achieve high performance standards. The opposite has proven true, as documented reports and literature have shown the performance deficiencies of many government-managed irrigation systems has increased (see, *e.g.*, World Bank, 1997).

The deteriorated performance of irrigation systems under government agencies is generally the resultant of the following:

- the failure to operate and maintain systems adequately;
- the financial burden of subsidizing agencies to manage the system has become more onerous for many governments due to the low fee recovery rates from farmers;
- major difficulties in maintaining subsidies for irrigation systems that perform sub-optimally;
- difficulties in implementing water pricing and cost recovery as a traditional economic solution of "getting the prices right";
- local information constraints and inappropriate incentives for government employees.

Many of the issues delineated above have been problems in the Gaza Strip, and so significant consideration should be given to whether a governmental approach will achieve the goals of this project.

Scenario 2 – Water User Association Management

1. In this scenario, the Recovery and Reuse Systems are owned and operated by the WUA.
2. This would mean:
   a. WUA will own and operate the Recovery System;
   b. WUA will own and operate the Reuse System;

c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it firmly places control and management into the hands of the WUA. As mentioned above, several benefits are expected to accrue from involving the WUA in owning and managing the network, including greater overall sustainability of the project.

The greatest detriment of this scenario is that NWC (CMWU) is much more knowledgeable and much better positioned to handle the system than the WUA. The WUA will need significant capacity building and technical assistance to step into this role, as discussed below.

For this approach, governments have followed two different methods to hand over irrigation systems to farmers. Some have favored the quick establishment of the WUA and a rapid transfer of responsibilities to it. Most countries, however, have favored a phased handing over, accompanied by training programs for the leaders of the WUA. The general belief is that a phased program has better chance of success and provides more opportunities to change course, if required.

Scenario 3: Joint Management

1. In this scenario, NWC would own (and for the first few years, also operate) the Recovery and Reuse Systems with the ultimate goal of transferring operation and management to the WUA.
2. This would mean:
   a) NWC would own the Recovery System, and operate it for the first three years of the project.
   b) NWC would own the Reuse System, and operate it for the first three years of the project.
   c) During the first three years, the WUA would receive intensive capacity building.
   d) After the first three years of the project, the WUA would assume operation and management of the Recovery and Reuse Systems.
   e) NWC would continue to own the Recovery and Reuse Systems but would lease them to the WUA.
3. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it blends the resources and knowledge of the NWC (CMWU) with the appropriate level of input and phased-in management by the users (WUA).

This scenario also dovetails nicely with the recommended **Investment Scenario 3**, where the capital investments necessary to build both Phase I and Phase II of the Recovery and Reuse schemes would be paid by the government (or by a donor), and the O&M of the Recovery and Reuse schemes and the capital expenditures and O&M of the On-Farm development would be paid by the farmers.

The main detriment of this scenario is that it is a more complex arrangement, necessitating various agreements and contracts between parties to delineate roles and responsibilities.

If this Scenario is chosen, the WUA could contract CMWU to manage the Recovery and Reuse Systems for a limited period of time, say 3 years. Also during that time, the WUA could contract the Union of Agricultural Work Committees (UAWC) to manage the training and extension services to the farmers to establish the executive capacity needed within the WUA.

Complete governmental or complete farmer management are both relatively rare in the world. The in-between option of joint management has become the norm, albeit with different variations. The Consultant recommends that PWA take advantage of world experience and select a joint management model.

WATER USER ASSOCIATIONS

WUAS IN GAZA

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – a “collective well”. Namely, a farmer owns one well and other neighboring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The baseline survey of this Complementary Feasibility Study shows that 92% of the farmers depend on the “collective well” system, owned by the remaining 8%.

Usually, the farmers using a collective well do not sign any formal agreement, neither are they linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmers do not pay his share in due time, thus undermining the efficient operation of the well.

The few existing WUAs in Gaza are generally small and loosely organized. This low level of organization makes it difficult to initiate joint actions. They are also faced with harsh economic and financial circumstances, including limited access to the international market for agricultural products. Greater farmer cooperation under the umbrella of a WUA could yield significant gains.

COMMON TASKS OF WUAS

The main tasks and activities commonly found in WUAs include:

- Choose and specify the water source and take part in the planning, designing and implementation.
- Define the roles and responsibilities to manage, operate and maintain the water source and its structures.
- Solve conflicts among water users by achieving a fair water distribution among the users.
- By mutual control and increased sense of ownership and responsibility, reduce violations over water.
- Take part in the tasks and functions for the management of irrigation projects.
- Help to develop irrigation efficiency at a field and network level, also by facilitating the spread of modern irrigation techniques.

TRAINING NEEDS AND CAPACITY BUILDING

A capacity building program should be carried out to enable the WUA to achieve its mandate.

On-farm technical assistance and training on irrigation topics, in conjunction with best agricultural practice, will be handled by the Ministry of Agriculture and the non-profit organization Union of Agricultural Workers Committees (UAWC).

Table 20: WUA capacity building and training needs; estimated costs for 20 farmers

TOPIC	**NO.** PARTICIPANTS	**DURATION** (Days)	**ESTIMATED** COST (US$)
FACILITATION AND TRAINING SKILLS	10	30	$120,000.00
DESIGN, OPERATION AND MAINTENANCE ON modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc. Basic level.	20	15	$120,000.00
DESIGN, OPERATION AND MAINTENANCE ON modern irrigation technologies, such as on-farm low pressure systems, localized irrigation, etc. Advanced level.	20	10	$80,000.00

DESIGN, OPERATION AND MAINTENANCE OF modern on-farm surface irrigation systems.	20	5	$40,000.00
DESIGN, OPERATION AND MAINTENANCE OF ON-farm drainage systems.	20	7	$55,000.00
ON FARM DRAINAGE, DRAINAGE WATER REMOVAL and conveyance out of the irrigation areas towards the drainage outfalls	20	10	$80,000.00
SOIL science, salt leaching, land reclamation	20	5	$40,000.00
COMPUTER MODELS APPLICATION IN I&D	5	5	$10,000.00
GIS AND REMOTE SENSING APPLICATION FOR improved water management in I&D	5	5	$10,000.00
I&D MANAGEMENT TRANSFER (INCLUDING participatory irrigation management/WUAs formation process and backstopping)	5	15	$30,000.00
STUDY TOUR TO ABROAD (TO BE SELECTED)	5	7	$52,500.00
USE OF THE AGRO-METEO STATIONS NETWORK. Interpretation of weather forecasting and recommendation for farmers	5	15	$112,500.00
IRRIGATION METHODS AND SCHEDULE FOR effective pest and disease control	20	7	$56,000.00
		Total	**$806,000.00**

ECONOMIC SUSTAINABILITY OF WUAS AND COSTS

While they may be entitled to claim subsidies or state assistance, WUAs are usually largely self-financing, the bulk of their income being provided by their participants. For NGEST, it is presumed that farmers will cover the costs related to the WUA's management and basic activities (e.g. office rent, administration staff salaries etc.) from the beginning of the organization. Additionally, farmers are expected to pay the OPEX costs of the recovery and reuse scheme, and any on-farm development. The proposed water tariff options in this Report have been made with these expenditures in mind.

It should be noted that, because they are non-profit, WUA-specific legislation could confer powers on WUAs to take and impose compulsory measures. These can include: the right to impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; the right to make binding operational rules concerning, for example, the use and allocation of irrigation water; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts (FAO, 2007). None of these powers are currently in the Draft WUA Regulation. If they are not included in the final version, some aspect of these concerns must be addressed in whatever contractual agreement is brokered between the WUA and either CMWU or PWA.

Table 21 shows an estimated cost breakdown for the establishment and operation of a WUA (gathering approximately 20 farmers) for the NGEST Water Reuse Scheme.

Table 21: Estimated costs for the establishment and operation of one WUA, for 1 year

ITEM	UNIT	COST (USD)
4X4 CAR	1	25,000 USD
OFFICE AUTOMATION EQUIPMENT FOR	Forfeit	25,000 USD

administrative affairs		
SALARY FOR ADMINISTRATIVE STAFF	1	30,000 USD
RUNNING COSTS	Forfeit	20,000 USD
	Total	100,000 US$

COST SHARING MECHANISMS

Typically, WUA costs include some, or all, of the following:

- The cost of obtaining a permit to abstract and use water and/or to drain water or to dispose of wastewater together with any water use and wastewater disposal charges payable pursuant to such permit;
- Charges in respect of water supplied to the WUA on a contractual basis by a state agency or some other bulk water supplier;
- The WUA's own costs of operating and maintaining the infrastructure under its authority, which may include staff salaries, office expenses (including the costs of rent, utilities and communication), operation costs including the costs of electricity if pumps are used, system maintenance including routine and annual maintenance, the maintenance of an emergency reserve fund, small replacement fund, transport expenses, purchase of equipment, social charges and taxes; and
- Investment costs for the construction, rehabilitation or reconstruction of infrastructure.

As mentioned above, a key feature of WUAs across the world is that they are usually self-funding, at least as far as operating costs are concerned. The typical sources of WUAs finance include fees and charges for services provided by WUAs to its participants as well as loans, grants and subsidies, income from assets or capital owned by WUAs, and fines from participants who have breached its operating rules.

The way in which the level of fees is determined can be left up to WUAs or specified in the relevant legislation. The amounts payable by individual WUA participants can be based on, for example, the volume of water supplied (if the main WUA service is water provision), flat rate charged per hectare of land (in case of a range of different and not easily measurable services provided by WUA), or value of possessed agricultural land. For the NGEST project, a proposal is made to charge the farmers based on the water delivered to their farms at a rate that ranges between 0.9 and 1.5 ILS/m^3. This fee would cover the expenses of the O&M of the Recovery and Reuse Systems and running the WUA organization.

If farmers are not able to pay the fee until after the irrigation season is over and they have harvested their crops, a range of solutions can be applied, such as: participants can pay deposits, the WUAs can borrow money by way of a loan or bank overdraft or issuing bonds, or receiving governmental or other grants.

Ideally, a WUA fund would be established to provide support for the creation and early administration of the WUA (an initial capital of, say, US$ 1 million). Otherwise the WUA may fail due to low membership fees from the farmers in the NGEST project area, most of whom own small plots of land.

RECOMMENDATIONS

- **Immediately pass enabling legislation for the creation of WUAs**

The Draft WUA Regulation from 2016 should be finalized, promulgated and implemented as quickly as possible. The draft Regulation sets out the basic parameters within which the design of each individual WUA can be crafted. Several important legal rights, however, have not been addressed.

One of those legal rights is the long-term right to abstract water from a natural source or, depending on which Scenario is chosen, a long term contractual right with a bulk water supplier (e.g. NWC). As written, the Draft WUA Regulation states that PWA may cancel a WUA’s right to use a water source; it does not say what process or justification would be required for PWA to do so. Moreover, if PWA cancels a WUA's right to use a source, the Regulation states that the WUA will be terminated by the Ministry of Agriculture. This prospect may have a chilling effect in WUA members' willingness to contribute to the long-term investment needs of the system. Although PWA's cancellation may be appealed, if the Association and its work may be terminated at the whim of a ministry, that creates an impression of a less secure institution overall.

Additionally, as mentioned above, WUAs will very often need to have express legal rights to do things like impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts. Without this authority, the work of the WUA may be significantly hampered.

- **International Norms**

To mitigate health and environmental risks, common international norms and standards for the quality of irrigation water should be followed.

STAFFING REQUIREMENTS OF THE PIU

The Project Implementation Unit (PIU) should have a multi-disciplinary technical team. Table 22 illustrates the proposed PIU composition.

The PIU shall assist field activities, and act as coordination unit for related on-farm initiatives. The PIU shall be directly linked with the future WUA that will be established to manage irrigation water distribution.

Table 22: PIU Staff Composition

NO.	AREA OF EXPERTISE	INSTITUTION	QUALIFICATION
1	On farm irrigation technology and water distribution	CMWU	Eng.
2	Land reclamation	CMWU	Eng.
3	Information Technology	CMWU	Eng.
4	Plant Production and Soil Fertility	MoAg	MSc
5	Plant Protection	MoAg	MSc
6	Agro-meteorology	MoAg	MSc
7	Rural Extension	MoAg	MSc
8	Administration		

Expert on On-farm irrigation technology and water distribution

Duties / Responsibilities:

- Review the irrigation requirements and water balance analysis performed and recommend further detailed studies as needed;
- Assist relevant team members in the preparation of work programs and schedules;
- Develop a quality assurance program for civil works for the irrigation component, and train staff on the in implementation of the quality control program;
- Operates power equipment and hand tools to install, maintain and repair irrigation systems and related components including irrigation lines, sprinkler heads, control panels, valves, pumps, etc.;

- Checks system for proper operation and timing. May participate in the design or modification of new or existing systems. Performs seasonal maintenance such as system charging and draining;
- Maintains inventory of related parts and supplies. May lead workers on irrigation projects and work on other grounds related assignments as needed.

Expert on Land reclamation

Duties / Responsibilities:

- Advise farmers about appropriate land management and conservation practices, adapted to the project environment;
- Advise other experts about environmental management and conservation;
- Design specific plans to reclaim non-cultivated areas in the project zone;
- Apply knowledge or research findings to address environmental problems;
- Train personnel in technical or scientific procedures;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Information Technology

Duties / Responsibilities:

- Design, program, and maintain IAS website using HTML5/JavaScript/CSS. Interface with SQL databases as required;
- Maintain Microsoft SharePoint site layout and permissions. Develop custom SharePoint lists and libraries;
- Contribute to Social Media system including creating original content, assisting users in content generation, and account management;
- Interact with and provide services to the other members of the staff in a highly dynamic and occasionally time-critical environment.
- Perform other duties as required.

Expert on Plant Production and Soil Fertility

Duties / Responsibilities:

- Support farmers in designing sustainable and productive cropping patterns;
- Help in crop budgeting & planning;
- Take soil samples, prepare and submit them for testing;
- Review soil test results and provide advice to farmers;
- Inspect crops in accordance with guidance;
- Record crop outcomes as requested;
- Manage required field services such as fertility, soil amendments, crop
- production, and more;
- Maintain crop and financial data in accordance with requirements;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Plant Protection

Duties / Responsibilities:

- Identify plant protection problems in the project area and provide technical support for the promotion of safe and sustainable plant protection activities, based on IPM solutions;

- Design and conduct periodic reviews and appraisals of the situation of plant pest and pesticide problems in the project area and advise farmers on necessary actions to implement pest and pesticide management programmes;
- Provide advice to IAS in training technical personnel through targeted training programmes, workshops and seminars related to plant protection and maintain close relations with international and national research institutions for the transfer of research findings;
- Perform other related duties as required;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Agro-meteorology

Duties / Responsibilities:

- Mainstreaming agro-met advisory services into the agricultural extension system;
- Developing and engaging in the delivery of a training plan to improve skills within the extension system for interpretation and analysis of climate information to inform agronomic advice;
- Developing and engaging in education programs for farmers regarding benefits of agro-met advisory services.
- Supporting integration of agro-met within extension packages.
- Reviewing proposed approaches for dissemination and communication of climate information and feedback.

Expert on Rural Extension

Duties / Responsibilities:

- Encourage farmers to adopt best practice techniques by providing exposure to new knowledge, information, skills, inputs and processes;
- Assess individual farms and making technical recommendations for improved production and sustainability;
- Collaborate with farmers in developing processing and post-harvest schemes;
- Suggest research priorities to research committees;
- Organise and manage field days, speak at grower groups, write fact sheets and publications, present courses;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Administration

Duties / Responsibilities:

- Support team leader in ensuring effective and efficient financial management system;
- Maintain efficient and effective financial system;
- Support in periodic financial planning, including Annual Plan and Budget (APB);
- Supervise general administration of IAS;
- Perform other duties as required.

INSTITUTIONAL CAPACITY ASSESSMENT

There are a number of particular skills that need to be developed for the successful implementation of the NGEST project, including management of MAR and sludge as well as the design, operation and maintenance of modern irrigation technologies. Communication and cooperative approaches should also be fostered through trainings on developing the WUA or community awareness to bolster support for the project.

In order to adequately assess the specific capacity development needs for each aspect of the project, this *Report* has interwoven capacity building throughout each section: Managed Aquifer Recharge; Farmer Assistance; WUAs; and Operation and Maintenance of the Irrigation System. Therefore, although there are recommendations below for Institutional Capacity Building, overall capacity development should be viewed through the context of the entire *Report*.

RECOMMENDATIONS

A capacity development system for the Water Sector in Palestine already exists and a substantial amount of resources are being invested to enhance capacities in this sector (PWA, 2016). Compared to some other countries, where capacity development efforts have to be developed from scratch, Palestine boasts a substantial foundation of sufficiently developed institutions and a high number of human resources investments. Palestinian Universities, polytechnics, industrial secondary schools and vocational training schools produce a constant inflow of trained professionals for the water sector, and international donors have expended considerable sums for training of water sector stakeholders.

However, there needs to be better coordination of capacity development initiatives with policies and strategies so that there is a more efficient utilization of resources and the training better meets the needs of the sector. In particular, PWA, NWC, CMWU and the WUA need targeted capacity building to implement the water law, to make effective and efficient use of increased investments, and to maintain the existing and new infrastructure.

In addition, work needs to be done to create an environment in which skill and knowledge acquisition can take place, including, for example, fostering a professional atmosphere in which technical growth is rewarded and there are incentives for participation, allocating a sufficient budget for on-going development, and ensuring monitoring and follow-up of capacity development efforts.

Below is a truncated list of institutional capacity building recommendations. As mentioned above, for a more detailed analysis of capacity development needs, see the other relevant sections of this *Report*.

Capacity Development Coordination. There is a need for sector-wide monitoring and evaluation of capacity development interventions. The current lack of the monitoring and evaluation is directly correlated with the need for coordination, but also lends itself to the mismanagement of limited resources, decline in performance and loss of value for money spent. It is expected that the newly created Capacity Development Directorate of PWA will lead this coordination as well as execute the recommendations contained in PWA’s Water Sector Capacity Development Policy and Strategy of 2016.

Focus on Practical Skills. There should be increased focus on the development of practical knowledge and competencies to address existing and emerging water sector challenges, for example negotiation with the Joint Water Committee, and how to build, manage, repair and renew a modern irrigation system.

Encourage On-going Capacity Development. Water professionals need to refresh and expand their knowledge base in a number of training days each year to be able to excel in their work. Organizational Capacity Development Action plans, covering a 3-5 year period, should be prepared by the relevant units and persons within the respective organizations. These plans should be approved by the organization itself, endorsed at national level, and updates should be made annually.

Help Prepare CMWU. Because CMWU will likely handle the operation and management of the NGEST Recovery and Reuse schemes until the creation of the NWC and WUA, the capacity of CMWU should be expanded to provide this service. Additionally, there may be the need to modify the current mandate of the CMWU to reflect this change.

Sludge Management. Training is needed that tackles sludge collection, treatment, or dumping and sludge management. Sludge represents a completely new sector, which should be organized and well regulated in order to benefit from it.

MAR Training. A simplistic view that treating water to near drinking standards before recharge will protect the aquifer and recovered water is incorrect. For example chlorination, to remove pathogens that would be removed in the aquifer anyway can result in water recovered from some aquifers containing excessive chloroform. In some locations, drinking water injected into potable aquifers has resulted in excessive arsenic concentrations on recovery due to reactions between injected water and pyrite containing arsenic. Source water that has been desalinated to a high purity dissolves more minerals within the aquifer than water that has been less treated (Dillon, 2009).

Therefore, PWA (and any other ministry that will be responsible for the MAR scheme) needs to understand how this aquifer will interact with the recharged water. More specifically, it should have hydrogeological and geotechnical knowledge, as well as knowledge on water storage and treatment design, water quality management, hydrology and modelling, monitoring and reporting. It needs to understand pathogen inactivation and biodegradation. The response of an aquifer to any water quality hazard depends on specific conditions within the aquifer, including temperature, presence of oxygen, nitrate, organic carbon and other nutrients and minerals, and prior exposure to the hazard, so the Authority should receive adequate training on these subjects.

Additionally, PWA (and any other ministry that will regulate the MAR scheme) should acquire basic stratigraphic and hydrogeological information for each well drilled. This information should be stored in departmental data bases, which would ideally be publically accessible on the web.

Create a MAR Unit. The human resources at PWA are limited as the number of staff is already not sufficient to perform all needed tasks (e.g. data evaluation, quality control) let alone to fulfil new tasks related to MAR. Therefore, it is recommended to create a MAR unit to handle strategic planning and the oversight of MAR activities.

FARMER CAPACITY BUILDING

PRESENT FARMERS' ORGANIZATIONS

The Union of Agricultural Work Committees (UAWC) is the main organization[7] active in the project area, already working with a few farmers. UAWC is a non-profit organization founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union aims to help Palestinian farmers to market their produce and provides agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions.

Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors, in the West Bank and Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in different Palestinian rural areas. UAWC receives funding from numerous western governments and aid organizations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organizations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like MoAg. Relationships are also established with international development agencies, like FAO.

The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, such as land reclamation; building greenhouses; products quality enhancement and new crops introduction. Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistical and financial support for exporting goods such as strawberries and medical herbs, which usually ensure a good revenue.

[7] Other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

IMPROVING FARMERS TECHNICAL SKILLS

The farmers interviewed during the baseline survey stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.

According to the outcomes of the baseline survey and the agronomic characteristics of the new proposed irrigated cropping system, the following training and technical assistance needs have been identified for the farmers:

Training on appropriate use of irrigation. So far, the irrigation practice has been left in the domain of individual farmers without any technical assistance. Underground water is being managed without considering the actual water requirements of crops, after computing the water balance of the area. Without an appropriate approach to irrigation, the amount of water supplied to crops is often under- or overestimated hence causing low yields and problems of uncontrollable pests and diseases on the cultivated crops. The envisaged training program has the objective to make the farmers fully capable to design an irrigation plan suitable for their cropping pattern for various irrigation methods (e.g. surface, sprinkle or drip irrigation).

Training on integrated pest management (IPM). It has been observed that use of pesticides on crops is often high in north Gaza, although these products are quite expensive since imported from Israel. Pests outbreaks are common in the target area, probably because of irrigation misuse (see above). However, farmers lack specific knowledge on effective methods for preventing pests and diseases, which should allow them to drastically reduce the amount of sprayed pesticides, so saving money and making the farming environment healthier. The IPM method has been conceived in the ’70. It is a pest control strategy that uses a variety of complementary strategies including: mechanical devices, physical devices, genetic, biological, cultural management, and chemical management. These methods are done in three stages: prevention, observation, and intervention. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. IPM practices have been so far successfully implemented on vegetables and fruit tree crops in the Middle East. These crop groups represent 65% of the new cropping pattern proposed for the project.

Training on Integrated Plant Nutrient Management (IPNM). This methodology has been devised by the Food and Agriculture Organization of the UN. It allows to match crop nutrient needs with sufficient accuracy to prevent surplus of fertilization. This in turn limits soil and water chemical pollution which usually is a consequence of the use of mineral fertilizers. The purpose is to maintain or enhance soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients, including biological nitrogen fixation. IPNM focuses first on the seasonal or annual cropping system (namely, the entire crop rotation applied by a farm), rather than on an individual crop; secondly, on the management of plant nutrients in the whole farming system; and, thirdly, on the concept of village or community areas rather than individual fields. The proper application of IPNM, among others, allows to minimize the use of mineral fertilizers which are particularly costly in Gaza, because imported from Israel.

Farming field schools (FFS) for effective training on IPM and IPNM. The Farmer Field School is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It was initially developed to help farmers tailor their IPM practices to diverse and dynamic ecological conditions, but subsequently the method has embraced also other relevant topics for improving farmers’ technical skills. In regular sessions from planting till harvest, groups of neighboring farmers observe and discuss dynamics of the crop’s ecosystem, under the guidance of a facilitator (usually an agricultural extensionist, well trained on running a FFS). Simple experimentation helps farmers further improve their understanding of functional relationships within the agro-ecosystem (e.g. pests-natural enemy population dynamics and crop damage-yield relationships). In this cyclical learning process, farmers develop the expertise that enables them to make their own crop management decisions. Special group activities encourage learning from peers, and strengthen communicative skills and group building. Farmer Field Schools for vegetable crops have been successfully implemented by FAO in Egypt, Jordan, Syria, Iraq and in Palestine (West Bank).

BUILDING FARMERS' CAPACITY ALONG THE VALUE CHAIN

Supporting farmers in establishing organizations. Collective action can create a more effective market chain that is more stable and can produce the products required at the time needed and of the quality wanted. As a group, producers can provide a more stable and higher quality supply of raw material, which also improves the economic efficiency of the value chain. The higher bargaining power and improved access to markets for group members are made possible by creating a link with other actors along the chain (retailers, traders and processors). However, a farmer organisation cannot be simply created by a top-down approach from the government (for example, by providing strong subsidies to farmers if they join an organisation; or providing inputs for free). Many worldwide experiences clearly show that farmers organisations (under the shape of cooperatives, associations, etc.) fail when members are not fully convinced that collective action is really an opportunity for them to grow and improve their lives. Farmer organisations also fail when their members do not firmly aim at economic independence, but rather rely on external aid. The survey carried out in the project area highlighted that farmers work on individual basis. Even when they share collectively the same private well, everybody keeps on working on his own. It is also noted that only one organisation is existing in the project area, joining a small number of farmers.

To cope with this reluctance toward cooperation, farmers should be invited - through a tailored training programme - to progressively share their activities. For instance, an initial stage of farmer collective action may be started just by purchasing the farming inputs together, which will allow a discount from the seller. Then, farmer collective action can further evolve in growing crops together, according to a cropping plan that has been specifically designed to meet the market needs in a certain period of the year. When collective crop production is finally carried out relationships with the merchants (wholesalers, traders at any level of the supply chain) can be strengthened and options of contract farming may become feasible. Furthermore, associated farmers may start processing the raw materials and their marketing action will become more targeted and complex. By following this progressive process, the farmers' organisation purchasing power and its share of added value along the supply chain will increase.

Training on post-harvest operations and food processing and establishing suitable physical structures. This training programme requires high investments and well established farmer's organisations, which will handle the operations and run the post-harvest and processing structures. The survey carried out by the consultant highlighted that in northern Gaza the existing food industries do not buy raw food materials from the local farmers but they rather import it from Israel, probably because the industry cannot find the required amounts according to its needs. While this specific demand from the industry could be properly satisfied by an organised group of farmers (see above), on the other hand organised and well trained farmers could start simple post-harvest processing activities, such as sorting and packing fresh fruit and vegetables; preparing plant preserves, purée, jams, etc. Another option would be processing dairy products, considering the good milk production from cows, sheep and goats which are being reared in the project area.

All the above-mentioned activities will improve products quality and introduce new products into the local market which will increase the farmers' earnings.

However most of the farmers seem they cannot afford the cost of the initial investment (e.g. purchasing a refrigerator unit, packaging materials, other equipment for processing), nor bank loans seem available in north Gaza. Therefore, external aid should be foreseen together with sound training sessions.

MANAGED AQUIFER RECHARGE

Managed aquifer recharge (MAR), also known as enhanced recharge, water banking and sustainable underground storage, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can be used to store water from various sources, such as stormwater, reclaimed water, mains water, desalinated seawater, rainwater or even groundwater from other aquifers. With appropriate pre-treatment before recharge and sometimes post-treatment on recovery of the water, it may be used for drinking water supplies, industrial water, irrigation, toilet flushing, and sustaining ecosystems. The figure below shows the basic MAR process for an unconfined aquifer.

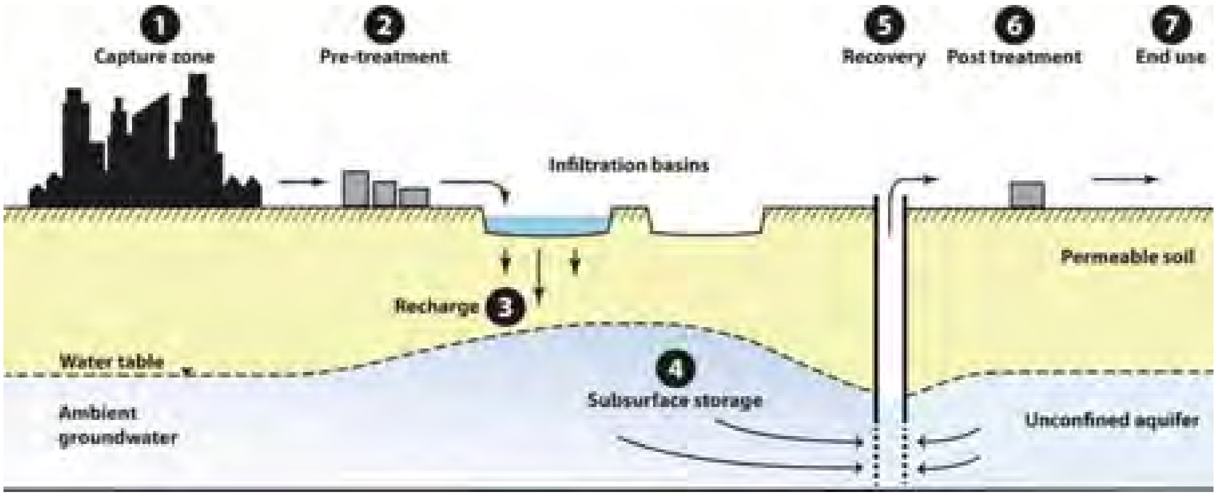


Figure 18: Schematization of Managed Aquifer Recharge System (Source: Dillon, 2009)

Several past documents describe the NGEST Project as if it is a treated-wastewater-for-irrigation project. It is not. Rather, it is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation. The difference is significant and has considerable implications for the feasibility and sustainability of the project. Outlined below are some of the central considerations and concerns for managing this segment of the project.

REGULATORY ISSUES

The main objectives of MAR regulations should be the protection of groundwater from pollution and the assurance of public health. Topics covered in a regulatory framework often include technical issues, water quality requirements to protect groundwater and human health, regulations on the authorization to recharge and to recover water, and institutional arrangements (NRC, 2008).

The quality of the water extracted from the aquifer should meet the most stringent standards related to the intended water use. The quality of the water of a recharged aquifer is a function of multiple factors, including:

- the quality of the recharge water;
- the recharge method used;
- the physical characteristics of the vadose zone and the aquifer layers;
- the water residence time;
- the amount of blending with other sources;
- the history of the recharge.

Setting requirements for indirect recharge is not an easy task. The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, thanks to retention and oxidation processes. These processes affect organic matter, nutrients, microorganisms, heavy metals and trace organic pollutants. However, though much is known about these processes (Bouwer, 1996; Drewes & Jekel, 1996), forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is complex. Performances depend on a number of factors such as depth of the unsaturated zone, physical and mineralogical characteristics of the soil layers, heterogeneity, hydraulic load, infiltration schedule and infiltrated water quality (Dillon, 2009).

Therefore, particularly when transfer through the vadose zone is part of the treatment intended to bring the water up to the required water quality, pollutant removal tests should be performed, at the laboratory and onsite, to ensure the water achieves the desired quality. The example of the Dan Project in Israel shows that submitting secondary effluents to a Soil Aquifer Treatment system in a dune sand aquifer can result in the production of a nearly potable water (Sack, Icekson-Tal & Cikurel, 2001).

The complexity of reactive transport processes in the unsaturated zone highlights two of the main stumbling blocks that must be taken into consideration if treated wastewater is being considered for MAR: one specific challenge is to have numerical models that can include all of the hydro-biogeochemical processes involved in reactive transport, while a second, more operational, is the need to have a complete biogeochemical and hydrogeological characterisation specific to each MAR site. These should be taken into consideration in assessing the capacity building needs of PWA and other stakeholders involved in managing the NGEST project.

Several countries (the United States and Australia, for example) have developed guidelines for the use of treated wastewater for recharge (USEPA 2004, 2012; WHO 2006a, b). These guidelines focus mainly on the health and environmental risks that result from the presence of pathogenic microorganisms, suspended solids and dissolved organic carbon in this water. There are few recommendations concerning trace element contents in water (e.g. USEPA 2012), except as concerns five trace metals. These are: (i) arsenic; (ii) nickel, which is only weakly toxic but which accumulates in plants; (iii) cadmium, which is considered to be the metallic pollutant of greatest concern due to its rapid accumulation in plants and its proven toxicity even at low concentrations (acceptable daily intake (ADI) 0.057 mg/day/individual); (iv) mercury, which can be highly mobile; and (v) lead, the injection of which, even at low doses, can cause neurotoxic and hepatotoxic disturbances (Dillon et al. 2009a).

Although these guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse. Land use planning and environmental impact assessment legislation add to the complexity of the regulatory frameworks currently available for MAR schemes.

Under many countries prevailing water resources legislation (e.g. Israel, South Africa, Spain, USA, Australia), groundwater which has been recharged with TWW is subject to the extraction and management rules of native groundwater, and is regulated accordingly through abstraction licenses or concessions from the un-differentiated groundwater pool.

IMPLICATIONS FOR THE APPLICATION OF PALESTINIAN WASTEWATER REGULATIONS

The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater. As has been discussed in past NGEST documents, the Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced. There has been some expressed concern whether this regulation applies to the NGEST irrigation scheme, which would significantly restrict the types of crops farmers could grow in the project area and, as a result, have severe implications for the financial sustainability of the project.

But the concern of whether the regulation applies to the irrigation scheme stems from the misunderstanding of the nature of this project highlighted at the beginning of this section. The NGEST project does not entail using treated wastewater for irrigation *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. The recovered water, therefore, is no longer “treated wastewater,” and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.

That being said, the regulation also covers the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A"). See the below Table 23 for the basic parameters for each category.

Table 23: Palestinian reuse standards (PS 742/2003)

CLASS	QUALITY	BOD MG/L	TSS MG/L	**FEACAL** Coliform MPN/100ml
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000
D	Low	60	90	1,000

The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.

The project, therefore, is in complete compliance with the Palestinian regulation, so long as the water quality parameters for aquifer recharge are met.

OPERATION AND MAINTENANCE

Clogging is the most limiting technical problem in artificial recharge and can only be managed with regular maintenance and pretreatment. Clogging can be caused by various mechanisms like physical clogging by suspended solids, chemical clogging due to precipitation or clay dispersion, mechanical clogging due to entrapped air or biological clogging due to microbial growth (Bouwer, 2002). Clogging leads to the decrease in porosity and hydraulic conductivity and is experienced at the bottom of infiltration basins as well as around injection wells. There are two basic principles for the management of clogging: (a) pretreatment of recharge water and (b) redevelopment (Brown et al., 2006).

Apart from maintenance related to clogging, regular inspections of the facility are needed to assess if any repair works or cleaning is needed. This could include the cleaning of any screens, change of batteries, lubrication or replacement for equipment prone to wear and tear, repair of damage done by natural forces or vandalism. If mechanical or electrical parts are involved their proper functioning needs to be tested.

RECOMMENDATIONS

REGULATING EXTRACTION

MAR is one of the measures that can be implemented to secure water supply, compensate for some effects of climate change and, more generally, handle the quantity and quality of groundwater bodies. It is not, however, a substitute for groundwater management based on decreasing abstraction and adapting withdrawal to resource availability.

There are a number of private wells in the Gaza Strip, only some of which are officially registered. Thousands of wells are estimated to have been drilled without authorization, which has contributed to more rapid deterioration of the aquifer. (UNEP, 2014) To protect the aquifer and for the success of the NGEST project, both the authorized and unauthorized agricultural wells should cease operation.

In order to do that, PWA, which is the institution responsible for issuing and renewing licenses for agricultural wells, plans to include a new clause in the next annual renewal of licenses that specifies that the operation of an agricultural well should be stopped when reuse water is available. At the same time, the voluntary adhesion to the new irrigation scheme shall be pursued.

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

MAR TRAINING

There are various institutes within the Gaza Strip that currently provide training regarding water and wastewater management. These institutes should be encouraged to establish short courses for MAR operators and regulators. These could also help ensure risk management plans are designed and implemented effectively and management issues are understood and addressed.

More is said on the needs of MAR training in the section on Institutional Capacity Building.

AQUIFER PROTECTION

It is recommended to develop a holistic MAR strategy and to implement transparent and comprehensive regulations specifying maintenance, monitoring and reporting requirements. Regulations should also address water allocation, ownership issues and demand management.

GROUNDWATER MONITORING

OVERALL MONITORING STRATEGY

Before preparing a groundwater monitoring plan, the overall strategy of the groundwater monitoring program should be defined to guide the development of the plan. In this sense, “strategy” refers to the manner in which a hypothetical release from a regulated unit will be detected or measured. Examples of issues that should be addressed when developing a monitoring strategy include:

- The type of monitoring data needed;
- The locations (both horizontal and vertical) from which the samples are to be collected (i.e., definition of “target monitoring zones”);
- The manner in which the samples will be obtained; and
- The ability of the monitoring features to rapidly detect a change in groundwater quality.

Development of a groundwater monitoring strategy is illustrated in Figure 19 and Figure 20. As shown in these figures, the potential sources of contamination and the aquifer of concern should be characterized before developing a groundwater monitoring strategy because selection of target monitoring zones cannot be made until the source and the aquifer have been evaluated, usually through a detailed hydrogeological evaluation of the site. When evaluating the ability of a monitoring system to rapidly detect a release from a potential source, the impact of preferential flow paths and vertical gradients should be carefully evaluated; a two-dimensional analysis of groundwater elevation may not reveal actual upgradient or down gradient locations of groundwater flow. The presence of vertical gradients may significantly effect the selection of monitoring locations.

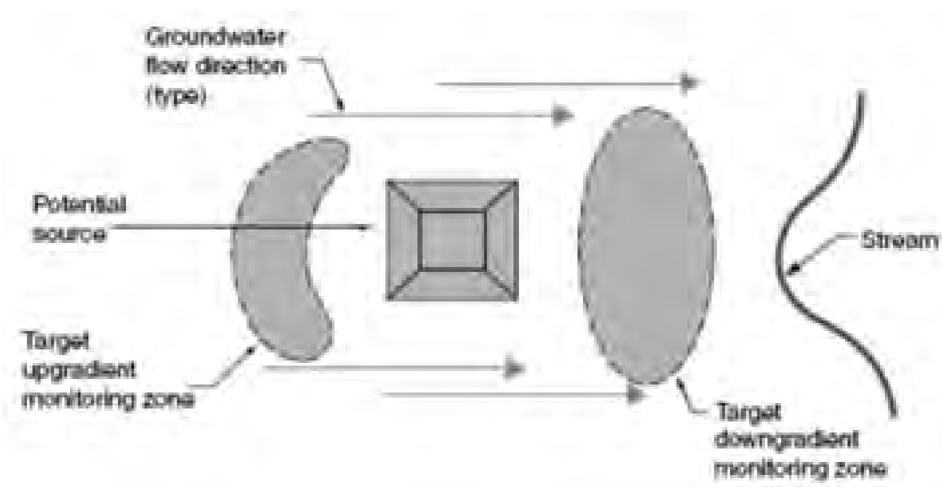


Figure 19: Plan view of typical unconfined aquifer groundwater monitoring system

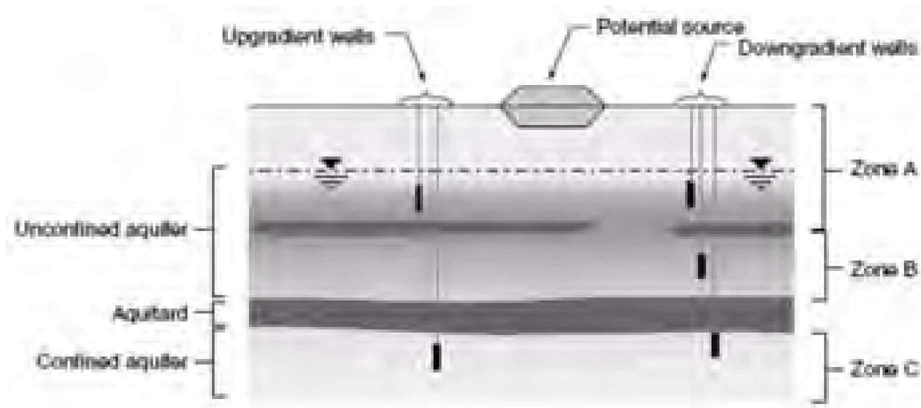


Figure 20: Vertical cross section of target monitoring zones.

MONITORING LOCATIONS AND PARAMETERS

Locating the appropriate monitoring point locations is essential in designing a monitoring network capable of providing data of adequate quality. Selected monitoring locations should provide the most reliable data needed to detect or assess a groundwater contaminant plume. To verify that the monitoring network can accomplish this goal, target monitoring zones must be selected based on the site hydrogeologic conditions and anticipated contaminant pathways. Figure 21 shows the recommended locations of the monitoring wells which was set up based on the location of the recovery wells.

The groundwater monitoring program in the NGEST Project is designed to evaluate the status of the groundwater quality after infiltration of partially treated and treated wastewater. The monitoring wells are distributed in two rows: around 400 to 500 m from the infiltration basin and the second row will be of 1100 to 1200 m from the basin. The first monitoring well row should be located before the first row of the recovery wells in the direction of the infiltration basin, and the second row of the monitoring wells should be located after the second row of the recovery wells to check the quality of groundwater outside the recovery wells areas. The monitoring network will also use the existing 5 monitoring wells constructed recently by PWA and used to monitor the infiltration basin. In addition, the recovery wells will be part of the monitoring network as shown in Figure 21.

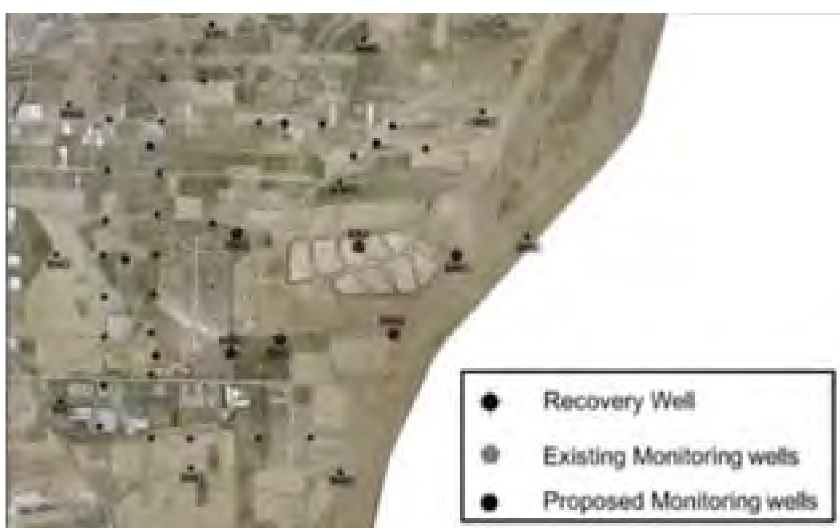


Figure 21: Monitoring wells location

The main objective of monitoring is to check the groundwater quality after infiltration and check the operation of SAT process. The consultant made extensive reviews of similar projects such Gosh Dan Project where several parameters are monitored. Among these parameters, the consultant proposed in Table 24 some parameters which would reflect the status of groundwater after infiltration and could be analysed in Gaza Strip laboratories.

Table 24: Monitored Parameters and Frequency of Monitoring

WATER LEVEL	Monthly
PH	Four Times a year
TDS	Four Times a year
BOD	Four Times a year
COD	Four Times a year
DOC	Four Times a year
TC	Four Times a year
AMMONIA AS N	Four Times a year
NO_3	Four Times a year
NO_2	Four Times a year
T.N	Four Times a year
CL	Four Times a year
DETERGENT	Four Times a year
F.C	Four Times a year
PHOSPHORUS	Four Times a year
HEAVY METALS	Four Times a year
O_2	Four Times a year
NITROGEN AND OXYGEN ISOTOPES	Four Times a year
MG	Four Times a year

Samples will be collected from the monitoring wells to characterize the geochemistry of groundwater. The nitrogen and oxygen isotopes of groundwater nitrate will be used in conjunction with other geochemical data to place constraints on potential nitrate sources.

CONCLUSION

This *Complementary Feasibility Report* brings mostly good news. By reworking the original design, the project can save 21.5% of the water use while using 15% less energy, and can operate with a less complex irrigation schedule. It was determined that the project is in full compliance with Palestinian law, and should be financially sustainable by farmers. The review resulted in a new cropping pattern and design network, and offered a range of scenarios for the water tariff and O&M of the Recovery and Reuse Systems.

This *Report* also confirmed the validity of the original design for the recovery scheme and of the original design for the reuse scheme, confirming the selection of materials, the general layout and the selection of the pumping system. The newly proposed system fixes design inconsistencies of the original so that a minimum water pressure of 2.5 bars is provided to every farm gate.

The good news, however, is contingent. The water and energy savings, simplified irrigation schedule, and farmer profitability are contingent on improving the original design of the reuse scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern. The project's compliance with Palestinian law is contingent on a minimum level quality of water coming from the WWTP and being disposed of in the infiltration basins. And the project's feasibility overall is contingent on carrying out robust capacity building for ministerial and farmer stakeholders, and of adequately monitoring the Managed Aquifer Recharge component of the project.

Ultimately, therefore, the feasibility and success of the project hinge on whether all the essential stakeholders cooperate to fulfill their role.

ANNEXES

ANNEX 1: DRAFT MOU

A Memorandum of understanding (MOU) is a document describing a bilateral or multilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action. It is often used to establish a clear understanding of how common activities will practically function and each party's role and compensation. The contents of an MOU must (a) identify the contracting parties (b) spell out the subject matter of the agreement and its objectives (c) summarize the essential terms of the agreement, and (d) must be signed by the contracting parties.

Similar to a contract, a memorandum of understanding is an agreement between two or more parties. Unlike a contract, however, an MOU need not contain legally enforceable promises. While the parties to a contract must intend to create a legally binding agreement, the parties to an MOU may intend otherwise. For example, an MOU may recite that the parties "agree to promote and support the joint use of facilities." This type of provision establishes an important public statement of cooperation, but it does not constitute a legally enforceable obligation. Alternatively, an MOU may outline the terms of an agreement but state that each party's responsibilities are only enforceable "in the event that the parties' decide to enter a joint use agreement." Additionally, a non-legally binding MOU may be useful to serve as an agreement between two or more departments within a single public entity where a contract may not be legally appropriate.

Although there can be legal distinctions between contracts and MOUs, there may be no legal or practical difference if they are written with similar language. The key is whether the parties intend to be legally bound by the terms of the agreement. If so, they have likely created a legally enforceable contract regardless of whether they call it a contract or an MOU. Therefore, parties should address the legal status of their agreement early in the negotiation process.

Successful MOUs require a lot of thought, effort, and cooperation to reach agreement on a range of issues. In addition to the subjects listed above, an MOU can also cover issues such as: (a) who bears responsibility for the costs of maintenance and repairs, (b) insurance and liability, (c) staffing and communications, and (d) conflict resolution. Below is a sample MOU which lays out the basic provisions of an agreement. To agree on any specifics, however, it is highly advised that the parties meet to discuss the terms of the MOU, ideally with a mediator, facilitator or other neutral third party.

Sample

MEMORANDUM OF UNDERSTANDING

BETWEEN [AGENCY]

AND [AGENCY]

1. **Parties.** This Memorandum of Understanding (hereinafter referred to as "MOU") is made and entered into by and between the [agency name], whose address is ______ , and the [agency name], whose address is ______ .

2. **Purpose.** The purpose of this MOU is to establish the terms and conditions under which the NGEST Project partners will coordinate and function.

3. **Duration of MOU.** This MOU shall become effective upon the last signature by the authorized officials from the (list partners) and will remain in effect until modified

or terminated by any one of the partners by mutual consent. In the absence of mutual agreement by the authorized officials from (list partners), this MOU shall end on (end date of partnership).

4. **Responsibilities of [agencies]**. [Delineate all obligations of the first party listed above. Include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, beneficial use of equipment belonging to other agencies while acting pursuant to this MOU.]

5. **Responsibilities of [other agencies].** [Delineate all obligations of the other agencies listed above. Identify the agency covered by this MOU, and include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, benefits and use of equipment belonging to an agency while acting pursuant to this MOU.]

6. **General Provisions**
   A. Each Party pledges in good faith to go forward with this MOU and to further the goals and purposes of this MOU, subject to the terms and conditions of this MOU. The Parties shall attempt to resolve disputes through good faith discussions.
   B. Either Party may unilaterally withdraw at any time from this MOU by transmitting a signed writing to that effect to the other Party. This MOU and the public/private partnership created thereby shall be considered terminated sixty (60) days from the date the non-withdrawing Party actually receives the notice of withdrawal from the withdrawing Party.
   C. By mutual agreement, which may be either formal or informal, the Parties may modify the list of intended activities set forth in Paragraph 4.0 above and/or determine the practical manner by which the goals, purposes and activities of this MOU will be accomplished. However, any modification to any other written part of this MOU must be made in writing and signed by both Parties or their designees. Applicable Law. The construction, interpretation and enforcement of this MOU shall be governed by the laws of the State of Palestine. The courts of the State of Palestine shall have jurisdiction over any action arising out of this MOU and over the parties.
   D. Entirety of Agreement. This MOU, consisting of [insert number], pages, represents the entire and integrated agreement between the parties and supersedes all prior negotiations, representations and agreements, whether written or oral.
   E. Severability. Should any portion of this MOU be judicially determined to be illegal or unenforceable, the remainder of the MOU shall continue in full force and effect, and either party may renegotiate the terms affected by the severance.
   F. Third Party Beneficiary Rights. The parties do not intend to create in any other individual or entity the status of a third party beneficiary, and this MOU shall not be construed so as to create such status. The rights, duties and obligations contained in this MOU shall operate only between the parties to this MOU, and shall inure solely to the benefit of the parties to this MOU. The provisions of this MOU are intended only to assist the parties in determining and performing their obligations under this MOU.

The parties to this MOU intend and expressly agree that only parties signatory to this MOU shall have any legal or equitable right to seek to enforce this MOU, to seek any remedy arising out of a party's performance or failure to perform any term or condition of this MOU, or to bring an action for the breach of this MOU.

Partner name

Partner representative

Position

Address

Telephone

E-mail

Partner name

Partner representative

Position

Address

Telephone

E-mail

Date:

(Partner signature)

(Partner name, organization, position)

Date:

(Partner signature)

(Partner name, organization, position)

ANNEX 2: WATER SUPPLY CONTRACT COMPONENTS

Either CMWU or NWC will need to sign a bulk water supply agreement with the WUA. Given the complexity and legal sensitivity of such an agreement, an actual contract is not included here. Instead, below is a list of thirteen areas that should be covered in any future water supply contract. This list is not exhaustive (it doesn't include boilerplate contract components, for example) but it does cover the items most needed for a comprehensive agreement.

1. Price and non-price terms

A bulk supply agreement should include both price and non-price terms so that the parties know what services are being provided at what price.

The price terms could include:

- a standing charge and volumetric rate for each water supply;
- charges for any volumes of water the WUA takes that are above the maximum amount allowed in the agreement;
- a minimum charge that the WUA pays whether it takes any water or not;
- a capital contribution to the connection cost;
- charges for the provision of information; and
- rules about the periodic adjustment of charges.

The non-price terms could include the ownership and responsibility for the assets used in the supply (discussed below), how charges are to be paid and how the parties are to operate the bulk supply.

2. Ownership of and responsibility for the assets

The agreement should be clear about who owns and who is responsible for operating the assets that are used to provide the bulk supply (which will depend on which Scenario is chosen). One way of doing this would be to include a detailed operational plan, which, as well as defining ownership and operating responsibilities, could include details such as maximum flow rate. This information will help in resolving any operational problems and will have a bearing on the price terms of the contract.

3. Measuring the water supplied

A bulk supply agreement should specify how the water supplied is to be objectively quantified. In this case, a meter will likely be used, which will need to measure the water supplied to the degree of accuracy specified in the agreement. To ensure the accuracy of meter readings, meters should be tested (ideally, the type of test should also be specified in the agreement). Even with testing, there can be occasions when a meter is found to be faulty. To prevent a possible impasse between the parties the bulk supply agreement could specify the mechanism for determining the volume of water supplied in this case.

4. Quality of the water supplied

The agreement usually states the quality of the water to be provided and how it is to be assessed. This could be done by specifying the water quality parameters the non-potable water should meet. It is the WUA receiving the bulk supply that is responsible for the quality of water supplied to its customers (the farmers) but NWC (CMWU) must inform the WUA of any events that might lead to harmful water being supplied.

5. Adjusting prices

Price terms can be set in different ways. For example, some bulk supply agreements include volumetric charges for the supply of water. Other bulk supply agreements include contributions to the capital costs of building the bulk supply assets or the ongoing costs of operating the bulk supply.

As well as setting out the price terms, the bulk supply agreement might also explain how those price terms are to be adjusted to allow for inflation. Typically, bulk supply agreements include provisions for annual adjustments to the price terms to allow for inflation, although the parties could agree different frequencies of adjustment. The adjustments could be by set amounts, percentages or linked to measures of specific costs or general inflation. If the parties agree that no adjustment is to be made to the price, they could set this out for clarity.

6. Interruptible or firm supply

The bulk supply agreement should include details of any allowed interruptions. It would need to explain the number and duration of interruptions that NWC could make and under what conditions interruptions could happen. There might be a link between when NWC can make interruptions and interruptions for planned maintenance, emergencies and water shortages.

7. Interruptions of supply to carry out planned maintenance

Planned maintenance can disrupt the flow of water from NWC to the WUA. The WUA will want to know when maintenance will happen so that it can make alternative arrangements to supply the farmers.

The bulk supply agreement could put a requirement on NWC to minimize the frequency and length of any disruption to the bulk supply as a result of planned maintenance work. The agreement would need to define what is meant by ‘planned maintenance’.

The agreement might set out the process by which NWC would consult the WUA over the timing of planned maintenance. It could specify how far in advance NWC should notify the WUA of the planned maintenance. The agreement might also allow a reasonable period for the WUA to express its views and could require NWC to consider them before making a final decision on the timing and duration of the maintenance.

8. Co-operation in emergency situations

Emergency situations could arise during the period of a bulk supply agreement that affect the quality of the water supplied, the volumes of the water supplied or some other aspect of the bulk supply agreement. It would be helpful if the agreement defined what is meant by an ‘emergency’ and explained how the parties would deal with one.

Obligations on parties to cooperate in an emergency could include:

- cooperating to prevent an emergency from occurring;
- notifying the other party of the existence and cause, if known, of the
- emergency;
- ensuring, as far as is reasonably practicable, that any emergency has the minimum possible effect on the supply of water;
- agreeing reductions in supply where this is reasonable to prevent or mitigate the effects of an emergency;
- ensuring that priority is given to vulnerable customers if a supply of water is restricted because of an emergency, and co-operate in agreeing categories of vulnerable customers;
- using all reasonable endeavors to restore the supply;
- investigating the cause of an emergency that has occurred; and
- sharing any lessons learned to prevent a recurrence of the emergency.

9. Co-operation at times of water shortage

The agreement could specify what is to happen during a time of water shortage. It might also place an obligation on both parties to cooperate in such situations.

The terms relating to water shortages could include:

- a definition of the circumstances under which NWC may limit the water it supplies under the agreement;
- an obligation for NWC to notify the WUA if it intends to impose a temporary ban on the use of water by some or all of its customers; and
- provisions relating to the actions the WUA should take to reduce water taken from the bulk supply in the event of a water shortage.

10. Liability for planned and unplanned interruptions

To give the WUA comfort that it would be adequately compensated for losses arising due to unplanned non-emergency interruptions, the agreement might include categories of costs such as:

- costs incurred in securing alternative sources of supply. The parties may wish to include a non-exhaustive list of potential alternative sources that would need to be deployed – for example, tankered water supplies; and
- GSS (guaranteed standards scheme) payments to customers.

To provide greater certainty, the agreement might allow for liquidated damages, that is, an estimate in advance of the losses the WUA might incur if the supply was not made available. To limit NWC's risk exposure, the liabilities in the agreement might be capped.

11. Duration

It might take many years for the revenues from the bulk supply to cover the cost of the dedicated bulk supply assets. A bulk supply agreement might therefore need to be long enough to allow for the parties to recover the costs of the assets. On the other hand, a long duration agreement can create problems if circumstances change and the agreement is no longer beneficial for one or both parties.

12. Dispute resolution

Disputes might arise from time to time with regard to the bulk supply agreement. It would be sensible for the agreement to include a provision to resolve disputes. It is best if this is comprised of an internal escalation process that must be followed before a matter may be referred to arbitration, the courts or some other form of formal adjudication.

Some energy contracts specify a time limit after which a party cannot raise a dispute about the other party's previous performance of the contract. For example, the contract might specify that parties must raise a dispute about an incorrect payment within a year of the payment being made.

13. Termination

The agreement should set out how it can be terminated by either or both parties. Ways in which a bulk supply agreement could be terminated include:

- on a date specified in the agreement;
- on either party giving a specified period of notice;
- by mutual agreement;
- if the WUA is terminated;

- if there is a material breach of the contract that is not remedied. A material breach could include repeated failure to pay on time or a one-off failure to pay on time which was not corrected within a specified period, or a persistent failure to supply.

ANNEX 3: SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT

INTRODUCTION

The summary below was prepared as part of the deliverable "Supplementary Environmental and Social Impact Assessment (SESIA)", which involved the preparation of an independent ESIA of the North Gaza Emergency Sewage Treatment Project (NGESTP), Effluent Recovery & Reuse System and Remediation Works.

The specific objectives related of this SESIA were as follow:

- Highlight the legislation under which the project will be implemented. Besides the Palestinian Laws and Regulations, the study also highlighted the Regional Laws and Regulations, especially from Jordan, Israel and Egypt, associated with wastewater reuse and sludge management and reuse. In addition, the International Standard and Guidelines, including World Bank (WB) procedures and FAO and WHO Guidelines were highlighted.
- Provide baseline environment and socio economic conditions of the project components.
- Identify of the possible positive and negative social impacts, permanent or temporary, of the project components. In addition, the analysis and mitigation measures will be developed to reduce the negative impacts resulted from the project component.
- Identify of any potential temporary or permanent land acquisition requirements associated with civil works. In addition, develop the outline of the vulnerable groups that might be affected by the project and identify the appropriate mitigation measures
- Develop an Environmental and Social Management Plan (ESMP) and monitoring plan to manage, mitigate and monitor any possible negative impacts. Moreover, a capacity assessment of the implementing party to implement the ESMP and recommendations for any capacity-building needs

In addition, as assessment was made for sludge management for the sludge resulting from the North Gaza Wastewater Treatment Plant (NGWWTP) and intended to be used in agriculture as part in the effluent recovery and reuse scheme or in emergency cases to be dumped to landfill.

The study was undertaken throughout July - October 2012. The team developed a cross-sectional study that used a multi-data source approach including site visits, primary data, secondary data, surveys and site measurements.

ENVIRONMENTAL BASELINE CONDITION OF THE PROJECT COMPONENTS

a. General Characteristics of the Project areas

Beit Lahia Wastewater Treatment Plant (BLWWTP) and Effluent Lake

- BLWWTP was constructed in 1976. It is located some 1.5 km east of the town center of the Beit Lahia, northern part of Gaza Strip.
- BLWWTP was built in sand dunes overlying a clay layer of variable thickness with un-continuous impermeable clay layer. It was constructed in stages and modification and rehabilitation activities were performed in order to increase capacity of the plant.
- • During the past few years the situation escalated. With the increase of wastewater network connection, the volume of wastewater inflow had far exceeded the plant's treatment capacity that have led to deterioration of the effluent quality and have led to clogging effects in the neighboring sand dune areas. The ongoing decrease of the infiltration capacity of the flooded areas and the increasing wastewater volumes have resulted in the formation of enduring ponds and finally a lake.
- Over the years the effluent lake had a volume of about 2 million m3 of foul wastewater, which covers around 300 dunums and continued to rise and was threatening to flood the whole sewage collection system and the neighboring communities.
- Starting in 2007 (NGESTP was starting to be implemented), almost 90% of the effluent lake had been dried due to weathering and limited discharge to the lake. Currently the wet area occupies around 10% of the total lake.

Agriculture Land Proposed for irrigation/Sludge use

- The area in the vicinity of NGWWTP is assigned designated to benefit from the recovery water and the treated sewage sludge in the agricultural activities.
- The proposed area is divided into two zones according to its location from NGWWTP. Zone A (northern part of NGWWTP) with about 10,100 dunums whereas, Zone B (southern part of NGWWTP) with about 5,000 dunums. Most of the area is considered as under rain-fed conditions.
- Citrus, Olives, fruits and vegetables are among the crops grown in the proposed agriculture land for reuse scheme.

b. Physical and Biological Environment of the project areas

- The project sites have a typical semi-arid Mediterranean climate with long hot and dry summer (from 25ºC in summer and 13oC in winter with maximum daily temperature can reach 29-30ºC and the minimum temperature is around 9ºC). The proximity of the Mediterranean Sea has a moderating effect on temperatures and promotes high humidity throughout the year. The prevailing wind direction is South West with an average speed of 4.2 m/s (winter) and from North West (summer).
- The average annual evaporation rate is around 1,900 mm/y (5.2 mm/day). The maximum evaporation rate increases during the summer and may reach over 6 mm/day between June and August.
- Ambient air and noise quality at the project sites are consider normal with a slightly high on BLWWTP due to more rapid population surrounding the area.
- The dominate soil type in the irrigation area can be considered as heavy soil with a deep soil profile, which means will not limit root penetration for deep rooted crops. The irrigation scheme assessment was done with taking into account the climate change through the mentioned 10 years by increase the air temperature of 1.5oC.
- The soil at different locations of the effluent lake has a normal pH range and Organic Matter content with negative and low Fecal Coliform. In addition, the Electrical Conductivity at the wet part indicates the higher number due to remaining heavy metal from the stabilized sludge that is present in the top layers of the effluent lake.
- No major fault type formations have been observed in Gaza Strip area.
- Mainly aquatic birds and the reptiles (rats, snake, crows, barn owl and other wild species) are present at the BLWWTP and the Effluent Lake. The effluent lake provides breeding, nesting, roosting and feeding habitats for different birds' species. Typical effluent lake landscape consists of sand dunes covered with Acacia shrubs.
- In the proposed agriculture land for effluent recovery reuse, many Olive, Plum, Almond, Citrus or Orchards have been encountered at agriculture land allocated for irrigation of recovered water and sludge reuse. Many wildlife species; particularly birds were found to inhabit these agro-ecosystems.

c. Water (groundwater quality) of the project components

- The water quality in this study focused on chloride and nitrate concentrations (the most important contamination indicators in the groundwater in the Northern Gaza aquifer).
- The highest chloride sources are expected in the areas affected by seawater intrusion and the deeper groundwater layer (generally exceed 250 mg/l). The seawater intrusion zone covers the western part with 2 to 3 km inland the aquifer. Most of the municipal wells were concentrated in this zone and due the high pumping rate of these wells resulted in accelerating the seawater intrusion.
- NO3 concentration exceeds the WHO drinking water guidelines in most of the Northern Gaza aquifer. In 2003 at the infiltration site (adjacent to NGWWTP), the maximum nitrate concentration in the groundwater was about 30 mg/l due to the operation of the infiltration basin using partially treated wastewater.
- Cl concentration in the wells close to the infiltration basin ranges between 350 to 650 mg/l (till the middle of 2012). The trend of the chloride concentration recorded is steady since

2011 in some wells. In addition, Nitrate concentration for the same period ranges between 20 to 120mg/l.

- From the analysis it found that the groundwater is free of Salmonella, Nematodes and Amoeba & Gardia. However, the total Bacteria ranges between 30 to 395 cfu/ml and the total coliform ranges between 6 to 50 cfu/100 ml in some wells.
- The heavy metals concentrations in all analyzed wells were less than the Palestinian standard values for irrigation. However, there were some wells that have concentrations of Boron and Mercury higher than the standard values.
- The groundwater quality under the effluent lake and the BLWWTP sites is improving after drying the lake.
- According to the groundwater modeling result, the recovered water is not expected to have bacteria, including fecal coliform due to the infiltration process (treated by the soil). In fact, the water quality, especially after the NGWWTP will have better quality than the wastewater reuse. However, to ensure the public health concern related to wastewater and sludge reuse, the monitoring plan is determined in the monitoring plan (including the mitigation measures for epidemiology).
- There is no archeological or historical site as well as the protectorate areas nearby the project component sites. The only site consider important and respected (psychologically important) by the community is the El Shuhada Cemetery, which is nearby the location of storage tanks and booster pumps (water distribution network).

POSITIVE ENVIRONMENTAL AND SOCIAL IMPACTS

The positive environmental and social impacts of the project are:

1. The recovered effluent from the groundwater will be an important source of irrigation water, as water resources in the Gaza Strip are scarce; especially during summer time, as a source of water will be continuously available.
2. The groundwater quality is suitable for Unrestricted Use. The only restriction is for the Total-N, which is higher than 15 mg/l. This could be considered as an advantage for agricultural use. However, it is advisable to restrict the use the recovered water for uncooked vegetables at least for the first year of implementation.
3. The recovery scheme will limit the horizontal dispersion and the vertical building up of the water table, which without recovery will have a negative impact on current land use.
4. Effluent reuse of the recovered water will solve the problem of the disposal of wastewater, as it will be treated and injected for agricultural use.
5. The groundwater quality after drying the lake is improving.
6. Sludge has a high content of organic matter that can help conserving soil organic matter, and sludge stimulates biological activity in the soil.
7. The sludge reuse brings possibility for farmers to supply their lands with organic fertilizer at low costs and reliably available. It is expected that the sludge will cost as low as the transport cost of around 1 ILS/50 kg (compare with 50 ILS/50 kg for Israeli imported fertilizer). Another level of competition reported was with the Palestinian organic fertilizers (each dunum needs about 8 cubic meter from this fertilizer. That cost around 850 ILS per ton which is relatively expensive). Thus, the produced sludge will be a competitive product if it cost less than 300 ILS/T.
8. The sludge reuse is environmentally the best solution compared to disposal inland fills or incineration plants and appealing solution for sustainable sludge management.
9. Sludge is one of the outputs of the project, and will increase the income for those who work in sludge trading,
10. Sludge reuse will work for reduction of chemical fertilizers.
11. Reduction of health risks associated with exposure of villagers or inhabitant surrounding the effluent lake and BLWWTP to environmental risks and nuisance released from the BLWWTP, such as effluent lake flooding and the risk of water borne disease, will be seen. In addition, the project will protect the livelihood status of people who suffered due to the flooding of BLWWTP,

12. The provision of recovered water will reduce the cost of water needed for irrigation in the area. The utilization of the recovered water of high quality and of less price might work for the benefit of the farmers (increase their profits)
13. The new lands gained due to the decommissioning of BLWWTP will be used in agriculture activities or as a recreational or residential place.
14. Potential increase of the price of lands and dwellings due to the implementation of the project,
15. Provision of jobs due to the implementation of the project components, both during construction and operation phase.
16. After decommissioning of BLWWRP, it will considerably reduce odor, mosquitoes and flies.
17. As soon as the NGWWTP is completed and starts its operation (2013) the infiltration of a high-quality effluent in the infiltration ponds will begin to compensate the negative effects on groundwater.
18. The construction of the site and the carrier line will improve the road network connecting the existing and the emergency area.

NEGATIVE ENVIRONMENTAL IMPACT ANALYSIS AND THEIR MITIGATION

a) During Construction Phase
   i. Air Quality and Noise Pollution (low impact and temporary)

It is concluded that the air quality impacts associated with dust generation will be of “low” significance. However, whenever the dust emission becomes higher than normal and create disturbance to the workers and project activities, it is recommended to spray the location with water to reduce the impact.

   ii. Gaseous Emissions (low impact and temporary)

Air emission impacts associated with the proposed project will be of “low” significance. However, to reduce and minimize the impact, it is recommended to check the vehicles regularly for the exhaust gas and minimize the vehicles and heavy equipment movement at the same time.

   iii. Noise (low impact and temporary)

The noise generation is not expected to represent a significant issue to local residents (due to distance from the residential area, only during the day time and on a short period). The most affected people from noise impacts are the construction workers. The mitigation measures recommended in the ESMP and Monitoring Plan for control of noise and air emissions, especially to the workers are based on compliance with the Palestinian Outdoor Noise Standards.

   iv. Vibration (low to medium impact and temporary for the water distribution networks and low impact and temporary for other project components)

The closest sensitive structure to the site of the booster pumps (due to psychological perspective of the respected site according to the people in Gaza) is El Shuhada Cemetery (around 10 m away). Consequently, medium vibration impacts could be anticipated to occur. The mitigation measures proposed during the construction of water distribution network component (storage tank and booster pump), near the El Shuhada Cemetery area are as follows:

- The base camp (workers site camp) and place for storage of equipment have to be on the future land dedicated for future expansion (pumps and the storage tanks).
- The construction of the storage tank and the booster pumps room including the generators and the electrical rooms have to be separated and not overlapped.
- The ready mix concrete is preferred to be used instead of onsite concrete mix. Beside the reduction of the dust transmitted to the agricultural land due to mixing onsite and reduction of the hazardous wastes and other solid wastes on site, the vibrational load will be also reduced significantly (use of concrete pumps will be advantageous).

- In addition, due to the sensitivity of the groundwater, the vibration around the wells construction site should be minimized in order to avoid groundwater contamination due to potential spills.

v. Construction Waste and Handling of Hazardous Waste (low to medium impacts)

Based on the expected waste generation associated with the proposed NGESTP project activities, the impact will be of “low to medium” significance. The following mitigation measures are proposed:

- Onsite domestic sewage collection and disposal (adequate sanitation facilities) shall be provided by the contractor for construction workers’ needs.
- Site waste management plan should be developed by the contractor prior to commencement of construction works.
- The burning of any type of wastes should be avoided.
- The reused clay or excavated sand should be stockpiled and stored away from
- Nearby sanitary landfill should be notified to receive the unusable non-hazardous construction wastes or damaged construction materials.

vi. Soil Contamination during Decommissioning of BLWWTP (medium impacts)

Soil may be exposed to contamination due to the movement of construction vehicles and equipment. The contamination will occur due to oil and fuel spills from the engines of machines, and also due to polluted wheels (importing pollutants from outside of the site). It is concluded, based on the above, impacts associated with soil contamination will be of “medium” significance. Mitigation measures proposed during the decommissioning of the treatment plant are as follows:

- The decanting activities should be done with a care and the pipe should be have sufficient length to prevent the spillage to the ground
- Preventive maintenance for any vehicle or equipment that has an engine that leaks oil or fuel.
- Preparing a special fuelling and oil change station on site to contain any possible fuel or engine oil spill. Otherwise fuelling and oil change should be conduct in the private oil stations out of site (concrete paved station on site).
- If any machine is broken on site, a containment system should be used to prevent the spill of oil or fuel on the soil.
- The vehicles moving in and out of site should be checked at the inlet gates of BLWWTP to assure that they are not importing pollutants through the wheels.
- The paved path / concrete paved parking or loading and uploading sites can be made to ensure that the vehicle will not transport the pollutant from the site.

vii. Remediation Works at the Effluent Lake

The best options for financially and technically feasible options (excluded the land investment cost) are the Phytoremediation, clay placement and three layers clay placement. The most sensitive criteria for the remediation selection is the land investment. As the land is being rented and the longer term of the remediation activities will affect the initial cost, in addition, the three layers of clay cap is not necessary as the contamination does not need deep soil replacement, the clay cap placement is the most suitable option, financially and technically.

Heavy machinery and vehicles might be used are excavators and heavy trucks. Impacts associated with remediation works will be of “medium” significance. Mitigation measures proposed during the remediation works of the effluent lake are as follows:

- Standard protection to the workers during the overall remediation activities
- Special tools for handling the dangerous wildlife found
- On site sanitation should be established for the workers
- Avoid the disturbance of the existing plants and wildlife as much as possible during the site preparation

- Handle with care found wildlife (catchment dangerous wildlife). It is recommended to seek the assistance from Ministry of Health and Ministry of Agriculture for the best practice for handling the catch dangerous wildlife
- Minimize the soil contamination by site management plan (place for temporary
- storage, handling, transportation and disposal)
- Replanting the affected plant that has to be displaced. If the replanting is not feasible, planting 2 new trees to compensate 1 removed tree has to be done by the contractor
- Notification to the designated landfill should be done prior to the soil disposal.

viii. Changes in Hydrology and Groundwater Quantity and Quality (low impact)

During the construction of the recovery scheme, remediation of effluent lake and decommissioning of BLWWTP there will be no impact on groundwater. It is expected the depth of the excavation will not significantly impact the groundwater but the wells construction. It is recommended to hire the highly qualified contractor for wells establishment. Therefore, the impact negligible for decommissioning and remediation activities and low impact on the water distribution networks (only for wells construction).

The mitigation measures to avoid the hydrology of groundwater quantity and quality are similar to the general wells construction. To reduce the impact on wells construction, highly qualified contractor has to be contracted, isolate the access and the site area to avoid outside disturbance that can make the land fallen down to the wells.

ix. Health and Safety (low to medium impacts)

During the construction phase, as the proposed project are at a large distance from the nearest population or residential area and on the agriculture land, the health of the population is not expected to be significant and considered minimal.

Negative impacts will mainly concern the works for construction of new facilities, which are mainly within water distribution networks. It will have few limited negative impacts such as temporary discomfort and localized pollution to the communities caused by worksites (noise, exhaust fumes, dust and vibration, risk of accidents due to increased traffic in the project impact area, the presence of workers, very limited disruption of wildlife and vegetation, poor management of handled products: fuels and lubricants as well as worksite waste, etc.).

However, although the impact is considered low and temporary for the communities, the mitigation measures are developed to minimize the impact. In addition, due to the health and safety of the workers, which accidents might occur on site in various construction project activities, mitigation measures are as well developed to mitigate the risk of health and injuries to the workers. Mitigation measures developed to minimize the risk related to health and safety, both for community and workers are:

- Raising awareness campaigns to workers and community members to promote safety, and health and safety monitor should be appointed. The monitor can be chosen from among community members who accepted to work in the project.
- Workers should wear standard protection especially due to the dangerous wildlife on BLWWTP and effluent lake sites.
- Workers should be trained to cover the completed parts and keep their work areas safe. In case of causing an accidents, the workers should be penalized either by deduction of salaries or dismissal.
- Existing utilities (especially at BLWWTP and water distribution network), if exist, would be located and staked before construction begins, including and at intersections of other pipes and crossings. This would confirm the location and depth to ensure new construction does not impact the existing utilities.
- 5. The identification of the existing infrastructure (other pipelines, cables, etc) has to be identified prior to the construction phase.

- Heavy equipment would not normally be operating over the existing utilities during construction of the new line. If heavy equipment or trucks must cross the existing utilities, thus additional soil cover is needed to protect the existing pipe.
- Onsite inspectors would be present during construction to verify that the construction contractor is following engineering specifications and meeting regulatory requirements.
- Workers should take the following steps to protect themselves from falls during high construction:
    - Use 100% fall protection when working on higher construction site
    - Participate in all training programs offered by the employer (contractor). c) Follow safe work practices identified by worker training programs.
    - Inspect equipment daily and report any damage or deficiencies

As a mitigation measure, safety measures should be put into consideration and addressed with the workers. The contractor and the PMU are mainly responsible for any safety procedures to be applied

x. Archaeological Disturbance (low impact)

Surveys in the area of the BLWWTP and Effluent Lake concluded that there is no archaeological sites were identified. The confirmation letter was sent to the Archaeological Authority for assurance and clarification of the assessment and the replied letter indicating that the project components (including the irrigation lands) have non-existence of the archaeological site.

Although the sites do not have any archaeological importance, the Jordanian Antiquities Law still applicable and can be applied if there is any archaeological and valuable objects is found.

xi. Ecological Disturbance (medium impacts)

Wetland ecosystem and vertebrates living at the area surrounding the BLWWTP and the effluent lake might be affected during the decommissioning of the treatment plant and the remediation works of the effluent lake.

Although the biodiversity, especially fauna identified within the vicinity of the project sites (effluent lake and BLWWTP), are commonly found, it is not belong to endanger wildlife and in fact it could cause a vertebrate pest outbreak or other health impact, the mitigation measures have to be developed to avoid the ecological disturbance and provide safe and adequate relocation for found wildlife and re-plantation for the fauna. Based on the ecological disturbance impact, the project at BLWWTP and effluent lake will have significant medium impacts.

However, due to the decommissioning activity and the remediation of the effluent lake, after the finalization of the works activities, the site will provide a permanent positive impact. The biodiversity disturbance of the site due to the remediation works and decommissioning activities, either by relocation, temporary shelter or re-plantation to another site or still within the project site area, will be compensated with the long term positive impact. In addition, as the fauna and flora found in the project site is a local and not belong to the endanger species, they will easily adapted and continue their life cycle.

Mitigation measures to reduce and minimize the impact of the existing wildlife and plantation within the BLWWTP and effluent lake are as follow:

- Standard procedure for health and safety of the workers at the site, especially the equipment that protect them from the wildlife.
- Equipment to handle the vertebrates should be prepared (this includes cages, snake sticks, net, etc.) in case of the found vertebrate during the activities.
- Assistance from the staff of Ministry of Health and Ministry of Agriculture is needed to advice the contractor for temporary relocation of the found wildlife.
- Re-plantation of the trees, if needed, should be done by the contractor, if it is needed. The re-plantation can be done within the area of the effluent lake.

- Avoid the disturbance of the nesting, breeding site. The found nesting or breeding found has to be handled with care and replace it to the safe site.

Regarding the water distribution network site, there is an opportunity that the networks will be laid in agricultural land and impose on the existing crops and local animals around the site. Mitigation measures shall be developed to limit and to reduce the impacts. Based on the ecological assessment, the project will have low to medium impacts.

Mitigation measures develop to avoid the crop and animal disturbances in the vicinity are as follow:

- Temporary construction fences have to be installed prior to the construction of the water networks and other components for recovery water distribution to avoid the fallen of the local animal and to localize the site from the local animals.
- In case the destruction of the crops or plants at the farms near the construction of the recovery water distribution network, compensation has to be settled.
- If it is needed, the replanting or trees relocation (temporary or permanently) has to be done. If the relocation or replanting of the existing trees is not feasible, the compensation of planting 2 trees (for removal of one tree) has to be done in the other area. It is advisable to plant locally trees.

xii. Land Use and Accessibility (medium impacts)

During the decommissioning and remediation activities, the impact on land use and accessibility is considered “low”. Regarding the land use and accessibility of the water distribution networks for the recovery reuse scheme, the main impact on roads traffic will be during possible lying of water distribution networks along or across main roads. In addition to the limited access road for the community during construction, this access difficulty will have more impacts on elderly people, handicapped and children, who may accidentally fall in open trenches or make tedious long cycles before they reach their targeted locations.

Mitigation measures proposed are as follow:

- Selection of suitable location for temporary storage of construction materials, equipment, tools and machinery prior to starting construction, especially on the site that is close to El Shuhada Cemetery.
- The employed machinery drivers should receive training on safe utilization of their machines to minimize accidents risks.
- Clear signs indicating the project site and temporary fences shall be installed prior to the preparation of the site, especially the water distribution networks area.
- Avoid the side of the road for all the temporary storage materials and the place for standby equipment.
- All the activities have to be during the daytime and have to be scheduled to avoid conjunction with the school and working peak hours (morning and afternoon).
- The traffic department should be informed and involved to manage the traffic during the congested time. In addition, the preferred route and an alternative road have to be recommended by the traffic department.
- If the digging (open trenches) is not completed within a day period, the clear sign (by light or fluorescence lights) has to be considered to determine and identify the site during the night.
- When the land use and accessibility is disturbed and the safety of the communities passing by the project location is triggered (especially to the children, handicapped or the elderly who might use the access road), the temporary access road has to be considered with the traffic department assistance.
- Temporary resettlement that might occur during the preparation and the construction phase has to be defined and accordingly has to be compensated.

b) During Operation Phase

i. Air Emissions and Noise Pollution (low to medium impacts)

The impact of such air emissions are considered minor, because the diesel generators are only expected to operate temporarily during power cut-offs. The compliance of generator emissions with Palestinian Standard for Ambient Air will be sufficient to safeguard against unacceptable air emissions impacts to the neighboring areas.

A relatively higher impact will be on the Pumping Station staff, which may be exposed to intermittent pumping noise. The standard protection of the workers, including earmuffs, has to be practiced all the time, especially at the Pumping Station area.

ii. Odor

The operation of the water distribution network system is not expected to have significant impacts on odor. However, due to the remaining pond #7 that will be used as the emergency pond, the operation of anaerobic ponds will have significant impact associated with generation of odor (mainly H2S) and vectors that mostly generated from raw sewage storage. The mitigation measures proposed for Pond #7 is as follows:

- Minimum standard is set to consider as an emergency (monitoring plan is presented at ESMP section). Maximum permissible level of the overflow or raw wastewater discharge in the pond is 2 m height.
- Maintaining high performance of biological treatment of wastewater. In addition, to be as far as possible from odor recipients and keeping buffer zones between odorous units and neighbors.
- The aerator from the aeration tank can be installed on the pond to maintain reasonable dissolved oxygen in the water to avoid anaerobic conditions.

iii. Vibration

Concerning the vibration at the effluent lake and the decommissioning site (including remaining pond #7 and the PS adjacent to pond #7), the impacts is considered negligible. The main impact (medium impact) expected during the operation of the water distribution network is on the site of booster pump (special attention has to be made to reduce the vibration impact at the pumping station and the generator to minimize the impact due to the close distance with the El Shuhada Cemetery). The mitigation measures to minimize the vibration impacts of the machines are:

- Tree plantation, heavy leaf trees to absorb the vibration and noise generated, is recommended to be planted at the Cemetery area along the proposed main road at the other side of the pumping station.
- Maintenance of the machines and equipment has to be maximized (less than the standard period required).

iv. Water Resource Contamination

The impacts on groundwater is one of the most important issues associated with the reuse project, as part of the project has been designed to prevent impacts on the groundwater from infiltrating partially treated sewage. To identify the impact of the groundwater, the verification of the available water quality monitoring (four rounds from PWA) has been analyzed and the groundwater modeling with different scenarios has been run (with and without recovery schemes and different scenarios of recovery wells implemented (12 wells and 25 wells) and during the different year of implementations; 12 wells implemented on the year 2013 and 2015). Based on the modeling results, the groundwater monitoring plan has been developed.

The groundwater monitoring programme is the key mitigation measures to indicate the water resource contamination. The groundwater monitoring programme will be explained in detailed on the following section, ESMP.

v. Impacts on Local Agriculture, Public Health and Water Resources

Based on the design project report three scenarios that considered the expected water quality recommended are as follows:

- Scenario I: It is more advisable to cultivate orchards on the available area to the west of the project along Al Karama Road. Based on crops water requirements, the available reclaimed water is just enough to irrigate 5,375 dunums divided into citrus, olives, fruit trees, alfalfa and grains (water quality does not have impact on the crops selection)
- Scenario II: Wastewater will be treated more effectively and consequently the effluent will be of better quality in general. The quantity of effluent diverted to the infiltration basin will increase to approximately 23,100 m3 daily. This reclaimed water will be used to irrigate additional land to 7,525 dunums in total.
- Scenario III: This Scenario assumes that the planned WWTP in East Jabalia will work with its full capacity by year 2025. The quality of reclaimed water (39,160m3/day) is expected for unrestricted use. The quantity of reclaimed water will be enough to irrigate about 12,577 dunums. In this scenario vegetable crops will be introduced with an area of 1,258 dunums.

vi. Decommissioning of BLWWTP on Groundwater Quality (positive impacts)

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

vii. Recovery Water Quantity and Quality (medium impacts)

Based on the groundwater modeling and analyses, the recovery water quantity and quality is expected to be acceptable for agricultural irrigation for unrestricted crops, but unacceptable to be used for drinking water. Besides continuous groundwater monitoring, public awareness is needed to ensure that the community is not using the recovery water as a drinking water.

Although the NGWWTP is located nearby the Israeli border, the flood risk is not expected to cross the fence to Israeli border due to the topographical nature of the project site. In addition, as the groundwater modeling result from different scenarios, the plume will not be significantly crossed the Israeli border as the infiltration basins are located more than 300 m downstream of the border and with the recovery wells implementation, the wells will accelerate the flow in the downstream direction away from the Israeli border.

After decommissioning the lake and BWWTP, a positive impact will be clearly found on

the groundwater quality in the aquifer under the lake.

viii. Land Use of Effluent Lake Remediate and Decommission of Beit Lahia Wastewater Treatment Plant (medium impacts)

In one year period, the remediation activities will be finalized. Afterward, the remediated effluent lake can be used for agriculture purposes or residential, depending on the Urban Planning of the area and El Awqaf future plan.

After the completion of the remediation works, depending on the urban planning of the area and the future plan of Ministry El Awqaf, the land use of the effluent lake will be mitigated. Based on the soil assessment prior to the completion of the remediation works, there are two options of land use which can be applied:

- To be used as an agriculture land. Although the area will not need additional filling or leveling, but due to the huge amount of the soil excavated at the nearby landfill site (Johr Eldeek) that will be implemented during 2018, if needed, the excavated soil can be transported to the effluent lake site as far as the soil is considered good. The soil quality has to be determined (soil analysis done at the landfill site, by the landfill management), before transporting it to another area.

The agreement between Ministry of Awqaf and the Land Authority or the Ministry of Economic in addition to the agreement of the Landfill management shall be reached prior to transferring the soil to the effluent lake. According to the capacity analysis during the EA of NGESTP, a maximum of 1.5 million m3 of soil can be transferred to fill the effluent lake

- To be used for residential purposes. Additional soil for leveling and soil conditioning, if needed, at the effluent lake site when the urban planning of the area is dedicated for residential area. The soil analysis will not be crucial as the option 1 and the agreement shall be reached only between Ministry El Awqaf and the Ministry of Economic and Land Authority in addition to the agreement of the landfill management for transporting the soil to the remediated effluent lake.

Due to the remaining pond # 7, the mitigation measures are developed to minimize the impacts due to the operation of pond # 7. The impact on the land use and accessibility of the decommissioning land and remaining pond #7 is of "medium" significance. Mitigation measures developed to reduce the impacts are as follows:

- Fences surrounding pond # 7 have to be constructed to reduce the accessibility of the community to the pond area. During the Public consultation, Beit Lahia Mayor announced that there is a budget allocated to build the permanent fence around the pond #7. The agreement between PWA and Beit Lahia Municipality can be reached on the construction procedures.
- There should be 10-15 m distance between the pond area and the fences to be constructed on the surrounding pond.
- The trees shall be planted nearby the fences, in order to reduce the odor or nuisance and separate the pond site from the surrounding neighboring area and future land use of the other decommissioning ponds. Planted trees will also bring positive impact on the visual impact.
- The site is only connected to one main gate and the access road to the neighboring site in addition the pond site should be connected with the pumping station at the vicinity for ease access

ix. Public Health related to Using Recovery Water for Irrigation (medium impacts)

Health protection measures which can be applied to the agricultural use are:

- Crop restriction
- Human exposure control and promotion of hygiene

Adopting crop restriction as a means of health protection in reuse schemes will require a strong institutional framework and the capacity to monitor and control compliance with regulations and to enforce them. Farmers must be advised why such crop restriction is necessary and be assisted in developing a balanced mix of crops so that production of surplus of a specific crop is avoided.

Control measures aimed at protecting agricultural field workers and crop handlers include:

- The provision (and insistence on the wearing) of protective clothing, the maintenance of high levels of hygiene and immunization against (or chemotherapeutic control) selected infections.
- Risks to consumers can be reduced through cooking the agricultural products before consumption and by high standards of food hygiene, which should be emphasized in the health education associated with irrigation schemes.
- Local residents should be kept fully informed on the use of recovery water in agriculture so that they, and their children, can avoid these areas.
- Special care must always be taken to ensure that agricultural workers or the public do not use irrigation water for drinking or domestic purposes by accident or for lack of an alternative.

All measures should be coordinated with the awareness campaign of using treated wastewater and pilot projects of using treated wastewater for irrigation. According to the clarification from the PWA team responsible for the effluent reuse study and pilot projects in Gaza, currently there are ongoing projects related to the awareness and the pilot projects, i.e. awareness workshops carried out for farmers, operators and managers of recovered wastewater (and more awareness will be carried out during the operationalization of the pilot projects).

Recovered water reuse, as it is demonstrated on the groundwater modeling concluded that there is no indication of bacteria or viruses, including the Fecal Coliform. The combination use of recovered water and the sludge for the same area proposed will not have significant impact to the soil, as only the nitrate is considered higher than standard (in this regard, it is not recommended to be used as a drinking but is considered an advantage for the agriculture).

Concerning the epidemiology due to the reuse of the recovered water and sludge for irrigation and soil at the irrigated land, based on the expected water quality, there will be no bacteria, viruses and other related pathogens that lead to the waterborne diseases, i.e. cholera, hookworm, diarrheal diseases or other helminthic infections is expected. However, the monitoring of the epidemiological diseases shall be done by the Ministry of Health through the health centers, especially the health centers within the area of the irrigated land using the recovered water and sludge. Once there is indication of patient with symptom of the diseases mentioned above, the Ministry of Health shall report the case to PWA to investigate the water quality of the water distribution network and sludge quality. The investigation should conclude the source of the infections or diseases.

When the source is due to the recovered water or sludge reuse, the emergency procedure shall be prepared by the PWA in coordination with CMWU to stop the distribution for further investigation. When the infections or diseases resulted from other source, the standard procedure of the Ministry of Health concerning the outbreak or endemic should be followed.

x. Contamination from Reuse and Disposal of Sludge (medium impacts)

When the sewage sludge fails to meet Rule 503 Class-A on sludge use requirements, it will pose hazardous health and environmental impacts if applied to the lands for agriculture use. The potential contamination will affect soil, air, groundwater and crops. If for some reason the sludge fails to meet Class-A requirements, it will be disposed in a landfill. The most probable impact is high concentration of pathogens (over 1000 cells/100 ml). High concentrations of heavy metals (higher than those in Class- A standards) are not expected as verified by the sludge analysis results.

Concerning the reuse of the recovered water and the reuse of the sludge at the same area proposed, according to the groundwater analysis and current measurement, the recovered water does not contain any possible health risk as well as heavy metal that could have a significant effect on crops. In addition, based on the sludge analysis and the treatment technology at NGWWTP and low content of heavy metal found, the sludge is already stabilized and predicted to meet the Class A rules for sludge reuse.

However, the importance parameter to be ensured for recovered water is the pH and for the sludge is the stability of the sludge. Using the combination of the recovered water and the sludge are not expected to have high significant negative impacts on crop and soil. In addition, with the sludge reuse implementation schedule, sludge monitoring plan and the groundwater monitoring plan implemented during the operation phase, the impact associated is considered low. The importance of the monitoring plan for sludge and recovered water are highly significant. Accordingly, with the possibility of lack of enforcement, the trained qualified personnel for management and monitoring plan has to be taken into consideration. The good management monitoring practice, documentations and reporting has to be well defined and prepared accordingly

Proposed mitigation measures for emergency situation when the sludge is not meeting the requirement of Rule 503 Class A include:

- Sludge not meeting these requirements should not be used for agricultural purposes and should be disposed to landfills.
- As a protection measure in this project, is limiting the sludge application for vegetables that are eaten uncooked despite the fact that Rule 503 Class A sludge allows sludge application for all types of vegetables.
- Adhering to the monitoring and testing requirements
- If the sludge does not meet the Class-A requirements especially with respect to pathogen concentration it should be mixed with lime (the same way that floating sludge is treated) and disposed to landfills.

- Training and guidance for farmers and sludge transporters regarding healthy handling and usage of sludge in agriculture.
- Some precautions to protect farmers are to wear suitable clothes, gloves and boots; washing before eating; and using a facemask if the sludge is dusty.
- Vehicles should be carefully selected for their local suitability and transport routes chosen so as to minimize inconvenience to the public. Special care must be taken to prevent vehicles carrying mud onto the highway.
- Enclosed trucks should be used for transporting treated sludge to prevent sludge spill and to avoid any odor release.
- Keeping good communication between customer, regulator, public and stakeholders including landowners and retailers.

NEGATIVE SOCIO ECONOMIC IMPACTS AND THEIR MITIGATIONS

- Decommission of the BLWWTP will reduce water that some of the farmers relied upon to water their plants. Indicating that their income might be affected that will be mitigated through: i) Provision of recovered water of a competitive price to minimize the potential impacts. ii) Due to the fact that the sewage untreated water should be banned, appropriate laws shall be developed to criminalize the use of untreated water
- Potential risk for the people in the adjacent areas due to having no fence around Pond #7 that might affect children. Mitigation measures will be through constructing fences.
- The use of lands might be limited due to the pond as having recreational activities; especially in case of not having a fence surrounding the pond #7. In addition, the construction of residential compounds in decommissioned area will be limited due to the existence of the pond. Again, the fence will be the most appropriate mitigation.
  - The construction of the carrier pipes will have negative impact due to noise and obstruction of traffic and use of agricultural land during the construction stages. The project should reduce the disturbance to community using most appropriate environmental mitigation measures in addition to information sharing.
  - Due to the unfavorable odor, mosquitoes and flies might affect the health of the adjacent communities. The flies should be combated using hygienic and environmentally friendly procedures.
  - The sludge reuse for fertilizer might affect those who work in the chemical fertilizers sector in Gaza Strip, especially, those who import fertilizers. Integrating laborers in the new market could be an appropriate mitigation measure.
  - Negative impact on the livelihood status of those who operate wells. Potential loss of income for those who own and operate the wells that will be closed due to project implementation. The laborers and the well owners might be affected severely. It could be mitigated by provision of appropriate compensation i.e. jobs or monetary.
  - Put limitation to the plantation of certain crops in the beneficiaries who will use the recovered water. Orientation sessions should be presented to raise farmers awareness regarding the type of crops that should be planted using recovered water
  - Expropriation for the areas of lands needed to construct the recovery well and lands needed for the project. The 27 well and the expansion of the treatment plant need about 18,175 m2 (please note, during the social investigation, the wells implementation considered was 27, as it was stated on the design report). Mitigation measures include protective procedures should be applied to limit the resettlements; avoiding small plots in order not to raise poverty and compensation should be paid in a full market price.

POTENTIALLY AFFECTED PARTIES

According to the ranking for the most affected groups who has no alternative livelihood approach were ranked and recognized as follow:

1. The Operators of wells (who are uneducated, untrained) might suffer due the termination of wells. They are maximum 10 people. The magnitude of their vulnerability shall be mitigated
2. The Owners of wells (who might be terminated) will be badly affected due to losing a valuable asset (the well), as well as, being in critical need for alternative source of water, which will cost a lot. In addition, some of them used to gain his income through selling water which will not be available (indicating that his income will be badly affected)
3. Those who Rent Lands from Awqaf for a few amount of money that includes the cost of water. They will be affected in sense of losing their lands and paying for water.
4. The Owners of small plots of lands who will be expropriated during the construction of the recovery wells. Some of them have small plot of lands that don't exceed one dunum. The wells will pass in the middle of such plots of lands and the remaining land will be too small for any use.
5. Other Project Affected Persons due to the implementation of the project during the construction activities

The mitigation of impacts described in detailed in the mitigation measures section. However the discussion of mitigation measures with the above mentioned affected groups based on the entitlement characteristics, any one that might be affected due to expropriation should be compensated. It is recommended to develop a Resettlement Action Plan in order to identify accurately the Project Affected Persons (PAPs), their entitlement, compensation valuation and mechanisms proposed for compensation.

Residual Impacts and Costs of Applying Mitigation Measure

This discussion will cover the whole potential impacts resulted due to land acquisition and expropriation during the preparation, construction and operation phase.

The estimated cost for applying the different activities related to the potential expropriation and land acquisition will be mainly based on:

- Cooperation with the municipalities and other organizations Negotiation with the Awqaf
- Negotiation with the affected people

Therefore, any budget estimations for such activities is based on non-solid rationale

Willingness to Pay, Cost Analysis and Tariff Survey

Surveys have been conducted for willingness to pay for the wastewater and sludge reuse, water distribution network and cost analysis including proposed tariffs for the effluent recovery. The result is a stand-alone report that is presented in Annex 8.

Regarding the increment cost of the reuse system, the draft vision toward the reuse system is under developed. The study includes tariff assessment; cost analysis for water reuse as well as the sludge reuse. However, the tariff survey and willingness to pay conducted under this study should be taken into consideration.

Resettlement Action Plan (RAP)

Based on findings and the consultant's recommendation in addition to the WB approval, the RAP should be prepared as a document due to the certainty of the OP 4.12 triggered.

Once the RAP ToR is cleared (by the donors), work towards the RAP is underway. In specific, the RAP should provide details on how the affected parties are identified, consulted on the project and the adverse impacts they will experience, the compensation, and the modes of grievance redress that is available to them. More specifically, detailed information on the operators of the wells (license or unlicensed), owners of wells, those who rent lands from the Awqaf should be developed, and owners of small plots of lands who will be affected /expropriated; permanently or temporary (due to the disturbances; i.e. land use and accessibility, traffic, etc) should be identified.

Project Alternative

Basically, the objectives of the Effluent Recovery and Reuse, in addition of decommissioning of BLLWTP and remediation works of Effluent Lake adjacent to BLWWTP is to improve the environmental, socio economic and public health conditions in Gaza Strip, especially at the project areas. Accordingly it is expected, by definition, that the environmental and social benefits will overweigh the impacts.

All the environmental and social negative impacts discussed are mainly site-specific and could be managed / minimized through implementing the proposed mitigation measures as described earlier. Comparing the benefits to the impacts in a strategic level, it could concluded that the “no project alternative” is not supported from the environmental and social perspective, given that the project impacts will be controlled as recommended in this ESIA.

In addition, the implementation shall be implemented and start to be operated before 2015, otherwise the recovery scheme will not be able to catch the pollution and they will affect the irrigation wells around the recovery wells.

Environmental and Social Management Plan (ESMP)

ESMP was developed to reduce or eliminate the negative impacts of the project component. The table of the ESMP both during construction and operation phase (environmental and social perspectives) are presented at the following tables (Table 1 – Table 3). The tables also include the monitoring plan, the institutional responsibility for inspection and monitoring including the budget proposed for management and monitoring proposed. The Institutional set up and the roles and responsibility for implementation and supervision during the construction and operation phase of the project components is presented on detailed on the main report of SESIA.

Grievances and Compensation

All grievances received verbally or in written shall be documented in a grievance register and handled by the PMU (PWA). It is of importance to react as quickly as possible to the grievance of the citizens. A best practice standard is to acknowledge all complaints within 10 days. Due to the different character of the complaints, some of them cannot be resolved immediately. In this case medium or long-term corrective actions are required, which need a formal procedure recommended to be implemented within 30 days:

1. The petitioner has to be informed of the proposed corrective measure.

2. In case if a corrective action is not required, the petitioner has also to be informed accordingly.

3. Implementation of the corrective measure and its follow up has to be communicated to the complainant and recorded in the grievance register

The comprehensive grievance mechanism including the institutional responsibility, monitoring, responses procedure and disclosure of the grievance is presented at the main report of the SESIA.

Cash flow, and their respective representations in the financial statements, represent the best explanatory force in providing the reader strong information related to the project performance to create a positive cash flow resulting from the current management processes and/or investment/financing processes. The analysis of cash flow also allows the analyst to verify the existence of proper financial balance between sources of raising investment and the use of the same.

A cash flow statement is a listing of the flows of cash into and out of the project: Revenues and subsidies/grant are the cash inflow, Investments and the costs are the cash outflows. The balance is net cash flow at a specific point in time.

Scenario 3 considers a situation where the construction costs relating to the work of recovery of the waters and of the wastewater reuse projects, provided both in Phase 1 and in 2 are paid in full by funds provided by Donors or the government. The other operating costs of the plant and the maintenance are, however, by paying a water tariff by farms benefiting from irrigation.

The basic aspects of financial and economic analysis, which Scenario 3 has been submitted, are summarized below.

A) Financial analysis

Farm-level investments for an estimated total of about 18.7 million ILS (orchard plants, plant irrigation adjustments etc.) have been graduated over a period of four years.

Staff training activities, much smaller in scope, were instead paid on the first year.

The civil works and the equipment of the recovery wells - tank and booster system, (30,83 million ILS) based on the executive design, were planned to be carried out between the first and the second year of the twenty-five years of the analysis. The 24th year will require procedures for the rebuilding of some of the equipment at the end of useful life, with an estimated cost of 10 mln ILS.

Investments for the implementation of the consortium irrigation network (99,33 million ILS) , to be carried out as a result of the progress of the previous work, are attributed to the second and third year, at the end of which can be considered the final construction stage.

So the project management phase begins. Even for the irrigation network, after twenty-five years, it will be necessary to partially reconstruct the less durable components of the plant.

In the gradual phase of the investment, the irrigation management phase begins with the project.

In the first 4 years, farmers will increase their costs due to the progressive introduction of orchards and greenhouses. From the 4th year, with the full production of orchards and greenhouses, costs and revenues are estimated constant for the remaining 21 years.

It should be considered that farm management costs include, of course, irrigation costs (in the net income statement the cost of irrigation on farms is calculated as the water tariff multiplied by cubic meters of irrigated water).

The water tariff includes the general costs of recover, distribution and control of the irrigation network.

With regard to the investments and the related management costs, the revenues of the project consist of:

- Farm revenues: are calculated on the basis of surveys and estimates carried out in the early months of the year even at project farms;
- Water tariff paid by Industry: 70,000 cubic meters of water per year, consumed by industrial activities in the area at a tariff of 2ILS / CM;
- From the time saving of the farmers, for the lack of irrigation water coming from private wells; These time savings have been prudently estimated, and the hours saved by farmers can be dedicated to the farm, or to other, paid jobs;

- Last but not least, payments by Government / Donors, after one year, come to cover the investments already made for the project under consideration.

The cash flow balance, obtained from the costs and revenues just described, leads to a highly positive result in financial terms. The result holds high values even during the simulations; These were carried out by applying incremental interest rates, at which two financial indicators (Financial Net Present Value and Benefit Cost Ratio), maintains full performance.

B) Economic Analysis

The components of economic analysis include investment and management costs, as highlighted in the previous chapter.

To these have been added:

- Correction of labour cost from financial to economic, consisting of the attribution of labour costs, linked to social costs, such as payroll & social security tax rate;
- VAT Investment Adjustment;
- VAT Revenues / Costs Adjustment.

From the sum of these amounts to the financial ones, an economic flow has been estimated, which, according to the present, shows a good robustness of the project. In fact, by performing simulations with incremental interest rates, even economic analysis after the financial one keeps values steadily positive.

A cash flow statement is a listing of future flows of cash that occurred during the life of the project. A cash flow statement is not only concerned with the amount of the cash flows but also the timing of the flows. In this analysis, a forecast of expected flows and outflows for the next 25 years of project has been made.

ANNEX 5: BALANCE SHEET FOR INDIVIDUAL CROPS

Table 25: Balance sheet for Citrus

Citrus p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,800.00	1.72	*3,096.00*	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	80.00	5.00	400.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.			-	
Plant Protection*	kg.	4.00	100.00	400.00	
irrigation	m3	827.20	1.50	1,240.80	
Harvesting - Labour	dd	14.00	40.00	560.00	
Harvesting - machinery	h			-	
Depreciation of the plant	**1,380**	duration yrs	35.00	39.43	
TOTAL				*2,990.23*	*105.77*
Labour & Enterprise					665.77

Table 26: Balance sheet for Olive

Olive p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
olive oil 50%		45.00	16.00		
tables olive %		300.00	4.00	*1,920.00*	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	450.00	0.50	225.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	3.00	40.00	120.00	
irrigation	m3	705.10	1.50	1,057.65	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h	5.00	6.00	30.00	
Olive's milling	kg.	45.00	3.50	157.50	
Depreciation of the plant	**1,780**	duration yrs	40.00	44.50	
TOTAL				*2,274.65*	*-354.65*
Labour & Enterprise					- 34.65

Table 27: Balance sheet for Peaches

Peaches p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,100.00	2.50	*2,750.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	628.60	1.50	942.90	
Harvesting - Labour	dd	4.00	40.00	160.00	
Harvesting - machinery	h			-	
Depreciation of the plant	1,980.00	duration yrs	35.00	56.57	
TOTAL				*2,129.47*	*620.53*
Labour & Enterprise					*780.53*

Table 28: Balance sheet for Grains

Grains p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		450.00	1.50	*675.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.33	60.00	79.80	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	100.00	0.50	50.00	
Irrigation pipes (/5 y)	ml	1400.00	0.70	196.00	
Plant Protection	kg.	4.00	15.00	60.00	
irrigation	m3	309.90	1.50	464.85	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h			-	
Seedings	kg.	20.00	2.25	45.00	
TOTAL				*1,415.65*	*-740.65*
Labour & Enterprise					*-420.65*

Table 29: Balance sheet for Other fruit crop

Other fruit crops p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		750.00	3.35	*2,512.50*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.50	60.00	150.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	250.00	0.50	125.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting - Labour	dd	8.00	40.00	320.00	
Harvesting - machinery	h	5.00	6.00	30.00	
Depreciation of the plant	1,800.00	duration yrs	20.00	90.00	
TOTAL				*2,348.45*	**164.05**
Labour & Enterprise					**484.05**

Table 30: Balance sheet for Summer vegetables

Summer vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		5,000.00	0.80	*4,000.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	500.00	0.50	250.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	15.00	25.00	375.00	
irrigation	m3	650.10	1.50	975.15	
Harvesting - Labour	dd	15.00	40.00	600.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				*2,822.15*	*1,177.85*
Labour & Enterprise					*1,777.85*

Table 31: Balance sheet for winter vegetables

Winter vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		3,000.00	1.30	*3,900.00*	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	50.00	5.00	250.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	12.00	25.00	300.00	
irrigation	kg.	293.90	1.50	440.85	
Harvesting - Labour	dd	20.00	40.00	800.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				*2,412.85*	*1,487.15*
Labour & Enterprise					2,287.15

Table 32: Balance sheet for winter tomato greenhouses

winter tomato greenhouses p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		7,000.00	1.50	*10,500.00*	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	25.00	25.00	625.00	
irrigation	m3	141.80	1.50	212.70	
Harvesting - Labour	dd	30.00	40.00	1,200.00	
Harvesting - machinery	h			-	
Seedings	kg.	0.02	8,000.00	120.00	
Depreciation of greenhouse	mq	750.00	50.00	1,875.00	** 20 year*
TOTAL				*4,682.70*	*5,817.30*
Labour & Enterprise					7,017.30

Table 33: Balance sheet for Almond

Almond p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		180.00	8.00	*1,440.00*	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.			-	
Plant Protection	kg.	8.00	25.00	200.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting - Labour	dd	3.00	40.00	120.00	
Harvesting - machinery	h			-	
Depreciation of the plant	2,180.00	duration yrs	25.00	87.20	
TOTAL				*1,810.65*	*-370.65*
Labour & Enterprise					- 250.65

Table 34: Balance sheet for Alpha-Alpha

alpha-alpha p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		4,500.00	0.35	*1,575.00*	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	0.00	100.00	-	
Chemical Fertilizers	kg.	0.00	5.00	-	
Organic Fertilizers	kg.	0.00	0.50	-	
Soil Disinfection	kg.			-	
Plant Protection	kg.	0.00	25.00	-	
irrigation	m3	878.50	1.50	1,317.75	
Harvesting - Labour	dd	6.00	40.00	240.00	
Harvesting - machinery	h			-	
Depreciation of the plant	1,360.00	duration yrs	4.00	340.00	
TOTAL				*1,897.75*	*-322.75*
Labour & Enterprise					- 82.75

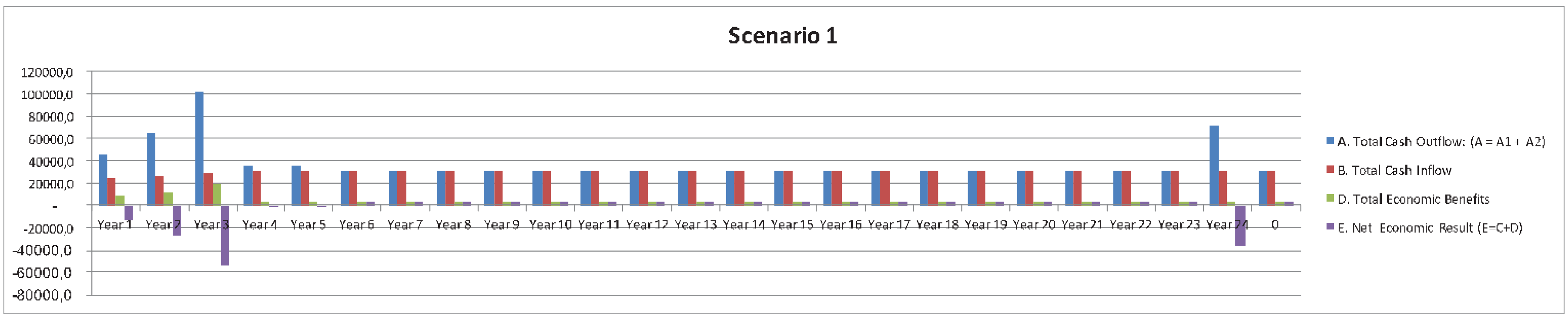
ANNEX 6: DETAILS OF THE FINANCIAL AND ECONOMIC ANALYSES

SCENARIO 1 – FULL COST/SOLUTION 1

Value in ILS*000										=>		
Details				**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**
A. Cost: Cash outflow: (NIS)												
A1. Capital Cost												
Investment cost at Farm level					4,695	4,695	4,695	4,695				
Training activities				1,456	1,456							
Recovery wells - tank ans booster				22,997	7,838							
Irrigation network					27,161	72,169						
A2. Operating Cost (Recurrent Expenses)												
Farmers pay off the investment							3742	3742	3742	3742	3742	3742
Cost at Farm level (including v	1.50	ILS/CM)		21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238
Total investment			*147,162*									
A. Total Cash Outflow: (A = A1 + A2)			**944,282**	46,266	64,771	102,295	35,675	35,675	30,980	30,980	30,980	30,980
B. Benefit: Cash inflow: (NIS)												
Direct & indirect benefit												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cı *	2.0	ILS/CM		140	140	140	140	140	140	140	140	140
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657
Paid by Government/Donors												
Subsidies				0	0	0	0	0	0	0	0	0
B. Total Cash Inflow			**757,216**	24,695	26,721	28,748	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)			**-187,067**	-21,572	-38,050	-73,547	-4,900	-4,900	-205	-205	-205	-205
Financial Internal Rate of Return			**#NUM!**	FNPV@3%	**-155,002**	BCR@3%	**0.772**					
Scenario 1 - full stage investment				FNPV@5%	**-140,864**	BCR@5%	**0.750**					
				FNPV@7%	**-130,096**	BCR@7%	**0.728**					
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic				2830	3668	5993	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				3680	5600	11547	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1729	1871	2012	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits				8,238	11,138	19,552	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)				-13,333	-26,912	-53,994	-996	-996	3,700	3,700	3,700	3,700
Economic Internal Rate of Return			**#NUM!**	ENPV@3% -	**61,667**	BCR@3%	**0.909**					
Scenario 1 - full stage investment				ENPV@5% -	**61,628**	BCR@5%	**0.891**					
				ENPV@7% -	**61,454**	BCR@7%	**0.871**					

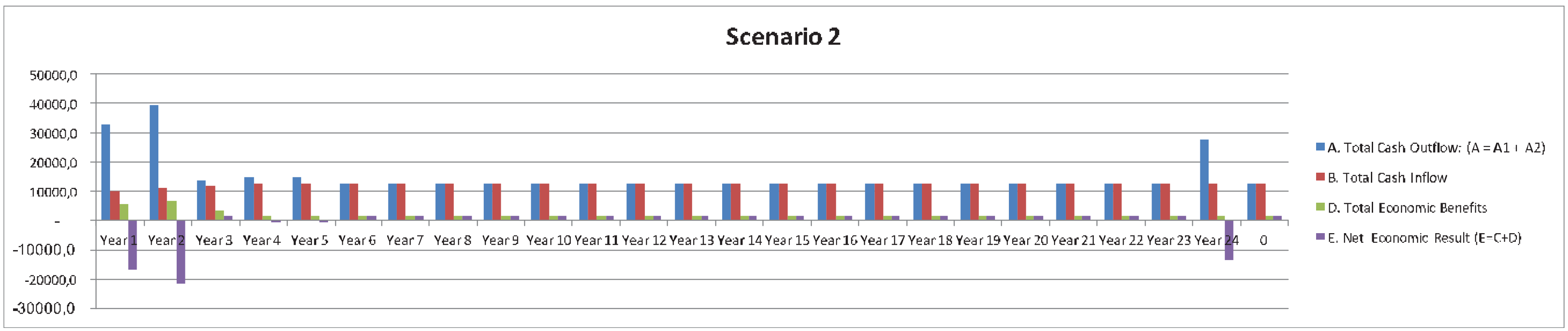
Details	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Farmers pay off the investment	3742	3742	3742	3742	3742	3742	3742	3742
Cost at Farm level	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657
Subsidies	0	0	0	0	0	0	0	0
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-205	-205	-205	-205	-205	-205	-205	-205
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700

Details	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Recovery wells - tank ans booster							10,000	
Irrigation network							30,000	
Farmers pay off the investment	3742	3742	3742	3742	3742	3742	3742	3742
Cost at Farm level	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,980	30,980	30,980	30,980	30,980	30,980	70,980	30,980
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657
Subsidies	0	0	0	0	0	0	0	0
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-205	-205	-205	-205	-205	-205	-40,205	-205
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	3,700	3,700	3,700	3,700	3,700	3,700	-36,300	3,700



SCENARIO 2 – FULL COST/SOLUTION 2

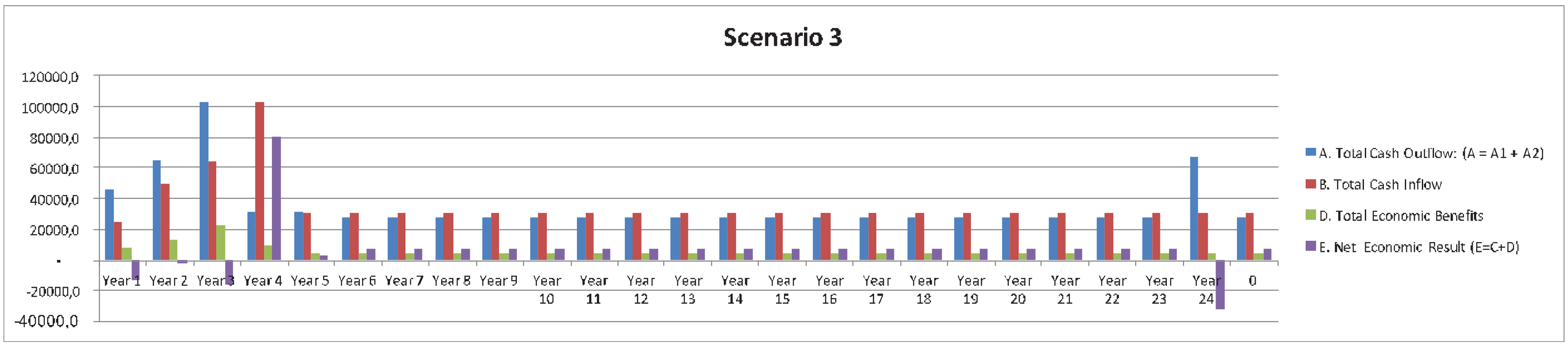
Value in ILS*000								=>																		
Details		**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)																										
A1. Capital Cost																										
Investment cost at Farm level			1,925	1,925	1,925	1,925																				
Training activities		597	597																							
Recovery wells - tank ans booster system		22,997																							5,000	
Irrigation network			27,161																						10,000	
A2. Operating Cost (Recurrent Expenses)																										
Farmers pay off the investment				1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492
Cost at Farm level (including water tariff 1.50 ILS/CM)		8,944	9,685	10,426	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168
Total investment	*57,126*																									
A. Total Cash Outflow: (A = A1 + A2)	**383,109**	32,537	39,367	13,843	14,585	14,585	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	27,660	12,660
B. Benefit: Cash inflow: (NIS)																										
Direct & indirect benefit																										
Revenue at Farm level		9,798	10,629	11,460	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291
Water tariff paid by Industry 40,000 cm * 2.0 ILS/CM		80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Time saved for non management of private wells		269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269
Paid by Government/Donors																										
Subsidies		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Total Cash Inflow	**311,023**	10,147	10,978	11,809	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640
C. Cash Flow Results: (C=B-A)	**- 72,085**	-22,390	-28,389	-2,034	-1,944	-1,944	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-15,019	-19
Financial Internal Rate of Return	**#NUM!**	FNPV@3%	**-61,389**	BCR@3%	**0.778**																					
Scenario 2 -only Phase I investment		FNPV@5%	**-56,792**	BCR@5%	**0.753**																					
		FNPV@7%	**-53,353**	BCR@7%	**0.728**																					
D. Economic Valuation																										
Economic benefit																										
Correction of labour cost from financial to economic		1160	1504	2457	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718
VAT Investment Adjustement		3680	4346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement		710	768	827	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885
D. Total Economic Benefits		5,550	6,618	3,284	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602
E. Net Economic Result (E=C+D)		-16,840	-21,771	1,250	-342	-342	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	-13,417	1,583
Economic Internal Rate of Return	**#NUM!**	ENPV@3%	- **23,386**	BCR@3%	**0.915**																					
Scenario 2 -only Phase I investment		ENPV@5%	- **24,446**	BCR@5%	**0.894**																					
		ENPV@7%	- **25,237**	BCR@7%	**0.871**																					



SCENARIO 3: CAPITAL SUBSIDIES

Value in ILS*000																	
Details					Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	=> Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
A. Cost: Cash outflow: (ILS)																	
A1. Capital Cost																	
Investment cost at Farm level						4,695	4,695	4,695	4,695								
Training activities					1,456	1,456											
Recovery wells - tank ans booster system					22,997	7,838											
Irrigation network						27,161	72,169										
A2. Operating Cost (Recurrent Expenses)																	
Cost at Farm level	(including water tariff=	1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment		147,162															
A. Total Cash Outflow: (A = A1 + A2)		861,958			46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
B. Benefit: Cash inflow: (NIS)																	
Direct & indirect benefit																	
Revenue at Farm level					23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry	70,000 cm	*	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells					657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors						22,997	34,999	72,169									
Subsidies																	
B. Total Cash Inflow		887,381			24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)		40,663			-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537
Financial Internal Rate of Return		**10.82%**			FNPV@3%	**17,400**	BCR@3%	**1.028**									
Scenario 3 - Capital cost payd by Donors					FNPV@5%	**12,152**	BCR@5%	**1.023**									
					FNPV@7%	**7,405**	BCR@7%	**1.017**									
D. Economic Valuation																	
Economic benefit																	
Correction of labour cost from financial to economic					2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement					3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement					1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits					8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)					-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442
Economic Internal Rate of Return		**61.68%**			ENPV@3%	**118,983**	BCR@3%	**1.190**									
Scenario 3 - Capital cost payd by Donors					ENPV@5%	**99,119**	BCR@5%	**1.190**									
					ENPV@7%	**83,307**	BCR@7%	**1.188**									

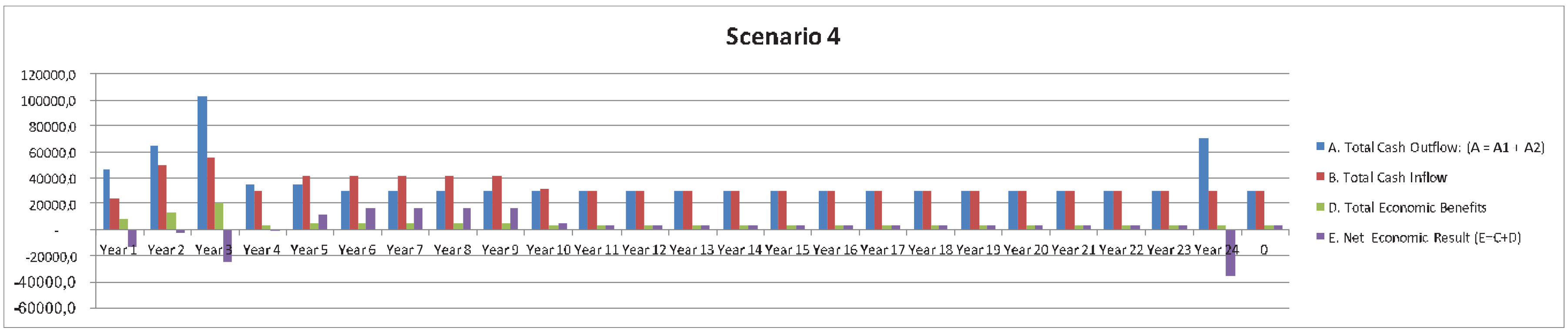
Details	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Recovery wells - tank ans booster system											10,000	
Irrigation network											30,000	
Cost at Farm level	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442



SCENARIO 4 - CAPITAL AND O&M SUBSIDIES/SOLUTION 1

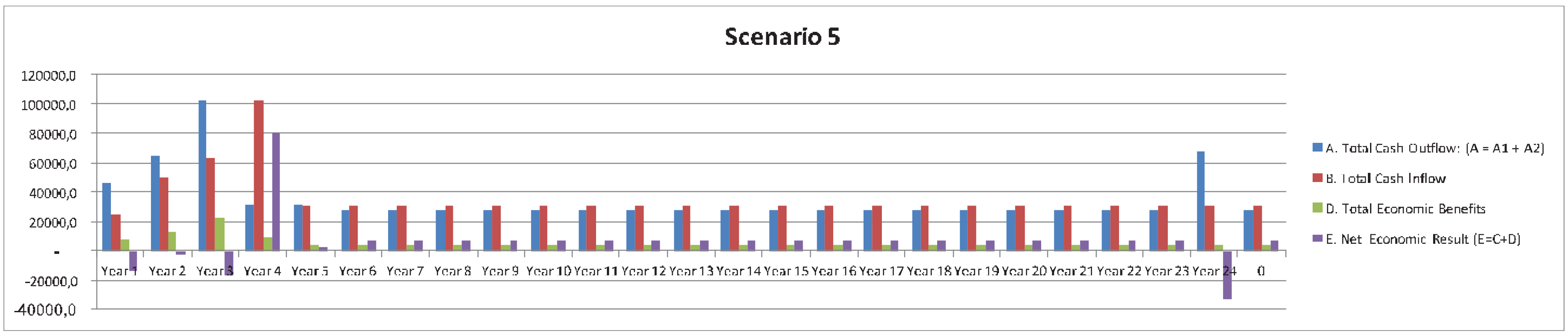
Value in ILS*000								=>						
Details		**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
A. Cost: Cash outflow: (ILS)														
A2. Operating Cost (Recurrent Expenses)														
Farmers pay off the investment					3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta 1.50 ILS/CM)		21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment	*147,162*													
A. Total Cash Outflow: (A = A1 + A2)	**931,258**	46,266	64,771	102,295	35,083	35,083	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388
B. Benefit: Cash inflow: (NIS)														
Direct & indirect benefit														
Revenue at Farm level		23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm * 2.0 ILS/CM		140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells		657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors			22,997	27,161										
Subsidies			3,433	6,866	11,443	11,443	11,443	11,443	11,443	11,443	1,047			
B. Total Cash Inflow	**865,637**	24,695	49,718	55,909	30,775	42,218	42,218	42,218	42,218	42,218	31,822	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**- 28,331**	-21,572	-15,053	-46,386	-4,308	7,135	11,831	11,831	11,831	11,831	1,434	387	387	387
Financial Internal Rate of Return	**#NUM!**	FNPV@3%	**-52,493**	BCR@3%	**0.922**	investm. Phase II		80,007						
Scenario 4 Capital cost phase 1 paid by government - subsidies for 9 years to farmer payd capital cost pha		FNPV@5%	**-48,408**	BCR@5%	**0.913**		subsidies	80,007						
		FNPV@7%	**-46,166**	BCR@7%	**0.902**	9 year of subsidies								
D. Economic Valuation														
Economic benefit														
Correction of labour cost from financial to economic		2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement		3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement		1729	3480	3914	2154	2955	2955	2955	2955	2955	2228	2154	2154	2154
D. Total Economic Benefits		8,238	12,748	21,454	3,904	4,705	4,705	4,705	4,705	4,705	3,978	3,904	3,904	3,904
E. Net Economic Result (E=C+D)		-13,333	-2,305	-24,932	-404	11,841	16,536	16,536	16,536	16,536	5,412	4,292	4,292	4,292
Economic Internal Rate of Return	**18.55%**	ENPV@3%	**47,413**	BCR@3%	**1.071**									
Scenario 4 Capital cost phase 1 paid by government - subsidies for 9 years to farmer payd capital cost pha		ENPV@5%	**36,828**	BCR@5%	**1.066**									
		ENPV@7%	**27,978**	BCR@7%	**1.059**									

Details	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
Farmers pay off the investment	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	70,388	30,388
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Subsidies				0								
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	387	387	387	387	387	387	387	387	387	387	-39,613	387
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	-35,708	4,292



SCENARIO 5 - CAPITAL AND O&M SUBSIDIES/SOLUTION 2

Value in ILS*000										=>																		
Details				**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)																												
A1. Capital Cost																												
Investment cost at Farm level					4,695	4,695	4,695	4,695																				
Training activities				1,456	1,456																							
Recovery wells - tank ans booster system				22,997	7,838																						10,000	
Irrigation network					27,161	72,169																					30,000	
A2. Operating Cost (Recurrent Expenses)																												
Cost at Farm level	(including water tariff=	1.50	ILS/CM)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment		*147,162*																										
A. Total Cash Outflow: (A = A1 + A2)		**861,958**		46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
B. Benefit: Cash inflow: (NIS)																												
Direct & indirect benefit																												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry	70,000 cm *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors					22,997	34,999	72,169																					
Subsidies					3,433	6,866	8,483					0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
B. Total Cash Inflow		**887,381**		24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)		**40,663**		-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
Financial Internal Rate of Return		**10.82%**		FNPV@3%	**17,400**	BCR@3%	**1.028**	investm. Fram level		18,782																		
Scenario 5 Capital cost payd by government and and O&M payd by government until repa				FNPV@5%	**12,152**	BCR@5%	**1.023**		subsidies	18,782																		
				FNPV@7%	**7,405**	BCR@7%	**1.017**		3 year of subsidies																			
D. Economic Valuation																												
Economic benefit																												
Correction of labour cost from financial to economic				2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				3680	5600	11547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits				8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)				-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442
Economic Internal Rate of Return		**61.68%**		ENPV@3%	**118,983**	BCR@3%	**1.190**																					
Scenario 5 Capital cost payd by government and and O&M payd by government until repa				ENPV@5%	**99,119**	BCR@5%	**1.190**																					
				ENPV@7%	**83,307**	BCR@7%	**1.188**																					



State of Palestine
Palestinian Water Authority

دولـــــة فلسـطيـن
سلطة الميـاه الفلسطينيـة

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 6

FINAL Complementary Feasibility Study

Final

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Submitted by

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ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CAPEX	CAPital EXpenses
CMWU	Coastal Municipal Water Utility
CP	Cropping Pattern
EQA	Environment Quality Authority
FAO	Food and Agriculture Organization of the United Nations
MAR	Managed Aquifer Recharge
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGEST	North Gaza Emergency Sewage Treatment
NWC	National Water Company
OPEX	OPerational EXpenses
PIU	Project Implementation Unit
PWA	Palestinian Water Authority
ToR	Term of Reference
UAWC	Union of Agricultural Work Committees

WB	World Bank
WSRC	Water Sector Regulatory Council
WUA	Water User Association
WWTP	Waste Water Treatment Plant

RESULTS AND RECOMMENDATIONS

KEY RESULTS

- By improving the original design of the water reuse scheme, introducing modernized irrigation methods and a newly proposed cropping pattern, it is possible to save nearly 3.2 Million Cubic Meter of water per year (MCM/year) or 21.5% less water than what was required by the original 2010 design. Less water requirements also leads to reduced energy needs for the recovery of water from the aquifer. More precisely, the proposed changes will save 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation schedule that largely differs from the original by providing water to the entire irrigation project each day (instead of on a 6-day rotation with 12 lots irrigated 2 at a time once a week). Pumping water into the system on a constant rate drastically reduces the complexity of managing the irrigation scheduling and eliminates the risk of overdrawing water from the storage tanks and stalling the system.
- Palestinian law restricting the use of treated wastewater for irrigation does not apply to the NGEST reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that may be infiltrated into the aquifer: the quality must be either moderate ("C"), good ("B"), or high ("A"). Utilizing poor ("D") wastewater for aquifer recharge is prohibited.
- Three water tariffs options are suggested for covering the OPEX costs (including operating the WUA): farmers will be charged a flat rate of 0.9 or 1.2 or 1.461 ILS/m^3 for water delivered at the farm gate. The lowest rate is possible if all energy requirements are provided by the national grid; the highest fees are necessary to cover the costs in case 100% of electricity is produced by diesel generators. The median rate is possible if a 50/50 mix of energy production is achieved. Even if the operator of the system is charged the highest rate of 1.461 ILS/m^3, this would still be less than what farmers are paying, on average, today.

KEY ASSUMPTIONS

- The feasibility of the project is tested against the most conservative scenario of energy generation, with an assumption that 100% of electricity will be provided by diesel generators.
- The capital investment required for the construction of the irrigation network (and the O&M costs associated with a more complex and expensive network) is assumed to be much higher than previously estimated. The capital investments required for the construction of the irrigation network have seen a 75% increase from the original estimates made in 2010, when the network was designed. Some of this increase is justified by price changes in cost and material over the past 7 years but the largest increase is due to subsequent modifications of the original design which, this *Report* argues, could be streamlined for a better (and less expensive) design of the system.

KEY RECCOMENDATIONS

- The recommended Investment Scenario is for the capital investments (CAPEX) needed for the reuse and recovery scheme to be paid for by the government/donors and the operating costs (OPEX) to be paid for by the farmers. If the proposed cropping pattern and modern irrigation methods are implemented as suggested by this *Report*, this scenario is feasible and profitable for both phases of the project even if 100% of the energy required to operate the scheme is produced by diesel generators.
- The recommended Institutional Arrangement is for the operation of the irrigation system to be a combination of both governmental and non-governmental management. More specifically, the bulk water supplier (CMWU and then, when created, NWC) will own and operate the recovery and reuse infrastructure for the first 3 years. During that time, the WUA would receive intensive capacity building. After the first 3 years of the project, the WUA would assume operation and management of the recovery and reuse scheme, leasing the infrastructure from NWC. The WUA (the farmers) would pay for the OPEX from the start of the organization, as outlined in the Investment Scenario 3 above.
- Design drawings for the water reuse scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a precise cadastral and topographic survey have been provided.
- The design of the network should be revised to consider the reduced flows that come with the newly proposed Cropping Pattern. By revising the network design with updated cadastral and topographic data and streamlined flow requirements it is likely that the overall cost for constructing and maintaining the reuse system will be significantly reduced.
- Donors' engagement and government assistance to farmers is a critical component for the success of the project. Donors/Government must assist the WUA (and farmers) by providing intensive and continuous training and technical support. Such assistance program should last at least 3 years from the construction of the irrigation network. A provisional budget of $806,000 has been defined for training WUA.
- Managed Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural resource. Monitoring is an integral part of MAR management and should be robustly undertaken to determine the effectiveness of the recharge scheme, evaluate water quality and address clogging and other operational issues.

IMMEDIATE ACTIONS

After reviewing the project, this *Report* recommends the following **immediate actions**:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA;
- Contract UAWC to provide technical assistance to both the WUA staff and members;
- Hold the negotiations necessary to broker project agreements (*viz*., the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc);
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years;
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017;
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;
- Start the construction of Phase I of the reuse scheme by early 2018, and initiate the process for construction of Phase II by early 2019.

PROJECT BACKGROUND AND RATIONALE

PROJECT BACKGROUND

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

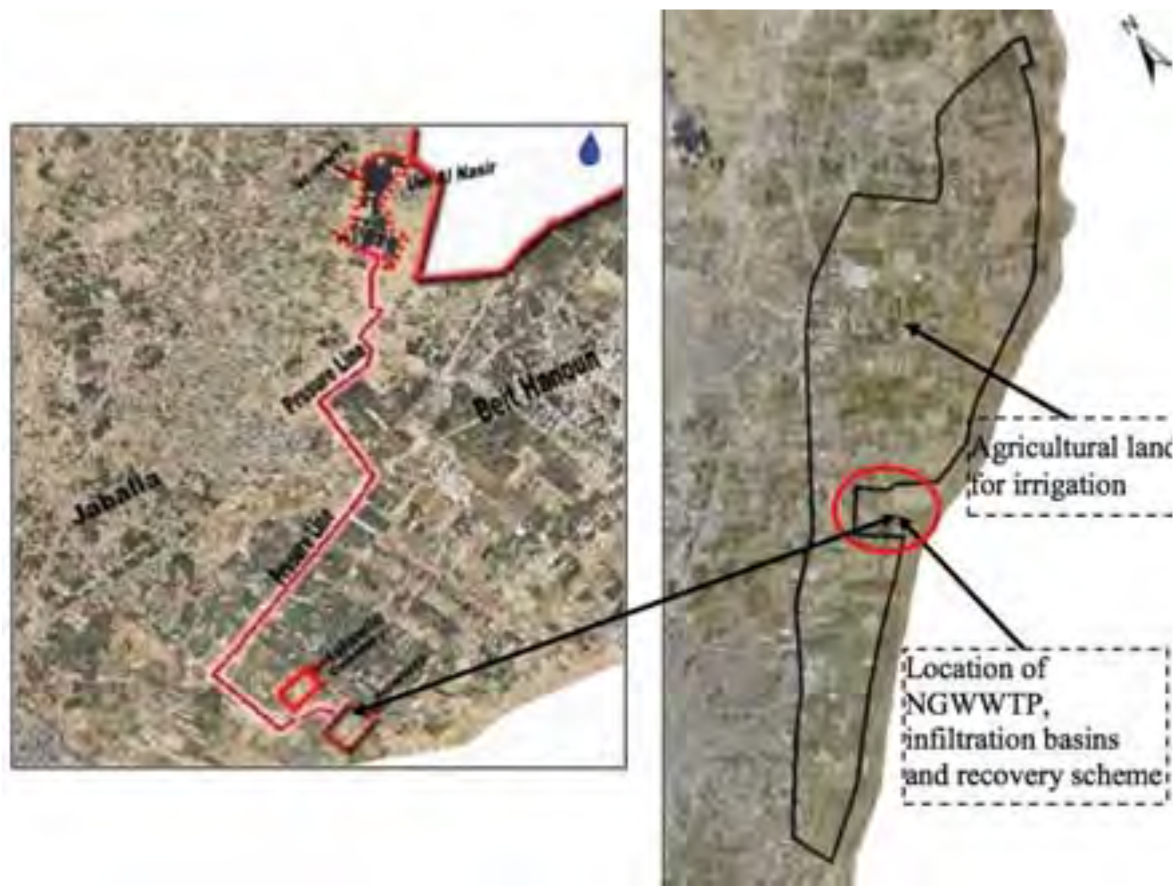


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

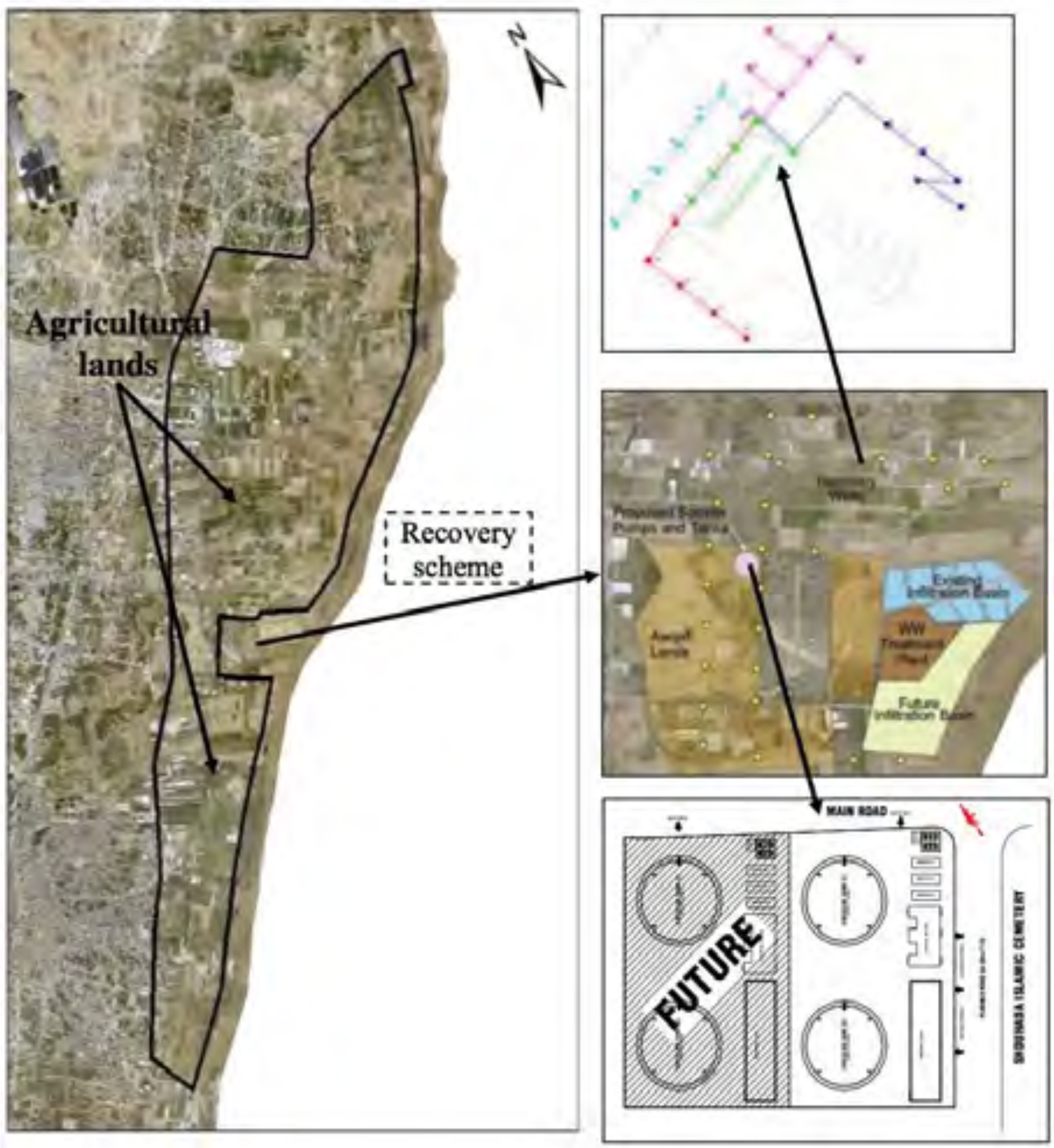


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, **supplementary phase** was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The treated sewage effluent will be disposed of into infiltration ponds, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 28 recovery wells, put into two storage reservoirs, and distributed throughout the network for irrigated agriculture.

THE PRESENT STUDY

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare this Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and making the project feasible. To carry out its task, this project has drawn upon data collection, field visits, and state-of-the-art computer modeling in order to best understand the irrigation project's hydraulics and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

COUNTRY AND SECTOR ISSUE AND POLICY

The activities of the NGEST project are in line with the policies and objectives of the National Water Policy (2012 – 2023), the Strategy for the Water and Wastewater Sector (2011-2013), the Draft Water Resources Management Strategy (1997), the National Water Policy (1995), Water Sector Strategy Planning Study (WSSPS, 2000), Water National Plan (NWP) 2000 and Coastal Aquifer Management Plan (CAMP) 1999-2004.

More specifically, this project puts into practice numerous water sector policy principles and statements, as set out in the National Water and Wastewater Strategy for Palestine, 2013, including:

Sustainable management of water resources:

- Water supply must be based on the sustainable development of all water resources (conventional and non-conventional, shared and endogenous).

- Develop additional quantities of water from non-conventional water resources without infringing upon Palestinian Water Rights.
- Recognize water users' associations (including farmers' associations) as formal entities entitled to negotiate and manage shared national water rights on behalf of their members.

Integrated water resources management:

- Agricultural, industrial, and other development and investments must be aligned to the water resource quantity available or to be developed.

Good Governance and Management:

- The responsibilities for water resources governance, being a regulatory function, and water services management, being an operational function, should be separated institutionally.
- Encourage the involvement of formal water users' associations to ensure optimal management of shared water resources (including wells, springs and treated wastewater) used for economic purposes (irrigation, industry, tourism).

Sustainable wastewater management:

- Treated wastewater effluent is considered a water resource and is added to the water balance.

Financial sustainability of water and wastewater utilities:

- Ensure that the abstraction, transmission and distribution of water, together with wastewater collection and treatment, is financially sustainable and that providers of these services can demonstrate their financial reliability as regards to the full recovery of operation, maintenance, capital investment and capital replacement costs.

Protecting the environment from pollution by wastewater:

- Treat all produced wastewater to a quality suitable for safe and productive reuse, in line with national standards, and support the distribution and productive reuse of treated wastewater.
- Priority shall be given to agricultural reuse of treated effluent. Blending of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.

PROJECT CHALLENGES

As described in the NGEST Assessment of Wastewater Treatment and Reuse Practices Report from 2011, there are several challenges and potential constraints to this project. A few of these challenges are outlined below.

Water Reuse Vision

An integrated vision for wastewater reuse issues in Palestine is still missing, which should include awareness-raising, targeted marketing, and a unified tariff. Greater effort should be devoted in producing good quality treated wastewater to be used for various purposes. Most of the treated wastewater (TWW) pilot projects have failed from the beginning, or only partially satisfied its objectives, mainly because:

- Some NGO's provide farmers of TWW with emergency subsidies, without a comprehensive system of follow up or sustainability.
- The absence of wastewater user associations to integrate and complete the role of donors and NGO's.
- The municipality was unable to operate the scheme because of lack of funds and lack of trained staff.
- The idea of reuse was not readily accepted by the farmers who had no incentive to use reclaimed wastewater.
- Some farmers could abstract fresh water from private wells at lower costs than the reclaimed wastewater.
- The effluent quality did not meet the standard required for reuse.

Political & Institutional Constraints

In Palestine, wastewater reuse projects face various political obstacles, in addition to financial, social, institutional, and technical ones. Although the reuse of reclaimed wastewater in Palestine is a priority confirmed in the Palestinian water policy and adopted in the strategies of the relevant institutions, the experience and promotion of water reuse is still in the early stages. The lack of coordination among stakeholders especially between governmental bodies and NGOs and the limited accessibility to data, information, and reports are hindering the scientific evaluation and the monitoring of implemented projects.

The installation of effective treatment systems to provide effluent that complies with water standards is a prerequisite for the success of this project. It is frequently the case that sewage treatment plants in Arab countries do not operate satisfactorily and, in most cases, treated wastewater discharges exceed the legal and/or hygienically acceptable maximum. This is usually

due to interrupted power supply, poor infrastructure and the lack of adequately trained staff with the technical skills to operate these plants, as well as the lack of an adequate budget for plant maintenance and operation.

Farmer Adherence

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

Training

A lack of technical knowledge and skills can cause failure in project implementation and, in the case of TWW MAR projects, can potentially increase environmental and public health risks. Training programs should be an integral part of the project, and it should include technical, environmental, health and socio-economic aspects. The educational input must provide farmers with an understanding of the details of techniques and their associated hazards and precautions. Capacity building in these areas are discussed in each of the relevant sections of this *Report*.

RATIONALE FOR DONOR INVOLVEMENT

Gaza faces a severe water crisis. Gaza relies almost completely on a coastal aquifer as the sole source of freshwater. However, 95% of the aquifer's water is not safe for drinking without treatment (PWA, 2014). Years of over-abstraction have taken a heavy toll on Gaza's present and future water resources. Annual abstraction of water from the aquifer has been well above the recharge rate by over 100 million cubic meters, almost twice the sustainable rate. Consequently, groundwater levels have declined, seawater from the Mediterranean has infiltrated and salinity levels have increased, making the water unsafe for drinking according to WHO standards (World Bank, 2009).

The over-abstraction and scarcity of drinking water have been exacerbated by crumbling sanitation infrastructure, while the Israeli blockade creates chronic shortages of electricity and fuel, which in turn aggravate contamination and the water crisis. The damage of contamination and over-abstraction is such that the aquifer may become unusable and, if unaddressed, the UN has stated the damage may be "irreversible" by 2020 (UNRWA, 2015a).

As early as 2009, the United Nations Environment Programme (UNEP) emphasized that prolonged over-abstraction and pollution jeopardized the sustainability of Gaza's aquifer unless it was rested (UNEP, 2009). The best suggested solution was to cease abstraction and install a monitoring system to continuously assess recovery. Once the aquifer recovers, sustainable abstraction may be resumed at carefully calculated levels. In the meantime, alternative solutions to the water crisis should be introduced, such as desalination, reduction of the loss of water in the distribution network, and wastewater treatment. Presently the application of wastewater treatment is limited because of the high cost and technological complexity of conventional systems.

In 2014, the Gaza Strip endured the third conflict of full-scale military operations in six years, coming on top of eight years of economic blockade. Reconstruction efforts have been extremely slow relative to the magnitude of devastation, and Gaza's local economy has not had a chance to recover. Socioeconomic conditions are at their lowest point since 1967 (UNCTD, 2015).

Large scale investment in water, electricity and sanitation infrastructure was needed even before the damage inflicted by the military operation in 2014. The operation resulted in severe damage to Gaza's water and sanitation infrastructure, including water wells and networks, tanks, desalination units, wastewater networks and pump stations. The preliminary static value of the damage is estimated by the Palestinian Water Authority at more than $34 million. However, long-term repair of the accumulated damage and decay of the water and sanitation infrastructure will require $620 million (UNCTD, 2015).

If the Gaza Strip is to overcome its uniquely disadvantaged situation, it will need help. Although the international community has failed to prevent these crises in Gaza from taking place, it can still play a role in its reconstruction and survival. Besides the rather stark moral imperative, as this *Report* has shown, the project has the potential to be sustainable and even profitable, arguably making the investment worth the risk on multiple levels.

LESSONS LEARNED FROM SIMILAR PROJECTS IN THE REGION

As stressed elsewhere in this *Report*, the NGEST project is not a treated wastewater for irrigation project. Rather, it is a treated wastewater for managed aquifer recharge project (TWW MAR). This section briefly looks at some of the experiences with MAR and TWW MAR in the region.

MAR in the Middle East and North Africa

Given the water scarcity in many Middle East North African (MENA) countries and the water saving capabilities of MAR, several countries have at least experimented with the technology. Although MAR is conducted in many countries in the region, monitoring is often lacking or

information is not published. As a result, the success of many of these schemes cannot be evaluated (Steinel, 2012). Below are brief descriptions of relevant projects.

Israel

Israel has been practicing wastewater treatment and reuse since the '50s, including through groundwater recharge (Soil Aquifer Treatment – SAT). The country has a 75% water reuse rate, which is much higher than most other countries [e.g. Spain 12%; Australia 9%] (Mekorot, 2013). Artificial groundwater recharge serves a number of purposes in Israel, such as increasing water reserves for periods of high demand (primarily for irrigation), reducing hydrological deficits, preventing saline intrusion from peripheral areas and ensuring efficient utilization of surplus water from Lake Kinneret (i.e. Lake Tiberias) (DWAF, 2007).

Comprehensive water quality monitoring is normally carried out throughout all stages of the recharge process. However, besides known problems related to clogging of recharge boreholes due to silt build-up and algae in the source water, health concerns have been raised lately, as endocrine disruptors, antibiotics and trace metals have been found in recycled water. In order to protect human health and groundwater quality, some experts are now calling for treatment to drinking water quality standards through desalination of treated sewage effluent by reverse osmosis (Tal, 2013).

The largest SAT facility in Israel is the Dan Region Wastewater Treatment Plant (Shafdan), where sewage water from the Tel Aviv region is treated. Wastewater treatment comprises four stages: pre-treatment, primary, secondary and tertiary treatment. Treatment methods include oxidation ponds, activated sludge and Mechanical Bio-Reactor (MBR). The Shafdan effluents are discharged into the soil for tertiary treatment and to recharge the aquifer. Water is then recovered and transported to the Negev for irrigation. The total effluent supplied for agricultural purposes is 216 million cubic meters per year (Mekorot, 2013).

Jordan

Jordanian law basically prohibits intentional recharge with reclaimed wastewater, as virtually all aquifers are also used for drinking water purposes. Yet as unintentional recharge of treated and untreated wastewater is taking place already through irrigational return flows and leaking sewage pipes, the standard is currently under review. The new standard is likely to loosen the restrictions to allow recharge of tertiary treated wastewater with near drinking water quality to all aquifers.

Jordan has one large recharge dam, Wala dam, where surface runoff is infiltrated via the side walls to recharge production wells downstream. Recently, sedimentation has decreased storage

volume and infiltration rates considerably as no sedimentation dams are installed upstream, necessitating the use of recharge wells.

Documentation on recharge volumes, water quality, clogging problems, and resulting increase in groundwater table is not available.

The expenses for MAR dam construction in Jordan are commonly covered by international donors, while the maintenance has to be summoned up by the governmental budget. Hence, the government sees it as cheaper to build a new dam rather than maintain existing ones, which is a significant flaw in the system. An important lesson learned from Jordan is that international donors should ensure that part of the budget is set aside for long-term maintenance during finance negotiations.

Iran

Iran practices aquifer recharge via a cascade of basins including settling basins or floodwater spreading systems (Hashemi et al., 2012). Removal of accumulated sediments is vital for maintaining infiltration rates in the infiltration basins (Mousavi and Rezai, 1999). In the flood spreading systems the accumulation of sediments is used as improvement to the soil for agriculture.

Oman

Oman has 15 recharge release dams that capture runoff from the mountains in the plain with high sediment loads (5 - 6 % of runoff volume) and infiltrate runoff downstream to prevent seawater intrusion and for irrigational reuse. Socio-political reasons and a lack of regulations are the main limiting factors and the recharge scheme does not generate economic benefits for irrigational reuse (Prathapar, 2012).

Saudi Arabia

Saudi Arabia has constructed a number of recharge dams, which are experiencing clogging problems. Sediment removal or release to downstream infiltration basins or the downstream wadi channel need to be undertaken (Al-Muttair et al., 1994). There are investigations to use treated wastewater in fully engineered artificial recharge and recovery systems in alluvial wadi aquifers (Missimer et al., 2012).

Tunisia

Tunisia recharges surface water for agricultural and domestic purposes after retention in small earth dams via basins and recharge wells. In upland areas, the reservoir area with collected sediments is often used for farming and further retained water is hence used for irrigation and

not for recharge. Profitability of the schemes is relevantly low (Ouessar et al., 2004). The release of captured flood water for downstream percolation in the wadi is also practiced (Ketata et al., 2011) and simulations showed much higher recharge rates especially when first flush release for silt removal was undertaken (Zammouri and Feki, 2005). In coastal regions seawater intrusions are controlled by recharge of reservoir water via wells (Bouri and Dhia, 2010). The infiltration of treated wastewater has also been investigated in coastal regions (Kallali et al., 2007).

Conclusion

MAR can only be successful if proper management plans and funding are in place and implemented. As seen in the region and around the world, clogging is a major issue, which can only be addressed with monitoring and proper maintenance. As seen in Jordan, international donors should be cautious in only funding the construction – and not also the maintenance – of MAR schemes. Lastly, water quality testing must evaluate not only regular parameters but also other emerging pollutants such as endocrine disruptors, antibiotics and trace metals, as shown in Israel's experience.

PROJECT DETAILED DESCRIPTION

OVERALL DEVELOPMENT OBJECTIVE AND SPECIFIC OBJECTIVES

The overall project objective is to more sustainably utilize water resources in the Gaza Strip by seeking out alternative water sources for irrigation. Specifically, utilizing treated wastewater for managed aquifer recharge, which will then be recovered for irrigated agriculture throughout the Strip.

When completed the project will have:

- A WWTP capable of handling 35,600 m^3 of waste each day;
- Remediation of the Beit Lahia effluent lake;
- Nine infiltration basin
- 28 recovery wells and a network of 15 monitoring wells;
- 15,000 dunums of irrigated agricultural land.

More specific objectives related to the implementation of the Supplementary Phase of the project include:

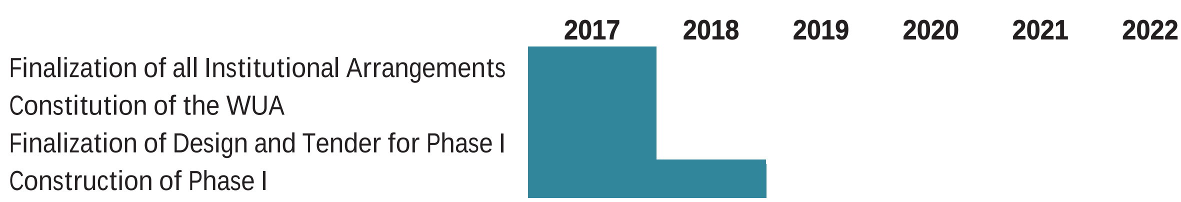
- Develop an irrigation project that assists local farmers to improve profitability and increase the value chain linked to agriculture;
- Test and promote MAR in Palestine;
- Improving groundwater health through introduction of higher quality water, and achieving more sustainable extraction practices;
- Promote the role of WUAs in managing and operating larger irrigation projects.

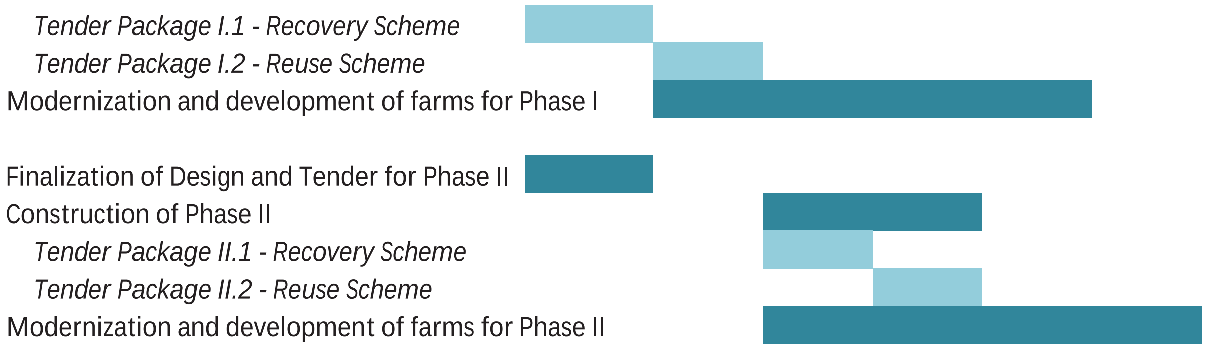
PROJECT COMPONENTS

LOGICAL FRAMEWORK

The logical framework and timetable for implementation is provided in the following Gantt chart. A detailed description of the various activities is provided in the following section.

Table 1: Project's Logical Framework





DETAILED ACTIVITIES

A gross agricultural area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit from the recovered water as well as the treated sewage sludge. This project component, known as the ‘Supplementary Project’, is divided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary component has been subdivided into three phases:

The **First Phase,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 14 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells – and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume from reaching agricultural and municipal wells located beyond the recovery wells.

The **Second Phase,** now scheduled for completion by the year 2020, would extend the recovery system by a second row of 14 supplementary wells (along with the previous 14 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated wastewater infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank,

booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **Third Phase**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

Phase I and Phase II shall be implemented via four separate tendering procedures: two related to Phase I and two related to Phase II. The following table provides a summary of the various tendering packages and proposed implementation schedule.

Phase	Package	Description	2017	2018	2019	2020
I	1	Supply and install 14 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	X			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		X		
II	1	Supply and install 14 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells			X	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)				X

Construction of the various component of the recovery and reuse schemes for both phases represent only one side of the overall project. Additional, critically needed, activities are defined as follows:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA. This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Contract UAWC to provide technical assistance to both the WUA staff and members. Also this activity should be implemented as soon as possible and ideally before tendering

procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017 so that training can be activated in conjunction to the development of the first phase of the reuse scheme. Training activities would then be intensified during the first year and carried on for a period of three years.

- Hold the negotiations necessary to broker project agreements (*viz.*, the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc). This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017. Such activities must be implemented before tendering procedures for Phase I of the reuse scheme are initiated. Updating the design and tendering documents for both Phases of the project (for the reuse part only) will require the acquisition of more detailed topographic survey and a precise cadastral survey. Considering the small scale of these tasks, it is likely that the entire process of acquiring additional field data and updating the design and tendering document can be completed before the end of the year 2017.
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years. The necessary procedures for the creation of such fund and identification of suitable financial tools to support farmers should be started during the present year 2017 and best completed before the completion of the first stage of the reuse scheme in 2018.
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;

ADDITIONAL TECHNICAL ASSISTANCE PACKAGES

The following Technical Assistance Packages are proposed:

1. Update topographic and cadastral survey of the project area;
2. Update detailed design and tendering documentation for Phase I and Phase II
3. Assistance for finalization of MoUs and Agreements and creation of the WUA;

A short description of each Technical Assistance (TA) Packages is provided below.

UPDATE TOPOGRAPHIC AND CADASTRAL SURVEY OF THE PROJECT AREA

Objectives: Update the existing topographic survey by expanding the survey area, collect additional survey points and provide a precise cadastral survey of the project area.

Level of Effort: 4 months/man to be divided between 1 senior topographer and supporting staff.

Deliverables: Revised topographic map and cadastral map

Tentative Budget: EUR 35,000

Proposed Timetable: The proposed program shall be implemented between the months of October and November 2017.

UPDATE DETAILED DESIGN AND TENDERING DOCUMENTATION FOR PHASE I AND PHASE II

Objectives: Prepare updated detail design and tendering document for both Phase I and Phase II of the project for the reuse scheme only.

Level of Effort: 4 months/man to be divided between 1 senior irrigation engineer, 1 junior irrigation engineer with the assistance of mechanical and electrical engineers

Deliverables: Revised detailed design for both Phase I and Phase II in addition to General and Detail Specifications and Tendering Documents. The update design shall be provided only for the irrigation (reuse) scheme as the existing design for the recovery scheme does not need modificaitons.

Tentative Budget: EUR 35,000

Proposed Timetable: The proposed program shall be implemented between the months of November and December 2017, and can be implemented only after updated topography and cadastral survey has been completed.

GOVERNAMENT ASSISTANCE PROGRAMS

Objectives: Assist parties in negotiating the necessary agreements for project implementation.

Level of Effort: 2 months/man of a senior legal advisor/mediator + local support staff

Deliverables: MoU[1] between CMWU and NWC (for CMWU to initially manage the system); a Contract between CMWU and the WUA (for CMWU to initially operate the system); a Water Supply Agreement between CMWU and the WUA (for bulk water supply); a Contract between the WUA and UAWC (for capacity building of the WUA); Lease agreement between whoever owns the system and whomever is going to operate it and collect fees (depending on the Scenario chosen).

Tentative Budget: EUR 25,000

Proposed Timetable: The proposed program shall be implemented between the months of October and November 2017.

[1] Because NWC and CMWU are both governmental entities, it is arguably more appropriate to have an MOU than a contract but this is open for discussion.

PROJECT APPRAISAL

BASELINE CONDITIONS

FIELD SURVEY

The foundation of this baseline assessment and a primary tool for collecting first-hand current data, the field survey aimed to **investigate the characteristics of the farming system** in the project area. A questionnaire was developed and tested in coordination with PWA. The questions were focused on the farm cropping system, market channels, selling prices, and incomes. Special emphasis was given to the water issue, by inquiring about the current use of water on crops, irrigation methods and the source and cost of water. Specific questions were dedicated to understanding the farmers' willingness to change/enlarge their cropping pattern and the role played by the farmers' associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017, by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 3.

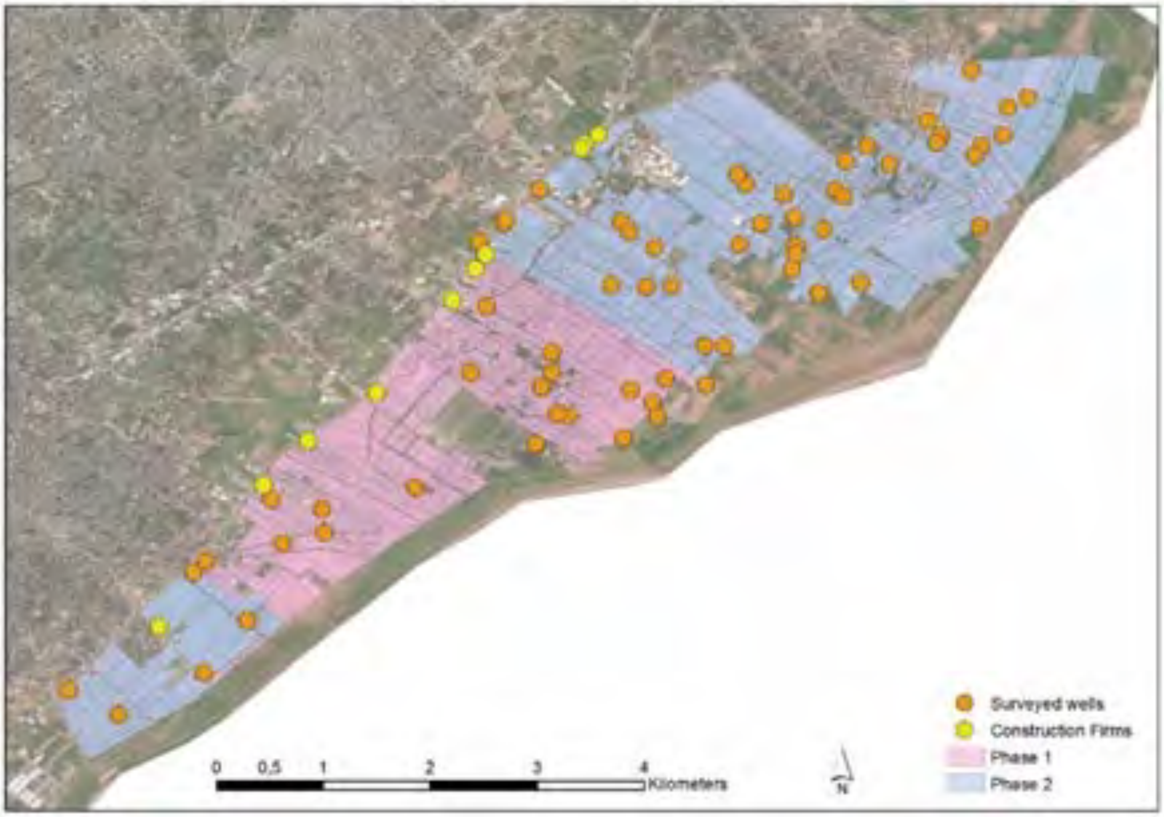


Figure 3: spatial location field survey

The survey resulted in the collection of **420 farm questionnaires**, **9 farm inputs questionnaires**, and **11 industry questionnaires**. The paragraphs below summarize the results obtained from the analysis of the questionnaires.

LAND TENURE AND CROPPING SYSTEM

FARM SIZE AND LAND TENURE

The Project area extends for 1,207 ha (12'068 du). As shown in Figure 4, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 du are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

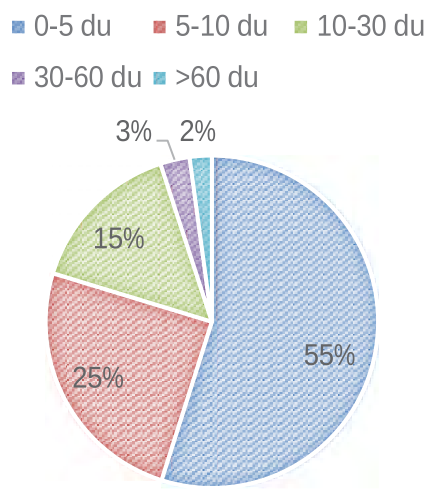


Figure 4. Distribution of farms by size.

CROPPING SYSTEM

The cropping pattern of the project area is shown in the following Figure 5.

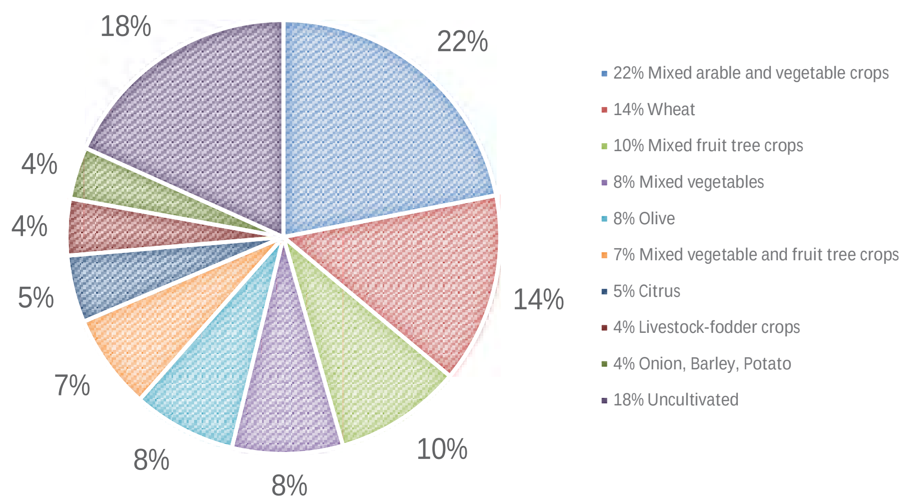


Figure 5: Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops. Almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 6). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 7).

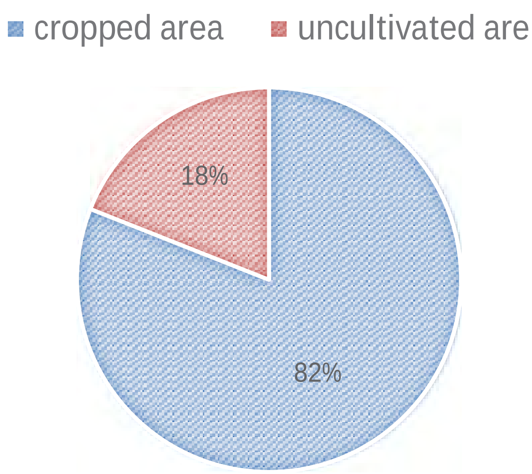


Figure 6. Cropped and Uncultivated Area

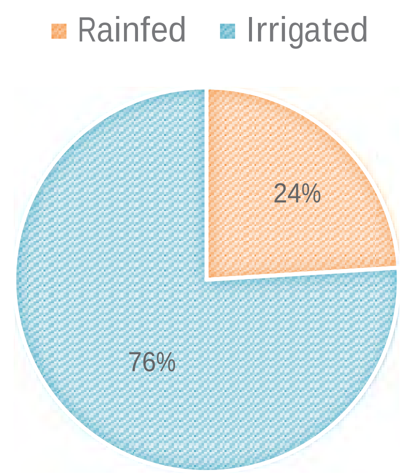


Figure 7: Irrigated and Rainfed Areas

CROP WATER REQUIREMENTS AND WATER CONSUMPTION IN AGRICULTURE

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well ("collective well") is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the "collective well" system owned by the remaining 8%.

Wells must be authorized by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also "non-legal" wells, estimated to be 3-4 times the number of the legal ones. The government does not close these wells but new unauthorized wells cannot be drilled.

The survey determined that water cost ranges[2] from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

[2] The value is the average among the ones provided by farmers during the field survey. During the filed survey, farmers provided the following rationale for their stated value for cost of water: a well's pump consumes 10 to 12 litters of diesel per hour to extract 40 to 60 m^3/hours at an average depth of 60 to 70 meters. The cost of diesel, on average, is between 6 and 7 ILS/litter. For that reason, the cost of water ranges from a minim of from 1 to a maximum of 2.1 ILS/m^3. On average, it is therefore approximately 1.5 ILS/m^3 or more.

Figure 8 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

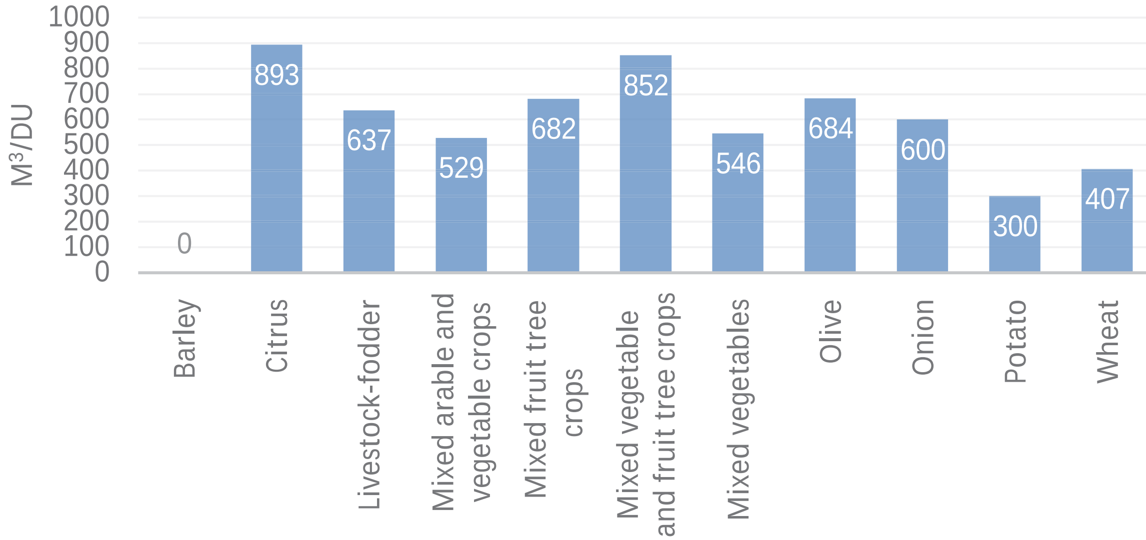


Figure 8. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m^3/du); Barley is rain fed.

The **total crop water requirements** for the agriculture currently developed across the whole 15,000 du is estimated to be **5.8 Mm³/year** with an **average daily water requirement of 15,990 m³/day**.

CAUSES OF THE PRESENT LAND ABANDONMENT

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is because of the frequent **land invasions by the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, as well as periodic herbicide sprays to keep the field clear, which kills the crops and makes farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out cropping operations (23%); and **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

WATER CONSUMPTION IN THE INDUSTRIES

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 3 their localization): generally, most of them are small factories (less than 10 employees), operating only a few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%) of them is using private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

VALUE CHAIN

Gaza Strip, with its high population density and reduced connections to a production system because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

Interviews with the producers showed that the vast majority of the agricultural products are sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

The market chain of horticultural and fruit products is as follows:

farmers → traders, wholesalers, middle men → retailers → consumers.

Next table summarizes revenues, costs and margins for the different crops expressed in the local currency.

Table 2. Summary of the single accounts cultivation statements of agricultural products

FARM/CROPS	REVENUES	COST	MARGIN	NET MARGIN PER KG	NET MARGIN + LH[3] PER KG
APPLE	1,000	2,495	-1,495	-2.99	-2.81

[3] LH: Labour Harvesting

BARLEY	655	1,630	-975	-2.02	-0.36
CITRUS	3,494	3,172	322	0.19	0.52
LEMON	1,400	2,048	-648	-0.65	-0.33
LIVESTOCK	1,582	2,310	-728	-	-
MELON	2,400	2,401	-1	0	0.17
MIXED ARABLE AND VEGETABLE CROPS	3,226	2,267	959	0.36	0.59
MIXED FRUIT TREE CROPS	2,487	2,472	15	0.02	0.34
MIXED VEGETABLES AND TREE CROPS	3,444	1,667	1,777	0.81	0.92
MIXED VEGETABLES	3,407	3,061	346	0.11	0.33
OLIVE	806	2,376	-1,570	-2.92	-2.05
ONION	675	1,837	-1,162	-2.58	-0.58
PEACH	1,000	1,055	-55	-0.11	0.07
POTATO	2,500	1,656	844	0.34	0.50
WHEAT	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

ASSESSMENT OF THE NGEST RECOVERY AND REUSE SCHEMES

PROJECT RECOVERY SCHEME

The recovery scheme comprises a system of 28 recovery wells and all related connection pipes as well as 15 monitoring wells. The following three sections provide a more detailed description of each component.

RECOVERY WELLS

There are 28 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 (groups) according to their geographical distribution. These zones are named Zone A, B, C, D, E, and F as shown in Figure 9. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

Figure 9: Location of the 27 Recovery Wells

The recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October, which is equal to 50,885 m^3/day. The total number of wells is 28 where each should have a capacity of pumping between 180 m^3/hr to 200 m^3/hr. 25 out of the 28 wells are assumed to be operational always with a capacity of 180 m^3/hr. The three additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure.

According to the numerical modelling results, the exact location of the 28 wells was selected to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 9 shows the locations of the recovery wells.

COLLECTION PIPES

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 10. The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

MONITORING WELLS

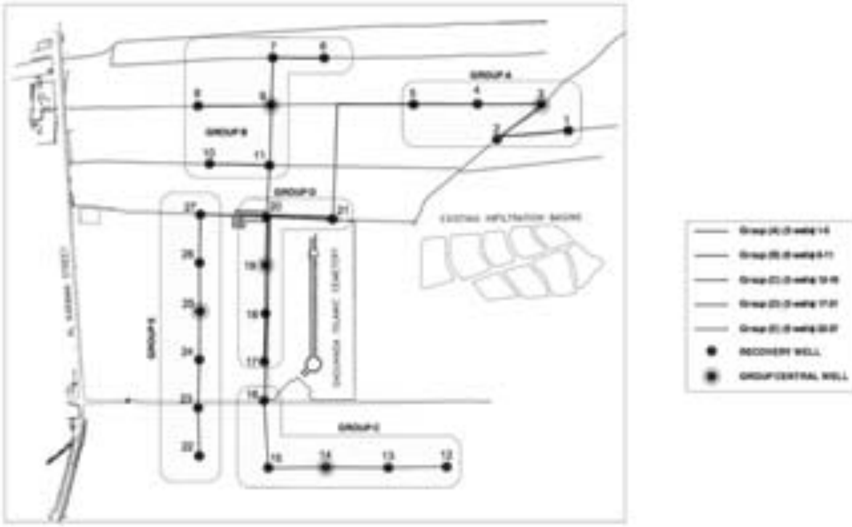


Figure 10: Wells grouping and Piping System

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore be taken and analyzed randomly at farm level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 43 wells will be implemented by using the 5 existing monitoring wells, the 28 newly built recovery wells and 10 new monitoring wells.

The location of the 43 wells is provided in the following Figure 11.

Figure 11: Location of the existing and newly proposed monitoring wells

PROJECT REUSE SCHEME

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 12. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 13.

In accordance with irrigation requirements, irrigation was to be carried out on a six-day rotational basis over six zones of almost equal size, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F, as shown in the following Figure 13. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 14.

Figure 12: Location of agricultural land

Figure 13: Proposed Irrigation Zones

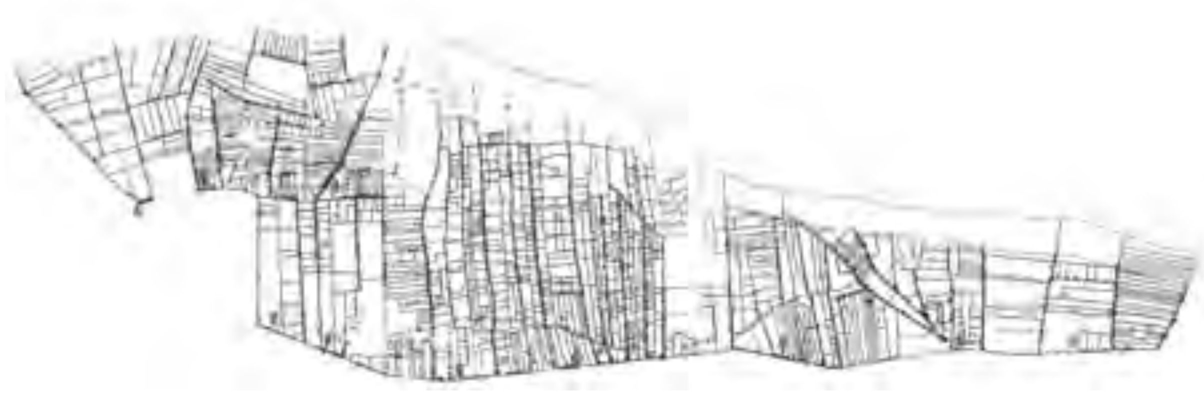


Figure 14: General Layout of the Originally Proposed Irrigation Network

REVIEW OF REUSE SCHEME: ADDITIONAL FINDINGS AND RECOMMENDATIONS

In addition to the key findings listed in the Executive Summary above, the following achievements were obtained while reviewing the original design of the Irrigation Project:

- A review of the original irrigation project layout resolved some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gate (the original design failed to do so for a sizable number of farms);
- A review of the original design for the recovery scheme confirmed its validity;
- A review of the original design for the reuse scheme confirmed the selection of materials, the general layout and the selection of the pumping system;
- The overall cost for the construction of the water reuse scheme has significantly increased (nearly 75% increase) from its original estimation. Although this might be justifiable in the context of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%. Further to that, it is possible that a further reduction in the overall cost for the construction of the irrigation scheme might be achieved with the adoption of a optimized layout. Particularly, several trunk lines had to be doubled up (sometimes even tripled up) to guarantee that the right water pressure is delivered thought the network. These changes are driving the cost of the construction up and could be optimized with the aid of a proper topographic survey and a further refinement of the original design.

PROJECT ECONOMIC AND FINANCIAL SUSTAINABILITY

The newly proposed development plan assumes that the entire project area (Phase I + Phase II) will be able to adopt the proposed cropping pattern within four years from the completion of the irrigation scheme. The adoption of the new cropping pattern involves not only planting new crops but also modernizing the farm and adapting it to the proposed irrigation method. The cost for the adoption of the cropping pattern and the modernization/development of the farms is expected to be 4.695 Million ILS (approximately 1.3 Million US$) per year for a period of four years assuming that Phase I and II are developed one after the other over a period of two years.

Farmers will require intense training to be able to implement the proposed plan. Additionally, maximizing the output of the irrigation project will require the farmers to cooperate via one Water User Associations (WUA), which has yet to be created. The macro-economic analysis assumes that the WUA should immediately invest approximately 3 Million ILS (approximately 0.8 Million US$) in trainings.

Finally, operating and maintaining the system (on-farm and off-farm, including the water recovery and reuse scheme) will cost anywhere between 7.2 Million ILS (approximately 1.98 Million US$) and 11.4 Million ILS (approximately 3.17 Million US$) per year depending on the cost of energy. The O&M costs include 0.36 Million ILS/year (100,000 US$) for the running costs of the WUA. Farmers will pay for the O&M of the system through their water bills.

In order to track the amount used, water consumed by each farm will be metered at the farm gate. Gross Irrigation water demand, excluding water needs for Industries (estimated to be 70,000 m^3/year) but including all system losses[4] and climate change[5], is estimated to be 11,110,000 m^3/year. The net irrigation water requirements (after all system losses are considered), is estimated to be 7,833,484 m^3. Farmers will be charged for the water delivered to their farms. The tariff farmers will have to pay to cover O&M costs will vary from a minimum of 0.9 ILS/m^3 to a

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[4] System losses includes both on farm and off farm losses.

[5] The estimates for water demand assumes that, due the rising of temperatures over the next decades, water requirements for irrigation will increase.

maximum of 1.5 ILS/m^3 depending on the cost of electricity (if entirely provided by the national grid or entirely generated by the stand-by diesel generators installed at the site).

Then, after the new cropping pattern and modernized irrigation methods have been implemented, the irrigation project should generate a stream of revenue that, after the first three years, would provide a steady income of approximately 30 Million ILS/year (approximately 8.3 Million US$/year).

MICRO-ECONOMIC CONDITIONS

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

This section of the *Report* assesses what the net income for farmers would be with and without the project and assesses the availability in the farmers' budget to pay for water.

EVOLUTION OF THE CROPPING PATTERN

The analysis assumes that famers will be able to fully implement the proposed cropping pattern and irrigation methods over a period of four years after the construction of the irrigation network. These changes, changing the existing land use and planting trees and vegetables, are expected to increase land productivity.

The analysis of the value chain has shown that some crops such as fresh fruit (peaches, apricots, plums) are scarcely produced and often imported goods. Olive, as a crop to produce olive oil, is often sold at a low price and profitability might be improved by nearly 50% if olives, especially the better-preserved ones of the right variety, are processed into eatable olives. The new cropping pattern also includes almond as a profitable and long-lasting, easy to preserve, type of crop.

The newly proposed cropping pattern cannot produce the desired increase in production and profits unless farmers are extensively trained (see above for specific recommendations on capacity building for water user associations and farmers). Furthermore, It would be desirable for farmers to unite in associations or cooperatives to jointly handle the supply chain through the use, for example, of refrigeration storage facilities that allow the consumption of perishable products over a longer period of time.

Table 3: Evolution of the Cropping Pattern

LAND DEVELOPMENT OVER TIME [YEARS]

	BEFORE		AFTER		Y1	Y2	Y3	Y4
CROPS AND CROP GROUPS (**)	%	du	%	du	du	du	du	du
CITRUS	5	603	22	2,655	1,116	1,629	2,142	2,655
OLIVE	8	930	23	2,776	1,392	1,853	2,314	2,776
ALMOND	2	272	10	1,207	506	739	973	1,207
PEACHES	5	587	7	845	652	716	780	845
OTHER FRUIT TREE CROPS	5	544	3	362	499	453	408	362
GRAINS*	31	3.684	12	1,448	3,125	2,566	2,007	1,448
WINTER VEGS	13	1.603	4	483	1,323	1,043	763	483
WINTER VEGS (TOMATO IN GREENHOUSE)	1	121	3	362	181	241	302	362
SUMMER VEGS	8	1.009	6	724	938	867	795	724
ALFALFA (GREEN FODDER)	4	509	10	1,207	684	858	1,032	1,207
UNCULTIVATED	18	2.205	0	0	1,654	1,102	551	-
TOTAL	100	12.068	100	12,068	12,068	12,068	12,068	12,068

* GRAINS: WHEAT + BARLEY

** CROPS MARKED IN RED ARE THOSE THAT, IN FUTURE CONDITIONS, WILL OCCUPY LESS LAND IF COMPARED TO PRESENT CONDITIONS

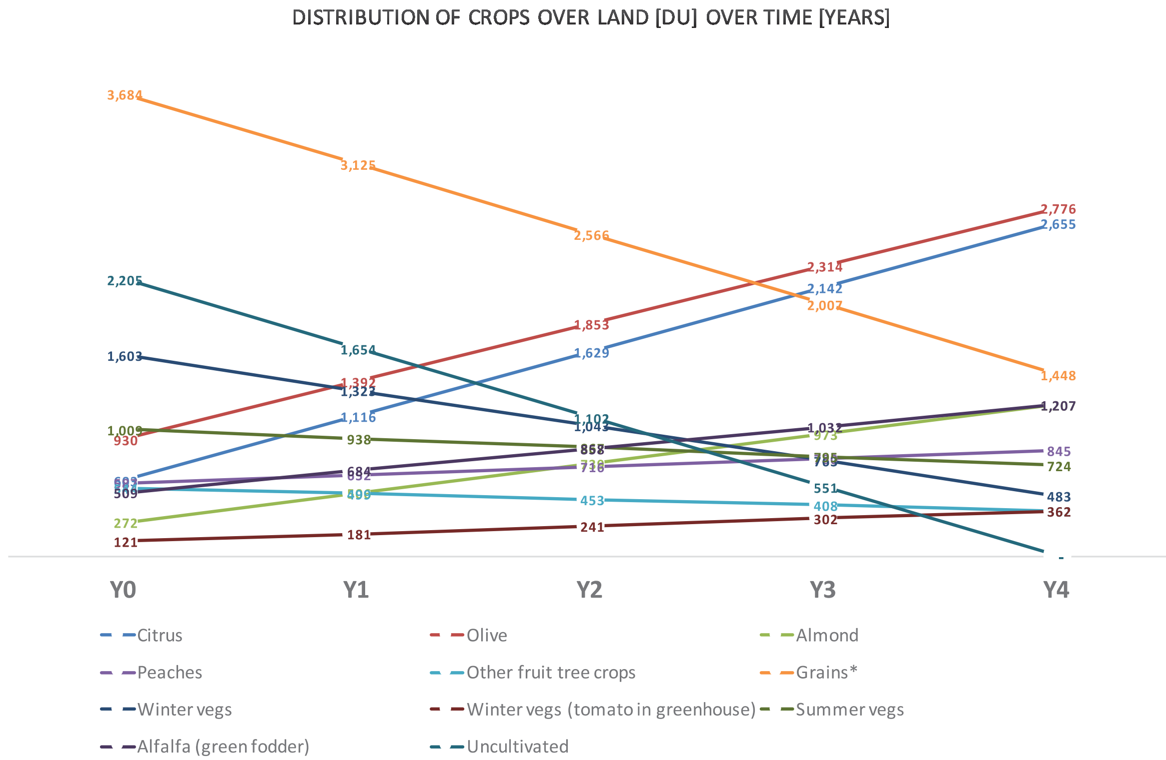


Figure 15: Evolution of the cropping pattern over land [du] over time [years]

FARM-LEVEL INVESTMENTS

Investments at the farm level would be largely spent on an increase in tree plantations and greenhouses placed in areas located away from the border with Israel.

The following table summarizes investments, expressed in Israeli New Shekel (ILS) per dunum (du) by type of crop and by type of material / activity required to produce such crop.

Table 4: Farm-level Investment [ILS] per dunum [du]

CROPS AND CROP GROUPS	*GREEN HOUSE*	*TREES*	*IRRIGATION GRID*	*LABOUR*	*MACHINERY*	*INPUTS*	*TOTAL*
CITRUS		400	380	400	0	200	1,380
OLIVE		800	380	400	0	200	1,780
ALMOND		1,200	380	400	0	200	2,180
PEACHES		1,000	380	400	0	200	1,980
OTHER FRUIT TREE CROPS							-
GRAINS							-
WINTER VEGS							-
WINTER VEGS (TOMATO IN GREENHOUSE)	37,500		492				37,992
SUMMER VEGS							-
ALFALFA (GREEN FODDER)			1,080	80	0	200	1,360

UNCULTIVATED	

Considering the evolution of the cropping pattern, total investments at farm level are provided in the following Table 5.

Table 5: Farm-level investments (ILS x 1,000) evolution during four years of full stage

CROPS AND CROP GROUPS	Y1	Y2	Y3	Y4
CITRUS	708	708	708	708
OLIVE	821	821	821	821
ALMOND	509	509	509	509
PEACH	128	128	128	128
OTHER FRUIT TREE CROPS				
GRAINS				
WINTER VEGS				
WINTER VEGS (TOMATO IN GREENHOUSE)	2,292	2,292	2,292	2,292
SUMMER VEGS				
ALFALFA (GREEN FODDER)	237	237	237	237
TOTAL ILS X 1,000	**4,695**	**4,695**	**4,695**	**4,695**

Based on the new cropping pattern, balance sheet statements have been re-calculated by considering:

- a new cultural organization;
- more modern and efficient farming practices due to training activities and better extensions services;
- better and more effective phytosanitary protection;
- a more rational distribution of the irrigation network of the farm;
- a sizable reduction in net irrigation water demand;
- a higher production, especially of the tree plants due to increased attention to thinning, correct ripening and fruit calibration;
- a water tariff based on the most conservative estimate of 1,461 ILS/m^3.

WATER TARIFF

The water tariff has been conservatively calculated including the effect of climate change, system losses, unexpected events due to pipe breaks, possible defects and/or breaks of the water metering system, possible reading errors of the water metering system and the assumption that 100% of the power requirements to run the recovery wells and the irrigation project will have to be generated by the stand-by generators and not by the national grid.

Ideally the water tariff should be able to cover all OPEX costs including those associated with running the Water User Association. Under these circumstances, farmers should be charged

based on the actual amount of water they consumed at a rate of 1.461 ILS/m^3 if energy is provided entirely by the diesel generators, 1.188 ILS/m^3 if energy is provided 50% by the national grid and 50% by the diesel generators and 0.916 ILS/m^3 if energy is provided 100% by the national grid. The details of such estimates are provided in the following tables.

Table 6: Water Tariff based on different energy generation scenarios

SCENARIO	ANNUAL COST FOR O&M AND WUAS [ILS/YEAR]	GROSS WATER REQUIREMENTS [M^3/YEAR]	NET IRRIGATION WATER REQUIREMENTS [M^3/YEAR]	TARIFF ILS/M^3
100% DIESEL	11,443,430	11,110,000	7,833,484	**1.461**
50% DIESEL	9,308,435			**1.188**
100% NATIONAL GRID	7,173,439			**0.916**

The details of the number presented above are given in the following Table 7.

Table 7: Gross and Net Irrigation Water Requirements at farm level and excluding industries

TYPE OF CROP	NET IRRIGATION WATER DEMAND	GROSS IRRIGATION WATER DEMAND
CROP	**m^3/year**	**m^3/year**
CITRUS	2,196,183	3,114,835
OLIVE	1,957,104	2.775,750
PEACHES	531,016	753,138
GRAINS	448,785	636,509
OTHER FRUIT	225,297	319,538
SUMMER VEGETABLES	470,724	667,626
WINTER VEGETABLES	141,871	201,216
WINTER TOMATO GREENHOUSES	51,337	72,811
ALMOND P	750,992	1,065,128
ALPHA-ALPHA P	1,060,174	1,503,639
TOTAL M^3/YEAR	**7,833,484**	**11,110,191**

BREAK-EVEN POINT FOR WATER TARIFF

In order to better qualify how the balance sheet of each individual crop changes by changing the water tariff, the break-even point between costs and revenues was estimated for each crop. The results, displayed in the following table, show that a large part of the crops has costs and revenues balance between a tariff of 0.90 ILS/m^3 and of 2.49 ILS/m^3.

Water price sensitivity is lower in summer and winter vegetables, while only vegetables grown in the greenhouse can withstand a high cost per cubic meter of water.

Table 8: Water tariff that involve zero net margin

CROPS	OLIVE	CITRUS	PEACHES	GRAIN	OTHER FRUIT CROP	SUMMER VEGETABLE	WINTER VEGETABLES	WINTER GREENHOUSES	ALMOND	ALPHA ALPHA
WATER TARIFF ILS/M^3	**1.00**	**1.63**	**2.49**	**-0.89**	**1.76**	**3.31**	**6.56**	**42.51**	**0.90**	**1.14**

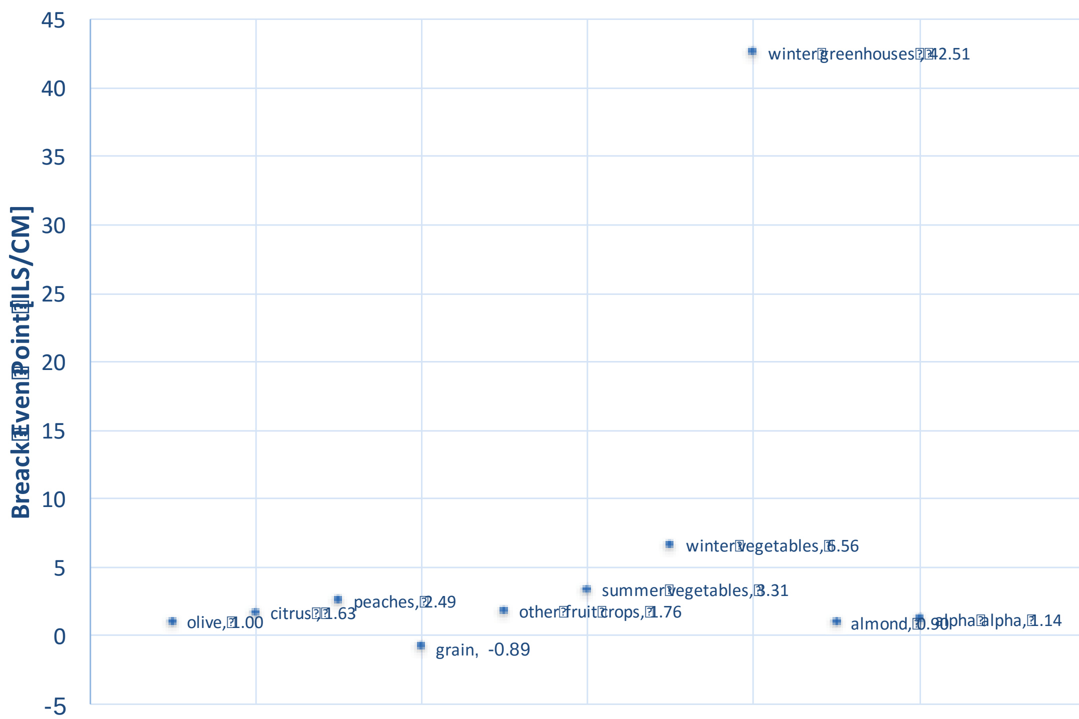


Figure 16: Water tariff that involve zero net margin

It is assumed that the following costs will be paid by the farmers: the Operation & Maintenance (O&M) costs of the recovery scheme, the reuse scheme and the irrigation network inside the farms, the costs for operating the Water User Associations (WUA). The farmers would be charged based on the actual water they consume. Water consumption is measured by a water meter installed at the manhole located at the farm gate.

BALANCE SHEET FOR THE CROPPING PATTERN

A summary and detailed analysis for both costs and revenues associated with each crop as suggested by the newly proposed cropping pattern is provided in the following series of tables.

Table 9 Summary of the Financial Costs [ILS x 1,000]

CROPS	Y1	Y2	Y3	Y4
CITRUS	2,493	3,639	4,784	5,930
OLIVE	2,253	2,999	3,746	4,493
PEACHES	995	1,094	1,192	1,291
GRAINS	3,584	2,943	2,302	1,661
OTHER FRUIT CROPS	857	779	701	622
SUMMER VEGETABLES	2,118	1,957	1,796	1,635
WINTER VEGETABLES	2,854	2,250	1,646	1,042
WINTER TOMATO GREENHOUSES	486	648	810	972
ALMOND	599	875	1,152	1,429
ALPHA-ALPHA	777	975	1,173	1,371
TOTAL FOR THE FINANCIAL COSTS [ILS X 1,000]	**17,016**	**18,159**	**19,302**	**20,445**

Table 10: Summary of the Financial Revenues [ILS x 1,000]

	Y1	Y2	Y3	Y4
CITRUS	3,456	5,044	6,632	8,220
OLIVE	2,672	3,558	4,444	5,329
PEACHES	1,792	1,969	2,146	2,323
GRAINS	2,109	1,732	1,355	978
OTHER FRUIT CROPS	1,253	1,139	1,024	910
SUMMER VEGETABLES	3,751	3,466	3,181	2,896
WINTER VEGETABLES	5,158	4,066	2,975	1,883
WINTER TOMATO GREENHOUSES	1,901	2,534	3,168	3,801
ALMOND	728	1,065	1,401	1,738
ALPHA-ALPHA	1,077	1,351	1,626	1,901
TOTAL FOR THE FINANCIAL REVENUES [ILS X 1,000]	**23,898**	**25,924**	**27,951**	**29,978**

The detailed balance sheet for each crop are provided in “Annex 5: Balance Sheet for Individual Crops”.

MACRO-ECONOMIC CONDITIONS

METHODOLOGY

Cost-benefit analysis (CBA) is a formal analysis technique used in public and private investment projects (Rakhra, 1991) as well as in programs and policies (Stoica, 2005) in order to make a comparative assessment of all the benefits and costs anticipated. It also represents an attempt to measure the costs endured and gains earned by a community or a private company after the project is implemented.

CBA proves its usefulness in feasibility studies (from an economic, environmental, social or technological perspective) by selecting the optimal option for investment projects (Hanley and Spash, 1993). The purpose of using CBA in a sector is to set up pragmatic administrative rules in order to *allocate resources efficiently*.

The use of cost-benefit analysis contributes to determining the financial sustainability as well as profitability of the NGEST water reuse scheme. It also:

a) highlights the economic and financial viability of the NGEST water reuse scheme for different scenarios;
b) enables the identification of possible errors in the design or implementation phase (incorrect information, unrealistic hypotheses, etc.); and
c) enables the correction needed to properly conduct the NGEST water reuse scheme.

GENERAL PROJECT ASSUMPTIONS

Within the CBA, costs are presented in terms of capital investments and operation and maintenance (O&M); the first being a one-time cost and the second being a recurring, yearly, cost.

The entire water recovery and re-use scheme requires capital investments to be implemented over time to provide water in two separate areas (Phase I for 500 ha and Phase II for 1,000 ha). The implementation of each phase has been subdivided into two separate tendering packages. The details are provided in the following Table 11 including the implementation schedule.

Table 11: Tendering Packages and proposed timeframe for the implementation of Phase I and Phase II

		DESCRIPTION	2017	2018	2019	2020
I	1	Supply and install 14 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$10,970,996.40			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		$7,519,531		

II	**1**	Supply and install 14 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$13,421,602.00	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)		$11,178,400.00

The O&M cost are provided in the following tables assuming three possible scenarios of cost for electricity. The first scenario assumes that energy will be provided 100% by the national grid, the second scenario assumes that 50% of the energy requirements are provided by the national grid and the other 50% by the standby diesel generators installed onsite. The third and most conservative scenario assumes that 100% of the energy requirements are provided by the standby diesel generators.

Table 12: Annual O&M costs (US$ and ILS) assuming all energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (ONLY NATIONAL GRID)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$1,074,060	$358,020	$716,040
FROM THE GRID (100%)	*$1,074,060*	*$358,020*	*$716,040*
FROM THE DIESEL GENERATORS (0%)	*$0*	*$0*	*$0*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	$1,886,002	$724,235	$1,161,767
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS	**$ 1,986,002**	**$824,235**	**$1,261,767**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 7,173,439**	ILS 2,977,000	ILS 4,558,000
WATER TARIFF (ILS/M^3)	0.918		

Table 13: Annual O&M costs (US$ and ILS) assuming 50% of the energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (50/50)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000

POWER CONSUMPTION	$1,665,144	$555,048	$1,110,096
FROM THE GRID (50%)	*$537,030*	*$179,010*	*$358,020*
FROM THE DIESEL GENERATORS (50%)	*$1,128,114*	*$376,038*	*$752,076*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$2,477,086**	**$921,263**	**$1,555,823**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	$2,577,086	**$ 1,021,263**	**$1,655,823**
TOTAL MANAGEMENT COSTS (ILS	**ILS 9,308,435**	3,689,000	5,981,000
WATER TARIFF (ILS/M^3)	**1.188**		

Table 14: Annual O&M costs (US$ and ILS) assuming 100% of the energy is provided by the standby diesel generators

OPERATION AND MAINTENANCE COST (ONLY GENERATOR)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$2,256,228	$752,076	$1,504,152
FROM THE GRID (0%)	*$0*	*$0*	*$0*
FROM THE DIESEL GENERATORS (100%)	*$2,256,228*	*$752,076*	*$1,504,152*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$3,068,170**	**$1,118,291**	**$1,949,879**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	**$3,168,170**	**$1,218,291**	**$2,049,879**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 11,443,430**	**ILS 4,400,000**	**ILS 7,404,000**
WATER TARIFF (ILS/M^3)	**1.461**		

Other costs that are included in this CBA are the water tariff, assumed to be 1.461 ILS/m^3, and the investments required at the farm level to support the introduction of the proposed cropping pattern.

Costs for supporting and training the Water User Association (WUA) are assumed to cost 3,000,000 ILS (equivalent to $806,000), divided in 2,000,000 ILS for the first year and 1,000,000 ILS for the second year.

FINANCIAL ANALYSIS

The financial analysis indicates whether the project will generate a positive net cash flow during the evaluation period (profitability) and whether the cumulative cash flow from the start of investment until the final prediction is negative (sustainability).

The analysis of the investment project's cash flow includes both the evaluation of the cash outflows (investment costs as well as and costs at farm level) and cash inflows (revenues at farm level, industries, grant and subsidies). As opposed to the economic analysis, in the financial analysis the cash flow does not include amortization, reserves and other accounting items.

From this perspective, the financial analysis was conducted with the following steps:

1. Estimating revenues and costs of the NGEST area farms and assessing the implications of these parameters on cash flow;
2. Defining the financing sources of investment and analyzing the financial profitability.
3. Determining the funding gap in achieving the investment project and identifying the best mechanisms to attract funding;
4. Checking whether the estimated cash flow could ensure the proper operation of the NGEST project. The investment project is financially sustainable if there is no risk of running out of cash during the operation.

For the financial analysis, the following costs and revenues were taken into account:

Cash Outflows (Costs)

- Capital cost – recovery wells, farm investment
- Costs related to the WUA operation and training
- Operation Costs at farm level including water tariff

Cash Inflows (Revenues)

- Revenues at farm level derived from the new cropping pattern
- Water tariff paid by Industry based on 2 ILS/m^3 per 70,000 m^3 /year
- Reduction of time spent in management of private wells
- Investments paid by Government/Donors
- Public Subsidies based on farm water tariff of 1.461 ILS/m^3 (worse case scenario).

The financial analysis carried out as part of the project's CBA uses market prices (which include VAT and indirect taxes) to check the balance of the investment and the sustainability of the project.

The cash flows accumulated in different years during the evaluation period (25 years) require a fair discount rate. The financial discount rate allows to account for the influence of time on the value of money and reflects the opportunity cost of the investor’s capital.

In general, it is recommended to use a discount rate of 5%, but the model also used 2 more points (7%) and less (3%) to evaluate the sensitivity of the net present value.

SCENARIOS

Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

(1) Capital Investment for the Water Recovery Scheme;

(2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm’s Gate;

(3) O&M Cost for the Water Recovery Scheme;

(4) O&M Costs for the Water Reuse (irrigation) Scheme;

(5) Capital Investments for Farm's Development.

The five scenarios are defined as follows

- **Scenario 1** - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under this scenario, farmers would pay back the full cost for the construction of both the recovery and the reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- **Scenario 2** - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built;
- **Scenario 3** - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government/donors and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the recovery and reuse schemes would be paid by the government or by a donor and every other cost would be paid by the farmer;
- **Scenario 4** - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that the Government/Donors would cover the cost for the construction of Phase I, but that the farmers will pay back the cost for the construction of Phase II. Farmers would also pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered

by the Government/Donors for the first 8 years (i.e. the time needed by the farmers to pay back the construction of Phase II). After that, the farmers will pay for the cost of O&M of the recovery and reuse schemes as well.

- **Scenario 5** - Capital and O&M Subsidies: considers costs (1) and (2) will be paid by the government/donors. Costs (3) and (4) would be subsidized by the Government only until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for the first 3 years (i.e. the time it takes for the farmers to be able to pay back for the improvement of their own farm). After that point, farmers will be responsible for paying O&M costs for the whole system.

A schematic representation of the five scenarios is provided in the following Table 15.

Table 15: Investment Scenarios

Scenario	Description	Cost Paid by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investments for Farm's Development	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Government and not charged to the Farmers		x	x	x	Paid by the Government and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Government until Farmers have paid back the Construction of Phase II	x	x	Paid by the Government and not charged to Farmers	x

5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5).	Paid by the Government and not charged to the Farmers	Subsidized by Donors/Government until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)	x	Paid by the Government and not charged to Farmers

FINANCIAL SUSTAINABILITY OF THE INVESTMENT PROJECT

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

In order to determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

FNPV represents the amount calculated when the estimated investments and operating costs of the project are deducted from the present value of the projected revenues. The investment project is profitable in the financial sense if FNPV has a positive value.

FIRR represents the discount rate for which FNPV is zero or which equals the present value of the financial cash flows projected for the reference period. If this indicator is less than the cost of the capital, the project is not profitable. When it is higher than the cost of capital, the project is acceptable because it will generate a positive FNPV.

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

The main results of the financial analysis are summarized in the following table.

Table 16: Main Results of the Financial Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]			BENEFIT COST RATIO (BCR)			INTERNAL RATE OF RETURN (FIRR)
	3%	5%	7%	3%	5%	7%	
1	-155,002	-140,864	-130,096	0.772	0.750	0.728	NF
2	-61,389	-56,792	-53,353	0.778	0.753	0.728	NF
3	**17,400**	**12,152**	**7,405**	**1.028**	**1.023**	**1.017**	**10.82%**
4	-52,493	-48,408	-46,166	0.922	0.913	0.902	NF
5	17,400	12,152	7,405	1.028	1.023	1.017	10.82%

ECONOMIC ANALYSIS

An economic analysis for major investment projects determines if the project contributes significantly to total economic welfare. It measures the project benefits depending on the following: the costs avoided due to project implementation; and the external benefits arising from the implementation, neither of which are included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. These externalities should be given a monetary equivalent.

In the economic CBA, some cost/benefits cannot be expressed in monetary units but only in qualitative terms. These costs/benefits are:

- Preservation and improvement of the quality of space for human life, as in the case of water pollution when human settlements located near water lose their basic quality.
- Prevention of flora and fauna destruction.
- Maintenance of natural system which will have a positive effect on people, like better mental condition and richer intellectual activities.

Benefits that cannot be expressed in monetary value are also called "intangible" benefits. Those benefits have been ignored in the cost-benefit analysis of the project. The reason is that these benefits cannot be assessed, and their detailed qualitative effects can be better described in an environmental impact assessment.

In the economic cost-benefit analysis the costs are expressed in accounting prices, and are measured in terms of 'resource' cost or 'opportunity' costs.

The economic analysis could be briefly described with the following steps:

- Conversion of market prices into accounting prices;
- Update the estimated costs and benefits;
- Calculation of economic performance indicators (Economic Net Present Value, Economic Rate of Return, benefit/cost ratio).

The corrections to be considered in the economic analysis are the following:

Fiscal Corrections. Fiscal Corrections are necessary because some transfers from one agent to another should be seen as pure transfers, without having an economic impact. For example, the subsidies provided by the government to those who want to invest in the NGEST Irrigation Project represent a pure transfer offering advantages to the beneficiaries, but not creating

economic value. The fiscal corrections are made for indirect taxes (VAT), subsidies and pure transfer payments (employer's obligation to pay social security contributions) which are generally included in the eligible costs and/or operating or maintenance costs. However, the prices should also include direct taxes. In addition, if certain indirect taxes/subsidies are aimed at correcting externalities, then they will be included in the analysis. In order to assess the project's economic impact, information on the tax system in the West Bank and Gaza, as calculated by World Bank, was used as presented in the following Table 17.

Table 17: Direct and indirect taxation in Gaza and West Bank

TAX OR MANDATORY CONTRIBUTION	PAYMENT (NUMBER)	NOTES ON PAYMENTS	TIME (HOURS)	STATUTORY TAX RATE	TAX BASE	TOTAL TAX RATE (% OF PROFIT)	NOTES ON TTR
CORPORATE INCOME TAX	2		18	15% - 20%	Taxable Profit	14.23	
CAPITAL GAIN TAX	1			15% - 20%	Capital Gains	0.76	
MUNICIPAL BUSINESS TAX	1			17%	Rental Value of Building	0.28	
EMPLOYEE PAID - PERSONAL INCOME TAX	12		96	5% - 20%	Taxable Salaries	0	withheld
IRRECOVERABLE VAT (ON FUEL)	0			15%	Fuel Consumption	0	
VALUE ADDED TAX (VAT)	12		48	16%	Value Added	0	not included
TOTALS	28		48			15.27	

Correction of labour cost from financial to economic. The correction of financial costs to economic costs of the price of labour has been made. The coefficient used to correct the financial value was 0.3 to consider taxation and social charges.

To carry out a neutral evaluation, positive and negative externalities of the project were not considered.

Based on the consideration presented above, the main results of the economic cost benefit analysis are presented in the following Table 18

Table 18: Main Results of the Economic Cost Benefit Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]	BENEFIT COST RATIO (BCR)

	3%	5%	7%	3%	5%	7%	INTERNAL RATE OF RETURN (EIRR)
1	-61,667	-61,628	-61,454	0.909	0.891	0.871	NF
2	-23,386	-24,446	-25,237	0.915	0.894	0.871	NF
3	**118,983**	**99,119**	**83,307**	**1.190**	**1.190**	**1.188**	**61.68%**
4	47,413	36,828	27,978	1.071	1.066	1.059	18.55%
5	118,983	99,119	83,307	1.190	1.190	1.188	61.68%

GENERAL ASPECTS

FINANCING MECHANISMS

The sources of funding provided by the various scenarios of the project are:

- government financial sources
- financial sources of international cooperation
- private financial sources

While government finance and international cooperation does not have direct impacts on the financial market system, it is necessary to provide support and guarantees to a private financing system. As we know the banking system requires, turning on a loan, guarantees and payment of the price of money (interest).

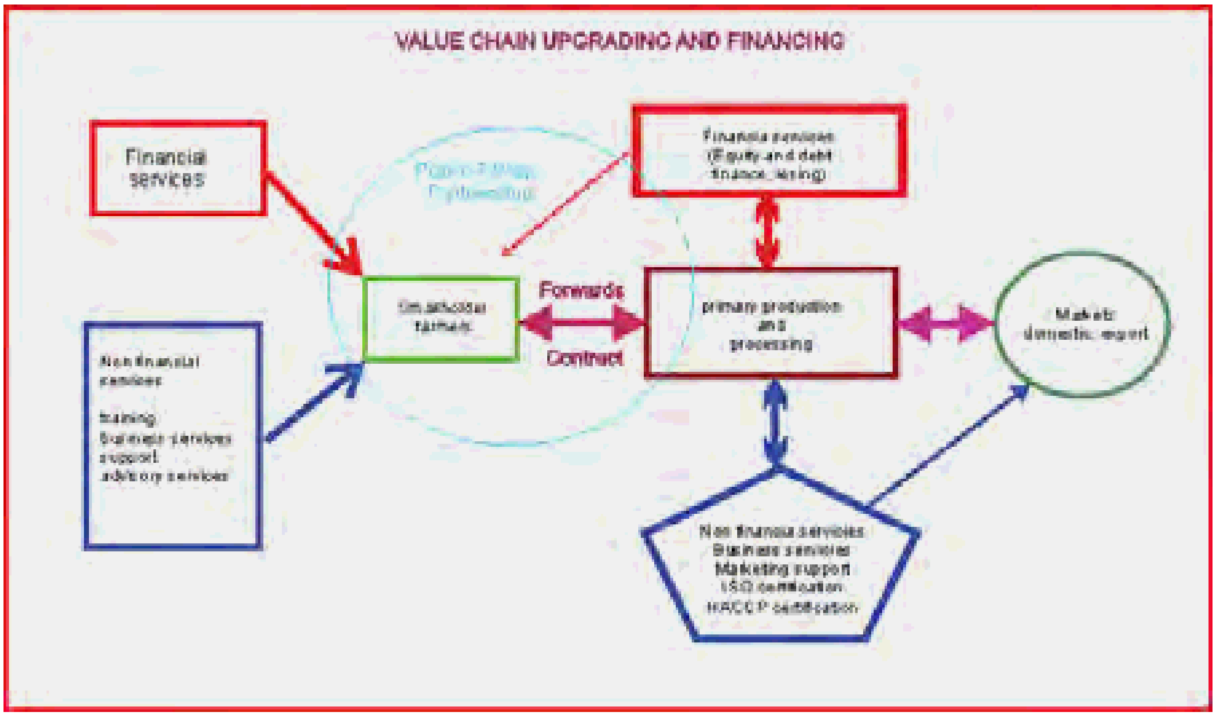
Farmers will need to have access to a banking system and most of them do not have enough income or capital to finance investment in farms or parts of the project, so it is necessary to provide them with support tools.

- First, the government must provide for a national guarantee fund supporting the banking system for when, due to personal problems or because of adverse meteorological conditions or distortions in market prices, the farmer is unable to repay the annual instalment of the loan.
- The second important thing is government or donor support for bank interest payments, given the high price of money locally. Farmers can repay the loan principal, but hardly the interest portion.

Farmers interested in the project are largely small companies (1 or 2 dunums) are heterogeneous and have different needs. It is important to identify the various sub-organizations of small owners and to evaluate their needs and constraints. In addition, small farmers do not only need credit

for agricultural activities, but also need credit for other family / needs, savings, payment systems and insurance.

Clearly knowledge of the needs of small farmers makes it possible to identify the real needs, in particular regarding the guarantees for the banking system. On systemic risk, agricultural insurance, catastrophic risk programs, price coverage through exchanges of goods or value chains, banks can provide some innovative solutions.



Agriculture value chain development is strongly influenced by:

Financial services Financial services identify the possibility of providing credit easily to small farmers who can expand their business by investing in more profitable crops, plant and machinery, improving the quality of agricultural production and starting up with other farmers on processing products in order to increase the value added on the farm.

On this point, it is important to develop warranty services, such as a **national guarantee fund** that supports the banking system in lending.

Another example of financial services for farms is the establishment of a **national rotation fund** for investment financing for small farmers.

Agricultural insurance must support farmers with regard to the risks of climate change that pose the greatest risk to agriculture and food security. It is clearly necessary to ensure farmers also for losses due to the contingent difficulties of the neighbouring Israel.

Financing needs are not high and are comprised between 1,000-2,000 ILS/du for new tree plantations, so they do not represent important figures to guarantee - only greenhouse construction requires more important investments around 35,000 ILS/du. Other investments relate to corporate mechanization as possible support for company work for medium-sized farms.

Non-financial services: Non-financial services are fundamental to farmers' training for new technologies, low-impact farming practices and organic farming. In addition, credit counselling services and advisory services for the processing and marketing of the products of their own farm are required.

Public-Private Partnerships (PPPs): Another element that could support the development of new financial management models is based on public-private collaboration.

Public-private partnerships (PPPs) enable the involvement of the private sector in the implementation and development of a programme. Various forms of PPPs can be implemented within the program are:

- Partnership with the private sector for better access of small producers to markets and enhancement of quality of production at grassroots level;
- Partnership with the public sector to enforce the necessary legal framework and to develop the indispensable infrastructure;
- Partnership with financial institutions inclusive of commercial banks, microfinance institutions and leasing companies to finance the needs of different stakeholders within value chains and service providers to the value chains;
- Partnership with insurance companies to develop specific products aiming at mitigating risks for stakeholders and financiers;
- Partnership with communities to strengthen their capacities to gradually own and operate productive assets and/or specifically created companies;
- Partnership with local SMEs and entrepreneurs to develop services to value chain stakeholders like processing, storage facilities, transport, maintenance and repair, inputs supply.

JOB IMPACTS

The project in its full version creates new employment, the estimate of the level of direct employment is about 150 new employees and the job security for current employees.

Table 19: Job Created

JOB CREATED	DAYS/YEAR
JOB DAYS CREATED AT FARM LEVEL	**23.741**

JOB DAYS CREATED WUAS			**4.400**
JOB DAYS CREATED O&M			**4.840**
TOTAL JOB DAYS CREATED			**32.981**
INCREMENTAL LABOUR	dd	**32981**	**+ 34%**
	n.people	150	

The government may provide subsidies for young farmers who undertake to work on the farm in order to reduce youth unemployment.

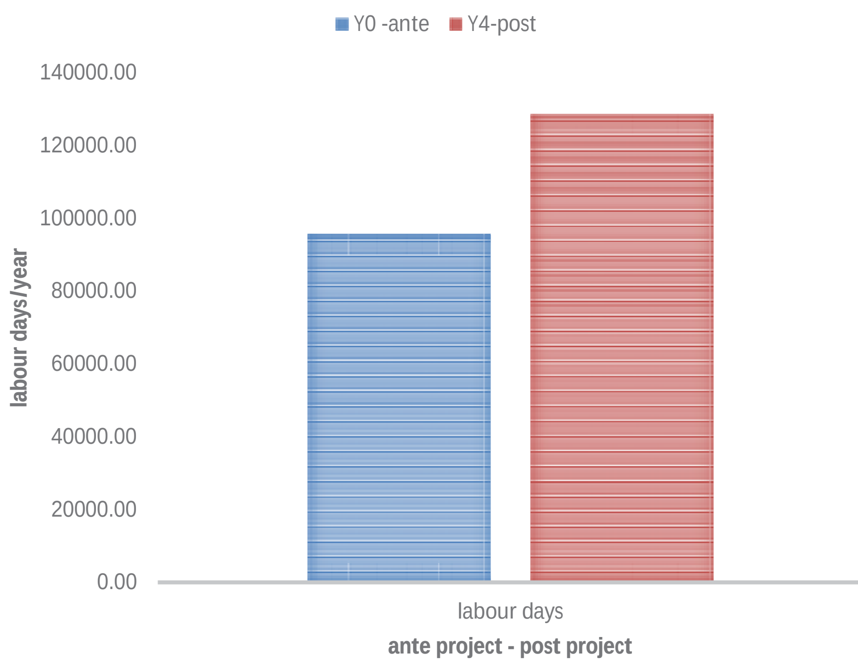


Figure 17: Job created per year before and after the project is implemented

PROJECT IMPLEMENTATION RECOMMENDATIONS

INSTITUTIONAL ARRANGEMENT

BACKGROUND

Traditional irrigation management in Palestine is community-based and informally organized around private wells in Gaza or springs in West Bank. Whereas in the Gaza Strip a small group of farmers share the operation and costs of a private irrigation well and organize the supply of water among themselves on a rotational basis, in the West bank, common irrigation schemes can supply up to a few hundred farmers and thousands of dunums, depending on the size of the spring. The organizational level is thus quite elaborate in West Bank, dealing with O&M, billing, and scheduling for hundreds of farmers in some cases. Still it is mainly informal, the number of WUAs in the Palestinian territories is very limited and the registered ones are very few. Governmental involvement in irrigation, therefore, has been very weak and limited to the licensing of agricultural wells.

INSTITUTIONAL OVERVIEW

Below is a summary of the responsibilities of the institutions that should be involved in the NGEST project, as outlined by the Water Law 2014 and the Draft Water User Association Regulation 2016.[6] It is important to note that the statements below are from the English translation of the laws. If there is a dispute as to the accuracy of a statement, the original Arabic version should be consulted.

As it pertains to this project, the PWA is responsible for (emphasis added):

- Setting a general policy for the planning and evaluation of water and wastewater projects in terms of their economic and social feasibility, setting design and quality control standards, technical specifications, and **monitoring their implementation**.
- Partake in the development of approved **standards of water quality** for various uses, in coordination and cooperation with the competent authorities, and ensure their implementation.

[6] Because the WUA Regulation is a draft, its provisions (outlined here) may be different in the final version.

- The **establishment of advanced monitoring systems** to monitor precipitation, surface flows, groundwater levels, utilization quantities, and water quality, as well as analysis of data to determine the safe and sustainable yield of Water Resources and improve water resources planning;
- Issue **licenses** for the drilling, exploration, extraction or collection of groundwater;
- Set the general policies for determining the water and wastewater **tariff**;
- Order the suspension of water extraction or water supply in cases of a water source or supply system pollution.

The Water Sector Regulatory Council is responsible for monitoring all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management. It has the responsibility and power to:

- Approve of **water prices**, costs of supply networks and other services required for the delivery of water and wastewater services, including setting a unified price for the provision of bulk water supply to Service Providers;
- Issue **licenses to Regional Water Utilities** and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of wastewater, and the levying of license fees;
- **Monitor operation processes** related to the production, transport, and distribution of water and operational processes of wastewater management;
- **Monitor water supply agreements**;
- Setting the basis for regulating the extent and percentage of **local authorities' participation** in the general assemblies of water utilities and ensuring implementation.

The National Water Company is responsible for the production and supply of bulk water at a national level. It is responsible for:

- The **supply and sale of bulk water** to water undertakings, local authorities, joint water councils and associations;
- The **extraction of water** from water resources, desalination of water, and **bulk water transmission** in accordance with a license issued by PWA for this purpose;
- The management, upgrade and development of any assets received from PWA;
- The provision of all the means necessary for the development of all activities and **infrastructure works related to the supply of bulk water**; and

- Propose a water supply tariff and submit to the WSRC for approval.

Service Providers include Regional Water Utilities and Water User Associations.

Regional Water Utilities provide water and wastewater services directly to the consumer, and are responsible for the provision of water and wastewater services within its specified administrative and geographical scope.

Water Users Associations are responsible for managing the service of supplying irrigation water at the local level. More specifically, it is responsible for:

- **Operation, maintenance and management of irrigation and drainage systems** in a fair, efficient and economical manner.
- **Produce or purchase water from its sources** at a certain rate and then redistribute it in a fair and timely manner to all farmers in the irrigation unit according to the criteria agreed with PWA;
- Determine the prices of water sold based on the tariff system in force;
- **Install, dismantle, repair and calibrate the means of measuring water** quantities used by water users.

To create a WUA, (at least) three people representing (at least) twenty farmers owning (at least) 100 dunums may submit an application to the Ministry of Agriculture. The application should contain basic information about the members, including the names and identity cards of the founding members, and the land owned or used by all members along with its agricultural pattern and water usage needs. The application should also include information about the Association, including its address, scope of work, and the water source to be used.

The Ministry of Agriculture will study the application and will then forward it to PWA, which in turn decides whether to grant a license to use the water source. If PWA approves the granting of a license, the Minister of Agriculture shall issue a decision to establish the Association. The application shall then be referred to the WSRC for approval to issue the license.

A WUA will be terminated if its approval to use a water source by PWA is cancelled.

The Ministry of Agriculture shall work with PWA and others in training WUAs on the following subjects:

- General training on participation in associations.

- Specialized training in the fields of financial, administrative and technical affairs necessary for the operation of the Association in accordance with the plans and programs established by PWA;
- Develop the operational plan, management and water distribution operations;
- Develop a maintenance plan for waterways, sockets and pumping mechanisms;
- Directly implement operation and maintenance plans; and
- Evaluation and follow-up.

During the transitionary period while the NWC, WUAs, and other new institutions are created, the relevant governmental authorities, official institutions, civil society organizations, and local authorities should continue to exercise their existing responsibilities and powers.

PUTTING IT ALL TOGETHER

Although it is clear which institutions should be involved in the various aspects of this project, what is not clear is where that authority exactly starts and stops. For example, it is stated that WUAs are responsible for "supplying irrigation water at the local level." But reasonable people may disagree with where that management should start in this project. Does it start at the recovery wells? At the booster station? Or somewhere else?

The main ambiguity, however, is regarding the responsibilities of NWC and the WUA. NWC is responsible for the extraction of water and bulk water transmission. Yet the WUA may "purchase ***or produce***" water, suggesting that the WUA may also be able to extract water itself without purchasing it from NWC. In the new Water Law, NWC is given the responsibility to sell to "associations", including WUAs. That statement alone, however, does not logically necessitate that associations *must* buy from NWC.

Moreover, the WUA is responsible for the irrigation system, which in the case of the NGEST project, coincides with the bulk water transmission system. In other words, the recovery wells extracting water and the pipes bringing the water to the farm gate can be characterized in one of two ways: 1) as bulk water supply (and therefore under the purview of NWC) or 2) as an irrigation system (and therefore under the purview of the WUA), or some combination thereof.

Below are three scenarios for O&M, which are meant to provide a starting point for discussions by Palestinian stakeholders on how best to run the project.

TERMS

Before introducing the scenarios, there should be some clarification of terms:

"**Recovery System**" includes the 28 recovery wells and 15 monitoring wells.

"**Reuse System**" includes all connecting pipes, two 4,000 m^3 water storage tanks, a booster station with 10 pumps, and an irrigation network of 126km of pipelines, which transports the water from the recovery wells to the farm gate and the water metering system.

"**On-Farm System**" is the infrastructure on each individual farm, including the tertiary pipe network to bring the water from the farm gate to the crops.

INSTITUTIONAL SCENARIOS

For the management of irrigation systems, world experience has generally followed three basic arrangements:

1) the government officials continue to manage the systems after completion;
2) the government turns the systems over to farmers to manage them; or
3) the government and farmers manage the systems jointly, meaning some parts of the physical system (generally the larger elements) are managed by governmental agencies while the smaller ones are the farmers' responsibility.

These scenarios are put into the NGEST context and discussed below.

It should be noted that during this transitional period, neither NWC nor the WUA exist. It is envisioned, therefore, that CMWU will handle the responsibilities of NWC until it is created and able to function. The WUA, which should be created as soon as practicable, will also be assisted by CMWU until it is ready.

Scenario 1 – Governmental Management

1. In this scenario, the Recovery and Reuse Systems would be owned and operated by the NWC.
2. This would mean:
    a. NWC will own and operate the Recovery System;
    b. NWC will own and operate the Reuse System;
    c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it is a simple, straightforward arrangement, whereby the governmental body that specializes in water distribution handles the supply.

The main detriments of this scenario are that it seems to contradict the spirit (if not the letter) of the law, which envisions a greater role for the WUA, and may perpetuate some of the problems with a centralized, governmental approach.

Countries have historically entrusted the management of their irrigation systems to government agencies, on the assumption that they will have the capacity and motivation to achieve high performance standards. The opposite has proven true, as documented reports and literature have shown the performance deficiencies of many government-managed irrigation systems has increased (see, *e.g.*, World Bank, 1997).

The deteriorated performance of irrigation systems under government agencies is generally the resultant of the following:

- the failure to operate and maintain systems adequately;
- the financial burden of subsidizing agencies to manage the system has become more onerous for many governments due to the low fee recovery rates from farmers;
- major difficulties in maintaining subsidies for irrigation systems that perform sub-optimally;
- difficulties in implementing water pricing and cost recovery as a traditional economic solution of "getting the prices right";
- local information constraints and inappropriate incentives for government employees.

Many of the issues delineated above have been problems in the Gaza Strip, and so significant consideration should be given to whether a governmental approach will achieve the goals of this project.

Scenario 2 – Water User Association Management

1. In this scenario, the Recovery and Reuse Systems are owned and operated by the WUA.
2. This would mean:
    a. WUA will own and operate the Recovery System;
    b. WUA will own and operate the Reuse System;
    c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it firmly places control and management into the hands of the WUA. As mentioned above, several benefits are expected to accrue from involving the WUA in owning and managing the network, including greater overall sustainability of the project.

The greatest detriment of this scenario is that NWC (CMWU) is much more knowledgeable and much better positioned to handle the system than the WUA. The WUA will need significant capacity building and technical assistance to step into this role, as discussed below.

For this approach, governments have followed two different methods to hand over irrigation systems to farmers. Some have favored the quick establishment of the WUA and a rapid transfer of responsibilities to it. Most countries, however, have favored a phased handing over, accompanied by training programs for the leaders of the WUA. The general belief is that a phased program has better chance of success and provides more opportunities to change course, if required.

Scenario 3: Joint Management

1. In this scenario, NWC would own (and for the first few years, also operate) the Recovery and Reuse Systems with the ultimate goal of transferring operation and management to the WUA.
2. This would mean:
   a) NWC would own the Recovery System, and operate it for the first three years of the project.
   b) NWC would own the Reuse System, and operate it for the first three years of the project.
   c) During the first three years, the WUA would receive intensive capacity building.
   d) After the first three years of the project, the WUA would assume operation and management of the Recovery and Reuse Systems.
   e) NWC would continue to own the Recovery and Reuse Systems but would lease them to the WUA.
3. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it blends the resources and knowledge of the NWC (CMWU) with the appropriate level of input and phased-in management by the users (WUA).

This scenario also dovetails nicely with the recommended **Investment Scenario 3**, where the capital investments necessary to build both Phase I and Phase II of the Recovery and Reuse schemes would be paid by the government (or by a donor), and the O&M of the Recovery and Reuse schemes and the capital expenditures and O&M of the On-Farm development would be paid by the farmers.

The main detriment of this scenario is that it is a more complex arrangement, necessitating various agreements and contracts between parties to delineate roles and responsibilities.

If this Scenario is chosen, the WUA could contract CMWU to manage the Recovery and Reuse Systems for a limited period of time, say 3 years. Also during that time, the WUA could contract the Union of Agricultural Work Committees (UAWC) to manage the training and extension services to the farmers to establish the executive capacity needed within the WUA.

Complete governmental or complete farmer management are both relatively rare in the world. The in-between option of joint management has become the norm, albeit with different variations. The Consultant recommends that PWA take advantage of world experience and select a joint management model.

WATER USER ASSOCIATIONS

WUAS IN GAZA

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – a "collective well". Namely, a farmer owns one well and other neighboring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The baseline survey of this Complementary Feasibility Study shows that 92% of the farmers depend on the "collective well" system, owned by the remaining 8%.

Usually, the farmers using a collective well do not sign any formal agreement, neither are they linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmers do not pay his share in due time, thus undermining the efficient operation of the well.

The few existing WUAs in Gaza are generally small and loosely organized. This low level of organization makes it difficult to initiate joint actions. They are also faced with harsh economic and financial circumstances, including limited access to the international market for agricultural products. Greater farmer cooperation under the umbrella of a WUA could yield significant gains.

COMMON TASKS OF WUAS

The main tasks and activities commonly found in WUAs include:

- Choose and specify the water source and take part in the planning, designing and implementation.
- Define the roles and responsibilities to manage, operate and maintain the water source and its structures.
- Solve conflicts among water users by achieving a fair water distribution among the users.
- By mutual control and increased sense of ownership and responsibility, reduce violations over water.
- Take part in the tasks and functions for the management of irrigation projects.
- Help to develop irrigation efficiency at a field and network level, also by facilitating the spread of modern irrigation techniques.

TRAINING NEEDS AND CAPACITY BUILDING

A capacity building program should be carried out to enable the WUA to achieve its mandate.

On-farm technical assistance and training on irrigation topics, in conjunction with best agricultural practice, will be handled by the Ministry of Agriculture and the non-profit organization Union of Agricultural Workers Committees (UAWC).

Table 20: WUA capacity building and training needs; estimated costs for 20 farmers

TOPIC	NO. PARTICIPANTS	DURATION (DAYS)	ESTIMATED COST (US$)
FACILITATION AND TRAINING SKILLS	10	30	$120,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN IRRIGATION TECHNOLOGIES, SUCH AS ON-FARM LOW PRESSURE SYSTEMS, LOCALIZED IRRIGATION, ETC. BASIC LEVEL.	20	15	$120,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN IRRIGATION TECHNOLOGIES, SUCH AS ON-FARM LOW PRESSURE SYSTEMS, LOCALIZED IRRIGATION, ETC. ADVANCED LEVEL.	20	10	$80,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN ON-FARM SURFACE IRRIGATION SYSTEMS.	20	5	$40,000.00

DESIGN, OPERATION AND MAINTENANCE OF ON-FARM DRAINAGE SYSTEMS.	20	7	$55,000.00
ON FARM DRAINAGE, DRAINAGE WATER REMOVAL AND CONVEYANCE OUT OF THE IRRIGATION AREAS TOWARDS THE DRAINAGE OUTFALLS	20	10	$80,000.00
SOIL SCIENCE, SALT LEACHING, LAND RECLAMATION	20	5	$40,000.00
COMPUTER MODELS APPLICATION IN I&D	5	5	$10,000.00
GIS AND REMOTE SENSING APPLICATION FOR IMPROVED WATER MANAGEMENT IN I&D	5	5	$10,000.00
I&D MANAGEMENT TRANSFER (INCLUDING PARTICIPATORY IRRIGATION MANAGEMENT/WUAS FORMATION PROCESS AND BACKSTOPPING)	5	15	$30,000.00
STUDY TOUR TO ABROAD (TO BE SELECTED)	5	7	$52,500.00
USE OF THE AGRO-METEO STATIONS NETWORK. INTERPRETATION OF WEATHER FORECASTING AND RECOMMENDATION FOR FARMERS	5	15	$112,500.00
IRRIGATION METHODS AND SCHEDULE FOR EFFECTIVE PEST AND DISEASE CONTROL	20	7	$56,000.00
		Total	**$806,000.00**

ECONOMIC SUSTAINABILITY OF WUAS AND COSTS

While they may be entitled to claim subsidies or state assistance, WUAs are usually largely self-financing, the bulk of their income being provided by their participants. For NGEST, it is presumed that farmers will cover the costs related to the WUA's management and basic activities (e.g. office rent, administration staff salaries etc.) from the beginning of the organization. Additionally, farmers are expected to pay the OPEX costs of the recovery and reuse scheme, and any on-farm development. The proposed water tariff options in this Report have been made with these expenditures in mind.

It should be noted that, because they are non-profit, WUA-specific legislation could confer powers on WUAs to take and impose compulsory measures. These can include: the right to impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; the right to make binding operational rules concerning, for example, the use and allocation of irrigation water; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts (FAO, 2007). None of these powers are currently in the Draft WUA Regulation. If they are not included in the final version, some aspect of these concerns must be addressed in whatever contractual agreement is brokered between the WUA and either CMWU or PWA.

Table 21 shows an estimated cost breakdown for the establishment and operation of a WUA (gathering approximately 20 farmers) for the NGEST Water Reuse Scheme.

Table 21: Estimated costs for the establishment and operation of one WUA, for 1 year

ITEM	UNIT	COST (USD)
4X4 CAR	1	25,000 USD
OFFICE AUTOMATION EQUIPMENT FOR ADMINISTRATIVE AFFAIRS	Forfeit	25,000 USD
SALARY FOR ADMINISTRATIVE STAFF	1	30,000 USD
RUNNING COSTS	Forfeit	20,000 USD
	Total	100,000 US$

COST SHARING MECHANISMS

Typically, WUA costs include some, or all, of the following:

- The cost of obtaining a permit to abstract and use water and/or to drain water or to dispose of wastewater together with any water use and wastewater disposal charges payable pursuant to such permit;
- Charges in respect of water supplied to the WUA on a contractual basis by a state agency or some other bulk water supplier;
- The WUA's own costs of operating and maintaining the infrastructure under its authority, which may include staff salaries, office expenses (including the costs of rent, utilities and

communication), operation costs including the costs of electricity if pumps are used, system maintenance including routine and annual maintenance, the maintenance of an emergency reserve fund, small replacement fund, transport expenses, purchase of equipment, social charges and taxes; and

- Investment costs for the construction, rehabilitation or reconstruction of infrastructure.

As mentioned above, a key feature of WUAs across the world is that they are usually self-funding, at least as far as operating costs are concerned. The typical sources of WUAs finance include fees and charges for services provided by WUAs to its participants as well as loans, grants and subsidies, income from assets or capital owned by WUAs, and fines from participants who have breached its operating rules.

The way in which the level of fees is determined can be left up to WUAs or specified in the relevant legislation. The amounts payable by individual WUA participants can be based on, for example, the volume of water supplied (if the main WUA service is water provision), flat rate charged per hectare of land (in case of a range of different and not easily measurable services provided by WUA), or value of possessed agricultural land. For the NGEST project, a proposal is made to charge the farmers based on the water delivered to their farms at a rate that ranges between 0.9 and 1.5 ILS/m^3. This fee would cover the expenses of the O&M of the Recovery and Reuse Systems and running the WUA organization.

If farmers are not able to pay the fee until after the irrigation season is over and they have harvested their crops, a range of solutions can be applied, such as: participants can pay deposits, the WUAs can borrow money by way of a loan or bank overdraft or issuing bonds, or receiving governmental or other grants.

Ideally, a WUA fund would be established to provide support for the creation and early administration of the WUA (an initial capital of, say, US$ 1 million). Otherwise the WUA may fail due to low membership fees from the farmers in the NGEST project area, most of whom own small plots of land.

RECOMMENDATIONS

- **Immediately pass enabling legislation for the creation of WUAs**

The Draft WUA Regulation from 2016 should be finalized, promulgated and implemented as quickly as possible. The draft Regulation sets out the basic parameters within which the design of each individual WUA can be crafted. Several important legal rights, however, have not been addressed.

One of those legal rights is the long-term right to abstract water from a natural source or, depending on which Scenario is chosen, a long term contractual right with a bulk water supplier

(e.g. NWC). As written, the Draft WUA Regulation states that PWA may cancel a WUA's right to use a water source; it does not say what process or justification would be required for PWA to do so. Moreover, if PWA cancels a WUA's right to use a source, the Regulation states that the WUA will be terminated by the Ministry of Agriculture. This prospect may have a chilling effect in WUA members' willingness to contribute to the long-term investment needs of the system. Although PWA's cancellation may be appealed, if the Association and its work may be terminated at the whim of a ministry, that creates an impression of a less secure institution overall.

Additionally, as mentioned above, WUAs will very often need to have express legal rights to do things like impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts. Without this authority, the work of the WUA may be significantly hampered.

- **International Norms**

To mitigate health and environmental risks, common international norms and standards for the quality of irrigation water should be followed.

STAFFING REQUIREMENTS OF THE PIU

The Project Implementation Unit (PIU) should have a multi-disciplinary technical team. Table 22 illustrates the proposed PIU composition.

The PIU shall assist field activities, and act as coordination unit for related on-farm initiatives. The PIU shall be directly linked with the future WUA that will be established to manage irrigation water distribution.

Table 22: PIU Staff Composition

NO.	AREA OF EXPERTISE	INSTITUTION	QUALIFICATION
1	On farm irrigation technology and water distribution	CMWU	Eng.
2	Land reclamation	CMWU	Eng.
3	Information Technology	CMWU	Eng.

4	Plant Production and Soil Fertility	MoAg	MSc
5	Plant Protection	MoAg	MSc
6	Agro-meteorology	MoAg	MSc
7	Rural Extension	MoAg	MSc
8	Administration		

Expert on On-farm irrigation technology and water distribution

Duties / Responsibilities:

- Review the irrigation requirements and water balance analysis performed and recommend further detailed studies as needed;
- Assist relevant team members in the preparation of work programs and schedules;
- Develop a quality assurance program for civil works for the irrigation component, and train staff on the in implementation of the quality control program;
- Operates power equipment and hand tools to install, maintain and repair irrigation systems and related components including irrigation lines, sprinkler heads, control panels, valves, pumps, etc.;
- Checks system for proper operation and timing. May participate in the design or modification of new or existing systems. Performs seasonal maintenance such as system charging and draining;
- Maintains inventory of related parts and supplies. May lead workers on irrigation projects and work on other grounds related assignments as needed.

Expert on Land reclamation

Duties / Responsibilities:

- Advise farmers about appropriate land management and conservation practices, adapted to the project environment;
- Advise other experts about environmental management and conservation;
- Design specific plans to reclaim non-cultivated areas in the project zone;
- Apply knowledge or research findings to address environmental problems;
- Train personnel in technical or scientific procedures;

- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Information Technology

Duties / Responsibilities:

- Design, program, and maintain IAS website using HTML5/JavaScript/CSS. Interface with SQL databases as required;
- Maintain Microsoft SharePoint site layout and permissions. Develop custom SharePoint lists and libraries;
- Contribute to Social Media system including creating original content, assisting users in content generation, and account management;
- Interact with and provide services to the other members of the staff in a highly dynamic and occasionally time-critical environment.
- Perform other duties as required.

Expert on Plant Production and Soil Fertility

Duties / Responsibilities:

- Support farmers in designing sustainable and productive cropping patterns;
- Help in crop budgeting & planning;
- Take soil samples, prepare and submit them for testing;
- Review soil test results and provide advice to farmers;
- Inspect crops in accordance with guidance;
- Record crop outcomes as requested;
- Manage required field services such as fertility, soil amendments, crop
- production, and more;
- Maintain crop and financial data in accordance with requirements;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Plant Protection

Duties / Responsibilities:

- Identify plant protection problems in the project area and provide technical support for the promotion of safe and sustainable plant protection activities, based on IPM solutions;

- Design and conduct periodic reviews and appraisals of the situation of plant pest and pesticide problems in the project area and advise farmers on necessary actions to implement pest and pesticide management programmes;
- Provide advice to IAS in training technical personnel through targeted training programmes, workshops and seminars related to plant protection and maintain close relations with international and national research institutions for the transfer of research findings;
- Perform other related duties as required;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Agro-meteorology

Duties / Responsibilities:

- Mainstreaming agro-met advisory services into the agricultural extension system;
- Developing and engaging in the delivery of a training plan to improve skills within the extension system for interpretation and analysis of climate information to inform agronomic advice;
- Developing and engaging in education programs for farmers regarding benefits of agro-met advisory services.
- Supporting integration of agro-met within extension packages.
- Reviewing proposed approaches for dissemination and communication of climate information and feedback.

Expert on Rural Extension

Duties / Responsibilities:

- Encourage farmers to adopt best practice techniques by providing exposure to new knowledge, information, skills, inputs and processes;
- Assess individual farms and making technical recommendations for improved production and sustainability;
- Collaborate with farmers in developing processing and post-harvest schemes;
- Suggest research priorities to research committees;
- Organise and manage field days, speak at grower groups, write fact sheets and publications, present courses;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Administration

Duties / Responsibilities:

- Support team leader in ensuring effective and efficient financial management system;
- Maintain efficient and effective financial system;
- Support in periodic financial planning, including Annual Plan and Budget (APB);
- Supervise general administration of IAS;
- Perform other duties as required.

INSTITUTIONAL CAPACITY ASSESSMENT

There are a number of particular skills that need to be developed for the successful implementation of the NGEST project, including management of MAR and sludge as well as the design, operation and maintenance of modern irrigation technologies. Communication and cooperative approaches should also be fostered through trainings on developing the WUA or community awareness to bolster support for the project.

In order to adequately assess the specific capacity development needs for each aspect of the project, this *Report* has interwoven capacity building throughout each section: Managed Aquifer Recharge; Farmer Assistance; WUAs; and Operation and Maintenance of the Irrigation System. Therefore, although there are recommendations below for Institutional Capacity Building, overall capacity development should be viewed through the context of the entire *Report*.

RECOMMENDATIONS

A capacity development system for the Water Sector in Palestine already exists and a substantial amount of resources are being invested to enhance capacities in this sector (PWA, 2016). Compared to some other countries, where capacity development efforts have to be developed from scratch, Palestine boasts a substantial foundation of sufficiently developed institutions and a high number of human resources investments. Palestinian Universities, polytechnics, industrial secondary schools and vocational training schools produce a constant inflow of trained professionals for the water sector, and international donors have expended considerable sums for training of water sector stakeholders.

However, there needs to be better coordination of capacity development initiatives with policies and strategies so that there is a more efficient utilization of resources and the training better meets the needs of the sector. In particular, PWA, NWC, CMWU and the WUA need targeted capacity building to implement the water law, to make effective and efficient use of increased investments, and to maintain the existing and new infrastructure.

In addition, work needs to be done to create an environment in which skill and knowledge acquisition can take place, including, for example, fostering a professional atmosphere in which technical growth is rewarded and there are incentives for participation, allocating a sufficient budget for on-going development, and ensuring monitoring and follow-up of capacity development efforts.

Below is a truncated list of institutional capacity building recommendations. As mentioned above, for a more detailed analysis of capacity development needs, see the other relevant sections of this *Report*.

Capacity Development Coordination. There is a need for sector-wide monitoring and evaluation of capacity development interventions. The current lack of the monitoring and evaluation is directly correlated with the need for coordination, but also lends itself to the mismanagement of limited resources, decline in performance and loss of value for money spent. It is expected that the newly created Capacity Development Directorate of PWA will lead this coordination as well as execute the recommendations contained in PWA's Water Sector Capacity Development Policy and Strategy of 2016.

Focus on Practical Skills. There should be increased focus on the development of practical knowledge and competencies to address existing and emerging water sector challenges, for example negotiation with the Joint Water Committee, and how to build, manage, repair and renew a modern irrigation system.

Encourage On-going Capacity Development. Water professionals need to refresh and expand their knowledge base in a number of training days each year to be able to excel in their work. Organizational Capacity Development Action plans, covering a 3-5 year period, should be prepared by the relevant units and persons within the respective organizations. These plans should be approved by the organization itself, endorsed at national level, and updates should be made annually.

Help Prepare CMWU. Because CMWU will likely handle the operation and management of the NGEST Recovery and Reuse schemes until the creation of the NWC and WUA, the capacity of CMWU should be expanded to provide this service. Additionally, there may be the need to modify the current mandate of the CMWU to reflect this change.

Sludge Management. Training is needed that tackles sludge collection, treatment, or dumping and sludge management. Sludge represents a completely new sector, which should be organized and well regulated in order to benefit from it.

MAR Training. A simplistic view that treating water to near drinking standards before recharge will protect the aquifer and recovered water is incorrect. For example chlorination, to remove

pathogens that would be removed in the aquifer anyway can result in water recovered from some aquifers containing excessive chloroform. In some locations, drinking water injected into potable aquifers has resulted in excessive arsenic concentrations on recovery due to reactions between injected water and pyrite containing arsenic. Source water that has been desalinated to a high purity dissolves more minerals within the aquifer than water that has been less treated (Dillon, 2009).

Therefore, PWA (and any other ministry that will be responsible for the MAR scheme) needs to understand how this aquifer will interact with the recharged water. More specifically, it should have hydrogeological and geotechnical knowledge, as well as knowledge on water storage and treatment design, water quality management, hydrology and modelling, monitoring and reporting. It needs to understand pathogen inactivation and biodegradation. The response of an aquifer to any water quality hazard depends on specific conditions within the aquifer, including temperature, presence of oxygen, nitrate, organic carbon and other nutrients and minerals, and prior exposure to the hazard, so the Authority should receive adequate training on these subjects.

Additionally, PWA (and any other ministry that will regulate the MAR scheme) should acquire basic stratigraphic and hydrogeological information for each well drilled. This information should be stored in departmental data bases, which would ideally be publically accessible on the web.

Create a MAR Unit. The human resources at PWA are limited as the number of staff is already not sufficient to perform all needed tasks (e.g. data evaluation, quality control) let alone to fulfil new tasks related to MAR. Therefore, it is recommended to create a MAR unit to handle strategic planning and the oversight of MAR activities.

FARMER CAPACITY BUILDING

PRESENT FARMERS' ORGANIZATIONS

The Union of Agricultural Work Committees (UAWC) is the main organization[7] active in the project area, already working with a few farmers. UAWC is a non-profit organization founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union aims to help Palestinian farmers to market their produce and provides

[7] Other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions.

Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors, in the West Bank and Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in different Palestinian rural areas. UAWC receives funding from numerous western governments and aid organizations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organizations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like MoAg. Relationships are also established with international development agencies, like FAO.

The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, such as land reclamation; building greenhouses; products quality enhancement and new crops introduction. Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistical and financial support for exporting goods such as strawberries and medical herbs, which usually ensure a good revenue.

IMPROVING FARMERS TECHNICAL SKILLS

The farmers interviewed during the baseline survey stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.

According to the outcomes of the baseline survey and the agronomic characteristics of the new proposed irrigated cropping system, the following training and technical assistance needs have been identified for the farmers:

Training on appropriate use of irrigation. So far, the irrigation practice has been left in the domain of individual farmers without any technical assistance. Underground water is being managed without considering the actual water requirements of crops, after computing the water balance of the area. Without an appropriate approach to irrigation, the amount of water supplied to crops is often under- or overestimated hence causing low yields and problems of uncontrollable pests and diseases on the cultivated crops. The envisaged training program has

the objective to make the farmers fully capable to design an irrigation plan suitable for their cropping pattern for various irrigation methods (e.g. surface, sprinkle or drip irrigation).

Training on integrated pest management (IPM). It has been observed that use of pesticides on crops is often high in north Gaza, although these products are quite expensive since imported from Israel. Pests outbreaks are common in the target area, probably because of irrigation misuse (see above). However, farmers lack specific knowledge on effective methods for preventing pests and diseases, which should allow them to drastically reduce the amount of sprayed pesticides, so saving money and making the farming environment healthier. The IPM method has been conceived in the '70. It is a pest control strategy that uses a variety of complementary strategies including: mechanical devices, physical devices, genetic, biological, cultural management, and chemical management. These methods are done in three stages: prevention, observation, and intervention. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. IPM practices have been so far successfully implemented on vegetables and fruit tree crops in the Middle East. These crop groups represent 65% of the new cropping pattern proposed for the project.

Training on Integrated Plant Nutrient Management (IPNM). This methodology has been devised by the Food and Agriculture Organization of the UN. It allows to match crop nutrient needs with sufficient accuracy to prevent surplus of fertilization. This in turn limits soil and water chemical pollution which usually is a consequence of the use of mineral fertilizers. The purpose is to maintain or enhance soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients, including biological nitrogen fixation. IPNM focuses first on the seasonal or annual cropping system (namely, the entire crop rotation applied by a farm), rather than on an individual crop; secondly, on the management of plant nutrients in the whole farming system; and, thirdly, on the concept of village or community areas rather than individual fields. The proper application of IPNM, among others, allows to minimize the use of mineral fertilizers which are particularly costly in Gaza, because imported from Israel.

Farming field schools (FFS) for effective training on IPM and IPNM. The Farmer Field School is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It was initially developed to help farmers tailor their IPM practices to diverse and dynamic ecological conditions, but subsequently the method has embraced also other relevant topics for improving farmers' technical skills. In regular sessions from planting till harvest, groups of neighboring farmers observe and discuss dynamics of the crop's ecosystem, under the guidance of a facilitator (usually an agricultural extensionist, well trained on running a FFS). Simple experimentation helps farmers further improve their

understanding of functional relationships within the agro-ecosystem (e.g. pests-natural enemy population dynamics and crop damage-yield relationships). In this cyclical learning process, farmers develop the expertise that enables them to make their own crop management decisions. Special group activities encourage learning from peers, and strengthen communicative skills and group building. Farmer Field Schools for vegetable crops have been successfully implemented by FAO in Egypt, Jordan, Syria, Iraq and in Palestine (West Bank).

BUILDING FARMERS' CAPACITY ALONG THE VALUE CHAIN

Supporting farmers in establishing organizations. Collective action can create a more effective market chain that is more stable and can produce the products required at the time needed and of the quality wanted. As a group, producers can provide a more stable and higher quality supply of raw material, which also improves the economic efficiency of the value chain. The higher bargaining power and improved access to markets for group members are made possible by creating a link with other actors along the chain (retailers, traders and processors). However, a farmer organisation cannot be simply created by a top-down approach from the government (for example, by providing strong subsidies to farmers if they join an organisation; or providing inputs for free). Many worldwide experiences clearly show that farmers organisations (under the shape of cooperatives, associations, etc.) fail when members are not fully convinced that collective action is really an opportunity for them to grow and improve their lives. Farmer organisations also fail when their members do not firmly aim at economic independence, but rather rely on external aid. The survey carried out in the project area highlighted that farmers work on individual basis. Even when they share collectively the same private well, everybody keeps on working on his own. It is also noted that only one organisation is existing in the project area, joining a small number of farmers.

To cope with this reluctance toward cooperation, farmers should be invited - through a tailored training programme - to progressively share their activities. For instance, an initial stage of farmer collective action may be started just by purchasing the farming inputs together, which will allow a discount from the seller. Then, farmer collective action can further evolve in growing crops together, according to a cropping plan that has been specifically designed to meet the market needs in a certain period of the year. When collective crop production is finally carried out relationships with the merchants (wholesalers, traders at any level of the supply chain) can be strengthened and options of contract farming may become feasible. Furthermore, associated farmers may start processing the raw materials and their marketing action will become more targeted and complex. By following this progressive process, the farmers' organisation purchasing power and its share of added value along the supply chain will increase.

Training on post-harvest operations and food processing and establishing suitable physical structures. This training programme requires high investments and well established farmer's organisations, which will handle the operations and run the post-harvest and processing structures. The survey carried out by the consultant highlighted that in northern Gaza the existing food industries do not buy raw food materials from the local farmers but they rather import it from Israel, probably because the industry cannot find the required amounts according to its needs. While this specific demand from the industry could be properly satisfied by an organised group of farmers (see above), on the other hand organised and well trained farmers could start simple post-harvest processing activities, such as sorting and packing fresh fruit and vegetables; preparing plant preserves, purée, jams, etc. Another option would be processing dairy products, considering the good milk production from cows, sheep and goats which are being reared in the project area.

All the above-mentioned activities will improve products quality and introduce new products into the local market which will increase the farmers' earnings.

However most of the farmers seem they cannot afford the cost of the initial investment (e.g. purchasing a refrigerator unit, packaging materials, other equipment for processing), nor bank loans seem available in north Gaza. Therefore, external aid should be foreseen together with sound training sessions.

MANAGED AQUIFER RECHARGE

Managed aquifer recharge (MAR), also known as enhanced recharge, water banking and sustainable underground storage, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can be used to store water from various sources, such as stormwater, reclaimed water, mains water, desalinated seawater, rainwater or even groundwater from other aquifers. With appropriate pre-treatment before recharge and sometimes post-treatment on recovery of the water, it may be used for drinking water supplies, industrial water, irrigation, toilet flushing, and sustaining ecosystems. The figure below shows the basic MAR process for an unconfined aquifer.

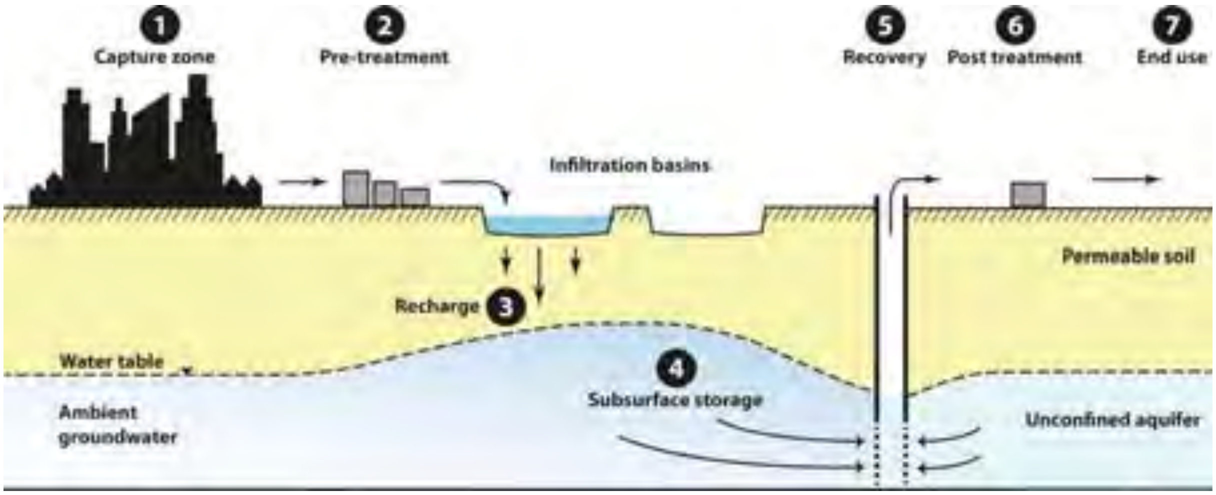


Figure 18: Schematization of Managed Aquifer Recharge System (Source: Dillon, 2009)

Several past documents describe the NGEST Project as if it is a treated-wastewater-for-irrigation project. It is not. Rather, it is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation. The difference is significant and has considerable implications for the feasibility and sustainability of the project. Outlined below are some of the central considerations and concerns for managing this segment of the project.

REGULATORY ISSUES

The main objectives of MAR regulations should be the protection of groundwater from pollution and the assurance of public health. Topics covered in a regulatory framework often include technical issues, water quality requirements to protect groundwater and human health, regulations on the authorization to recharge and to recover water, and institutional arrangements (NRC, 2008).

The quality of the water extracted from the aquifer should meet the most stringent standards related to the intended water use. The quality of the water of a recharged aquifer is a function of multiple factors, including:

- the quality of the recharge water;
- the recharge method used;
- the physical characteristics of the vadose zone and the aquifer layers;
- the water residence time;
- the amount of blending with other sources;
- the history of the recharge.

Setting requirements for indirect recharge is not an easy task. The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, thanks to retention and oxidation processes. These processes affect organic matter, nutrients, microorganisms, heavy

metals and trace organic pollutants. However, though much is known about these processes (Bouwer, 1996; Drewes & Jekel, 1996), forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is complex. Performances depend on a number of factors such as depth of the unsaturated zone, physical and mineralogical characteristics of the soil layers, heterogeneity, hydraulic load, infiltration schedule and infiltrated water quality (Dillon, 2009).

Therefore, particularly when transfer through the vadose zone is part of the treatment intended to bring the water up to the required water quality, pollutant removal tests should be performed, at the laboratory and onsite, to ensure the water achieves the desired quality. The example of the Dan Project in Israel shows that submitting secondary effluents to a Soil Aquifer Treatment system in a dune sand aquifer can result in the production of a nearly potable water (Sack, Icekson-Tal & Cikurel, 2001).

The complexity of reactive transport processes in the unsaturated zone highlights two of the main stumbling blocks that must be taken into consideration if treated wastewater is being considered for MAR: one specific challenge is to have numerical models that can include all of the hydro-biogeochemical processes involved in reactive transport, while a second, more operational, is the need to have a complete biogeochemical and hydrogeological characterisation specific to each MAR site. These should be taken into consideration in assessing the capacity building needs of PWA and other stakeholders involved in managing the NGEST project.

Several countries (the United States and Australia, for example) have developed guidelines for the use of treated wastewater for recharge (USEPA 2004, 2012; WHO 2006a, b). These guidelines focus mainly on the health and environmental risks that result from the presence of pathogenic microorganisms, suspended solids and dissolved organic carbon in this water. There are few recommendations concerning trace element contents in water (e.g. USEPA 2012), except as concerns five trace metals. These are: (i) arsenic; (ii) nickel, which is only weakly toxic but which accumulates in plants; (iii) cadmium, which is considered to be the metallic pollutant of greatest concern due to its rapid accumulation in plants and its proven toxicity even at low concentrations (acceptable daily intake (ADI) 0.057 mg/day/individual); (iv) mercury, which can be highly mobile; and (v) lead, the injection of which, even at low doses, can cause neurotoxic and hepatotoxic disturbances (Dillon et al. 2009a).

Although these guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse. Land use planning and environmental impact assessment legislation add to the complexity of the regulatory frameworks currently available for MAR schemes.

Under many countries prevailing water resources legislation (e.g. Israel, South Africa, Spain, USA, Australia), groundwater which has been recharged with TWW is subject to the extraction and management rules of native groundwater, and is regulated accordingly through abstraction licenses or concessions from the un-differentiated groundwater pool.

IMPLICATIONS FOR THE APPLICATION OF PALESTINIAN WASTEWATER REGULATIONS

The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater. As has been discussed in past NGEST documents, the Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced. There has been some expressed concern whether this regulation applies to the NGEST irrigation scheme, which would significantly restrict the types of crops farmers could grow in the project area and, as a result, have severe implications for the financial sustainability of the project.

But the concern of whether the regulation applies to the irrigation scheme stems from the misunderstanding of the nature of this project highlighted at the beginning of this section. The NGEST project does not entail using treated wastewater for irrigation *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. The recovered water, therefore, is no longer "treated wastewater," and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.

That being said, the regulation also covers the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A"). See the below Table 23 for the basic parameters for each category.

Table 23: Palestinian reuse standards (PS 742/2003)

CLASS	QUALITY	BOD MG/L	TSS MG/L	FEACAL COLIFORM MPN/100ML
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000

D	Low	60	90	1,000

The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.

The project, therefore, is in complete compliance with the Palestinian regulation, so long as the water quality parameters for aquifer recharge are met.

OPERATION AND MAINTENANCE

Clogging is the most limiting technical problem in artificial recharge and can only be managed with regular maintenance and pretreatment. Clogging can be caused by various mechanisms like physical clogging by suspended solids, chemical clogging due to precipitation or clay dispersion, mechanical clogging due to entrapped air or biological clogging due to microbial growth (Bouwer, 2002). Clogging leads to the decrease in porosity and hydraulic conductivity and is experienced at the bottom of infiltration basins as well as around injection wells. There are two basic principles for the management of clogging: (a) pretreatment of recharge water and (b) redevelopment (Brown et al., 2006).

Apart from maintenance related to clogging, regular inspections of the facility are needed to assess if any repair works or cleaning is needed. This could include the cleaning of any screens, change of batteries, lubrication or replacement for equipment prone to wear and tear, repair of damage done by natural forces or vandalism. If mechanical or electrical parts are involved their proper functioning needs to be tested.

RECOMMENDATIONS

REGULATING EXTRACTION

MAR is one of the measures that can be implemented to secure water supply, compensate for some effects of climate change and, more generally, handle the quantity and quality of groundwater bodies. It is not, however, a substitute for groundwater management based on decreasing abstraction and adapting withdrawal to resource availability.

There are a number of private wells in the Gaza Strip, only some of which are officially registered. Thousands of wells are estimated to have been drilled without authorization, which has contributed to more rapid deterioration of the aquifer. (UNEP, 2014) To protect the aquifer and

for the success of the NGEST project, both the authorized and unauthorized agricultural wells should cease operation.

In order to do that, PWA, which is the institution responsible for issuing and renewing licenses for agricultural wells, plans to include a new clause in the next annual renewal of licenses that specifies that the operation of an agricultural well should be stopped when reuse water is available. At the same time, the voluntary adhesion to the new irrigation scheme shall be pursued.

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

MAR TRAINING

There are various institutes within the Gaza Strip that currently provide training regarding water and wastewater management. These institutes should be encouraged to establish short courses for MAR operators and regulators. These could also help ensure risk management plans are designed and implemented effectively and management issues are understood and addressed.

More is said on the needs of MAR training in the section on Institutional Capacity Building.

AQUIFER PROTECTION

It is recommended to develop a holistic MAR strategy and to implement transparent and comprehensive regulations specifying maintenance, monitoring and reporting requirements. Regulations should also address water allocation, ownership issues and demand management.

GROUNDWATER MONITORING

OVERALL MONITORING STRATEGY

Before preparing a groundwater monitoring plan, the overall strategy of the groundwater monitoring program should be defined to guide the development of the plan. In this sense, "strategy" refers to the manner in which a hypothetical release from a regulated unit will be detected or measured. Examples of issues that should be addressed when developing a monitoring strategy include:

- The type of monitoring data needed;
- The locations (both horizontal and vertical) from which the samples are to be collected (i.e., definition of "target monitoring zones");
- The manner in which the samples will be obtained; and
- The ability of the monitoring features to rapidly detect a change in groundwater quality.

Development of a groundwater monitoring strategy is illustrated in Figure 19 and Figure 20. As shown in these figures, the potential sources of contamination and the aquifer of concern should be characterized before developing a groundwater monitoring strategy because selection of target monitoring zones cannot be made until the source and the aquifer have been evaluated, usually through a detailed hydrogeological evaluation of the site. When evaluating the ability of a monitoring system to rapidly detect a release from a potential source, the impact of preferential flow paths and vertical gradients should be carefully evaluated; a two-dimensional analysis of groundwater elevation may not reveal actual upgradient or down gradient locations of groundwater flow. The presence of vertical gradients may significantly effect the selection of monitoring locations.

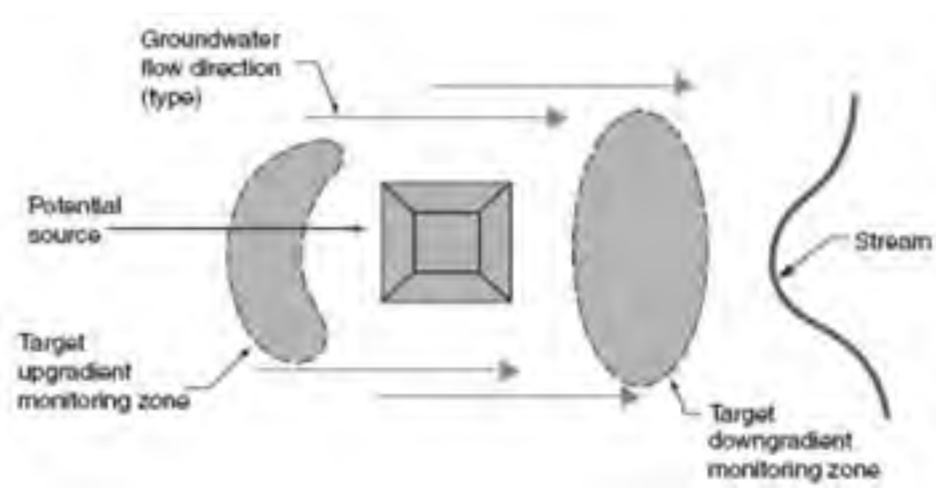


Figure 19: Plan view of typical unconfined aquifer groundwater monitoring system

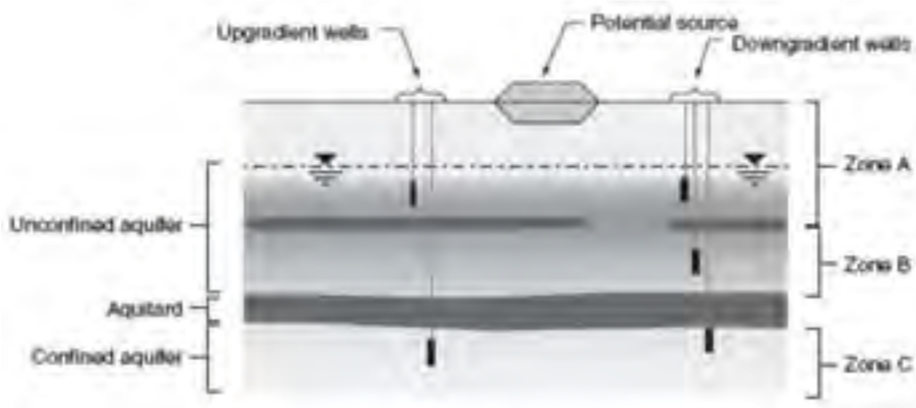


Figure 20: Vertical cross section of target monitoring zones.

MONITORING LOCATIONS AND PARAMETERS

Locating the appropriate monitoring point locations is essential in designing a monitoring network capable of providing data of adequate quality. Selected monitoring locations should provide the most reliable data needed to detect or assess a groundwater contaminant plume. To verify that the monitoring network can accomplish this goal, target monitoring zones must be selected based on the site hydrogeologic conditions and anticipated contaminant pathways. Figure 21 shows the recommended locations of the monitoring wells which was set up based on the location of the recovery wells.

The groundwater monitoring program in the NGEST Project is designed to evaluate the status of the groundwater quality after infiltration of partially treated and treated wastewater. The monitoring wells are distributed in two rows: around 400 to 500 m from the infiltration basin and the second row will be of 1100 to 1200 m from the basin. The first monitoring well row should be located before the first row of the recovery wells in the direction of the infiltration basin, and the second row of the monitoring wells should be located after the second row of the recovery wells to check the quality of groundwater outside the recovery wells areas. The monitoring network will also use the existing 5 monitoring wells constructed recently by PWA and used to monitor the infiltration basin. In addition, the recovery wells will be part of the monitoring network as shown in Figure 21.

Figure 21: Monitoring wells location

The main objective of monitoring is to check the groundwater quality after infiltration and check the operation of SAT process. The consultant made extensive reviews of similar projects such Gosh Dan Project where several parameters are monitored. Among these parameters, the consultant proposed in Table 24 some parameters which would reflect the status of groundwater after infiltration and could be analysed in Gaza Strip laboratories.

Table 24: Monitored Parameters and Frequency of Monitoring

WATER LEVEL	Monthly
PH	Four Times a year
TDS	Four Times a year
BOD	Four Times a year
COD	Four Times a year
DOC	Four Times a year
TC	Four Times a year
AMMONIA AS N	Four Times a year
NO_3	Four Times a year
NO_2	Four Times a year
T.N	Four Times a year
CL	Four Times a year
DETERGENT	Four Times a year
F.C	Four Times a year
PHOSPHORUS	Four Times a year
HEAVY METALS	Four Times a year
O_2	Four Times a year
NITROGEN AND OXYGEN ISOTOPES	Four Times a year

MG	Four Times a year

Samples will be collected from the monitoring wells to characterize the geochemistry of groundwater. The nitrogen and oxygen isotopes of groundwater nitrate will be used in conjunction with other geochemical data to place constraints on potential nitrate sources.

CONCLUSION

This *Complementary Feasibility Report* brings mostly good news. By reworking the original design, the project can save 21.5% of the water use while using 15% less energy, and can operate with a less complex irrigation schedule. It was determined that the project is in full compliance with Palestinian law, and should be financially sustainable by farmers. The review resulted in a new cropping pattern and design network, and offered a range of scenarios for the water tariff and O&M of the Recovery and Reuse Systems.

This *Report* also confirmed the validity of the original design for the recovery scheme and of the original design for the reuse scheme, confirming the selection of materials, the general layout and the selection of the pumping system. The newly proposed system fixes design inconsistencies of the original so that a minimum water pressure of 2.5 bars is provided to every farm gate.

The good news, however, is contingent. The water and energy savings, simplified irrigation schedule, and farmer profitability are contingent on improving the original design of the reuse scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern. The project's compliance with Palestinian law is contingent on a minimum level quality of water coming from the WWTP and being disposed of in the infiltration basins. And the project's feasibility overall is contingent on carrying out robust capacity building for ministerial and farmer stakeholders, and of adequately monitoring the Managed Aquifer Recharge component of the project.

Ultimately, therefore, the feasibility and success of the project hinge on whether all the essential stakeholders cooperate to fulfill their role.

ANNEXES

ANNEX 1: DRAFT MOU

A Memorandum of understanding (MOU) is a document describing a bilateral or multilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action. It is often used to establish a clear understanding of how common activities will practically function and each party's role and compensation. The contents of an MOU must (a) identify the contracting parties (b) spell out the subject matter of the agreement and its objectives (c) summarize the essential terms of the agreement, and (d) must be signed by the contracting parties.

Similar to a contract, a memorandum of understanding is an agreement between two or more parties. Unlike a contract, however, an MOU need not contain legally enforceable promises. While the parties to a contract must intend to create a legally binding agreement, the parties to an MOU may intend otherwise. For example, an MOU may recite that the parties "agree to promote and support the joint use of facilities." This type of provision establishes an important public statement of cooperation, but it does not constitute a legally enforceable obligation. Alternatively, an MOU may outline the terms of an agreement but state that each party's responsibilities are only enforceable "in the event that the parties' decide to enter a joint use agreement." Additionally, a non-legally binding MOU may be useful to serve as an agreement between two or more departments within a single public entity where a contract may not be legally appropriate.

Although there can be legal distinctions between contracts and MOUs, there may be no legal or practical difference if they are written with similar language. The key is whether the parties intend to be legally bound by the terms of the agreement. If so, they have likely created a legally enforceable contract regardless of whether they call it a contract or an MOU. Therefore, parties should address the legal status of their agreement early in the negotiation process.

Successful MOUs require a lot of thought, effort, and cooperation to reach agreement on a range of issues. In addition to the subjects listed above, an MOU can also cover issues such as: (a) who bears responsibility for the costs of maintenance and repairs, (b) insurance and liability, (c) staffing and communications, and (d) conflict resolution. Below is a sample MOU which lays out the basic provisions of an agreement. To agree on any specifics, however, it is highly advised that the parties meet to discuss the terms of the MOU, ideally with a mediator, facilitator or other neutral third party.

Sample

MEMORANDUM OF UNDERSTANDING

BETWEEN [AGENCY]

AND [AGENCY]

1. **Parties.** This Memorandum of Understanding (hereinafter referred to as "MOU") is made and entered into by and between the [agency name], whose address is ______ , and the [agency name], whose address is ______ .

2. **Purpose.** The purpose of this MOU is to establish the terms and conditions under which the NGEST Project partners will coordinate and function.

3. **Duration of MOU.** This MOU shall become effective upon the last signature by the authorized officials from the (list partners) and will remain in effect until modified or terminated by any one of the partners by mutual consent. In the absence of mutual agreement by the authorized officials from (list partners), this MOU shall end on (end date of partnership).

4. **Responsibilities of [agencies]**. [Delineate all obligations of the first party listed above. Include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, beneficial use of equipment belonging to other agencies while acting pursuant to this MOU.]

5. **Responsibilities of [other agencies].** [Delineate all obligations of the other agencies listed above. Identify the agency covered by this MOU, and include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, benefits and use of equipment belonging to an agency while acting pursuant to this MOU.]

6. **General Provisions**
    A. Each Party pledges in good faith to go forward with this MOU and to further the goals and purposes of this MOU, subject to the terms and

conditions of this MOU. The Parties shall attempt to resolve disputes through good faith discussions.

B. Either Party may unilaterally withdraw at any time from this MOU by transmitting a signed writing to that effect to the other Party. This MOU and the public/private partnership created thereby shall be considered terminated sixty (60) days from the date the non-withdrawing Party actually receives the notice of withdrawal from the withdrawing Party.

C. By mutual agreement, which may be either formal or informal, the Parties may modify the list of intended activities set forth in Paragraph 4.0 above and/or determine the practical manner by which the goals, purposes and activities of this MOU will be accomplished. However, any modification to any other written part of this MOU must be made in writing and signed by both Parties or their designees. Applicable Law. The construction, interpretation and enforcement of this MOU shall be governed by the laws of the State of Palestine. The courts of the State of Palestine shall have jurisdiction over any action arising out of this MOU and over the parties.

D. Entirety of Agreement. This MOU, consisting of [insert number], pages, represents the entire and integrated agreement between the parties and supersedes all prior negotiations, representations and agreements, whether written or oral.

E. Severability. Should any portion of this MOU be judicially determined to be illegal or unenforceable, the remainder of the MOU shall continue in full force and effect, and either party may renegotiate the terms affected by the severance.

F. Third Party Beneficiary Rights. The parties do not intend to create in any other individual or entity the status of a third party beneficiary, and this MOU shall not be construed so as to create such status. The rights, duties and obligations contained in this MOU shall operate only between the parties to this MOU, and shall inure solely to the benefit of the parties to this MOU. The provisions of this MOU are intended only to assist the parties in determining and performing their obligations under this MOU.

The parties to this MOU intend and expressly agree that only parties signatory to this MOU shall have any legal or equitable right to seek to enforce this MOU, to seek any remedy arising out of a party's performance or failure to perform any term or condition of this MOU, or to bring an action for the breach of this MOU.

Partner name

Partner representative

Position

Address

Telephone

E-mail

Partner name

Partner representative

Position

Address

Telephone

E-mail

Date:

(Partner signature)

(Partner name, organization, position)

Date:

(Partner signature)

(Partner name, organization, position)

ANNEX 2: WATER SUPPLY CONTRACT COMPONENTS

Either CMWU or NWC will need to sign a bulk water supply agreement with the WUA. Given the complexity and legal sensitivity of such an agreement, an actual contract is not included here. Instead, below is a list of thirteen areas that should be covered in any future water supply contract. This list is not exhaustive (it doesn't include boilerplate contract components, for example) but it does cover the items most needed for a comprehensive agreement.

1. Price and non-price terms

A bulk supply agreement should include both price and non-price terms so that the parties know what services are being provided at what price.

The price terms could include:

- a standing charge and volumetric rate for each water supply;
- charges for any volumes of water the WUA takes that are above the maximum amount allowed in the agreement;
- a minimum charge that the WUA pays whether it takes any water or not;
- a capital contribution to the connection cost;
- charges for the provision of information; and
- rules about the periodic adjustment of charges.

The non-price terms could include the ownership and responsibility for the assets used in the supply (discussed below), how charges are to be paid and how the parties are to operate the bulk supply.

2. Ownership of and responsibility for the assets

The agreement should be clear about who owns and who is responsible for operating the assets that are used to provide the bulk supply (which will depend on which Scenario is chosen). One way of doing this would be to include a detailed operational plan, which, as well as defining ownership and operating responsibilities, could include details such as maximum flow rate. This information will help in resolving any operational problems and will have a bearing on the price terms of the contract.

3. Measuring the water supplied

A bulk supply agreement should specify how the water supplied is to be objectively quantified. In this case, a meter will likely be used, which will need to measure the water supplied to the

degree of accuracy specified in the agreement. To ensure the accuracy of meter readings, meters should be tested (ideally, the type of test should also be specified in the agreement). Even with testing, there can be occasions when a meter is found to be faulty. To prevent a possible impasse between the parties the bulk supply agreement could specify the mechanism for determining the volume of water supplied in this case.

4. **Quality of the water supplied**

The agreement usually states the quality of the water to be provided and how it is to be assessed. This could be done by specifying the water quality parameters the non-potable water should meet. It is the WUA receiving the bulk supply that is responsible for the quality of water supplied to its customers (the farmers) but NWC (CMWU) must inform the WUA of any events that might lead to harmful water being supplied.

5. **Adjusting prices**

Price terms can be set in different ways. For example, some bulk supply agreements include volumetric charges for the supply of water. Other bulk supply agreements include contributions to the capital costs of building the bulk supply assets or the ongoing costs of operating the bulk supply.

As well as setting out the price terms, the bulk supply agreement might also explain how those price terms are to be adjusted to allow for inflation. Typically, bulk supply agreements include provisions for annual adjustments to the price terms to allow for inflation, although the parties could agree different frequencies of adjustment. The adjustments could be by set amounts, percentages or linked to measures of specific costs or general inflation. If the parties agree that no adjustment is to be made to the price, they could set this out for clarity.

6. **Interruptible or firm supply**

The bulk supply agreement should include details of any allowed interruptions. It would need to explain the number and duration of interruptions that NWC could make and under what conditions interruptions could happen. There might be a link between when NWC can make interruptions and interruptions for planned maintenance, emergencies and water shortages.

7. **Interruptions of supply to carry out planned maintenance**

Planned maintenance can disrupt the flow of water from NWC to the WUA. The WUA will want to know when maintenance will happen so that it can make alternative arrangements to supply the farmers.

The bulk supply agreement could put a requirement on NWC to minimize the frequency and length of any disruption to the bulk supply as a result of planned maintenance work. The agreement would need to define what is meant by 'planned maintenance'.

The agreement might set out the process by which NWC would consult the WUA over the timing of planned maintenance. It could specify how far in advance NWC should notify the WUA of the planned maintenance. The agreement might also allow a reasonable period for the WUA to express its views and could require NWC to consider them before making a final decision on the timing and duration of the maintenance.

8. **Co-operation in emergency situations**

Emergency situations could arise during the period of a bulk supply agreement that affect the quality of the water supplied, the volumes of the water supplied or some other aspect of the bulk supply agreement. It would be helpful if the agreement defined what is meant by an 'emergency' and explained how the parties would deal with one.

Obligations on parties to cooperate in an emergency could include:

- cooperating to prevent an emergency from occurring;
- notifying the other party of the existence and cause, if known, of the
- emergency;
- ensuring, as far as is reasonably practicable, that any emergency has the minimum possible effect on the supply of water;
- agreeing reductions in supply where this is reasonable to prevent or mitigate the effects of an emergency;
- ensuring that priority is given to vulnerable customers if a supply of water is restricted because of an emergency, and co-operate in agreeing categories of vulnerable customers;
- using all reasonable endeavors to restore the supply;
- investigating the cause of an emergency that has occurred; and
- sharing any lessons learned to prevent a recurrence of the emergency.

9. **Co-operation at times of water shortage**

The agreement could specify what is to happen during a time of water shortage. It might also place an obligation on both parties to cooperate in such situations.

The terms relating to water shortages could include:

- a definition of the circumstances under which NWC may limit the water it supplies under the agreement;
- an obligation for NWC to notify the WUA if it intends to impose a temporary ban on the use of water by some or all of its customers; and
- provisions relating to the actions the WUA should take to reduce water taken from the bulk supply in the event of a water shortage.

10. Liability for planned and unplanned interruptions

To give the WUA comfort that it would be adequately compensated for losses arising due to unplanned non-emergency interruptions, the agreement might include categories of costs such as:

- costs incurred in securing alternative sources of supply. The parties may wish to include a non-exhaustive list of potential alternative sources that would need to be deployed – for example, tankered water supplies; and
- GSS (guaranteed standards scheme) payments to customers.

To provide greater certainty, the agreement might allow for liquidated damages, that is, an estimate in advance of the losses the WUA might incur if the supply was not made available. To limit NWC's risk exposure, the liabilities in the agreement might be capped.

11. Duration

It might take many years for the revenues from the bulk supply to cover the cost of the dedicated bulk supply assets. A bulk supply agreement might therefore need to be long enough to allow for the parties to recover the costs of the assets. On the other hand, a long duration agreement can create problems if circumstances change and the agreement is no longer beneficial for one or both parties.

12. Dispute resolution

Disputes might arise from time to time with regard to the bulk supply agreement. It would be sensible for the agreement to include a provision to resolve disputes. It is best if this is comprised of an internal escalation process that must be followed before a matter may be referred to arbitration, the courts or some other form of formal adjudication.

Some energy contracts specify a time limit after which a party cannot raise a dispute about the other party's previous performance of the contract. For example, the contract might specify that parties must raise a dispute about an incorrect payment within a year of the payment being made.

13. Termination

The agreement should set out how it can be terminated by either or both parties. Ways in which a bulk supply agreement could be terminated include:

- on a date specified in the agreement;
- on either party giving a specified period of notice;
- by mutual agreement;
- if the WUA is terminated;
- if there is a material breach of the contract that is not remedied. A material breach could include repeated failure to pay on time or a one-off failure to pay on time which was not corrected within a specified period, or a persistent failure to supply.

ANNEX 3: SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT

INTRODUCTION

The summary below was prepared as part of the deliverable "Supplementary Environmental and Social Impact Assessment (SESIA)", which involved the preparation of an independent ESIA of the North Gaza Emergency Sewage Treatment Project (NGESTP), Effluent Recovery & Reuse System and Remediation Works.

The specific objectives related of this SESIA were as follow:

- Highlight the legislation under which the project will be implemented. Besides the Palestinian Laws and Regulations, the study also highlighted the Regional Laws and Regulations, especially from Jordan, Israel and Egypt, associated with wastewater reuse and sludge management and reuse. In addition, the International Standard and Guidelines, including World Bank (WB) procedures and FAO and WHO Guidelines were highlighted.
- Provide baseline environment and socio economic conditions of the project components.
- Identify of the possible positive and negative social impacts, permanent or temporary, of the project components. In addition, the analysis and mitigation measures will be developed to reduce the negative impacts resulted from the project component.
- Identify of any potential temporary or permanent land acquisition requirements associated with civil works. In addition, develop the outline of the vulnerable groups that might be affected by the project and identify the appropriate mitigation measures
- Develop an Environmental and Social Management Plan (ESMP) and monitoring plan to manage, mitigate and monitor any possible negative impacts. Moreover, a capacity assessment of the implementing party to implement the ESMP and recommendations for any capacity-building needs

In addition, as assessment was made for sludge management for the sludge resulting from the North Gaza Wastewater Treatment Plant (NGWWTP) and intended to be used in agriculture as part in the effluent recovery and reuse scheme or in emergency cases to be dumped to landfill.

The study was undertaken throughout July - October 2012. The team developed a cross-sectional study that used a multi-data source approach including site visits, primary data, secondary data, surveys and site measurements.

ENVIRONMENTAL BASELINE CONDITION OF THE PROJECT COMPONENTS

a. General Characteristics of the Project areas

Beit Lahia Wastewater Treatment Plant (BLWWTP) and Effluent Lake

- BLWWTP was constructed in 1976. It is located some 1.5 km east of the town center of the Beit Lahia, northern part of Gaza Strip.
- BLWWTP was built in sand dunes overlying a clay layer of variable thickness with un-continuous impermeable clay layer. It was constructed in stages and modification and rehabilitation activities were performed in order to increase capacity of the plant.

  • During the past few years the situation escalated. With the increase of wastewater network connection, the volume of wastewater inflow had far exceeded the plant's treatment capacity that have led to deterioration of the effluent quality and have led to clogging effects in the neighboring sand dune areas. The ongoing decrease of the infiltration capacity of the flooded areas and the increasing wastewater volumes have resulted in the formation of enduring ponds and finally a lake.
- Over the years the effluent lake had a volume of about 2 million m3 of foul wastewater, which covers around 300 dunums and continued to rise and was threatening to flood the whole sewage collection system and the neighboring communities.
- Starting in 2007 (NGESTP was starting to be implemented), almost 90% of the effluent lake had been dried due to weathering and limited discharge to the lake. Currently the wet area occupies around 10% of the total lake.

Agriculture Land Proposed for irrigation/Sludge use

- The area in the vicinity of NGWWTP is assigned designated to benefit from the recovery water and the treated sewage sludge in the agricultural activities.
- The proposed area is divided into two zones according to its location from NGWWTP. Zone A (northern part of NGWWTP) with about 10,100 dunums whereas, Zone B (southern part of NGWWTP) with about 5,000 dunums. Most of the area is considered as under rain-fed conditions.
- Citrus, Olives, fruits and vegetables are among the crops grown in the proposed agriculture land for reuse scheme.

b. Physical and Biological Environment of the project areas

- The project sites have a typical semi-arid Mediterranean climate with long hot and dry summer (from 25°C in summer and 13oC in winter with maximum daily temperature can reach 29-30°C and the minimum temperature is around 9°C). The proximity of the Mediterranean Sea has a moderating effect on temperatures and promotes high humidity throughout the year. The prevailing wind direction is South West with an average speed of 4.2 m/s (winter) and from North West (summer).

- The average annual evaporation rate is around 1,900 mm/y (5.2 mm/day). The maximum evaporation rate increases during the summer and may reach over 6 mm/day between June and August.
- Ambient air and noise quality at the project sites are consider normal with a slightly high on BLWWTP due to more rapid population surrounding the area.
- The dominate soil type in the irrigation area can be considered as heavy soil with a deep soil profile, which means will not limit root penetration for deep rooted crops. The irrigation scheme assessment was done with taking into account the climate change through the mentioned 10 years by increase the air temperature of 1.5oC.
- The soil at different locations of the effluent lake has a normal pH range and Organic Matter content with negative and low Fecal Coliform. In addition, the Electrical Conductivity at the wet part indicates the higher number due to remaining heavy metal from the stabilized sludge that is present in the top layers of the effluent lake.
- No major fault type formations have been observed in Gaza Strip area.
- Mainly aquatic birds and the reptiles (rats, snake, crows, barn owl and other wild species) are present at the BLWWTP and the Effluent Lake. The effluent lake provides breeding, nesting, roosting and feeding habitats for different birds' species. Typical effluent lake landscape consists of sand dunes covered with Acacia shrubs.
- In the proposed agriculture land for effluent recovery reuse, many Olive, Plum, Almond, Citrus or Orchards have been encountered at agriculture land allocated for irrigation of recovered water and sludge reuse. Many wildlife species; particularly birds were found to inhabit these agro-ecosystems.

c. Water (groundwater quality) of the project components

- The water quality in this study focused on chloride and nitrate concentrations (the most important contamination indicators in the groundwater in the Northern Gaza aquifer).
- The highest chloride sources are expected in the areas affected by seawater intrusion and the deeper groundwater layer (generally exceed 250 mg/l). The seawater intrusion zone covers the western part with 2 to 3 km inland the aquifer. Most of the municipal wells were concentrated in this zone and due the high pumping rate of these wells resulted in accelerating the seawater intrusion.
- NO3 concentration exceeds the WHO drinking water guidelines in most of the Northern Gaza aquifer. In 2003 at the infiltration site (adjacent to NGWWTP), the maximum nitrate concentration in the groundwater was about 30 mg/l due to the operation of the infiltration basin using partially treated wastewater.

- Cl concentration in the wells close to the infiltration basin ranges between 350 to 650 mg/l (till the middle of 2012). The trend of the chloride concentration recorded is steady since 2011 in some wells. In addition, Nitrate concentration for the same period ranges between 20 to 120mg/l.
- From the analysis it found that the groundwater is free of Salmonella, Nematodes and Amoeba & Gardia. However, the total Bacteria ranges between 30 to 395 cfu/ml and the total coliform ranges between 6 to 50 cfu/100 ml in some wells.
- The heavy metals concentrations in all analyzed wells were less than the Palestinian standard values for irrigation. However, there were some wells that have concentrations of Boron and Mercury higher than the standard values.
- The groundwater quality under the effluent lake and the BLWWTP sites is improving after drying the lake.
- According to the groundwater modeling result, the recovered water is not expected to have bacteria, including fecal coliform due to the infiltration process (treated by the soil). In fact, the water quality, especially after the NGWWTP will have better quality than the wastewater reuse. However, to ensure the public health concern related to wastewater and sludge reuse, the monitoring plan is determined in the monitoring plan (including the mitigation measures for epidemiology).
- There is no archeological or historical site as well as the protectorate areas nearby the project component sites. The only site consider important and respected (psychologically important) by the community is the El Shuhada Cemetery, which is nearby the location of storage tanks and booster pumps (water distribution network).

POSITIVE ENVIRONMENTAL AND SOCIAL IMPACTS

The positive environmental and social impacts of the project are:

1. The recovered effluent from the groundwater will be an important source of irrigation water, as water resources in the Gaza Strip are scarce; especially during summer time, as a source of water will be continuously available.
2. The groundwater quality is suitable for Unrestricted Use. The only restriction is for the Total-N, which is higher than 15 mg/l. This could be considered as an advantage for agricultural use. However, it is advisable to restrict the use the recovered water for uncooked vegetables at least for the first year of implementation.
3. The recovery scheme will limit the horizontal dispersion and the vertical building up of the water table, which without recovery will have a negative impact on current land use.
4. Effluent reuse of the recovered water will solve the problem of the disposal of wastewater, as it will be treated and injected for agricultural use.

5. The groundwater quality after drying the lake is improving.
6. Sludge has a high content of organic matter that can help conserving soil organic matter, and sludge stimulates biological activity in the soil.
7. The sludge reuse brings possibility for farmers to supply their lands with organic fertilizer at low costs and reliably available. It is expected that the sludge will cost as low as the transport cost of around 1 ILS/50 kg (compare with 50 ILS/50 kg for Israeli imported fertilizer). Another level of competition reported was with the Palestinian organic fertilizers (each dunum needs about 8 cubic meter from this fertilizer. That cost around 850 ILS per ton which is relatively expensive). Thus, the produced sludge will be a competitive product if it cost less than 300 ILS/T.
8. The sludge reuse is environmentally the best solution compared to disposal inland fills or incineration plants and appealing solution for sustainable sludge management.
9. Sludge is one of the outputs of the project, and will increase the income for those who work in sludge trading,
10. Sludge reuse will work for reduction of chemical fertilizers.
11. Reduction of health risks associated with exposure of villagers or inhabitant surrounding the effluent lake and BLWWTP to environmental risks and nuisance released from the BLWWTP, such as effluent lake flooding and the risk of water borne disease, will be seen. In addition, the project will protect the livelihood status of people who suffered due to the flooding of BLWWTP,
12. The provision of recovered water will reduce the cost of water needed for irrigation in the area. The utilization of the recovered water of high quality and of less price might work for the benefit of the farmers (increase their profits)
13. The new lands gained due to the decommissioning of BLWWTP will be used in agriculture activities or as a recreational or residential place.
14. Potential increase of the price of lands and dwellings due to the implementation of the project,
15. Provision of jobs due to the implementation of the project components, both during construction and operation phase.
16. After decommissioning of BLWWRP, it will considerably reduce odor, mosquitoes and flies.
17. As soon as the NGWWTP is completed and starts its operation (2013) the infiltration of a high-quality effluent in the infiltration ponds will begin to compensate the negative effects on groundwater.
18. The construction of the site and the carrier line will improve the road network connecting the existing and the emergency area.

NEGATIVE ENVIRONMENTAL IMPACT ANALYSIS AND THEIR MITIGATION

a) During Construction Phase

i. Air Quality and Noise Pollution (low impact and temporary)

It is concluded that the air quality impacts associated with dust generation will be of "low" significance. However, whenever the dust emission becomes higher than normal and create disturbance to the workers and project activities, it is recommended to spray the location with water to reduce the impact.

ii. Gaseous Emissions (low impact and temporary)

Air emission impacts associated with the proposed project will be of "low" significance. However, to reduce and minimize the impact, it is recommended to check the vehicles regularly for the exhaust gas and minimize the vehicles and heavy equipment movement at the same time.

iii. Noise (low impact and temporary)

The noise generation is not expected to represent a significant issue to local residents (due to distance from the residential area, only during the day time and on a short period). The most affected people from noise impacts are the construction workers. The mitigation measures recommended in the ESMP and Monitoring Plan for control of noise and air emissions, especially to the workers are based on compliance with the Palestinian Outdoor Noise Standards.

iv. Vibration (low to medium impact and temporary for the water distribution networks and low impact and temporary for other project components)

The closest sensitive structure to the site of the booster pumps (due to psychological perspective of the respected site according to the people in Gaza) is El Shuhada Cemetery (around 10 m away). Consequently, medium vibration impacts could be anticipated to occur. The mitigation measures proposed during the construction of water distribution network component (storage tank and booster pump), near the El Shuhada Cemetery area are as follows:

- The base camp (workers site camp) and place for storage of equipment have to be on the future land dedicated for future expansion (pumps and the storage tanks).
- The construction of the storage tank and the booster pumps room including the generators and the electrical rooms have to be separated and not overlapped.
- The ready mix concrete is preferred to be used instead of onsite concrete mix. Beside the reduction of the dust transmitted to the agricultural land due to mixing onsite and

reduction of the hazardous wastes and other solid wastes on site, the vibrational load will be also reduced significantly (use of concrete pumps will be advantageous).

- In addition, due to the sensitivity of the groundwater, the vibration around the wells construction site should be minimized in order to avoid groundwater contamination due to potential spills.

v. Construction Waste and Handling of Hazardous Waste (low to medium impacts)

Based on the expected waste generation associated with the proposed NGESTP project activities, the impact will be of "low to medium" significance. The following mitigation measures are proposed:

- Onsite domestic sewage collection and disposal (adequate sanitation facilities) shall be provided by the contractor for construction workers' needs.
- Site waste management plan should be developed by the contractor prior to commencement of construction works.
- The burning of any type of wastes should be avoided.
- The reused clay or excavated sand should be stockpiled and stored away from
- Nearby sanitary landfill should be notified to receive the unusable non-hazardous construction wastes or damaged construction materials.

vi. Soil Contamination during Decommissioning of BLWWTP (medium impacts)

Soil may be exposed to contamination due to the movement of construction vehicles and equipment. The contamination will occur due to oil and fuel spills from the engines of machines, and also due to polluted wheels (importing pollutants from outside of the site). It is concluded, based on the above, impacts associated with soil contamination will be of "medium" significance. Mitigation measures proposed during the decommissioning of the treatment plant are as follows:

- The decanting activities should be done with a care and the pipe should be have sufficient length to prevent the spillage to the ground
- Preventive maintenance for any vehicle or equipment that has an engine that leaks oil or fuel.
- Preparing a special fuelling and oil change station on site to contain any possible fuel or engine oil spill. Otherwise fuelling and oil change should be conduct in the private oil stations out of site (concrete paved station on site).
- If any machine is broken on site, a containment system should be used to prevent the spill of oil or fuel on the soil.

- The vehicles moving in and out of site should be checked at the inlet gates of BLWWTP to assure that they are not importing pollutants through the wheels.
- The paved path / concrete paved parking or loading and uploading sites can be made to ensure that the vehicle will not transport the pollutant from the site.

vii. Remediation Works at the Effluent Lake

The best options for financially and technically feasible options (excluded the land investment cost) are the Phytoremediation, clay placement and three layers clay placement. The most sensitive criteria for the remediation selection is the land investment. As the land is being rented and the longer term of the remediation activities will affect the initial cost, in addition, the three layers of clay cap is not necessary as the contamination does not need deep soil replacement, the clay cap placement is the most suitable option, financially and technically.

Heavy machinery and vehicles might be used are excavators and heavy trucks. Impacts associated with remediation works will be of “medium” significance. Mitigation measures proposed during the remediation works of the effluent lake are as follows:

- Standard protection to the workers during the overall remediation activities
- Special tools for handling the dangerous wildlife found
- On site sanitation should be established for the workers
- Avoid the disturbance of the existing plants and wildlife as much as possible during the site preparation
- Handle with care found wildlife (catchment dangerous wildlife). It is recommended to seek the assistance from Ministry of Health and Ministry of Agriculture for the best practice for handling the catch dangerous wildlife
- Minimize the soil contamination by site management plan (place for temporary storage, handling, transportation and disposal)
- Replanting the affected plant that has to be displaced. If the replanting is not feasible, planting 2 new trees to compensate 1 removed tree has to be done by the contractor
- Notification to the designated landfill should be done prior to the soil disposal.

viii. Changes in Hydrology and Groundwater Quantity and Quality (low impact)

During the construction of the recovery scheme, remediation of effluent lake and decommissioning of BLWWTP there will be no impact on groundwater. It is expected the depth of the excavation will not significantly impact the groundwater but the wells construction. It is recommended to hire the highly qualified contractor for wells establishment. Therefore, the

impact negligible for decommissioning and remediation activities and low impact on the water distribution networks (only for wells construction).

The mitigation measures to avoid the hydrology of groundwater quantity and quality are similar to the general wells construction. To reduce the impact on wells construction, highly qualified contractor has to be contracted, isolate the access and the site area to avoid outside disturbance that can make the land fallen down to the wells.

ix. Health and Safety (low to medium impacts)

During the construction phase, as the proposed project are at a large distance from the nearest population or residential area and on the agriculture land, the health of the population is not expected to be significant and considered minimal.

Negative impacts will mainly concern the works for construction of new facilities, which are mainly within water distribution networks. It will have few limited negative impacts such as temporary discomfort and localized pollution to the communities caused by worksites (noise, exhaust fumes, dust and vibration, risk of accidents due to increased traffic in the project impact area, the presence of workers, very limited disruption of wildlife and vegetation, poor management of handled products: fuels and lubricants as well as worksite waste, etc.).

However, although the impact is considered low and temporary for the communities, the mitigation measures are developed to minimize the impact. In addition, due to the health and safety of the workers, which accidents might occur on site in various construction project activities, mitigation measures are as well developed to mitigate the risk of health and injuries to the workers. Mitigation measures developed to minimize the risk related to health and safety, both for community and workers are:

- Raising awareness campaigns to workers and community members to promote safety, and health and safety monitor should be appointed. The monitor can be chosen from among community members who accepted to work in the project.
- Workers should wear standard protection especially due to the dangerous wildlife on BLWWTP and effluent lake sites.
- Workers should be trained to cover the completed parts and keep their work areas safe. In case of causing an accidents, the workers should be penalized either by deduction of salaries or dismissal.
- Existing utilities (especially at BLWWTP and water distribution network), if exist, would be located and staked before construction begins, including and at intersections of other pipes and crossings. This would confirm the location and depth to ensure new construction does not impact the existing utilities.

5. The identification of the existing infrastructure (other pipelines, cables, etc) has to be identified prior to the construction phase.

- Heavy equipment would not normally be operating over the existing utilities during construction of the new line. If heavy equipment or trucks must cross the existing utilities, thus additional soil cover is needed to protect the existing pipe.
- Onsite inspectors would be present during construction to verify that the construction contractor is following engineering specifications and meeting regulatory requirements.
- Workers should take the following steps to protect themselves from falls during high construction:
  - Use 100% fall protection when working on higher construction site
  - Participate in all training programs offered by the employer (contractor).

    c) Follow safe work practices identified by worker training programs.
  - Inspect equipment daily and report any damage or deficiencies

As a mitigation measure, safety measures should be put into consideration and addressed with the workers. The contractor and the PMU are mainly responsible for any safety procedures to be applied

x. Archaeological Disturbance (low impact)

Surveys in the area of the BLWWTP and Effluent Lake concluded that there is no archaeological sites were identified. The confirmation letter was sent to the Archaeological Authority for assurance and clarification of the assessment and the replied letter indicating that the project components (including the irrigation lands) have non-existence of the archaeological site.

Although the sites do not have any archaeological importance, the Jordanian Antiquities Law still applicable and can be applied if there is any archaeological and valuable objects is found.

xi. Ecological Disturbance (medium impacts)

Wetland ecosystem and vertebrates living at the area surrounding the BLWWTP and the effluent lake might be affected during the decommissioning of the treatment plant and the remediation works of the effluent lake.

Although the biodiversity, especially fauna identified within the vicinity of the project sites (effluent lake and BLWWTP), are commonly found, it is not belong to endanger wildlife and in fact it could cause a vertebrate pest outbreak or other health impact, the mitigation measures have to be developed to avoid the ecological disturbance and provide safe and adequate

relocation for found wildlife and re-plantation for the fauna. Based on the ecological disturbance impact, the project at BLWWTP and effluent lake will have significant medium impacts.

However, due to the decommissioning activity and the remediation of the effluent lake, after the finalization of the works activities, the site will provide a permanent positive impact. The biodiversity disturbance of the site due to the remediation works and decommissioning activities, either by relocation, temporary shelter or re-plantation to another site or still within the project site area, will be compensated with the long term positive impact. In addition, as the fauna and flora found in the project site is a local and not belong to the endanger species, they will easily adapted and continue their life cycle.

Mitigation measures to reduce and minimize the impact of the existing wildlife and plantation within the BLWWTP and effluent lake are as follow:

- Standard procedure for health and safety of the workers at the site, especially the equipment that protect them from the wildlife.
- Equipment to handle the vertebrates should be prepared (this includes cages, snake sticks, net, etc.) in case of the found vertebrate during the activities.
- Assistance from the staff of Ministry of Health and Ministry of Agriculture is needed to advice the contractor for temporary relocation of the found wildlife.
- Re-plantation of the trees, if needed, should be done by the contractor, if it is needed. The re-plantation can be done within the area of the effluent lake.
- Avoid the disturbance of the nesting, breeding site. The found nesting or breeding found has to be handled with care and replace it to the safe site.

Regarding the water distribution network site, there is an opportunity that the networks will be laid in agricultural land and impose on the existing crops and local animals around the site. Mitigation measures shall be developed to limit and to reduce the impacts. Based on the ecological assessment, the project will have low to medium impacts.

Mitigation measures develop to avoid the crop and animal disturbances in the vicinity are as follow:

- Temporary construction fences have to be installed prior to the construction of the water networks and other components for recovery water distribution to avoid the fallen of the local animal and to localize the site from the local animals.
- In case the destruction of the crops or plants at the farms near the construction of the recovery water distribution network, compensation has to be settled.
- If it is needed, the replanting or trees relocation (temporary or permanently) has to be done. If the relocation or replanting of the existing trees is not feasible, the

compensation of planting 2 trees (for removal of one tree) has to be done in the other area. It is advisable to plant locally trees.

xii. Land Use and Accessibility (medium impacts)

During the decommissioning and remediation activities, the impact on land use and accessibility is considered "low". Regarding the land use and accessibility of the water distribution networks for the recovery reuse scheme, the main impact on roads traffic will be during possible lying of water distribution networks along or across main roads. In addition to the limited access road for the community during construction, this access difficulty will have more impacts on elderly people, handicapped and children, who may accidentally fall in open trenches or make tedious long cycles before they reach their targeted locations.

Mitigation measures proposed are as follow:

- Selection of suitable location for temporary storage of construction materials, equipment, tools and machinery prior to starting construction, especially on the site that is close to El Shuhada Cemetery.
- The employed machinery drivers should receive training on safe utilization of their machines to minimize accidents risks.
- Clear signs indicating the project site and temporary fences shall be installed prior to the preparation of the site, especially the water distribution networks area.
- Avoid the side of the road for all the temporary storage materials and the place for standby equipment.
- All the activities have to be during the daytime and have to be scheduled to avoid conjunction with the school and working peak hours (morning and afternoon).
- The traffic department should be informed and involved to manage the traffic during the congested time. In addition, the preferred route and an alternative road have to be recommended by the traffic department.
- If the digging (open trenches) is not completed within a day period, the clear sign (by light or fluorescence lights) has to be considered to determine and identify the site during the night.
- When the land use and accessibility is disturbed and the safety of the communities passing by the project location is triggered (especially to the children, handicapped or the elderly who might use the access road), the temporary access road has to be considered with the traffic department assistance.
- Temporary resettlement that might occur during the preparation and the construction phase has to be defined and accordingly has to be compensated.

b) During Operation Phase

i. Air Emissions and Noise Pollution (low to medium impacts)

The impact of such air emissions are considered minor, because the diesel generators are only expected to operate temporarily during power cut-offs. The compliance of generator emissions with Palestinian Standard for Ambient Air will be sufficient to safeguard against unacceptable air emissions impacts to the neighboring areas.

A relatively higher impact will be on the Pumping Station staff, which may be exposed to intermittent pumping noise. The standard protection of the workers, including earmuffs, has to be practiced all the time, especially at the Pumping Station area.

ii. Odor

The operation of the water distribution network system is not expected to have significant impacts on odor. However, due to the remaining pond #7 that will be used as the emergency pond, the operation of anaerobic ponds will have significant impact associated with generation of odor (mainly $H2S$) and vectors that mostly generated from raw sewage storage. The mitigation measures proposed for Pond #7 is as follows:

- Minimum standard is set to consider as an emergency (monitoring plan is presented at ESMP section). Maximum permissible level of the overflow or raw wastewater discharge in the pond is 2 m height.
- Maintaining high performance of biological treatment of wastewater. In addition, to be as far as possible from odor recipients and keeping buffer zones between odorous units and neighbors.
- The aerator from the aeration tank can be installed on the pond to maintain reasonable dissolved oxygen in the water to avoid anaerobic conditions.

iii. Vibration

Concerning the vibration at the effluent lake and the decommissioning site (including remaining pond #7 and the PS adjacent to pond #7), the impacts is considered negligible. The main impact (medium impact) expected during the operation of the water distribution network is on the site of booster pump (special attention has to be made to reduce the vibration impact at the pumping station and the generator to minimize the impact due to the close distance with the El Shuhada Cemetery). The mitigation measures to minimize the vibration impacts of the machines are:

- Tree plantation, heavy leaf trees to absorb the vibration and noise generated, is recommended to be planted at the Cemetery area along the proposed main road at the other side of the pumping station.
- Maintenance of the machines and equipment has to be maximized (less than the standard period required).

iv. Water Resource Contamination

The impacts on groundwater is one of the most important issues associated with the reuse project, as part of the project has been designed to prevent impacts on the groundwater from infiltrating partially treated sewage. To identify the impact of the groundwater, the verification of the available water quality monitoring (four rounds from PWA) has been analyzed and the groundwater modeling with different scenarios has been run (with and without recovery schemes and different scenarios of recovery wells implemented (12 wells and 25 wells) and during the different year of implementations; 12 wells implemented on the year 2013 and 2015). Based on the modeling results, the groundwater monitoring plan has been developed.

The groundwater monitoring programme is the key mitigation measures to indicate the water resource contamination. The groundwater monitoring programme will be explained in detailed on the following section, ESMP.

v. Impacts on Local Agriculture, Public Health and Water Resources

Based on the design project report three scenarios that considered the expected water quality recommended are as follows:

- Scenario I: It is more advisable to cultivate orchards on the available area to the west of the project along Al Karama Road. Based on crops water requirements, the available reclaimed water is just enough to irrigate 5,375 dunums divided into citrus, olives, fruit trees, alfalfa and grains (water quality does not have impact on the crops selection)
- Scenario II: Wastewater will be treated more effectively and consequently the effluent will be of better quality in general. The quantity of effluent diverted to the infiltration basin will increase to approximately 23,100 m3 daily. This reclaimed water will be used to irrigate additional land to 7,525 dunums in total.
- Scenario III: This Scenario assumes that the planned WWTP in East Jabalia will work with its full capacity by year 2025. The quality of reclaimed water (39,160m3/day) is expected for unrestricted use. The quantity of reclaimed water will be enough to irrigate about 12,577 dunums. In this scenario vegetable crops will be introduced with an area of 1,258 dunums.

vi. Decommissioning of BLWWTP on Groundwater Quality (positive impacts)

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

vii. Recovery Water Quantity and Quality (medium impacts)

Based on the groundwater modeling and analyses, the recovery water quantity and quality is expected to be acceptable for agricultural irrigation for unrestricted crops, but unacceptable to be used for drinking water. Besides continuous groundwater monitoring, public awareness is needed to ensure that the community is not using the recovery water as a drinking water.

Although the NGWWTP is located nearby the Israeli border, the flood risk is not expected to cross the fence to Israeli border due to the topographical nature of the project site. In addition, as the groundwater modeling result from different scenarios, the plume will not be significantly crossed the Israeli border as the infiltration basins are located more than 300 m downstream of the border and with the recovery wells implementation, the wells will accelerate the flow in the downstream direction away from the Israeli border.

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

viii. Land Use of Effluent Lake Remediate and Decommission of Beit Lahia Wastewater Treatment Plant (medium impacts)

In one year period, the remediation activities will be finalized. Afterward, the remediated effluent lake can be used for agriculture purposes or residential, depending on the Urban Planning of the area and El Awqaf future plan.

After the completion of the remediation works, depending on the urban planning of the area and the future plan of Ministry El Awqaf, the land use of the effluent lake will be mitigated. Based on the soil assessment prior to the completion of the remediation works, there are two options of land use which can be applied:

- To be used as an agriculture land. Although the area will not need additional filling or leveling, but due to the huge amount of the soil excavated at the nearby landfill site (Johr Eldeek) that will be implemented during 2018, if needed, the excavated soil can be transported to the effluent lake site as far as the soil is considered good. The soil quality has to be determined (soil analysis done at the landfill site, by the landfill management), before transporting it to another area.

The agreement between Ministry of Awqaf and the Land Authority or the Ministry of Economic in addition to the agreement of the Landfill management shall be reached prior to transferring the soil to the effluent lake. According to the capacity analysis during the EA of NGESTP, a maximum of 1.5 million m3 of soil can be transferred to fill the effluent lake

- To be used for residential purposes. Additional soil for leveling and soil conditioning, if needed, at the effluent lake site when the urban planning of the area is dedicated for residential area. The soil analysis will not be crucial as the option 1 and the agreement shall be reached only between Ministry El Awqaf and the Ministry of Economic and Land Authority in addition to the agreement of the landfill management for transporting the soil to the remediated effluent lake.

Due to the remaining pond # 7, the mitigation measures are developed to minimize the impacts due to the operation of pond # 7. The impact on the land use and accessibility of the decommissioning land and remaining pond #7 is of "medium" significance. Mitigation measures developed to reduce the impacts are as follows:

- Fences surrounding pond # 7 have to be constructed to reduce the accessibility of the community to the pond area. During the Public consultation, Beit Lahia Mayor announced that there is a budget allocated to build the permanent fence around the pond #7. The agreement between PWA and Beit Lahia Municipality can be reached on the construction procedures.
- There should be 10-15 m distance between the pond area and the fences to be constructed on the surrounding pond.
- The trees shall be planted nearby the fences, in order to reduce the odor or nuisance and separate the pond site from the surrounding neighboring area and future land use of the other decommissioning ponds. Planted trees will also bring positive impact on the visual impact.
- The site is only connected to one main gate and the access road to the neighboring site in addition the pond site should be connected with the pumping station at the vicinity for ease access

ix. Public Health related to Using Recovery Water for Irrigation (medium impacts)

Health protection measures which can be applied to the agricultural use are:

- Crop restriction
- Human exposure control and promotion of hygiene

Adopting crop restriction as a means of health protection in reuse schemes will require a strong institutional framework and the capacity to monitor and control compliance with regulations and to enforce them. Farmers must be advised why such crop restriction is necessary and be assisted in developing a balanced mix of crops so that production of surplus of a specific crop is avoided.

Control measures aimed at protecting agricultural field workers and crop handlers include:

- The provision (and insistence on the wearing) of protective clothing, the maintenance of high levels of hygiene and immunization against (or chemotherapeutic control) selected infections.
- Risks to consumers can be reduced through cooking the agricultural products before consumption and by high standards of food hygiene, which should be emphasized in the health education associated with irrigation schemes.
- Local residents should be kept fully informed on the use of recovery water in agriculture so that they, and their children, can avoid these areas.
- Special care must always be taken to ensure that agricultural workers or the public do not use irrigation water for drinking or domestic purposes by accident or for lack of an alternative.

All measures should be coordinated with the awareness campaign of using treated wastewater and pilot projects of using treated wastewater for irrigation. According to the clarification from the PWA team responsible for the effluent reuse study and pilot projects in Gaza, currently there are ongoing projects related to the awareness and the pilot projects, i.e. awareness workshops carried out for farmers, operators and managers of recovered wastewater (and more awareness will be carried out during the operationalization of the pilot projects).

Recovered water reuse, as it is demonstrated on the groundwater modeling concluded that there is no indication of bacteria or viruses, including the Fecal Coliform. The combination use of recovered water and the sludge for the same area proposed will not have significant impact to the soil, as only the nitrate is considered higher than standard (in this regard, it is not recommended to be used as a drinking but is considered an advantage for the agriculture).

Concerning the epidemiology due to the reuse of the recovered water and sludge for irrigation and soil at the irrigated land, based on the expected water quality, there will be no bacteria, viruses and other related pathogens that lead to the waterborne diseases, i.e. cholera, hookworm, diarrheal diseases or other helminthic infections is expected. However, the monitoring of the epidemiological diseases shall be done by the Ministry of Health through the health centers, especially the health centers within the area of the irrigated land using the recovered water and sludge. Once there is indication of patient with symptom of the diseases mentioned above, the Ministry of Health shall report the case to PWA to investigate the water quality of the water

distribution network and sludge quality. The investigation should conclude the source of the infections or diseases.

When the source is due to the recovered water or sludge reuse, the emergency procedure shall be prepared by the PWA in coordination with CMWU to stop the distribution for further investigation. When the infections or diseases resulted from other source, the standard procedure of the Ministry of Health concerning the outbreak or endemic should be followed.

x. Contamination from Reuse and Disposal of Sludge (medium impacts)

When the sewage sludge fails to meet Rule 503 Class-A on sludge use requirements, it will pose hazardous health and environmental impacts if applied to the lands for agriculture use. The potential contamination will affect soil, air, groundwater and crops. If for some reason the sludge fails to meet Class-A requirements, it will be disposed in a landfill. The most probable impact is high concentration of pathogens (over 1000 cells/100 ml). High concentrations of heavy metals (higher than those in Class- A standards) are not expected as verified by the sludge analysis results.

Concerning the reuse of the recovered water and the reuse of the sludge at the same area proposed, according to the groundwater analysis and current measurement, the recovered water does not contain any possible health risk as well as heavy metal that could have a significant effect on crops. In addition, based on the sludge analysis and the treatment technology at NGWWTP and low content of heavy metal found, the sludge is already stabilized and predicted to meet the Class A rules for sludge reuse.

However, the importance parameter to be ensured for recovered water is the pH and for the sludge is the stability of the sludge. Using the combination of the recovered water and the sludge are not expected to have high significant negative impacts on crop and soil. In addition, with the sludge reuse implementation schedule, sludge monitoring plan and the groundwater monitoring plan implemented during the operation phase, the impact associated is considered low. The importance of the monitoring plan for sludge and recovered water are highly significant. Accordingly, with the possibility of lack of enforcement, the trained qualified personnel for management and monitoring plan has to be taken into consideration. The good management monitoring practice, documentations and reporting has to be well defined and prepared accordingly

Proposed mitigation measures for emergency situation when the sludge is not meeting the requirement of Rule 503 Class A include:

- Sludge not meeting these requirements should not be used for agricultural purposes and should be disposed to landfills.

- As a protection measure in this project, is limiting the sludge application for vegetables that are eaten uncooked despite the fact that Rule 503 Class A sludge allows sludge application for all types of vegetables.
- Adhering to the monitoring and testing requirements
- If the sludge does not meet the Class-A requirements especially with respect to pathogen concentration it should be mixed with lime (the same way that floating sludge is treated) and disposed to landfills.
- Training and guidance for farmers and sludge transporters regarding healthy handling and usage of sludge in agriculture.
- Some precautions to protect farmers are to wear suitable clothes, gloves and boots; washing before eating; and using a facemask if the sludge is dusty.
- Vehicles should be carefully selected for their local suitability and transport routes chosen so as to minimize inconvenience to the public. Special care must be taken to prevent vehicles carrying mud onto the highway.
- Enclosed trucks should be used for transporting treated sludge to prevent sludge spill and to avoid any odor release.
- Keeping good communication between customer, regulator, public and stakeholders including landowners and retailers.

NEGATIVE SOCIO ECONOMIC IMPACTS AND THEIR MITIGATIONS

- Decommission of the BLWWTP will reduce water that some of the farmers relied upon to water their plants. Indicating that their income might be affected that will be mitigated through: i) Provision of recovered water of a competitive price to minimize the potential impacts. ii) Due to the fact that the sewage untreated water should be banned, appropriate laws shall be developed to criminalize the use of untreated water
- Potential risk for the people in the adjacent areas due to having no fence around Pond #7 that might affect children. Mitigation measures will be through constructing fences.
- The use of lands might be limited due to the pond as having recreational activities; especially in case of not having a fence surrounding the pond #7. In addition, the construction of residential compounds in decommissioned area will be limited due to the existence of the pond. Again, the fence will be the most appropriate mitigation.
  - The construction of the carrier pipes will have negative impact due to noise and obstruction of traffic and use of agricultural land during the construction stages.

The project should reduce the disturbance to community using most appropriate environmental mitigation measures in addition to information sharing.

- Due to the unfavorable odor, mosquitoes and flies might affect the health of the adjacent communities. The flies should be combated using hygienic and environmentally friendly procedures.
- The sludge reuse for fertilizer might affect those who work in the chemical fertilizers sector in Gaza Strip, especially, those who import fertilizers. Integrating laborers in the new market could be an appropriate mitigation measure.
- Negative impact on the livelihood status of those who operate wells. Potential loss of income for those who own and operate the wells that will be closed due to project implementation. The laborers and the well owners might be affected severely. It could be mitigated by provision of appropriate compensation i.e. jobs or monetary.
- Put limitation to the plantation of certain crops in the beneficiaries who will use the recovered water. Orientation sessions should be presented to raise farmers awareness regarding the type of crops that should be planted using recovered water
- Expropriation for the areas of lands needed to construct the recovery well and lands needed for the project. The 27 well and the expansion of the treatment plant need about 18,175 m2 (please note, during the social investigation, the wells implementation considered was 27, as it was stated on the design report). Mitigation measures include protective procedures should be applied to limit the resettlements; avoiding small plots in order not to raise poverty and compensation should be paid in a full market price.

POTENTIALLY AFFECTED PARTIES

According to the ranking for the most affected groups who has no alternative livelihood approach were ranked and recognized as follow:

1. The Operators of wells (who are uneducated, untrained) might suffer due the termination of wells. They are maximum 10 people. The magnitude of their vulnerability shall be mitigated

2. The Owners of wells (who might be terminated) will be badly affected due to losing a valuable asset (the well), as well as, being in critical need for alternative source of water, which will cost a lot. In addition, some of them used to gain his income through selling water which will not be available (indicating that his income will be badly affected)
3. Those who Rent Lands from Awqaf for a few amount of money that includes the cost of water. They will be affected in sense of losing their lands and paying for water.
4. The Owners of small plots of lands who will be expropriated during the construction of the recovery wells. Some of them have small plot of lands that don't exceed one dunum. The wells will pass in the middle of such plots of lands and the remaining land will be too small for any use.
5. Other Project Affected Persons due to the implementation of the project during the construction activities

The mitigation of impacts described in detailed in the mitigation measures section. However the discussion of mitigation measures with the above mentioned affected groups based on the entitlement characteristics, any one that might be affected due to expropriation should be compensated. It is recommended to develop a Resettlement Action Plan in order to identify accurately the Project Affected Persons (PAPs), their entitlement, compensation valuation and mechanisms proposed for compensation.

Residual Impacts and Costs of Applying Mitigation Measure

This discussion will cover the whole potential impacts resulted due to land acquisition and expropriation during the preparation, construction and operation phase.

The estimated cost for applying the different activities related to the potential expropriation and land acquisition will be mainly based on:

- Cooperation with the municipalities and other organizations Negotiation with the Awqaf
- Negotiation with the affected people

Therefore, any budget estimations for such activities is based on non-solid rationale

Willingness to Pay, Cost Analysis and Tariff Survey

Surveys have been conducted for willingness to pay for the wastewater and sludge reuse, water distribution network and cost analysis including proposed tariffs for the effluent recovery. The result is a stand-alone report that is presented in Annex 8.

Regarding the increment cost of the reuse system, the draft vision toward the reuse system is under developed. The study includes tariff assessment; cost analysis for water reuse as well as the sludge reuse. However, the tariff survey and willingness to pay conducted under this study should be taken into consideration.

Resettlement Action Plan (RAP)

Based on findings and the consultant's recommendation in addition to the WB approval, the RAP should be prepared as a document due to the certainty of the OP 4.12 triggered.

Once the RAP ToR is cleared (by the donors), work towards the RAP is underway. In specific, the RAP should provide details on how the affected parties are identified, consulted on the project and the adverse impacts they will experience, the compensation, and the modes of grievance redress that is available to them. More specifically, detailed information on the operators of the wells (license or unlicensed), owners of wells, those who rent lands from the Awqaf should be developed, and owners of small plots of lands who will be affected /expropriated; permanently or temporary (due to the disturbances; i.e. land use and accessibility, traffic, etc) should be identified.

Project Alternative

Basically, the objectives of the Effluent Recovery and Reuse, in addition of decommissioning of BLLWTP and remediation works of Effluent Lake adjacent to BLWWTP is to improve the environmental, socio economic and public health conditions in Gaza Strip, especially at the project areas. Accordingly it is expected, by definition, that the environmental and social benefits will overweigh the impacts.

All the environmental and social negative impacts discussed are mainly site-specific and could be managed / minimized through implementing the proposed mitigation measures as described earlier. Comparing the benefits to the impacts in a strategic level, it could concluded that the "no project alternative" is not supported from the environmental and social perspective, given that the project impacts will be controlled as recommended in this ESIA.

In addition, the implementation shall be implemented and start to be operated before 2015, otherwise the recovery scheme will not be able to catch the pollution and they will affect the irrigation wells around the recovery wells.

Environmental and Social Management Plan (ESMP)

ESMP was developed to reduce or eliminate the negative impacts of the project component. The table of the ESMP both during construction and operation phase (environmental and social perspectives) are presented at the following tables (Table 1 – Table 3). The tables also include the monitoring plan, the institutional responsibility for inspection and monitoring including the budget proposed for management and monitoring proposed. The Institutional set up and the roles and responsibility for implementation and supervision during the construction and operation phase of the project components is presented on detailed on the main report of SESIA.

Grievances and Compensation

All grievances received verbally or in written shall be documented in a grievance register and handled by the PMU (PWA). It is of importance to react as quickly as possible to the grievance of the citizens. A best practice standard is to acknowledge all complaints within 10 days. Due to the different character of the complaints, some of them cannot be resolved immediately. In this case medium or long-term corrective actions are required, which need a formal procedure recommended to be implemented within 30 days:

1. The petitioner has to be informed of the proposed corrective measure.

2. In case if a corrective action is not required, the petitioner has also to be informed accordingly.

3. Implementation of the corrective measure and its follow up has to be communicated to the complainant and recorded in the grievance register

The comprehensive grievance mechanism including the institutional responsibility, monitoring, responses procedure and disclosure of the grievance is presented at the main report of the SESIA.

Cash flow, and their respective representations in the financial statements, represent the best explanatory force in providing the reader strong information related to the project performance to create a positive cash flow resulting from the current management processes and/or investment/financing processes. The analysis of cash flow also allows the analyst to verify the existence of proper financial balance between sources of raising investment and the use of the same.

A cash flow statement is a listing of the flows of cash into and out of the project: Revenues and subsidies/grant are the cash inflow, Investments and the costs are the cash outflows. The balance is net cash flow at a specific point in time.

Scenario 3 considers a situation where the construction costs relating to the work of recovery of the waters and of the wastewater reuse projects, provided both in Phase 1 and in 2 are paid in full by funds provided by Donors or the government. The other operating costs of the plant and the maintenance are, however, by paying a water tariff by farms benefiting from irrigation.

The basic aspects of financial and economic analysis, which Scenario 3 has been submitted, are summarized below.

A) Financial analysis

Farm-level investments for an estimated total of about 18.7 million ILS (orchard plants, plant irrigation adjustments etc.) have been graduated over a period of four years.

Staff training activities, much smaller in scope, were instead paid on the first year.

The civil works and the equipment of the recovery wells - tank and booster system, (30,83 million ILS) based on the executive design, were planned to be carried out between the first and the second year of the twenty-five years of the analysis. The 24th year will require procedures for the rebuilding of some of the equipment at the end of useful life, with an estimated cost of 10 mln ILS.

Investments for the implementation of the consortium irrigation network (99,33 million ILS) , to be carried out as a result of the progress of the previous work, are attributed to the second and third year, at the end of which can be considered the final construction stage.

So the project management phase begins. Even for the irrigation network, after twenty-five years, it will be necessary to partially reconstruct the less durable components of the plant.

In the gradual phase of the investment, the irrigation management phase begins with the project.

In the first 4 years, farmers will increase their costs due to the progressive introduction of orchards and greenhouses. From the 4th year, with the full production of orchards and greenhouses, costs and revenues are estimated constant for the remaining 21 years.

It should be considered that farm management costs include, of course, irrigation costs (in the net income statement the cost of irrigation on farms is calculated as the water tariff multiplied by cubic meters of irrigated water).

The water tariff includes the general costs of recover, distribution and control of the irrigation network.

With regard to the investments and the related management costs, the revenues of the project consist of:

- Farm revenues: are calculated on the basis of surveys and estimates carried out in the early months of the year even at project farms;
- Water tariff paid by Industry: 70,000 cubic meters of water per year, consumed by industrial activities in the area at a tariff of 2ILS / CM;
- From the time saving of the farmers, for the lack of irrigation water coming from private wells; These time savings have been prudently estimated, and the hours saved by farmers can be dedicated to the farm, or to other, paid jobs;
- Last but not least, payments by Government / Donors, after one year, come to cover the investments already made for the project under consideration.

The cash flow balance, obtained from the costs and revenues just described, leads to a highly positive result in financial terms. The result holds high values even during the simulations; These were carried out by applying incremental interest rates, at which two financial indicators (Financial Net Present Value and Benefit Cost Ratio), maintains full performance.

B) Economic Analysis

The components of economic analysis include investment and management costs, as highlighted in the previous chapter.

To these have been added:

- Correction of labour cost from financial to economic, consisting of the attribution of labour costs, linked to social costs, such as payroll & social security tax rate;
- VAT Investment Adjustment;
- VAT Revenues / Costs Adjustment.

From the sum of these amounts to the financial ones, an economic flow has been estimated, which, according to the present, shows a good robustness of the project. In fact, by performing

simulations with incremental interest rates, even economic analysis after the financial one keeps values steadily positive.

A cash flow statement is a listing of future flows of cash that occurred during the life of the project. A cash flow statement is not only concerned with the amount of the cash flows but also the timing of the flows. In this analysis, a forecast of expected flows and outflows for the next 25 years of project has been made.

ANNEX 5: BALANCE SHEET FOR INDIVIDUAL CROPS

Table 25: Balance sheet for Citrus

Citrus	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,800.00	1.72	***3,096.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	80.00	5.00	400.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.				
Plant Protection*	kg.	4.00	100.00	400.00	
irrigation	m3	827.20	1.50	1,240.80	
Harvesting Labour	dd	14.00	40.00	560.00	
Harvesting machinery	h				
Depreciation of the plant	**1,380**	duration yrs	35.00	39.43	
TOTAL				***2,990.23***	***105.77***
Labour & Enterprise					665.77

Table 26: Balance sheet for Olive

Olive	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
olive oil 50%		45.00	16.00		
tables olive %		300.00	4.00	***1,920.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	450.00	0.50	225.00	
Soil Disinfection	kg.				
Plant Protection	kg.	3.00	40.00	120.00	
irrigation	m3	705.10	1.50	1,057.65	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h	5.00	6.00	30.00	
Olive's milling	kg.	45.00	3.50	157.50	
Depreciation of the plant	**1,780**	duration yrs	40.00	44.50	
TOTAL				***2,274.65***	***-354.65***
Labour & Enterprise					-34.65

Table 27: Balance sheet for Peaches

Peaches	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,100.00	2.50	*2,750.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.				
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	628.60	1.50	942.90	
Harvesting Labour	dd	4.00	40.00	160.00	
Harvesting machinery	h				
Depreciation of the plant	1,980.00	duration yrs	35.00	56.57	
TOTAL				*2,129.47*	***620.53***
Labour & Enterprise					*780.53*

Table 28: Balance sheet for Grains

Grains	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		450.00	1.50	*675.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.33	60.00	79.80	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	100.00	0.50	50.00	
Irrigation pipes (/5 y)	ml	1400.00	0.70	196.00	
Plant Protection	kg.	4.00	15.00	60.00	
irrigation	m3	309.90	1.50	464.85	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h				
Seedings	kg.	20.00	2.25	45.00	
TOTAL				*1,415.65*	***-740.65***
Labour & Enterprise					*-420.65*

Table 29: Balance sheet for Other fruit crop

Other fruit crops p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		750.00	3.35	*2,512.50*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.50	60.00	150.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	250.00	0.50	125.00	
Soil Disinfection	kg.				
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h	5.00	6.00	30.00	
Depreciation of the plant	1,800.00	duration yrs	20.00	90.00	
TOTAL				*2,348.45*	164.05
Labour & Enterprise					484.05

Table 30: Balance sheet for Summer vegetables

Summer vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		5,000.00	0.80	*4,000.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	500.00	0.50	250.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	15.00	25.00	375.00	
irrigation	m3	650.10	1.50	975.15	
Harvesting Labour	dd	15.00	40.00	600.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				*2,822.15*	*1,177.85*
Labour & Enterprise					*1,777.85*

Table 31: Balance sheet for winter vegetables

Winter vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		3,000.00	1.30	***3,900.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	50.00	5.00	250.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	12.00	25.00	300.00	
irrigation	kg.	293.90	1.50	440.85	
Harvesting - Labour	dd	20.00	40.00	800.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				***2,412.85***	***1,487.15***
Labour & Enterprise					2,287.15

Table 32: Balance sheet for winter tomato greenhouses

winter tomato greenhouses p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		7,000.00	1.50	***10,500.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	25.00	25.00	625.00	
irrigation	m3	141.80	1.50	212.70	
Harvesting - Labour	dd	30.00	40.00	1,200.00	
Harvesting - machinery	h				
Seedings	kg.	0.02	8,000.00	120.00	
Depreciation of greenhouse	mq	750.00	50.00	1,875.00	** 20 year*
TOTAL				***4,682.70***	***5,817.30***
Labour & Enterprise					7,017.30

Table 33: Balance sheet for Almond

Almond	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		180.00	8.00	***1,440.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.				
Plant Protection	kg.	8.00	25.00	200.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting Labour	dd	3.00	40.00	120.00	
Harvesting machinery	h				
Depreciation of the plant	2,180.00	duration yrs	25.00	87.20	
TOTAL				***1,810.65***	***-370.65***
Labour & Enterprise					-250.65

Table 34: Balance sheet for Alpha-Alpha

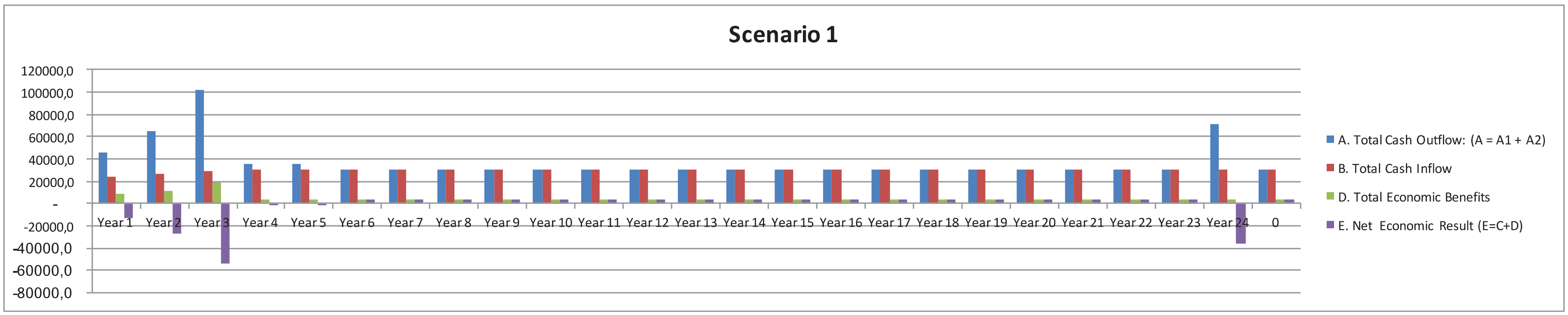
alpha-alpha	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		4,500.00	0.35	***1,575.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	0.00	100.00		
Chemical Fertilizers	kg.	0.00	5.00		
Organic Fertilizers	kg.	0.00	0.50		
Soil Disinfection	kg.				
Plant Protection	kg.	0.00	25.00		
irrigation	m3	878.50	1.50	1,317.75	
Harvesting Labour	dd	6.00	40.00	240.00	
Harvesting machinery	h				
Depreciation of the plant	1,360.00	duration yrs	4.00	340.00	
TOTAL				***1,897.75***	***-322.75***
Labour & Enterprise					-82.75

SCENARIO 1 – FULL COST/SOLUTION 1

Value in ILS*000								=>			
Details			**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**
A. Cost: Cash outflow: (NIS)											
A1. Capital Cost											
Investment cost at Farm level				4,695	4,695	4,695	4,695				
Training activities			1,456	1,456							
Recovery wells tank ans booster			22,997	7,838							
Irrigation network				27,161	72,169						
A2. Operating Cost (Recurrent Expenses)											
Farmers pay off the investment						3742	3742	3742	3742	3742	3742
Cost at Farm level (including v 1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238
Total investment		*147,162*									
A. Total Cash Outflow: (A = A1 + A2)		944,282	46,266	64,771	102,295	35,675	35,675	30,980	30,980	30,980	30,980
B. Benefit: Cash inflow: (NIS)											
Direct & indirect benefit											
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cr *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657
Paid by Government/Donors											
Subsidies			0	0	0	0	0	0	0	0	0
B. Total Cash Inflow		757,216	24,695	26,721	28,748	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)		-187,067	-21,572	-38,050	-73,547	-4,900	-4,900	-205	-205	-205	-205
Financial Internal Rate of Return		#NUM!	FNPV@3%	-155,002	BCR@3%	0.772					
Scenario 1 full stage investment			FNPV@5%	-140,864	BCR@5%	0.750					
			FNPV@7%	-130,096	BCR@7%	0.728					
D. Economic Valuation											
Economic benefit											
Correction of labour cost from financial to economic			2830	3668	5993	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement			3680	5600	11547	0	0	0	0	0	0
VAT Revenues/Costs Adjustement			1729	1871	2012	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits			8,238	11,138	19,552	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)			-13,333	-26,912	-53,994	-996	-996	3,700	3,700	3,700	3,700
Economic Internal Rate of Return		#NUM!	ENPV@3%	-61,667	BCR@3%	0.909					
Scenario 1 full stage investment			ENPV@5%	-61,628	BCR@5%	0.891					
			ENPV@7%	-61,454	BCR@7%	0.871					

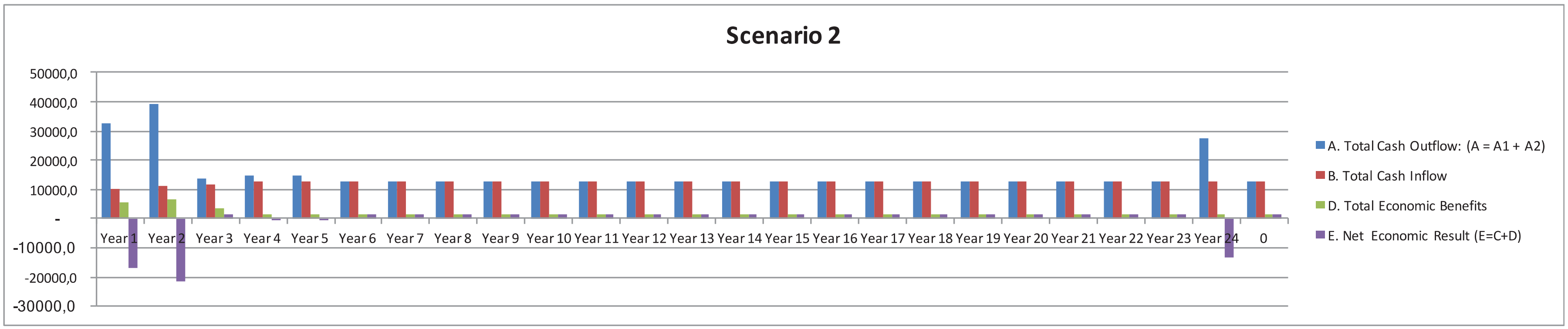
Details	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16
Farmers pay off the investment	3742	3742	3742	3742	3742	3742	3742	3742
Cost at Farm level	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657
Subsidies	0	0	0	0	0	0	0	0
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-205	-205	-205	-205	-205	-205	-205	-205
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700

Details	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Recovery wells tank ans booster							10,000	
Irrigation network							30,000	
Farmers pay off the investment	3742	3742	3742	3742	3742	3742	3742	3742
Cost at Farm level	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,980	30,980	30,980	30,980	30,980	30,980	70,980	30,980
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657
Subsidies	0	0	0	0	0	0	0	0
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-205	-205	-205	-205	-205	-205	-40,205	-205
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	3,700	3,700	3,700	3,700	3,700	3,700	-36,300	3,700



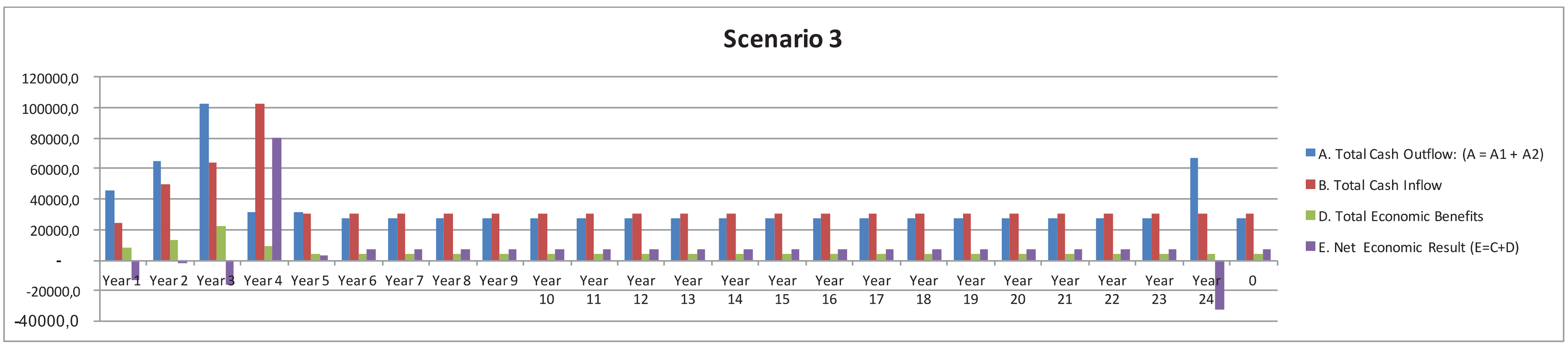
SCENARIO 2 – FULL COST/SOLUTION 2

Value in ILS*000										=>																		
Details				**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)																												
A1. Capital Cost																												
Investment cost at Farm level					1,925	1,925	1,925	1,925																				
Training activities				597	597																							
Recovery wells - tank ans booster system				22,997																							5,000	
Irrigation network					27,161																						10,000	
A2. Operating Cost (Recurrent Expenses)																												
Farmers pay off the investment						1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492
Cost at Farm level (including water tariff	1.50	ILS/CM	)	8,944	9,685	10,426	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168
Total investment		*57,126*																										
A. Total Cash Outflow: (A = A1 + A2)		**383,109**		32,537	39,367	13,843	14,585	14,585	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	27,660	12,660
B. Benefit: Cash inflow: (NIS)																												
Direct & indirect benefit																												
Revenue at Farm level				9,798	10,629	11,460	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291
Water tariff paid by Industry 40,000 cm	*	2.0	ILS/CM	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Time saved for non management of private wells				269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269
Paid by Government/Donors																												
Subsidies				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Total Cash Inflow		**311,023**		10,147	10,978	11,809	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640
C. Cash Flow Results: (C=B-A)		**-72,085**		-22,390	-28,389	-2,034	-1,944	-1,944	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-15,019	-19
Financial Internal Rate of Return		**#NUM!**		FNPV@3%	**-61,389**	BCR@3%	**0.778**																					
Scenario 2 only Phase I investment				FNPV@5%	**-56,792**	BCR@5%	**0.753**																					
				FNPV@7%	**-53,353**	BCR@7%	**0.728**																					
D. Economic Valuation																												
Economic benefit																												
Correction of labour cost from financial to economic				1160	1504	2457	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718
VAT Investment Adjustement				3680	4346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				710	768	827	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885
D. Total Economic Benefits				5,550	6,618	3,284	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602
E. Net Economic Result (E=C+D)				-16,840	-21,771	1,250	-342	-342	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	-13,417	1,583
Economic Internal Rate of Return		**#NUM!**		ENPV@3%	**-23,386**	BCR@3%	**0.915**																					
Scenario 2 only Phase I investment				ENPV@5%	**-24,446**	BCR@5%	**0.894**																					
				ENPV@7%	**-25,237**	BCR@7%	**0.871**																					



SCENARIO 3: CAPITAL SUBSIDIES

Value in ILS*000										=>																		
Details				Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
A. Cost: Cash outflow: (ILS)																												
A1. Capital Cost																												
Investment cost at Farm level					4,695	4,695	4,695	4,695																				
Training activities				1,456	1,456																							
Recovery wells tank ans booster system				22,997	7,838																						10,000	
Irrigation network					27,161	72,169																					30,000	
A2. Operating Cost (Recurrent Expenses)																												
Cost at Farm level (including water tariff=	1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment		147,162																										
A. Total Cash Outflow: (A = A1 + A2)		861,958		46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
B. Benefit: Cash inflow: (NIS)																												
Direct & indirect benefit																												
Revenue at Farm level				23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm	*	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells				657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors					22,997	34,999	72,169																					
Subsidies																												
B. Total Cash Inflow		887,381		24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)		40,663		-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
Financial Internal Rate of Return		**10.82%**		FNPV@3%	**17,400**	BCR@3%	**1.028**																					
Scenario 3 Capital cost payd by Donors				FNPV@5%	**12,152**	BCR@5%	**1.023**																					
				FNPV@7%	**7,405**	BCR@7%	**1.017**																					
D. Economic Valuation																												
Economic benefit																												
Correction of labour cost from financial to economic				2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement				3680	5600	11547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement				1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits				8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)				-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442
Economic Internal Rate of Return		**61.68%**		ENPV@3%	**118,983**	BCR@3%	**1.190**																					
Scenario 3 Capital cost payd by Donors				ENPV@5%	**99,119**	BCR@5%	**1.190**																					
				ENPV@7%	**83,307**	BCR@7%	**1.188**																					

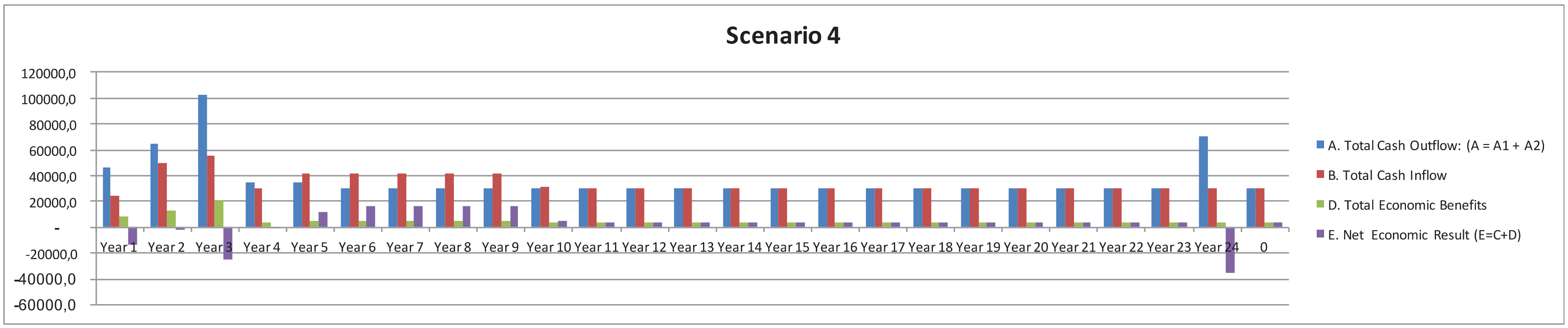


SCENARIO 4 - CAPITAL AND O&M SUBSIDIES/SOLUTION 1

Value in ILS*000 =>

Details		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
A. Cost: Cash outflow: (ILS)														
A2. Operating Cost (Recurrent Expenses)														
Farmers pay off the investment					3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta 1.50 ILS/CM)		21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total Investment	*147,162*													
A. Total Cash Outflow: (A = A1 + A2)	**931,258**	46,266	64,771	102,295	35,083	35,083	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388
B. Benefit: Cash inflow: (NIS)														
Direct & indirect benefit														
Revenue at Farm level		23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm * 2.0 ILS/CM		140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells		657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors			22,997	27,161										
Subsidies			3,433	6,866	11,443	11,443	11,443	11,443	11,443	11,443	1,047			
B. Total Cash Inflow	**865,637**	24,695	49,718	55,909	30,775	42,218	42,218	42,218	42,218	42,218	31,822	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**-28,331**	-21,572	-15,053	-46,386	-4,308	7,135	11,831	11,831	11,831	11,831	1,434	387	387	387
Financial Internal Rate of Return	**#NUM!**	FNPV@3%	-52,493	BCR@3%	0.922	investm. Phase I	80,007							
Scenario 4 Capital cost phase 1 paid by government subsidies for 9 years to farmer payd capital cost pha		FNPV@5%	-48,408	BCR@5%	0.913	subsidies	80,007							
		FNPV@7%	-46,166	BCR@7%	0.902	9 year of subsidies								
D. Economic Valuation														
Economic benefit														
Correction of labour cost from financial to economic		2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement		3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement		1729	3480	3914	2154	2955	2955	2955	2955	2955	2228	2154	2154	2154
D. Total Economic Benefits		8,238	12,748	21,454	3,904	4,705	4,705	4,705	4,705	4,705	3,978	3,904	3,904	3,904
E. Net Economic Result (E=C+D)		-13,333	-2,305	-24,932	-404	11,841	16,536	16,536	16,536	16,536	5,412	4,292	4,292	4,292
Economic Internal Rate of Return	**18.55%**	ENPV@3%	**7,413**	BCR@3%	**1.071**									
Scenario 4 Capital cost phase 1 paid by government subsidies for 9 years to farmer payd capital cost pha		ENPV@5%	**6,828**	BCR@5%	**1.066**									
		ENPV@7%	**27,978**	BCR@7%	**1.059**									

Details	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Farmers pay off the investment	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta 1.50 ILS/CM)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	70,388	30,388
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm * 2.0 ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Subsidies				0								
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	387	387	387	387	387	387	387	387	387	387	-39,613	387
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	-35,708	4,292



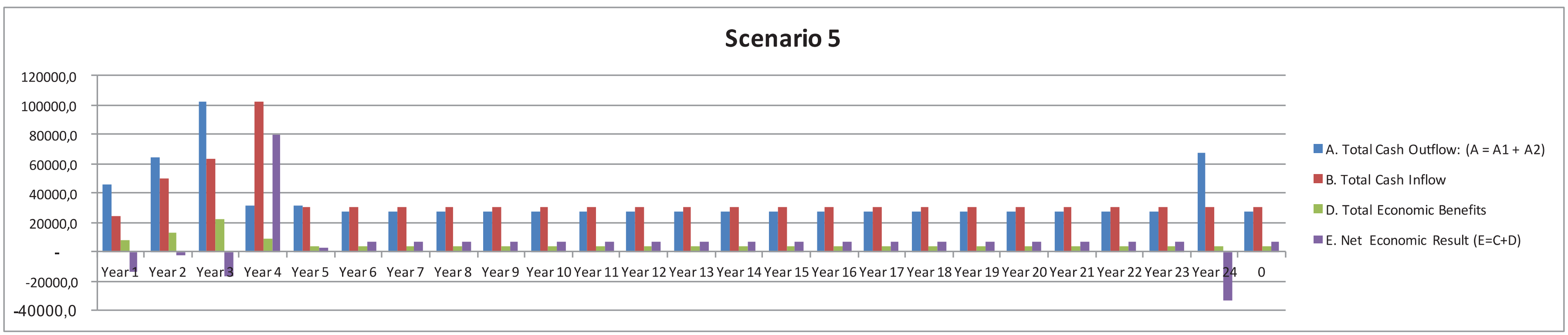
SCENARIO 5 - CAPITAL AND O&M SUBSIDIES/SOLUTION 2

Value in ILS*000

Details			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
									=>						
A. Cost: Cash outflow: (ILS)															
A1. Capital Cost															
Investment cost at Farm level				4,695	4,695	4,695	4,695								
Training activities			1,456	1,456											
Recovery wells - tank ans booster system			22,997	7,838											
Irrigation network				27,161	72,169										
A2. Operating Cost (Recurrent Expenses)															
Cost at Farm level (including water tariff= 1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total Investment	*147,162*														
A. Total Cash Outflow: (A = A1 + A2)	**861,958**		46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
B. Benefit: Cash inflow: (NIS)															
Direct & indirect benefit															
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors				22,997	34,999	72,169									
Subsidies				3,433	6,866	8,483					0	0	0	0	0
B. Total Cash Inflow	**887,381**		24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**40,663**		-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537
D. Economic Valuation															
Economic benefit															
Correction of labour cost from financial to economic			2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement			3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement			1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits			8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)			-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442

Details	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Recovery wells - tank ans booster system											10,000	
Irrigation network											30,000	
Cost at Farm level (including water tariff= 1.50 ILS/CM)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cm	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Subsidies	0	0	0	0	0	0	0	0	0	0		
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442

Financial Internal Rate of Return	**10.82%**	FNPV@3%	**17,400**	BCR@3%	**1.028**	investm. Fram level	8,782
Scenario 5 Capital cost payd by government and and O&M payd by government until rep		FNPV@5%	**12,152**	BCR@5%	**1.023**	subsidies	8,782
		FNPV@7%	**7,405**	BCR@7%	**1.017**	3 year of subsidies	
Economic Internal Rate of Return	**61.68%**	ENPV@3%	**118,983**	BCR@3%	**1.190**		
Scenario 5 Capital cost payd by government and and O&M payd by government until rep		ENPV@5%	**99,119**	BCR@5%	**1.190**		
		ENPV@7%	**83,307**	BCR@7%	**1.188**		



State of Palestine
Palestinian Water Authority

دولـــــة فلسـطيـن
سلطة الميـاه الفلسطينيـة

SELECTION OF CONSULTING SERVICE FOR COMPLEMENTARY FEASIBILITY STUDY FOR IRRIGATION SCHEME

Output 6

FINAL Complementary Feasibility Study

DRAFT

RFP/feasibility /01/2015; Grant No AFD- MOP / CPS 1060

Submitted by

Joint Venture ALMADINA-TIMESIS S.r.l.

July 2017

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Output 6 – Final Complementary Feasibility Report

ACRONYMS

AFD	French Development Agency
BLWWTP	Beit Lahia Wastewater Treatment Plant site
CAPEX	CAPital EXpenses
CMWU	Coastal Municipal Water Utility
CP	Cropping Pattern
EQA	Environment Quality Authority
FAO	Food and Agriculture Organization of the United Nations
MAR	Managed Aquifer Recharge
MOA	Ministry of Agriculture
MOH	Ministry of Health
MOLG	Ministry of Local Government
NGEST	North Gaza Emergency Sewage Treatment
NWC	National Water Company
OPEX	OPerational EXpenses
PIU	Project Implementation Unit
PWA	Palestinian Water Authority
ToR	Term of Reference
UAWC	Union of Agricultural Work Committees

WB	World Bank
WSRC	Water Sector Regulatory Council
WUA	Water User Association
WWTP	Waste Water Treatment Plant

RESULTS AND RECOMMENDATIONS

KEY RESULTS

- By improving the original design of the water reuse scheme, introducing modernized irrigation methods and a newly proposed cropping pattern, it is possible to save nearly 3.2 Million Cubic Meter of water per year (MCM/year) or 21.5% less water than what was required by the original 2010 design. Less water requirements also leads to reduced energy needs for the recovery of water from the aquifer. More precisely, the proposed changes will save 637 MWh, a reduction in energy consumption of over 15%.
- The introduction of an irrigation schedule that largely differs from the original by providing water to the entire irrigation project each day (instead of on a 6-day rotation with 12 lots irrigated 2 at a time once a week). Pumping water into the system on a constant rate drastically reduces the complexity of managing the irrigation scheduling and eliminates the risk of overdrawing water from the storage tanks and stalling the system.
- Palestinian law restricting the use of treated wastewater for irrigation does not apply to the NGEST reuse scheme because the water used for irrigation for this project is recovered from the local aquifer and not used directly from the NGEST WWTP. The regulation does apply, however, to the quality of water that may be infiltrated into the aquifer: the quality must be either moderate ("C"), good ("B"), or high ("A"). Utilizing poor ("D") wastewater for aquifer recharge is prohibited.
- Three water tariffs options are suggested for covering the OPEX costs (including operating the WUA): farmers will be charged a flat rate of 0.9 or 1.2 or 1.461 ILS/m^3 for water delivered at the farm gate. The lowest rate is possible if all energy requirements are provided by the national grid; the highest fees are necessary to cover the costs in case 100% of electricity is produced by diesel generators. The median rate is possible if a 50/50 mix of energy production is achieved. Even if the operator of the system is charged the highest rate of 1.461 ILS/m^3, this would still be less than what farmers are paying, on average, today.

KEY ASSUMPTIONS

- The feasibility of the project is tested against the most conservative scenario of energy generation, with an assumption that 100% of electricity will be provided by diesel generators.
- The capital investment required for the construction of the irrigation network (and the O&M costs associated with a more complex and expensive network) is assumed to be much higher than previously estimated. The capital investments required for the construction of the irrigation network have seen a 75% increase from the original estimates made in 2010, when the network was designed. Some of this increase is justified by price changes in cost and material over the past 7 years but the largest increase is due to subsequent modifications of the original design which, this *Report* argues, could be streamlined for a better (and less expensive) design of the system.

KEY RECCOMENDATIONS

- The recommended Investment Scenario is for the capital investments (CAPEX) needed for the reuse and recovery scheme to be paid for by the government/donors and the operating costs (OPEX) to be paid for by the farmers. If the proposed cropping pattern and modern irrigation methods are implemented as suggested by this *Report*, this scenario is feasible and profitable for both phases of the project even if 100% of the energy required to operate the scheme is produced by diesel generators.
- The recommended Institutional Arrangement is for the operation of the irrigation system to be a combination of both governmental and non-governmental management. More specifically, the bulk water supplier (CMWU and then, when created, NWC) will own and operate the recovery and reuse infrastructure for the first 3 years. During that time, the WUA would receive intensive capacity building. After the first 3 years of the project, the WUA would assume operation and management of the recovery and reuse scheme, leasing the infrastructure from NWC. The WUA (the farmers) would pay for the OPEX from the start of the organization, as outlined in the Investment Scenario 3 above.
- Design drawings for the water reuse scheme should be improved prior to finalizing the tendering document. Specifically, the network layout should be adjusted after a precise cadastral and topographic survey have been provided.
- The design of the network should be revised to consider the reduced flows that come with the newly proposed Cropping Pattern. By revising the network design with updated cadastral and topographic data and streamlined flow requirements it is likely that the overall cost for constructing and maintaining the reuse system will be significantly reduced.
- Donors' engagement and government assistance to farmers is a critical component for the success of the project. Donors/Government must assist the WUA (and farmers) by providing intensive and continuous training and technical support. Such assistance program should last at least 3 years from the construction of the irrigation network. A provisional budget of $806,000 has been defined for training WUA.
- Managed Aquifer Recharge (MAR) is a key component of the project that, if not managed properly, could not only have ramifications for the project but could also endanger local communities and an essential natural resource. Monitoring is an integral part of MAR management and should be robustly undertaken to determine the effectiveness of the recharge scheme, evaluate water quality and address clogging and other operational issues.

IMMEDIATE ACTIONS

After reviewing the project, this *Report* recommends the following **immediate actions**:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA;
- Contract UAWC to provide technical assistance to both the WUA staff and members;
- Hold the negotiations necessary to broker project agreements (*viz.*, the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc);
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years;
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017;
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;
- Start the construction of Phase I of the reuse scheme by early 2018, and initiate the process for construction of Phase II by early 2019.

PROJECT BACKGROUND AND RATIONALE

PROJECT BACKGROUND

The Palestinian Water Authority (PWA) is executing the Northern Gaza Emergency Sewage Treatment (NGEST) Project. Initiated in 2004, the project is being implemented in three phases. **Phase A** of the project comprised the construction of the terminal sewage pumping station at the Beit Lahia Wastewater Treatment Plant site (BLWWTP), the construction of a pressure pipeline to a new site about seven kilometres to the East of Jabalia, the construction of nine infiltration ponds at the new site and the commissioning of the pipeline to allow a large and dangerous emergency partial effluent pond at Beit Lahia to be drained. This phase was entirely completed in 2010.

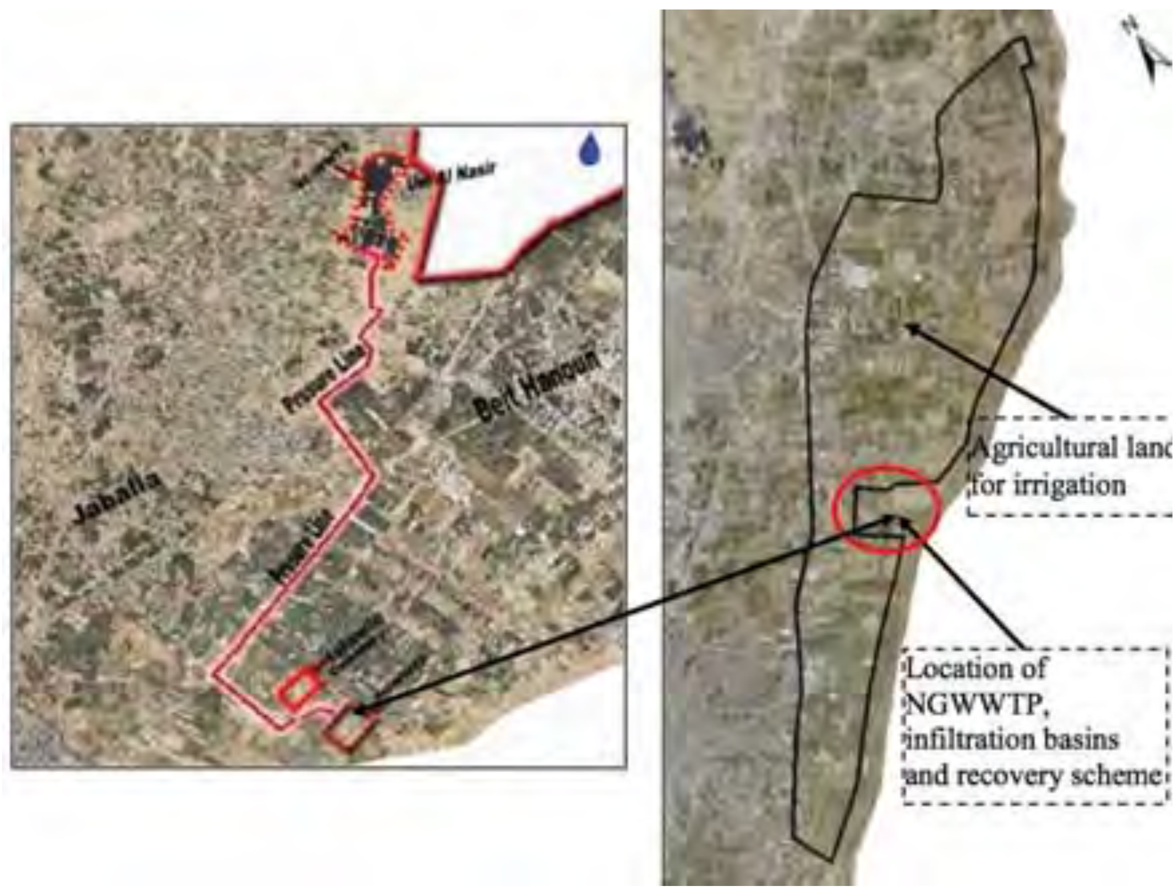


Figure 1: Main components of the NGEST project

Phase B of the project included the construction of the North Gaza Emergency Waste Water Treatment Plant (NGWWTP) at the new site. The first component of the NGWWTP is almost completed and will be fully functioning by the end of 2017, to treat up to 35,600 m^3 of sewage daily. Future expansion of the plant would bring the total treatment capacity to 69,000 m^3/day and will require the construction of an additional infiltration basin.

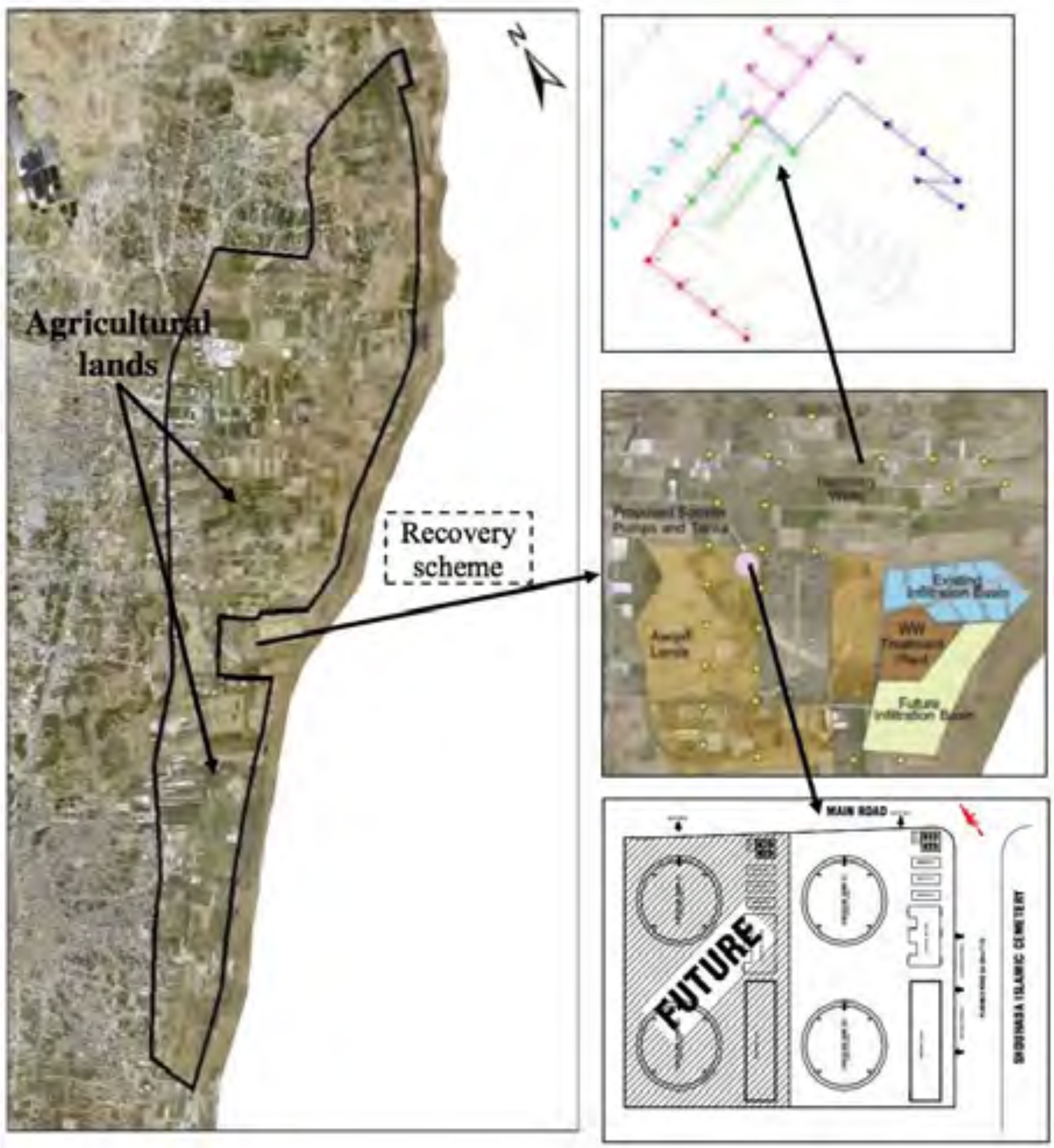


Figure 2: The proposed irrigation Project (figure on the left), NGWWTP and existing and future Infiltration basins (figure on the center right), recovery wells (figure on the top right) and storage tanks for all phases of the project (figure on the bottom right)

A third, **supplementary phase** was later added to the project to recover and reuse the treated effluent after the new WWTP is completed. The treated sewage effluent will be disposed of into infiltration ponds, the water will seep through an unsaturated zone of soil which will facilitate nutrient and pathogen removal, and eventually make its way to the unconfined aquifer. There, the water will be extracted by 27 recovery wells, put into a storage reservoir, and distributed throughout the network for irrigated agriculture.

THE PRESENT STUDY

Since January 2017, a Consortium of technical consultants has been working with PWA to prepare this Complementary Feasibility Study for the Irrigation Project. The Consortium is comprised of TIMESIS s.r.l. from Italy and AL MADINA LLC from Palestine.

The Consortium has worked with key staff of the PWA over the last several months in order to give the optimal recommendations for re-engaging farmers and making the project feasible. To carry out its task, this project has drawn upon data collection, field visits, and state-of-the-art computer modeling in order to best understand the irrigation project's hydraulics and strategic options. Equally importantly, the *Report* has been built with significant input from not only PWA and other ministries but also farmers, irrigation project and water control structure managers, and other technicians. The result, therefore, is a set of recommendations that are not only carefully crafted engineering solutions but also reflect the farmers needs and desires to cultivate the project area.

COUNTRY AND SECTOR ISSUE AND POLICY

The activities of the NGEST project are in line with the policies and objectives of the National Water Policy (2012 – 2023), the Strategy for the Water and Wastewater Sector (2011-2013), the Draft Water Resources Management Strategy (1997), the National Water Policy (1995), Water Sector Strategy Planning Study (WSSPS, 2000), Water National Plan (NWP) 2000 and Coastal Aquifer Management Plan (CAMP) 1999-2004.

More specifically, this project puts into practice numerous water sector policy principles and statements, as set out in the National Water and Wastewater Strategy for Palestine, 2013, including:

Sustainable management of water resources:

- Water supply must be based on the sustainable development of all water resources (conventional and non-conventional, shared and endogenous).

- Develop additional quantities of water from non-conventional water resources without infringing upon Palestinian Water Rights.
- Recognize water users' associations (including farmers' associations) as formal entities entitled to negotiate and manage shared national water rights on behalf of their members.

Integrated water resources management:

- Agricultural, industrial, and other development and investments must be aligned to the water resource quantity available or to be developed.

Good Governance and Management:

- The responsibilities for water resources governance, being a regulatory function, and water services management, being an operational function, should be separated institutionally.
- Encourage the involvement of formal water users' associations to ensure optimal management of shared water resources (including wells, springs and treated wastewater) used for economic purposes (irrigation, industry, tourism).

Sustainable wastewater management:

- Treated wastewater effluent is considered a water resource and is added to the water balance.

Financial sustainability of water and wastewater utilities:

- Ensure that the abstraction, transmission and distribution of water, together with wastewater collection and treatment, is financially sustainable and that providers of these services can demonstrate their financial reliability as regards to the full recovery of operation, maintenance, capital investment and capital replacement costs.

Protecting the environment from pollution by wastewater:

- Treat all produced wastewater to a quality suitable for safe and productive reuse, in line with national standards, and support the distribution and productive reuse of treated wastewater.
- Priority shall be given to agricultural reuse of treated effluent. Blending of treated wastewater with fresh water shall be made to improve quality where possible. Crops to be irrigated by the treated effluent or blend thereof with freshwater resources shall be selected to suit the irrigation water, soil type and chemistry, and the economics of the reuse operations.

PROJECT CHALLENGES

As described in the NGEST Assessment of Wastewater Treatment and Reuse Practices Report from 2011, there are several challenges and potential constraints to this project. A few of these challenges are outlined below.

Water Reuse Vision

An integrated vision for wastewater reuse issues in Palestine is still missing, which should include awareness-raising, targeted marketing, and a unified tariff. Greater effort should be devoted in producing good quality treated wastewater to be used for various purposes. Most of the treated wastewater (TWW) pilot projects have failed from the beginning, or only partially satisfied its objectives, mainly because:

- Some NGO's provide farmers of TWW with emergency subsidies, without a comprehensive system of follow up or sustainability.
- The absence of wastewater user associations to integrate and complete the role of donors and NGO's.
- The municipality was unable to operate the scheme because of lack of funds and lack of trained staff.
- The idea of reuse was not readily accepted by the farmers who had no incentive to use reclaimed wastewater.
- Some farmers could abstract fresh water from private wells at lower costs than the reclaimed wastewater.
- The effluent quality did not meet the standard required for reuse.

Political & Institutional Constraints

In Palestine, wastewater reuse projects face various political obstacles, in addition to financial, social, institutional, and technical ones. Although the reuse of reclaimed wastewater in Palestine is a priority confirmed in the Palestinian water policy and adopted in the strategies of the relevant institutions, the experience and promotion of water reuse is still in the early stages. The lack of coordination among stakeholders especially between governmental bodies and NGOs and the limited accessibility to data, information, and reports are hindering the scientific evaluation and the monitoring of implemented projects.

The installation of effective treatment systems to provide effluent that complies with water standards is a prerequisite for the success of this project. It is frequently the case that sewage treatment plants in Arab countries do not operate satisfactorily and, in most cases, treated wastewater discharges exceed the legal and/or hygienically acceptable maximum. This is usually

due to interrupted power supply, poor infrastructure and the lack of adequately trained staff with the technical skills to operate these plants, as well as the lack of an adequate budget for plant maintenance and operation.

Farmer Adherence

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

Training

A lack of technical knowledge and skills can cause failure in project implementation and, in the case of TWW MAR projects, can potentially increase environmental and public health risks. Training programs should be an integral part of the project, and it should include technical, environmental, health and socio-economic aspects. The educational input must provide farmers with an understanding of the details of techniques and their associated hazards and precautions. Capacity building in these areas are discussed in each of the relevant sections of this *Report*.

RATIONALE FOR DONOR INVOLVEMENT

Gaza faces a severe water crisis. Gaza relies almost completely on a coastal aquifer as the sole source of freshwater. However, 95% of the aquifer's water is not safe for drinking without treatment (PWA, 2014). Years of over-abstraction have taken a heavy toll on Gaza's present and future water resources. Annual abstraction of water from the aquifer has been well above the recharge rate by over 100 million cubic meters, almost twice the sustainable rate. Consequently, groundwater levels have declined, seawater from the Mediterranean has infiltrated and salinity levels have increased, making the water unsafe for drinking according to WHO standards (World Bank, 2009).

The over-abstraction and scarcity of drinking water have been exacerbated by crumbling sanitation infrastructure, while the Israeli blockade creates chronic shortages of electricity and fuel, which in turn aggravate contamination and the water crisis. The damage of contamination and over-abstraction is such that the aquifer may become unusable and, if unaddressed, the UN has stated the damage may be "irreversible" by 2020 (UNRWA, 2015a).

As early as 2009, the United Nations Environment Programme (UNEP) emphasized that prolonged over-abstraction and pollution jeopardized the sustainability of Gaza's aquifer unless it was rested (UNEP, 2009). The best suggested solution was to cease abstraction and install a monitoring system to continuously assess recovery. Once the aquifer recovers, sustainable abstraction may be resumed at carefully calculated levels. In the meantime, alternative solutions to the water crisis should be introduced, such as desalination, reduction of the loss of water in the distribution network, and wastewater treatment. Presently the application of wastewater treatment is limited because of the high cost and technological complexity of conventional systems.

In 2014, the Gaza Strip endured the third conflict of full-scale military operations in six years, coming on top of eight years of economic blockade. Reconstruction efforts have been extremely slow relative to the magnitude of devastation, and Gaza's local economy has not had a chance to recover. Socioeconomic conditions are at their lowest point since 1967 (UNCTD, 2015).

Large scale investment in water, electricity and sanitation infrastructure was needed even before the damage inflicted by the military operation in 2014. The operation resulted in severe damage to Gaza's water and sanitation infrastructure, including water wells and networks, tanks, desalination units, wastewater networks and pump stations. The preliminary static value of the damage is estimated by the Palestinian Water Authority at more than $34 million. However, long-term repair of the accumulated damage and decay of the water and sanitation infrastructure will require $620 million (UNCTD, 2015).

If the Gaza Strip is to overcome its uniquely disadvantaged situation, it will need help. Although the international community has failed to prevent these crises in Gaza from taking place, it can still play a role in its reconstruction and survival. Besides the rather stark moral imperative, as this *Report* has shown, the project has the potential to be sustainable and even profitable, arguably making the investment worth the risk on multiple levels.

LESSONS LEARNED FROM SIMILAR PROJECTS IN THE REGION

As stressed elsewhere in this *Report*, the NGEST project is not a treated wastewater for irrigation project. Rather, it is a treated wastewater for managed aquifer recharge project (TWW MAR). This section briefly looks at some of the experiences with MAR and TWW MAR in the region.

MAR in the Middle East and North Africa

Given the water scarcity in many Middle East North African (MENA) countries and the water saving capabilities of MAR, several countries have at least experimented with the technology. Although MAR is conducted in many countries in the region, monitoring is often lacking or

information is not published. As a result, the success of many of these schemes cannot be evaluated (Steinel, 2012). Below are brief descriptions of relevant projects.

Israel

Israel has been practicing wastewater treatment and reuse since the '50s, including through groundwater recharge (Soil Aquifer Treatment – SAT). The country has a 75% water reuse rate, which is much higher than most other countries [e.g. Spain 12%; Australia 9%] (Mekorot, 2013). Artificial groundwater recharge serves a number of purposes in Israel, such as increasing water reserves for periods of high demand (primarily for irrigation), reducing hydrological deficits, preventing saline intrusion from peripheral areas and ensuring efficient utilization of surplus water from Lake Kinneret (i.e. Lake Tiberias) (DWAF, 2007).

Comprehensive water quality monitoring is normally carried out throughout all stages of the recharge process. However, besides known problems related to clogging of recharge boreholes due to silt build-up and algae in the source water, health concerns have been raised lately, as endocrine disruptors, antibiotics and trace metals have been found in recycled water. In order to protect human health and groundwater quality, some experts are now calling for treatment to drinking water quality standards through desalination of treated sewage effluent by reverse osmosis (Tal, 2013).

The largest SAT facility in Israel is the Dan Region Wastewater Treatment Plant (Shafdan), where sewage water from the Tel Aviv region is treated. Wastewater treatment comprises four stages: pre-treatment, primary, secondary and tertiary treatment. Treatment methods include oxidation ponds, activated sludge and Mechanical Bio-Reactor (MBR). The Shafdan effluents are discharged into the soil for tertiary treatment and to recharge the aquifer. Water is then recovered and transported to the Negev for irrigation. The total effluent supplied for agricultural purposes is 216 million cubic meters per year (Mekorot, 2013).

Jordan

Jordanian law basically prohibits intentional recharge with reclaimed wastewater, as virtually all aquifers are also used for drinking water purposes. Yet as unintentional recharge of treated and untreated wastewater is taking place already through irrigational return flows and leaking sewage pipes, the standard is currently under review. The new standard is likely to loosen the restrictions to allow recharge of tertiary treated wastewater with near drinking water quality to all aquifers.

Jordan has one large recharge dam, Wala dam, where surface runoff is infiltrated via the side walls to recharge production wells downstream. Recently, sedimentation has decreased storage

volume and infiltration rates considerably as no sedimentation dams are installed upstream, necessitating the use of recharge wells.

Documentation on recharge volumes, water quality, clogging problems, and resulting increase in groundwater table is not available.

The expenses for MAR dam construction in Jordan are commonly covered by international donors, while the maintenance has to be summoned up by the governmental budget. Hence, the government sees it as cheaper to build a new dam rather than maintain existing ones, which is a significant flaw in the system. An important lesson learned from Jordan is that international donors should ensure that part of the budget is set aside for long-term maintenance during finance negotiations.

Iran

Iran practices aquifer recharge via a cascade of basins including settling basins or floodwater spreading systems (Hashemi et al., 2012). Removal of accumulated sediments is vital for maintaining infiltration rates in the infiltration basins (Mousavi and Rezai, 1999). In the flood spreading systems the accumulation of sediments is used as improvement to the soil for agriculture.

Oman

Oman has 15 recharge release dams that capture runoff from the mountains in the plain with high sediment loads (5 - 6 % of runoff volume) and infiltrate runoff downstream to prevent seawater intrusion and for irrigational reuse. Socio-political reasons and a lack of regulations are the main limiting factors and the recharge scheme does not generate economic benefits for irrigational reuse (Prathapar, 2012).

Saudi Arabia

Saudi Arabia has constructed a number of recharge dams, which are experiencing clogging problems. Sediment removal or release to downstream infiltration basins or the downstream wadi channel need to be undertaken (Al-Muttair et al., 1994). There are investigations to use treated wastewater in fully engineered artificial recharge and recovery systems in alluvial wadi aquifers (Missimer et al., 2012).

Tunisia

Tunisia recharges surface water for agricultural and domestic purposes after retention in small earth dams via basins and recharge wells. In upland areas, the reservoir area with collected sediments is often used for farming and further retained water is hence used for irrigation and

not for recharge. Profitability of the schemes is relevantly low (Ouessar et al., 2004). The release of captured flood water for downstream percolation in the wadi is also practiced (Ketata et al., 2011) and simulations showed much higher recharge rates especially when first flush release for silt removal was undertaken (Zammouri and Feki, 2005). In coastal regions seawater intrusions are controlled by recharge of reservoir water via wells (Bouri and Dhia, 2010). The infiltration of treated wastewater has also been investigated in coastal regions (Kallali et al., 2007).

Conclusion

MAR can only be successful if proper management plans and funding are in place and implemented. As seen in the region and around the world, clogging is a major issue, which can only be addressed with monitoring and proper maintenance. As seen in Jordan, international donors should be cautious in only funding the construction – and not also the maintenance – of MAR schemes. Lastly, water quality testing must evaluate not only regular parameters but also other emerging pollutants such as endocrine disruptors, antibiotics and trace metals, as shown in Israel's experience.

PROJECT DETAILED DESCRIPTION

OVERALL DEVELOPMENT OBJECTIVE AND SPECIFIC OBJECTIVES

The overall project objective is to more sustainably utilize water resources in the Gaza Strip by seeking out alternative water sources for irrigation. Specifically, utilizing treated wastewater for managed aquifer recharge, which will then be recovered for irrigated agriculture throughout the Strip.

When completed the project will have:

- A WWTP capable of handling 35,600 m^3 of waste each day;
- Remediation of the Beit Lahia effluent lake;
- One infiltration basin
- 27 recovery wells and a network of 42 monitoring wells;
- 15,000 dunums of irrigated agricultural land.

More specific objectives related to the implementation of the Supplementary Phase of the project include:

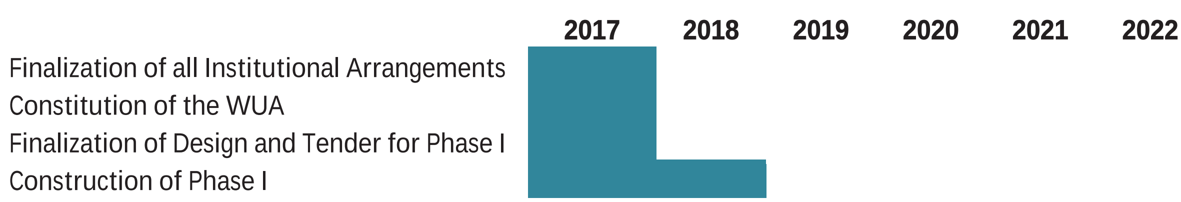
- Develop an irrigation project that assists local farmers to improve profitability and increase the value chain linked to agriculture;
- Test and promote MAR in Palestine;
- Improving groundwater health through introduction of higher quality water, and achieving more sustainable extraction practices;
- Promote the role of WUAs in managing and operating larger irrigation projects.

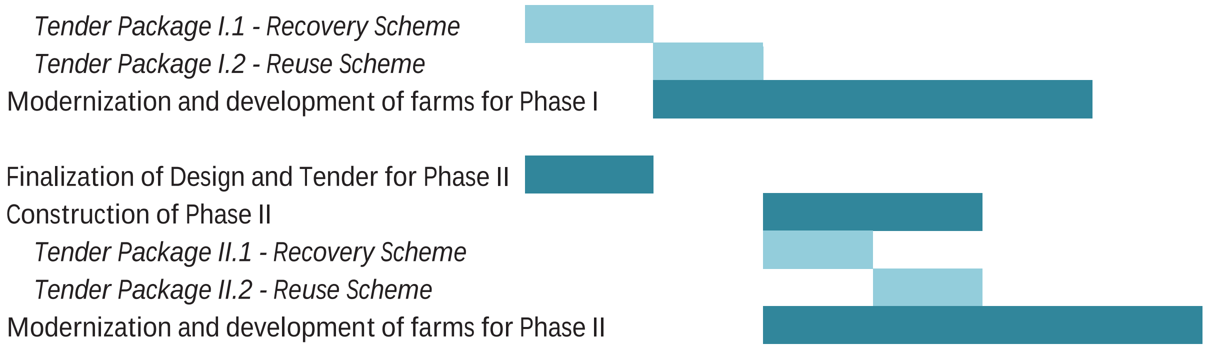
PROJECT COMPONENTS

LOGICAL FRAMEWORK

The logical framework and timetable for implementation is provided in the following Gantt chart. A detailed description of the various activities is provided in the following section.

Table 1: Project's Logical Framework





DETAILED ACTIVITIES

A gross agricultural area, extending for approximately 1,570 ha (15,700 du) in the immediate vicinity of the NGWWTP, has been proposed to benefit from the recovered water as well as the treated sewage sludge. This project component, known as the 'Supplementary Project', is divided into two sub-components, namely (i) the Water Recovery Scheme, and (ii) the Reuse Scheme. The original design, concluded in 2010, foresaw the possibility to use 35,600 m^3/day of treated water by the year 2015 and the full 69,000 m^3/day by the design year 2025. The overall implementation of the supplementary component has been subdivided into three phases:

The **First Phase,** originally scheduled for completion by the year 2017 and now possibly facing some delays, includes 15 recovery wells able to capture 16,500 m^3/day – the amount of daily infiltration from the BLWWTP in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells – and includes all connecting pipes, a 4,000 m^3 water storage tank, a booster station with 5 pumps, 5 monitoring wells and the appropriate irrigation network covering a gross agriculture area of 500 ha (5,000 du). After 6 years of infiltration of poorly treated water from the Beit Lahia pound and BLWWTP, this first stage mainly aims at preventing the pollution plume from reaching agricultural and municipal wells located beyond the recovery wells.

The **Second Phase,** now scheduled for completion by the year 2020, would extend the recovery system by a second row of 12 supplementary wells (along with the previous 15 recovery wells) and will, altogether, capture some 39,100 m^3/day (necessary to recover the 35,600 m^3/day of fully treated wastewater infiltrated once NGEST WWTP starts operating in addition to an extra 10% needed to ensure that the full amount of water infiltrated from the NGEST WWTP is extracted by the recovery wells) and all the related infrastructure (connecting pipes, water tank,

booster station, monitoring wells and irrigation networks) to cover an additional gross agriculture area of 1,000 ha (10,000 du).

A **Third Phase**, scheduled for completion by the year 2025, can be constructed after the extension of the NGEST WWTP to treat 69,000 m^3/day of effluent. The recovery and reuse scheme will then need further extension and the **reclaimed water will need to be transferred to other areas in the Gaza Strip**, considering that all the land available around NGEST would already be irrigated with the water produced by the two other stages defined above.

Phase I and Phase II shall be implemented via four separate tendering procedures: two related to Phase I and two related to Phase II. The following table provides a summary of the various tendering packages and proposed implementation schedule.

Phase	Package	Description	2017	2018	2019	2020
I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	X			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		X		
II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells			X	
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)				X

Construction of the various component of the recovery and reuse schemes for both phases represent only one side of the overall project. Additional, critically needed, activities are defined as follows:

- Finalize and promulgate the draft WUA regulation and establish an NGEST WUA. This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Contract UAWC to provide technical assistance to both the WUA staff and members. Also this activity should be implemented as soon as possible and ideally before tendering

procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017 so that training can be activated in conjunction to the development of the first phase of the reuse scheme. Training activities would then be intensified during the first year and carried on for a period of three years.

- Hold the negotiations necessary to broker project agreements (*viz*., the Bulk Water Supply agreement, MOU between CMWU and NWC; Lease agreement; WUA Technical Assistance contract, etc). This activity should be implemented as soon as possible and ideally before tendering procedures for the realization of the first phase of the reuse scheme are issued. The proposed timeframe is before the end of the current year 2017.
- Update the design of Phase I and Phase II: an activity that could lead to revised costs and tendering documents by the end of 2017. Such activities must be implemented before tendering procedures for Phase I of the reuse scheme are initiated. Updating the design and tendering documents for both Phases of the project (for the reuse part only) will require the acquisition of more detailed topographic survey and a precise cadastral survey. Considering the small scale of these tasks, it is likely that the entire process of acquiring additional field data and updating the design and tendering document can be completed before the end of the year 2017.
- A fund should be established and maintained to cover the O&M costs of the recovery and reuse system during the transitionary period of the first 3 years. The necessary procedures for the creation of such fund and identification of suitable financial tools to support farmers should be started during the present year 2017 and best completed before the completion of the first stage of the reuse scheme in 2018.
- PWA should immediately begin actively monitoring the infiltration basin and aquifer;

ADDITIONAL TECHNICAL ASSISTANCE PACKAGES

The following Technical Assistance Packages are proposed:

1. Update topographic and cadastral survey of the project area;
2. Update detailed design and tendering documentation for Phase I and Phase II
3. Assistance for finalization of MoUs and Agreements and creation of the WUA;

A short description of each Technical Assistance (TA) Packages is provided below.

UPDATE TOPOGRAPHIC AND CADASTRAL SURVEY OF THE PROJECT AREA

Objectives: Update the existing topographic survey by expanding the survey area, collect additional survey points and provide a precise cadastral survey of the project area.

Level of Effort: 4 months/man to be divided between 1 senior topographer and supporting staff.

Deliverables: Revised topographic map and cadastral map

Tentative Budget: EUR 35,000

Proposed Timetable: The proposed program shall be implemented between the months of October and November 2017.

UPDATE DETAILED DESIGN AND TENDERING DOCUMENTATION FOR PHASE I AND PHASE II

Objectives: Prepare updated detail design and tendering document for both Phase I and Phase II of the project for the reuse scheme only.

Level of Effort: 4 months/man to be divided between 1 senior irrigation engineer, 1 junior irrigation engineer with the assistance of mechanical and electrical engineers

Deliverables: Revised detailed design for both Phase I and Phase II in addition to General and Detail Specifications and Tendering Documents. The update design shall be provided only for the irrigation (reuse) scheme as the existing design for the recovery scheme does not need modificaitons.

Tentative Budget: EUR 35,000

Proposed Timetable: The proposed program shall be implemented between the months of November and December 2017, and can be implemented only after updated topography and cadastral survey has been completed.

GOVERNAMENT ASSISTANCE PROGRAMS

Objectives: Assist parties in negotiating the necessary agreements for project implementation.

Level of Effort: 2 months/man of a senior legal advisor/mediator + local support staff

Deliverables:	MoU[1] between CMWU and NWC (for CMWU to initially manage the system); a Contract between CMWU and the WUA (for CMWU to initially operate the system); a Water Supply Agreement between CMWU and the WUA (for bulk water supply); a Contract between the WUA and UAWC (for capacity building of the WUA); Lease agreement between whoever owns the system and whomever is going to operate it and collect fees (depending on the Scenario chosen).
Tentative Budget:	EUR 25,000
Proposed Timetable:	The proposed program shall be implemented between the months of October and November 2017.

[1] Because NWC and CMWU are both governmental entities, it is arguably more appropriate to have an MOU than a contract but this is open for discussion.

PROJECT APPRAISAL

BASELINE CONDITIONS

FIELD SURVEY

The foundation of this baseline assessment and a primary tool for collecting first-hand current data, the field survey aimed to **investigate the characteristics of the farming system** in the project area. A questionnaire was developed and tested in coordination with PWA. The questions were focused on the farm cropping system, market channels, selling prices, and incomes. Special emphasis was given to the water issue, by inquiring about the current use of water on crops, irrigation methods and the source and cost of water. Specific questions were dedicated to understanding the farmers' willingness to change/enlarge their cropping pattern and the role played by the farmers' associations of the project area. Furthermore, the survey estimated the size of abandoned cultivable land, and farmers were asked to explain why they have stopped cultivating that land.

The field survey was carried out from 18 February to 28 March 2017, by a team of local technical surveyors and international experts, under PWA supervision.

The final distribution of farmers interviewed around each well is shown in Figure 3.

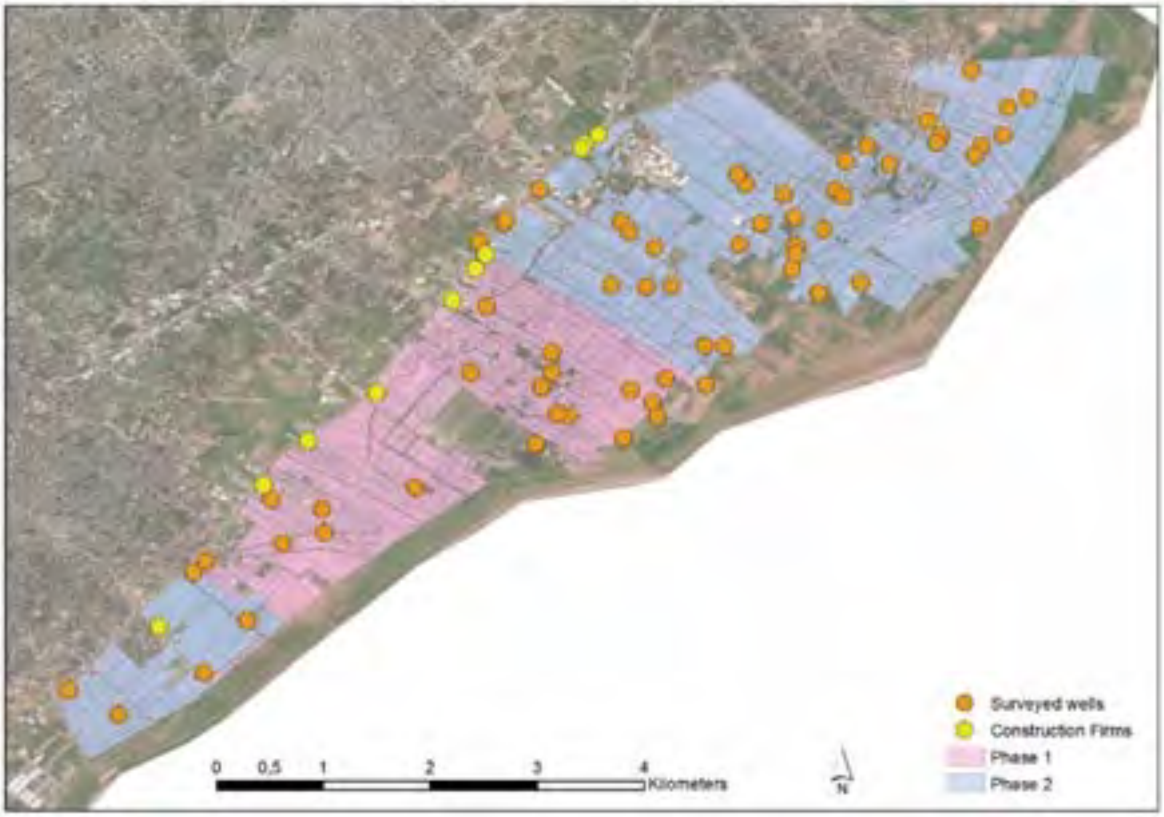


Figure 3: spatial location field survey

The survey resulted in the collection of **420 farm questionnaires**, **9 farm inputs questionnaires**, and **11 industry questionnaires**. The paragraphs below summarize the results obtained from the analysis of the questionnaires.

LAND TENURE AND CROPPING SYSTEM

FARM SIZE AND LAND TENURE

The Project area extends for 1,207 ha (12’068 du). As shown in Figure 4, nearly 55% of the farms are smaller than 5 du, and 25% of them are comprised between 5 and 10 du. The larger farms are only a small portion of the total number: farms larger than 30 du are less than 5%.

The survey highlighted that most farmers own their land (88%), whereas tenants represent just 10%.

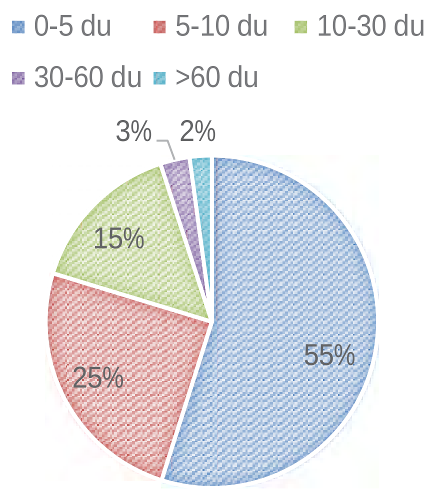


Figure 4. Distribution of farms by size.

CROPPING SYSTEM

The cropping pattern of the project area is shown in the following Figure 5.

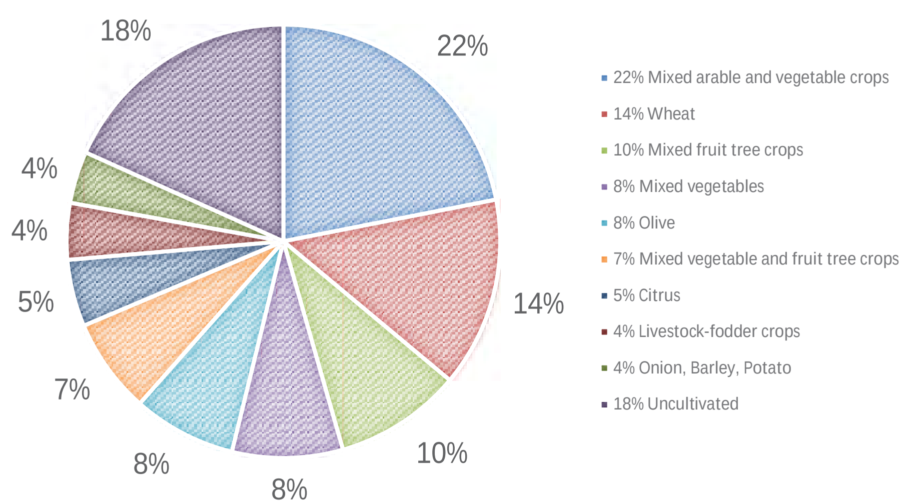


Figure 5: Indicative cropping pattern of the project area

The majority (22%) of the surveyed area is cultivated with mixed arable and vegetable crops. Almost half of the farms has a mixed crop pattern, mostly based on arable, vegetable and fruit tree crops, among which citrus and olive are the most important. Arable crops, such as wheat (14%) and barley (1%), are quite important as staple food for the household. On the other hand, onion, barley and potatoes represent together less than 5% of the cropping pattern.

Almost one fifth of the land, 18%, results uncultivated (Figure 6). Around 24% of total cultivable land is rain-fed, while the remaining 76% is being irrigated through wells (Figure 7).

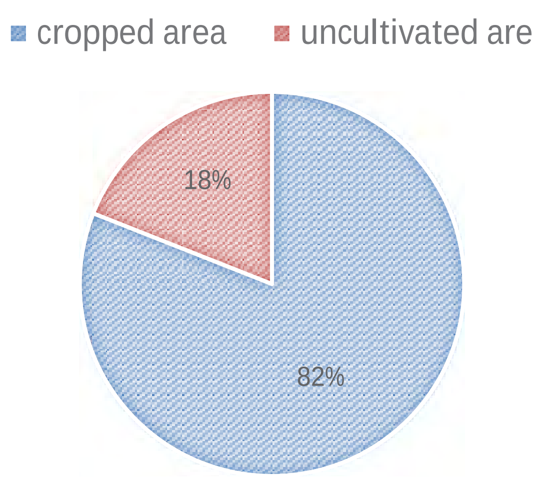


Figure 6. Cropped and Uncultivated Area

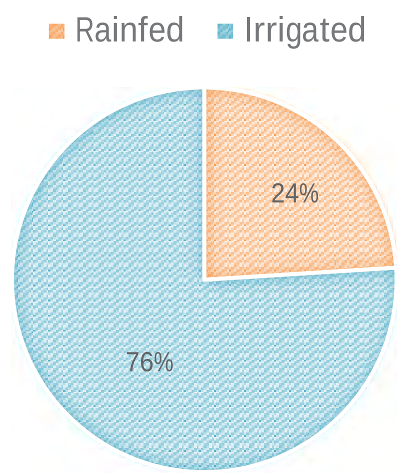


Figure 7: Irrigated and Rainfed Areas

CROP WATER REQUIREMENTS AND WATER CONSUMPTION IN AGRICULTURE

The sole source of water for irrigation is groundwater, which is abstracted from **private wells** evenly distributed throughout the project area. Typically, the same well ("collective well") is shared by more farmers; each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. The survey shows that 92% of the farmers depend on the "collective well" system owned by the remaining 8%.

Wells must be authorized by the government. A legal well pays one-off 4,000 ILS plus 100 ILS/year license. However, there are also "non-legal" wells, estimated to be 3-4 times the number of the legal ones. The government does not close these wells but new unauthorized wells cannot be drilled.

The survey determined that water cost ranges[2] from 1 to 1.5 ILS/m^3. Therefore, use of water is worthwhile only for economically competitive crops.

[2] The value is the average among the ones provided by farmers during the field survey. During the filed survey, farmers provided the following rationale for their stated value for cost of water: a well's pump consumes 10 to 12 litters of diesel per hour to extract 40 to 60 m^3/hours at an average depth of 60 to 70 meters. The cost of diesel, on average, is between 6 and 7 ILS/litter. For that reason, the cost of water ranges from a minim of from 1 to a maximum of 2.1 ILS/m^3. On average, it is therefore approximately 1.5 ILS/m^3 or more.

Figure 8 illustrates the average amounts of water supplied to the unit area for each crop type, as communicated by the interviewed farmers.

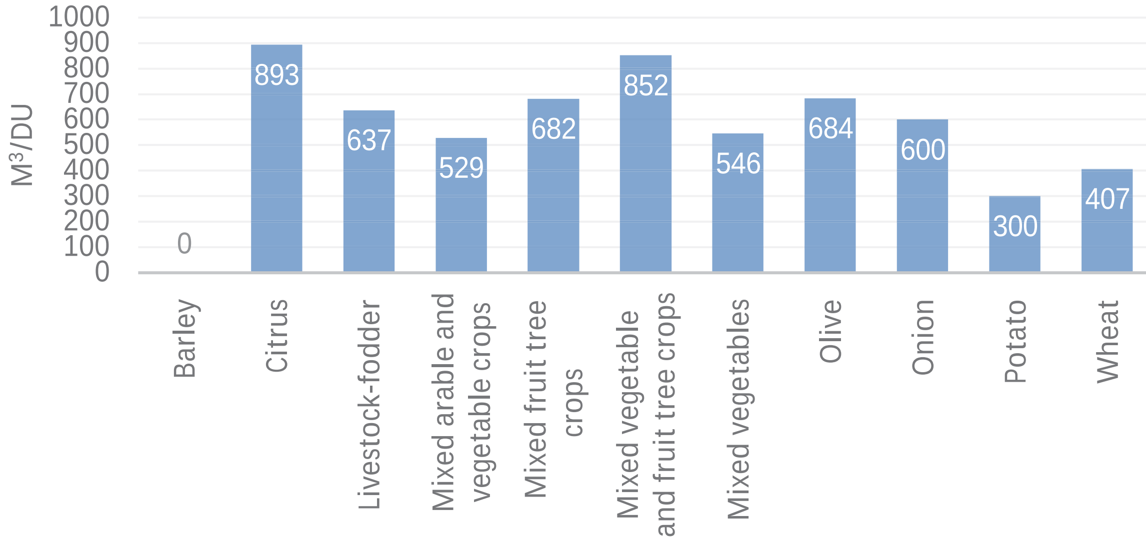


Figure 8. Water use for the current cropping pattern.

Citrus and mixed vegetables with fruit are the most irrigated crops (893 and 852 m^3/du); Barley is rain fed.

The **total crop water requirements** for the agriculture currently developed across the whole 15,000 du is estimated to be **5.8 Mm^3/year** with an **average daily water requirement of 15,990 m^3/day**.

CAUSES OF THE PRESENT LAND ABANDONMENT

As already pointed out, 18% of total project area is currently not cultivated. The survey highlighted that the **main reason for land abandonment** is because of the frequent **land invasions by the Israeli army** (45% of the respondents), which destroys agricultural structures and plantations, as well as periodic herbicide sprays to keep the field clear, which kills the crops and makes farming conditions unhealthy.

The second reason of land abandonment in order of importance is the **lack of financial resources** needed to carry out cropping operations (23%); and **water scarcity** is the third reason (17% of respondents). These last two reasons are strongly linked to the high cost of water extraction.

WATER CONSUMPTION IN THE INDUSTRIES

In the Project area, there are currently 14 industrial facilities extending over a total surface of approximately 50 du (see in Figure 3 their localization): generally, most of them are small factories (less than 10 employees), operating only a few days a week. They use the urban water supply network as their sole source of water, around 2,000 m^3 of water per year on average, and their combined consumption is less than 30,000 m^3 per year. A large majority (>80%) of them is using private wells for their water supply. A few exceptions (<20%) use a combination of private wells and municipal water supply. Less than 20% of the existing factories get their water solely from the municipal water system.

Most of the factories (>70%) do not know the quality of the water they are getting although they all see that the low quality of the water is negatively impacting their products.

VALUE CHAIN

Gaza Strip, with its high population density and reduced connections to a production system because of tensions with Israel, fails to produce consumer goods and food in sufficient quantity and is therefore greatly dependent on imports.

Interviews with the producers showed that the vast majority of the agricultural products are sold in the local market for fresh consumption, through wholesalers or directly by the farmers' family network. At present, the few food industries operating in the area do not usually purchase the farmers' products.

The market chain of horticultural and fruit products is as follows:

farmers → traders, wholesalers, middle men → retailers → consumers.

Next table summarizes revenues, costs and margins for the different crops expressed in the local currency.

Table 2. Summary of the single accounts cultivation statements of agricultural products

FARM/CROPS	REVENUES	COST	MARGIN	NET MARGIN PER KG	NET MARGIN + LH[3] PER KG
APPLE	1,000	2,495	-1,495	-2.99	-2.81

[3] LH: Labour Harvesting

BARLEY	655	1,630	-975	-2.02	-0.36
CITRUS	3,494	3,172	322	0.19	0.52
LEMON	1,400	2,048	-648	-0.65	-0.33
LIVESTOCK	1,582	2,310	-728	-	-
MELON	2,400	2,401	-1	0	0.17
MIXED ARABLE AND VEGETABLE CROPS	3,226	2,267	959	0.36	0.59
MIXED FRUIT TREE CROPS	2,487	2,472	15	0.02	0.34
MIXED VEGETABLES AND TREE CROPS	3,444	1,667	1,777	0.81	0.92
MIXED VEGETABLES	3,407	3,061	346	0.11	0.33
OLIVE	806	2,376	-1,570	-2.92	-2.05
ONION	675	1,837	-1,162	-2.58	-0.58
PEACH	1,000	1,055	-55	-0.11	0.07
POTATO	2,500	1,656	844	0.34	0.50
WHEAT	492	1,438	-946	-2.37	-1.40

The **highest margin** is reached by cultivations of **mixed vegetables and tree crops** (net margin + *labour harvesting* of 0.92 ILS/kg of production); other profitable cultivations are mixed arable and vegetable crops (0.59), citrus (0.52), potato (0.50), mixed fruit (0.34), mixed vegetables (0.33), melons (0.17), peaches (0.07). Other cultivations have a negative margin: the **most unprofitable crop is apple** (-2.81), followed by olives (-2.05), wheat (-1.40), onion (-0.58), barley (-0.36), lemon (-0.33).

ASSESSMENT OF THE NGEST RECOVERY AND REUSE SCHEMES

PROJECT RECOVERY SCHEME

The recovery scheme comprises a system of 27 recovery wells and all related connection pipes as well as 10 monitoring wells. The following three sections provide a more detailed description of each component.

RECOVERY WELLS

There are 27 recovery wells to be constructed across an area extending for approximately 1.3 x 1.3 km^2. These wells are split into 5 zones (groups) according to their geographical distribution.

These zones are named Zone A, B, C, D, E, and F as shown in Figure 9. For each zone, there is a High-Voltage (22kV) node and an electrical service building.

Figure 9: Location of the 27 Recovery Wells

The recovery wells will be able to capture water infiltrated from the NGEST WWTP (i.e.: 35,600 m^3/day) in addition to an extra 10% (i.e.: 3,560 m^3/day) necessary to guarantee that all infiltrated water is captured by the wells.

The number of recovery wells was calculated based on the maximum quantity of water that should be recovered during the peak month of October, which is equal to 50,885 m^3/day. The total number of wells is 27 where each should have a capacity of pumping between 150 m^3/hr to 200 m^3/hr. 25 out of the 27 wells are assumed to be operational always with a capacity of 170 m^3/hr. The two additional wells are included to give more flexibility to the system and serve as a backup in the event of a failure.

According to the numerical modelling results, the exact location of the 27 wells was selected to guarantee that all the water infiltrated from the basin is recovered within 1000 days and cannot move past the row of wells located the farthest (i.e. 750 m) from the infiltration basin itself. Figure 9 shows the locations of the recovery wells.

COLLECTION PIPES

The recovery wells are connected to the water tanks using five collection pipe networks shown schematically in Figure 2 and more in details in Figure 10The proposed piping system extends for a total of 6.7 km. Most of the collection pipe networks are placed along existing roads and the remaining networks are in new proposed roads.

MONITORING WELLS

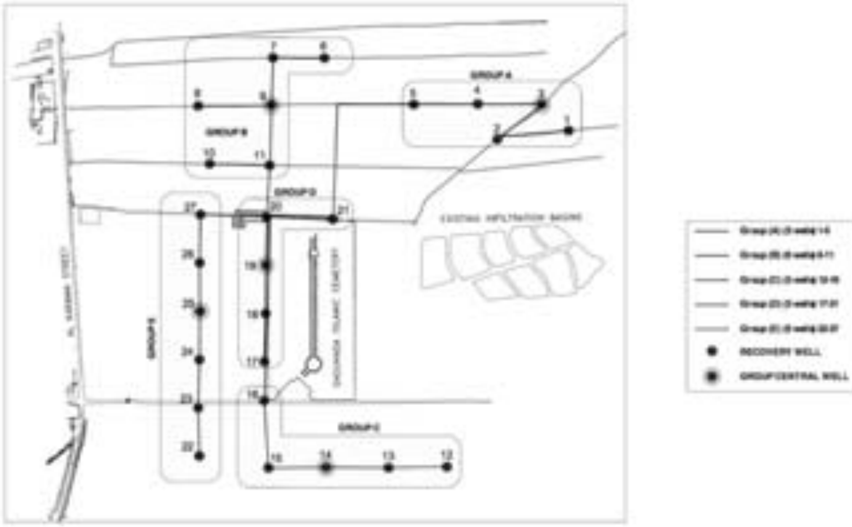


Figure 10: Wells grouping and Piping System

The water pumped to the irrigation network should be monitored from the moment it is extracted from the ground to the point it is delivered to the farmers.

Samples of water should be therefore be taken and analyzed randomly at farm level, trunk lines, water tanks, and irrigation networks. Constant monitoring should be implemented across the recovery well system. To this extent, a system of 42 monitoring wells will be implemented by using the 5 existing monitoring wells, the 27 newly built recovery wells and 10 new monitoring wells.

The location of the 42 monitoring wells is provided in the following Figure 11.

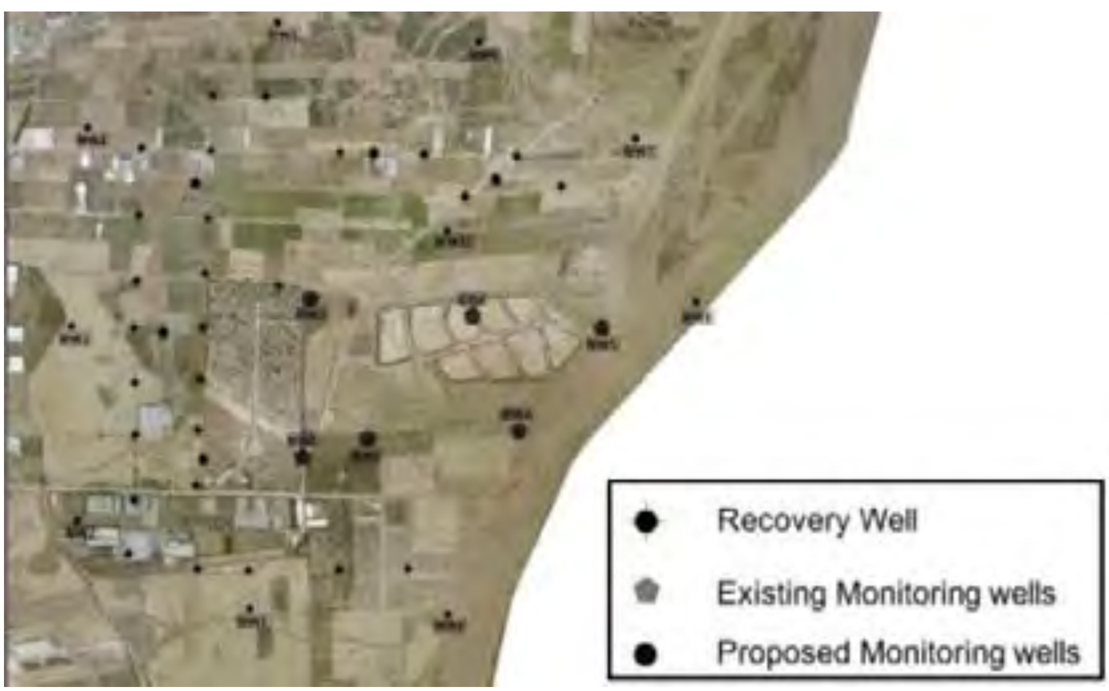


Figure 11: Location of the existing and newly proposed monitoring wells

PROJECT REUSE SCHEME

The gross agricultural area is approximately 1,570 ha (15,700 du) and it is located at the north-east side of the Gaza Strip adjacent to the eastern border as shown in the following Figure 12. The net irrigated area is approximately 1,260 ha (12,600 du) whereas the remaining 300 ha (3,000 du) of land is for other uses such as industrial and residential areas and roads. For optimizing construction and operation scheduling, the entire project was originally subdivided into two main parts (A and B) relative to their locations with the infiltration basins. Part A extended for about 1,010 ha (10,100 du) and Part B for an additional 500 ha (5,000 du) and were respectively located to the north and to the south of the infiltration basins as shown in the following Figure 13.

In accordance with irrigation requirements, irrigation was to be carried out on a six-day rotational basis over six zones of almost equal size, i.e. A (A1 and A2), B (B1 and B2), C (C1 and C2), D, E and F, as shown in the following Figure 13. According to the original design, each day, only one of these six zones would have been irrigated. The original design determined the agricultural land based on cropping patterns, daily and monthly crop water requirements, irrigation methods, and amount of recovered water. The proposed layout of the irrigation network is depicted in Figure 14.

Figure 12: Location of agricultural land

Figure 13: Proposed Irrigation Zones

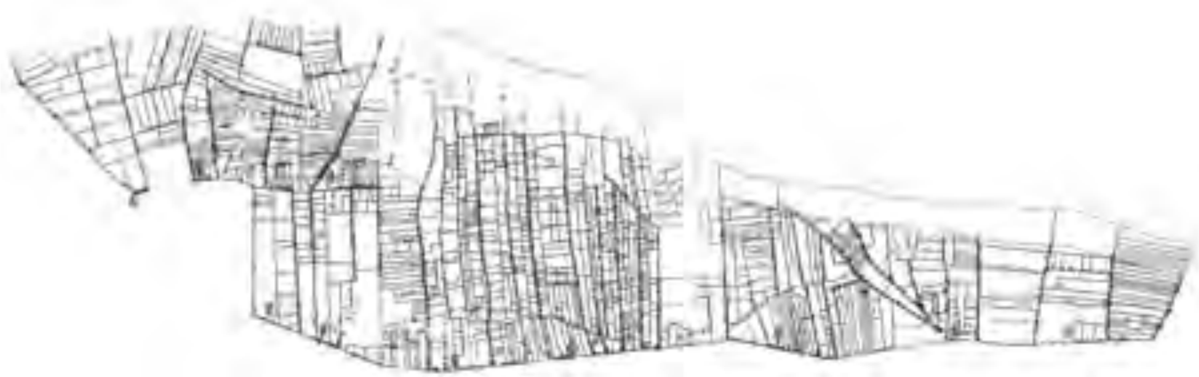


Figure 14: General Layout of the Originally Proposed Irrigation Network

REVIEW OF REUSE SCHEME: ADDITIONAL FINDINGS AND RECOMMENDATIONS

In addition to the key findings listed in the Executive Summary above, the following achievements were obtained while reviewing the original design of the Irrigation Project:

- A review of the original irrigation project layout resolved some of its design inconsistencies and guarantees that a minimum water pressure of 2.5 bars is provided to the farm gate (the original design failed to do so for a sizable number of farms);
- A review of the original design for the recovery scheme confirmed its validity;
- A review of the original design for the reuse scheme confirmed the selection of materials, the general layout and the selection of the pumping system;
- The overall cost for the construction of the water reuse scheme has significantly increased (nearly 75% increase) from its original estimation. Although this might be justifiable in the context of doing construction in Gaza, it still represents a large economic burden for the overall feasibility of the project. While revising the detailed design and tender documents, PWA should consider revising the overall design considering the reduced flows that now, thanks to the new CP, will be delivered across the network. It is possible that such a revision might lead to a cost saving of up to 15-20%. Further to that, it is possible that a further reduction in the overall cost for the construction of the irrigation scheme might be achieved with the adoption of a optimized layout. Particularly, several trunk lines had to be doubled up (sometimes even tripled up) to guarantee that the right water pressure is delivered thought the network. These changes are driving the cost of the construction up and could be optimized with the aid of a proper topographic survey and a further refinement of the original design.

PROJECT ECONOMIC AND FINANCIAL SUSTAINABILITY

The newly proposed development plan assumes that the entire project area (Phase I + Phase II) will be able to adopt the proposed cropping pattern within four years from the completion of the irrigation scheme. The adoption of the new cropping pattern involves not only planting new crops but also modernizing the farm and adapting it to the proposed irrigation method. The cost for the adoption of the cropping pattern and the modernization/development of the farms is expected to be 4.695 Million ILS (approximately 1.3 Million US$) per year for a period of four years assuming that Phase I and II are developed one after the other over a period of two years.

Farmers will require intense training to be able to implement the proposed plan. Additionally, maximizing the output of the irrigation project will require the farmers to cooperate via one Water User Associations (WUA), which has yet to be created. The macro-economic analysis assumes that the WUA should immediately invest approximately 3 Million ILS (approximately 0.8 Million US$) in trainings.

Finally, operating and maintaining the system (on-farm and off-farm, including the water recovery and reuse scheme) will cost anywhere between 7.2 Million ILS (approximately 1.98 Million US$) and 11.4 Million ILS (approximately 3.17 Million US$) per year depending on the cost of energy. The O&M costs include 0.36 Million ILS/year (100,000 US$) for the running costs of the WUA. Farmers will pay for the O&M of the system through their water bills.

In order to track the amount used, water consumed by each farm will be metered at the farm gate. Gross Irrigation water demand, excluding water needs for Industries (estimated to be 70,000 m^3/year) but including all system losses[4] and climate change[5], is estimated to be 11,110,000 m^3/year. The net irrigation water requirements (after all system losses are considered), is estimated to be 7,833,484 m^3. Farmers will be charged for the water delivered to their farms. The tariff farmers will have to pay to cover O&M costs will vary from a minimum of 0.9 ILS/m^3 to a

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[4] System losses includes both on farm and off farm losses.

[5] The estimates for water demand assumes that, due the rising of temperatures over the next decades, water requirements for irrigation will increase.

maximum of 1.5 ILS/m^3 depending on the cost of electricity (if entirely provided by the national grid or entirely generated by the stand-by diesel generators installed at the site).

Then, after the new cropping pattern and modernized irrigation methods have been implemented, the irrigation project should generate a stream of revenue that, after the first three years, would provide a steady income of approximately 30 Million ILS/year (approximately 8.3 Million US$/year).

MICRO-ECONOMIC CONDITIONS

The micro-economic analysis of this project looks at the costs and revenues associated with the introduction a new cropping pattern and the modernization of irrigation methods at the farm level where several investments are required to improve productivity and profitability. Within the project area, there exists various current conditions: some farms are cultivated but rely only on rain-fed irrigation; some farms are already cultivated but water is drawn only from wells; large swaths of land are not currently farmed and land levelling and full reclamation might be required.

This section of the *Report* assesses what the net income for farmers would be with and without the project and assesses the availability in the farmers' budget to pay for water.

EVOLUTION OF THE CROPPING PATTERN

The analysis assumes that famers will be able to fully implement the proposed cropping pattern and irrigation methods over a period of four years after the construction of the irrigation network. These changes, changing the existing land use and planting trees and vegetables, are expected to increase land productivity.

The analysis of the value chain has shown that some crops such as fresh fruit (peaches, apricots, plums) are scarcely produced and often imported goods. Olive, as a crop to produce olive oil, is often sold at a low price and profitability might be improved by nearly 50% if olives, especially the better-preserved ones of the right variety, are processed into eatable olives. The new cropping pattern also includes almond as a profitable and long-lasting, easy to preserve, type of crop.

The newly proposed cropping pattern cannot produce the desired increase in production and profits unless farmers are extensively trained (see above for specific recommendations on capacity building for water user associations and farmers). Furthermore, It would be desirable for farmers to unite in associations or cooperatives to jointly handle the supply chain through the use, for example, of refrigeration storage facilities that allow the consumption of perishable products over a longer period of time.

Table 3: Evolution of the Cropping Pattern

LAND DEVELOPMENT OVER TIME [YEARS]

	BEFORE		AFTER		Y1	Y2	Y3	Y4
CROPS AND CROP GROUPS (**)	%	du	%	du	du	du	du	du
CITRUS	5	603	22	2,655	1,116	1,629	2,142	2,655
OLIVE	8	930	23	2,776	1,392	1,853	2,314	2,776
ALMOND	2	272	10	1,207	506	739	973	1,207
PEACHES	5	587	7	845	652	716	780	845
OTHER FRUIT TREE CROPS	5	544	3	362	499	453	408	362
GRAINS*	31	3.684	12	1,448	3,125	2,566	2,007	1,448
WINTER VEGS	13	1.603	4	483	1,323	1,043	763	483
WINTER VEGS (TOMATO IN GREENHOUSE)	1	121	3	362	181	241	302	362
SUMMER VEGS	8	1.009	6	724	938	867	795	724
ALFALFA (GREEN FODDER)	4	509	10	1,207	684	858	1,032	1,207
UNCULTIVATED	18	2.205	0	0	1,654	1,102	551	-
TOTAL	100	12.068	100	12,068	12,068	12,068	12,068	12,068

* GRAINS: WHEAT + BARLEY

** CROPS MARKED IN RED ARE THOSE THAT, IN FUTURE CONDITIONS, WILL OCCUPY LESS LAND IF COMPARED TO PRESENT CONDITIONS

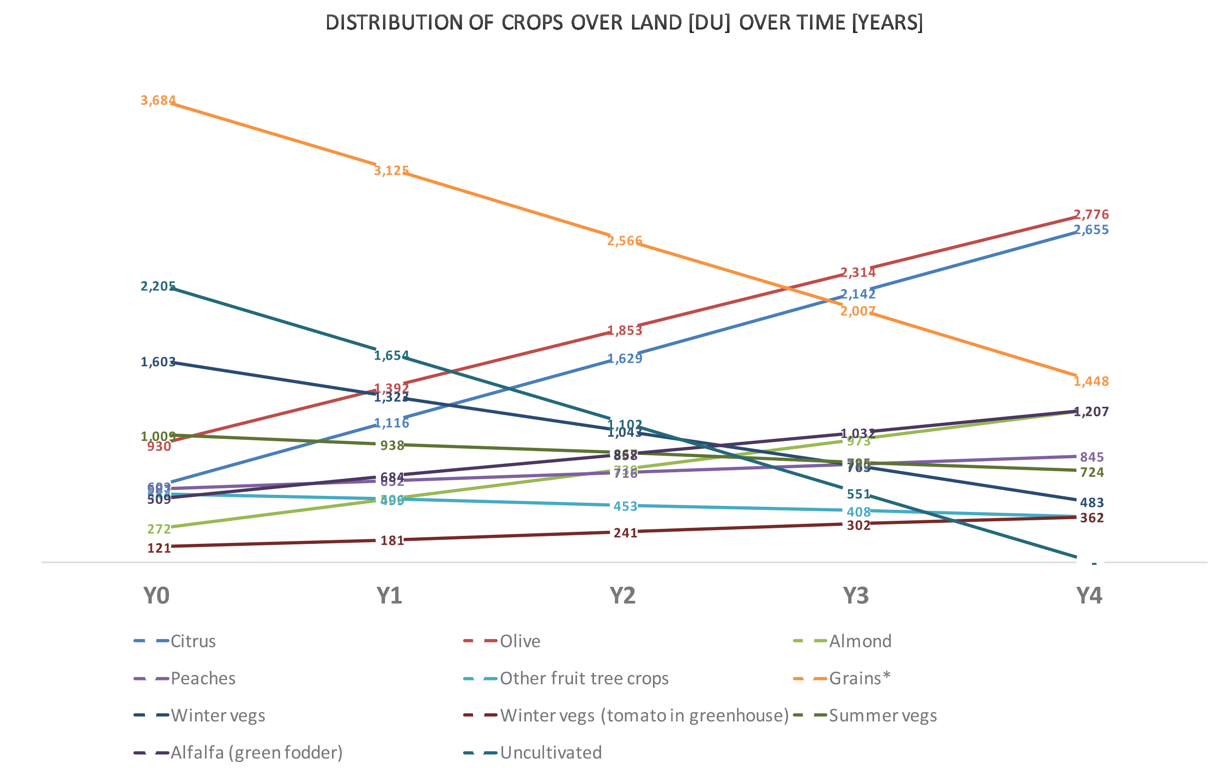


Figure 15: Evolution of the cropping pattern over land [du] over time [years]

FARM-LEVEL INVESTMENTS

Investments at the farm level would be largely spent on an increase in tree plantations and greenhouses placed in areas located away from the border with Israel.

The following table summarizes investments, expressed in Israeli New Shekel (ILS) per dunum (du) by type of crop and by type of material / activity required to produce such crop.

Table 4: Farm-level Investment [ILS] per dunum [du]

CROPS AND CROP GROUPS	*GREEN HOUSE*	*TREES*	*IRRIGATION GRID*	*LABOUR*	*MACHINERY*	*INPUTS*	*TOTAL*
CITRUS		400	380	400	0	200	1,380
OLIVE		800	380	400	0	200	1,780
ALMOND		1,200	380	400	0	200	2,180
PEACHES		1,000	380	400	0	200	1,980
OTHER FRUIT TREE CROPS							-
GRAINS							-
WINTER VEGS							-
WINTER VEGS (TOMATO IN GREENHOUSE)	37,500		492				37,992
SUMMER VEGS							-
ALFALFA (GREEN FODDER)			1,080	80	0	200	1,360

UNCULTIVATED	

Considering the evolution of the cropping pattern, total investments at farm level are provided in the following Table 5.

Table 5: Farm-level investments (ILS x 1,000) evolution during four years of full stage

CROPS AND CROP GROUPS	Y1	Y2	Y3	Y4
CITRUS	708	708	708	708
OLIVE	821	821	821	821
ALMOND	509	509	509	509
PEACH	128	128	128	128
OTHER FRUIT TREE CROPS				
GRAINS				
WINTER VEGS				
WINTER VEGS (TOMATO IN GREENHOUSE)	2,292	2,292	2,292	2,292
SUMMER VEGS				
ALFALFA (GREEN FODDER)	237	237	237	237
TOTAL ILS X 1,000	**4,695**	**4,695**	**4,695**	**4,695**

Based on the new cropping pattern, balance sheet statements have been re-calculated by considering:

- a new cultural organization;
- more modern and efficient farming practices due to training activities and better extensions services;
- better and more effective phytosanitary protection;
- a more rational distribution of the irrigation network of the farm;
- a sizable reduction in net irrigation water demand;
- a higher production, especially of the tree plants due to increased attention to thinning, correct ripening and fruit calibration;
- a water tariff based on the most conservative estimate of 1,461 ILS/m^3.

WATER TARIFF

The water tariff has been conservatively calculated including the effect of climate change, system losses, unexpected events due to pipe breaks, possible defects and/or breaks of the water metering system, possible reading errors of the water metering system and the assumption that 100% of the power requirements to run the recovery wells and the irrigation project will have to be generated by the stand-by generators and not by the national grid.

Ideally the water tariff should be able to cover all OPEX costs including those associated with running the Water User Association. Under these circumstances, farmers should be charged

based on the actual amount of water they consumed at a rate of 1.461 ILS/m^3 if energy is provided entirely by the diesel generators, 1.188 ILS/m^3 if energy is provided 50% by the national grid and 50% by the diesel generators and 0.916 ILS/m^3 if energy is provided 100% by the national grid. The details of such estimates are provided in the following tables.

Table 6: Water Tariff based on different energy generation scenarios

SCENARIO	ANNUAL COST FOR O&M AND WUAS [ILS/YEAR]	GROSS WATER REQUIREMENTS [M^3/YEAR]	NET IRRIGATION WATER REQUIREMENTS [M^3/YEAR]	TARIFF ILS/M^3
100% DIESEL	11,443,430	11,110,000	7,833,484	**1.461**
50% DIESEL	9,308,435			**1.188**
100% NATIONAL GRID	7,173,439			**0.916**

The details of the number presented above are given in the following Table 7.

Table 7: Gross and Net Irrigation Water Requirements at farm level and excluding industries

TYPE OF CROP	NET IRRIGATION WATER DEMAND	GROSS IRRIGATION WATER DEMAND
CROP	**m^3/year**	**m^3/year**
CITRUS	2,196,183	3,114,835
OLIVE	1,957,104	2.775,750
PEACHES	531,016	753,138
GRAINS	448,785	636,509
OTHER FRUIT	225,297	319,538
SUMMER VEGETABLES	470,724	667,626
WINTER VEGETABLES	141,871	201,216
WINTER TOMATO GREENHOUSES	51,337	72,811
ALMOND P	750,992	1,065,128
ALPHA-ALPHA P	1,060,174	1,503,639
TOTAL M^3/YEAR	**7,833,484**	**11,110,191**

BREAK-EVEN POINT FOR WATER TARIFF

In order to better qualify how the balance sheet of each individual crop changes by changing the water tariff, the break-even point between costs and revenues was estimated for each crop. The results, displayed in the following table, show that a large part of the crops has costs and revenues balance between a tariff of 0.90 ILS/m^3 and of 2.49 ILS/m^3.

Water price sensitivity is lower in summer and winter vegetables, while only vegetables grown in the greenhouse can withstand a high cost per cubic meter of water.

Table 8: Water tariff that involve zero net margin

CROPS	OLIVE	CITRUS	PEACHES	GRAIN	OTHER FRUIT CROP	SUMMER VEGETABLE	WINTER VEGETABLES	WINTER GREENHOUSES	ALMOND	ALPHA ALPHA
WATER TARIFF ILS/M^3	**1.00**	**1.63**	**2.49**	**-0.89**	**1.76**	**3.31**	**6.56**	**42.51**	**0.90**	**1.14**

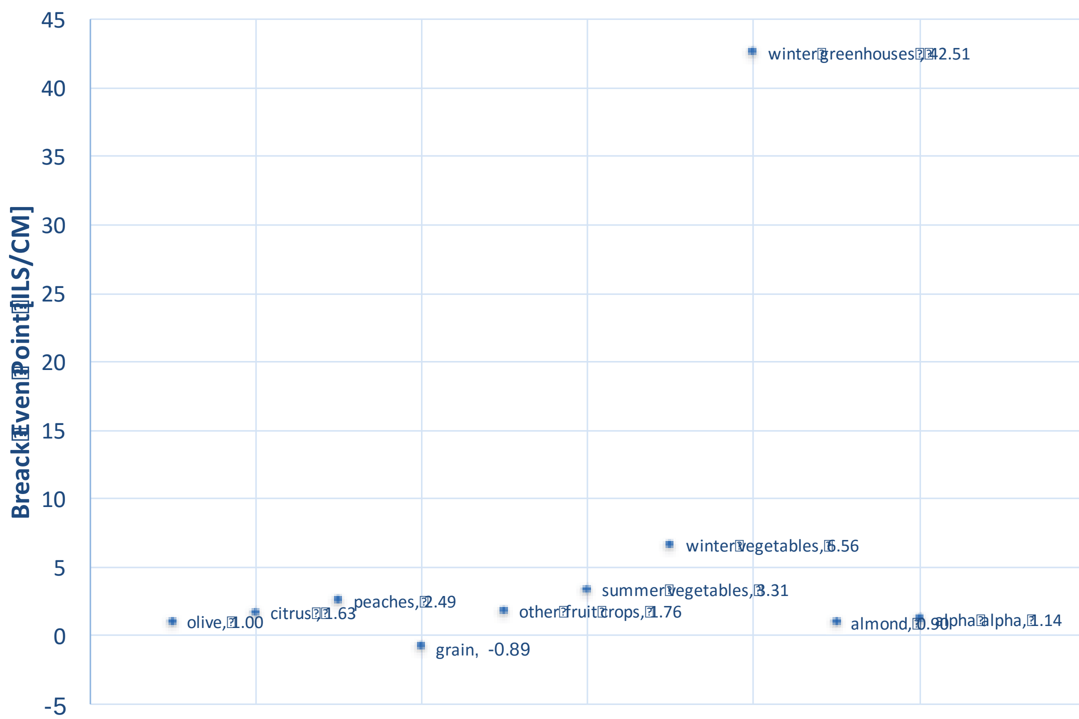


Figure 16: Water tariff that involve zero net margin

It is assumed that the following costs will be paid by the farmers: the Operation & Maintenance (O&M) costs of the recovery scheme, the reuse scheme and the irrigation network inside the farms, the costs for operating the Water User Associations (WUA). The farmers would be charged based on the actual water they consume. Water consumption is measured by a water meter installed at the manhole located at the farm gate.

BALANCE SHEET FOR THE CROPPING PATTERN

A summary and detailed analysis for both costs and revenues associated with each crop as suggested by the newly proposed cropping pattern is provided in the following series of tables.

Table 9 Summary of the Financial Costs [ILS x 1,000]

CROPS	Y1	Y2	Y3	Y4
CITRUS	2,493	3,639	4,784	5,930
OLIVE	2,253	2,999	3,746	4,493
PEACHES	995	1,094	1,192	1,291
GRAINS	3,584	2,943	2,302	1,661
OTHER FRUIT CROPS	857	779	701	622
SUMMER VEGETABLES	2,118	1,957	1,796	1,635
WINTER VEGETABLES	2,854	2,250	1,646	1,042
WINTER TOMATO GREENHOUSES	486	648	810	972
ALMOND	599	875	1,152	1,429
ALPHA-ALPHA	777	975	1,173	1,371
TOTAL FOR THE FINANCIAL COSTS [ILS X 1,000]	**17,016**	**18,159**	**19,302**	**20,445**

Table 10: Summary of the Financial Revenues [ILS x 1,000]

	Y1	Y2	Y3	Y4
CITRUS	3,456	5,044	6,632	8,220
OLIVE	2,672	3,558	4,444	5,329
PEACHES	1,792	1,969	2,146	2,323
GRAINS	2,109	1,732	1,355	978
OTHER FRUIT CROPS	1,253	1,139	1,024	910
SUMMER VEGETABLES	3,751	3,466	3,181	2,896
WINTER VEGETABLES	5,158	4,066	2,975	1,883
WINTER TOMATO GREENHOUSES	1,901	2,534	3,168	3,801
ALMOND	728	1,065	1,401	1,738
ALPHA-ALPHA	1,077	1,351	1,626	1,901
TOTAL FOR THE FINANCIAL REVENUES [ILS X 1,000]	**23,898**	**25,924**	**27,951**	**29,978**

The detailed balance sheet for each crop are provided in "Annex 5: Balance Sheet for Individual Crops".

MACRO-ECONOMIC CONDITIONS

METHODOLOGY

Cost-benefit analysis (CBA) is a formal analysis technique used in public and private investment projects (Rakhra, 1991) as well as in programs and policies (Stoica, 2005) in order to make a comparative assessment of all the benefits and costs anticipated. It also represents an attempt to measure the costs endured and gains earned by a community or a private company after the project is implemented.

CBA proves its usefulness in feasibility studies (from an economic, environmental, social or technological perspective) by selecting the optimal option for investment projects (Hanley and Spash, 1993). The purpose of using CBA in a sector is to set up pragmatic administrative rules in order to *allocate resources efficiently*.

The use of cost-benefit analysis contributes to determining the financial sustainability as well as profitability of the NGEST water reuse scheme. It also:

a) highlights the economic and financial viability of the NGEST water reuse scheme for different scenarios;
b) enables the identification of possible errors in the design or implementation phase (incorrect information, unrealistic hypotheses, etc.); and
c) enables the correction needed to properly conduct the NGEST water reuse scheme.

GENERAL PROJECT ASSUMPTIONS

Within the CBA, costs are presented in terms of capital investments and operation and maintenance (O&M); the first being a one-time cost and the second being a recurring, yearly, cost.

The entire water recovery and re-use scheme requires capital investments to be implemented over time to provide water in two separate areas (Phase I for 500 ha and Phase II for 1,000 ha). The implementation of each phase has been subdivided into two separate tendering packages. The details are provided in the following Table 11 including the implementation schedule.

Table 11: Tendering Packages and proposed timeframe for the implementation of Phase I and Phase II

		DESCRIPTION	2017	2018	2019	2020
I	1	Supply and install 15 recovery wells and concerned connection pipes, the civil works within the booster pumping station, five boosters pumps, one 4,000 m^3 water tank and 5 monitoring wells	$6,366,817			
	2	Small works related to the procurement and construction of the irrigation network for an area of 500 ha (5,000 du)		$7,519,531		

II	1	Supply and install 12 recovery wells and concerned connection pipes, the remaining civil works within the booster pumping station, five booster pumps, a second 4,000 m^3 water tank and 5 monitoring wells	$2,169,983
	2	Small works related to the procurement and construction of the irrigation network for an area of 1,000 ha (10,000 du)	$19,980,469

The O&M cost are provided in the following tables assuming three possible scenarios of cost for electricity. The first scenario assumes that energy will be provided 100% by the national grid, the second scenario assumes that 50% of the energy requirements are provided by the national grid and the other 50% by the standby diesel generators installed onsite. The third and most conservative scenario assumes that 100% of the energy requirements are provided by the standby diesel generators.

Table 12: Annual O&M costs (US$ and ILS) assuming all energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (ONLY NATIONAL GRID)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$1,074,060	$358,020	$716,040
FROM THE GRID (100%)	*$1,074,060*	*$358,020*	*$716,040*
FROM THE DIESEL GENERATORS (0%)	*$0*	*$0*	*$0*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	$1,886,002	$724,235	$1,161,767
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS	**$ 1,986,002**	**$824,235**	**$1,261,767**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 7,173,439**	ILS 2,977,000	ILS 4,558,000
WATER TARIFF (ILS/M^3)	0.918		

Table 13: Annual O&M costs (US$ and ILS) assuming 50% of the energy is provided by the National Grid

OPERATION AND MAINTENANCE COST (50/50)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000

POWER CONSUMPTION	$1,665,144	$555,048	$1,110,096
FROM THE GRID (50%)	*$537,030*	*$179,010*	*$358,020*
FROM THE DIESEL GENERATORS (50%)	*$1,128,114*	*$376,038*	*$752,076*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$2,477,086**	**$921,263**	**$1,555,823**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	$2,577,086	**$ 1,021,263**	**$1,655,823**
TOTAL MANAGEMENT COSTS (ILS	**ILS 9,308,435**	3,689,000	5,981,000
WATER TARIFF (ILS/M^3)	**1.188**		

Table 14: Annual O&M costs (US$ and ILS) assuming 100% of the energy is provided by the standby diesel generators

OPERATION AND MAINTENANCE COST (ONLY GENERATOR)		PHASE I	PHASE II
DESCRIPTION	**US$**	**US$**	**US$**
MANPOWER	$180,000	$90,000	$90,000
POWER CONSUMPTION	$2,256,228	$752,076	$1,504,152
FROM THE GRID (0%)	*$0*	*$0*	*$0*
FROM THE DIESEL GENERATORS (100%)	*$2,256,228*	*$752,076*	*$1,504,152*
MAINTENANCE AND REPAIR WORKS	$271,574	$137,352	$134,222
CONSUMABLES & MISCELLANEOUS	$360,368	$138,863	$221,505
TOTAL O&M COST USD/YEAR	**$3,068,170**	**$1,118,291**	**$1,949,879**
WUAS ANNUAL COSTS	$100,000	$100,000	$100,000
TOTAL MANAGEMENT COSTS (US$)	**$3,168,170**	**$1,218,291**	**$2,049,879**
TOTAL MANAGEMENT COSTS (ILS)	**ILS 11,443,430**	**ILS 4,400,000**	**ILS 7,404,000**
WATER TARIFF (ILS/M^3)	**1.461**		

Other costs that are included in this CBA are the water tariff, assumed to be 1.461 ILS/m^3, and the investments required at the farm level to support the introduction of the proposed cropping pattern.

Costs for supporting and training the Water User Association (WUA) are assumed to cost 3,000,000 ILS (equivalent to $806,000), divided in 2,000,000 ILS for the first year and 1,000,000 ILS for the second year.

FINANCIAL ANALYSIS

The financial analysis indicates whether the project will generate a positive net cash flow during the evaluation period (profitability) and whether the cumulative cash flow from the start of investment until the final prediction is negative (sustainability).

The analysis of the investment project's cash flow includes both the evaluation of the cash outflows (investment costs as well as and costs at farm level) and cash inflows (revenues at farm level, industries, grant and subsidies). As opposed to the economic analysis, in the financial analysis the cash flow does not include amortization, reserves and other accounting items.

From this perspective, the financial analysis was conducted with the following steps:

1. Estimating revenues and costs of the NGEST area farms and assessing the implications of these parameters on cash flow;
2. Defining the financing sources of investment and analyzing the financial profitability.
3. Determining the funding gap in achieving the investment project and identifying the best mechanisms to attract funding;
4. Checking whether the estimated cash flow could ensure the proper operation of the NGEST project. The investment project is financially sustainable if there is no risk of running out of cash during the operation.

For the financial analysis, the following costs and revenues were taken into account:

Cash Outflows (Costs)

- Capital cost – recovery wells, farm investment
- Costs related to the WUA operation and training
- Operation Costs at farm level including water tariff

Cash Inflows (Revenues)

- Revenues at farm level derived from the new cropping pattern
- Water tariff paid by Industry based on 2 ILS/m^3 per 70,000 m^3 /year
- Reduction of time spent in management of private wells
- Investments paid by Government/Donors
- Public Subsidies based on farm water tariff of 1.461 ILS/m^3 (worse case scenario).

The financial analysis carried out as part of the project's CBA uses market prices (which include VAT and indirect taxes) to check the balance of the investment and the sustainability of the project.

The cash flows accumulated in different years during the evaluation period (25 years) require a fair discount rate. The financial discount rate allows to account for the influence of time on the value of money and reflects the opportunity cost of the investor's capital.

In general, it is recommended to use a discount rate of 5%, but the model also used 2 more points (7%) and less (3%) to evaluate the sensitivity of the net present value.

SCENARIOS

Five scenarios involving donors, government and farmers have been suggested to evaluate possible project implementation and financing opportunities based on the following elements of the project:

(1) Capital Investment for the Water Recovery Scheme;
(2) Capital Investment for the Water Reuse (Irrigation) Scheme up to the Farm's Gate;
(3) O&M Cost for the Water Recovery Scheme;
(4) O&M Costs for the Water Reuse (irrigation) Scheme;
(5) Capital Investments for Farm's Development.

The five scenarios are defined as follows

- **Scenario 1** - Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II. Under this scenario, farmers would pay back the full cost for the construction of both the recovery and the reuse schemes for both phases of the project. On top of that, farmers would cover operation and maintenance costs for the whole system while covering investments and operating costs necessary for the development of their own farms;
- **Scenario 2** - Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built). This scenario is identical to Scenario 1 except that only Phase I of the project will be built;
- **Scenario 3** - Capital Subsidies (consider only costs 3 + 4 + 5) for Phase I + Phase II. Construction costs would be paid by the government/donors and not charged back to the farmers. This scenario assumes that the capital investments necessary to build both Phase I and Phase II of the recovery and reuse schemes would be paid by the government or by a donor and every other cost would be paid by the farmer;
- **Scenario 4** - Capital and O&M Subsidies: this scenario considers only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II. This scenario assumes that the Government/Donors would cover the cost for the construction of Phase I, but that the farmers will pay back the cost for the construction of Phase II. Farmers would also pay for the development and O&M of their own farm. The cost for the O&M of the recovery and reuse schemes (Phase I + II) would be covered

by the Government/Donors for the first 8 years (i.e. the time needed by the farmers to pay back the construction of Phase II). After that, the farmers will pay for the cost of O&M of the recovery and reuse schemes as well.

- **Scenario 5** - Capital and O&M Subsidies: considers costs (1) and (2) will be paid by the government/donors. Costs (3) and (4) would be subsidized by the Government only until Farmers have paid back Cost (5). Farmers are expected to pay for the development of their own farm. All other costs are paid by the Government/Donors for the first 3 years (i.e. the time it takes for the farmers to be able to pay back for the improvement of their own farm). After that point, farmers will be responsible for paying O&M costs for the whole system.

A schematic representation of the five scenarios is provided in the following Table 15.

Table 15: Investment Scenarios

Scenario	Description	Cost Paid by the Farmers					Construction Phase to be Paid by the Farmers	
		(1) Capital Investment for the Recovery System	(2) Capital Investment for the Irrigation System up to the Farm's Gate	(3) O&M Cost for Recovery System and Irrigation System	(4) O&M Costs at Farm Level	(5) Capital Investments for Farm's Development	(Phase I)	(Phase II)
1	Full Costs (1 + 2 + 3 + 4 + 5) for Phase I + Phase II;	x	x	x	x	x	x	x
2	Full Costs (1 + 2 + 3 + 4 + 5) only for Phase I (Phase II will not be built);	x	x	x	x	x	x	Not Built
3	Capital Subsidies (consider only costs 3 and 4 and 5) for Phase I + Phase II. Construction costs will be paid by the government and not charged back to the farmers;	Paid by the Government and not charged to the Farmers		x	x	x	Paid by the Government and not charged to Farmers	
4	Capital and O&M Subsidies: consider only cost (1) and (2) for Phase II and costs (4) and (5) for both Phase I and II. Cost (3) is subsidized by the Government/Donors for several years so that farmers can pay back costs (1), (2) and (3) for Phase II.	x	x	Subsidized by Donors/Government until Farmers have paid back the Construction of Phase II	x	x	Paid by the Government and not charged to Farmers	x

5	Capital and O&M Subsidies: considers costs (1), (2), (3) and (4) paid by the government/donors. Costs (3) and (4) are subsidized by the Government until Farmers have paid back Cost (5).	Paid by the Government and not charged to the Farmers	Subsidized by Donors/Government until Farmers have paid back Cost (5) and are able to paid for O&M (3) + (4)	x	Paid by the Government and not charged to Farmers

FINANCIAL SUSTAINABILITY OF THE INVESTMENT PROJECT

The financial sustainability involves having a cumulative positive cash flow for each year of the projections. Therefore, there should be enough cash for smooth running of operations every year (without the risk of lacking liquidity). Demonstrating the financial sustainability of the project makes it necessary to weigh cash inflows with cash outflows for the entire reference period of the project.

In order to determine the profitability of the investment project, it is necessary to calculate the financial performance indicators for the overall investment, as well as the capital invested. The financial performance indicators of the investment project are Financial Net Present Value (FNPV) and Financial Internal Rate of Return (FIRR).

FNPV represents the amount calculated when the estimated investments and operating costs of the project are deducted from the present value of the projected revenues. The investment project is profitable in the financial sense if FNPV has a positive value.

FIRR represents the discount rate for which FNPV is zero or which equals the present value of the financial cash flows projected for the reference period. If this indicator is less than the cost of the capital, the project is not profitable. When it is higher than the cost of capital, the project is acceptable because it will generate a positive FNPV.

The profitability indicators are calculated considering all the investment costs of the project, regardless of its sources of funding. If FNPV is positive and FIRR is higher than the discount rate, the project is profitable. If FNPV is negative and FIRR is lower than the discount rate, the project is not profitable and therefore it needs financial support.

The main results of the financial analysis are summarized in the following table.

Table 16: Main Results of the Financial Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]			BENEFIT COST RATIO (BCR)			INTERNAL RATE OF RETURN (FIRR)
	3%	5%	7%	3%	5%	7%	
1	-155,002	-140,864	-130,096	0.772	0.750	0.728	NF
2	-61,389	-56,792	-53,353	0.778	0.753	0.728	NF
3	**17,400**	**12,152**	**7,405**	**1.028**	**1.023**	**1.017**	**10.82%**
4	-52,493	-48,408	-46,166	0.922	0.913	0.902	NF
5	17,400	12,152	7,405	1.028	1.023	1.017	10.82%

ECONOMIC ANALYSIS

An economic analysis for major investment projects determines if the project contributes significantly to total economic welfare. It measures the project benefits depending on the following: the costs avoided due to project implementation; and the external benefits arising from the implementation, neither of which are included in the financial analysis.

In this analysis, the benefits should be seen from the perspective of two key issues. First, the revenues identified in the financial analysis will be corrected by applying a conversion factor. This factor allows the conversion between the economic and the financial prices. Secondly, the attention should focus on the positive externalities arising from compliance with environmental standards. These externalities should be given a monetary equivalent.

In the economic CBA, some cost/benefits cannot be expressed in monetary units but only in qualitative terms. These costs/benefits are:

- Preservation and improvement of the quality of space for human life, as in the case of water pollution when human settlements located near water lose their basic quality.
- Prevention of flora and fauna destruction.
- Maintenance of natural system which will have a positive effect on people, like better mental condition and richer intellectual activities.

Benefits that cannot be expressed in monetary value are also called "intangible" benefits. Those benefits have been ignored in the cost-benefit analysis of the project. The reason is that these benefits cannot be assessed, and their detailed qualitative effects can be better described in an environmental impact assessment.

In the economic cost-benefit analysis the costs are expressed in accounting prices, and are measured in terms of 'resource' cost or 'opportunity' costs.

The economic analysis could be briefly described with the following steps:

- Conversion of market prices into accounting prices;
- Update the estimated costs and benefits;
- Calculation of economic performance indicators (Economic Net Present Value, Economic Rate of Return, benefit/cost ratio).

The corrections to be considered in the economic analysis are the following:

Fiscal Corrections. Fiscal Corrections are necessary because some transfers from one agent to another should be seen as pure transfers, without having an economic impact. For example, the subsidies provided by the government to those who want to invest in the NGEST Irrigation Project represent a pure transfer offering advantages to the beneficiaries, but not creating

economic value. The fiscal corrections are made for indirect taxes (VAT), subsidies and pure transfer payments (employer's obligation to pay social security contributions) which are generally included in the eligible costs and/or operating or maintenance costs. However, the prices should also include direct taxes. In addition, if certain indirect taxes/subsidies are aimed at correcting externalities, then they will be included in the analysis. In order to assess the project's economic impact, information on the tax system in the West Bank and Gaza, as calculated by World Bank, was used as presented in the following Table 17.

Table 17: Direct and indirect taxation in Gaza and West Bank

TAX OR MANDATORY CONTRIBUTION	PAYMENT (NUMBER)	NOTES ON PAYMENTS	TIME (HOURS)	STATUTORY TAX RATE	TAX BASE	TOTAL TAX RATE (% OF PROFIT)	NOTES ON TTR
CORPORATE INCOME TAX	2		18	15% - 20%	Taxable Profit	14.23	
CAPITAL GAIN TAX	1			15% - 20%	Capital Gains	0.76	
MUNICIPAL BUSINESS TAX	1			17%	Rental Value of Building	0.28	
EMPLOYEE PAID - PERSONAL INCOME TAX	12		96	5% - 20%	Taxable Salaries	0	withheld
IRRECOVERABLE VAT (ON FUEL)	0			15%	Fuel Consumption	0	
VALUE ADDED TAX (VAT)	12		48	16%	Value Added	0	not included
TOTALS	28		48			15.27	

Correction of labour cost from financial to economic. The correction of financial costs to economic costs of the price of labour has been made. The coefficient used to correct the financial value was 0.3 to consider taxation and social charges.

To carry out a neutral evaluation, positive and negative externalities of the project were not considered.

Based on the consideration presented above, the main results of the economic cost benefit analysis are presented in the following Table 18

Table 18: Main Results of the Economic Cost Benefit Analysis

SCENARIO	NET PRESENT VALUE (NPV) [ILS X 1,000]	BENEFIT COST RATIO (BCR)

	3%	5%	7%	3%	5%	7%	INTERNAL RATE OF RETURN (EIRR)
1	-61,667	-61,628	-61,454	0.909	0.891	0.871	NF
2	-23,386	-24,446	-25,237	0.915	0.894	0.871	NF
3	**118,983**	**99,119**	**83,307**	**1.190**	**1.190**	**1.188**	**61.68%**
4	47,413	36,828	27,978	1.071	1.066	1.059	18.55%
5	118,983	99,119	83,307	1.190	1.190	1.188	61.68%

GENERAL ASPECTS

FINANCING MECHANISMS

The sources of funding provided by the various scenarios of the project are:

- government financial sources
- financial sources of international cooperation
- private financial sources

While government finance and international cooperation does not have direct impacts on the financial market system, it is necessary to provide support and guarantees to a private financing system. As we know the banking system requires, turning on a loan, guarantees and payment of the price of money (interest).

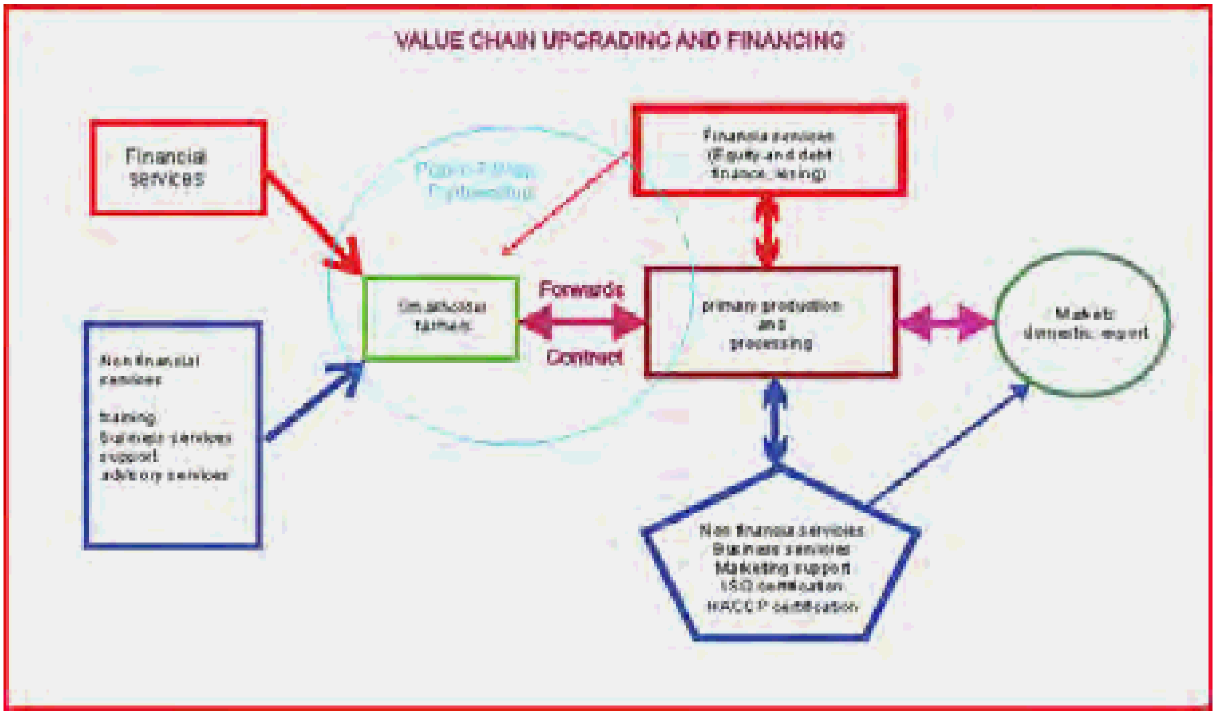
Farmers will need to have access to a banking system and most of them do not have enough income or capital to finance investment in farms or parts of the project, so it is necessary to provide them with support tools.

- First, the government must provide for a national guarantee fund supporting the banking system for when, due to personal problems or because of adverse meteorological conditions or distortions in market prices, the farmer is unable to repay the annual instalment of the loan.
- The second important thing is government or donor support for bank interest payments, given the high price of money locally. Farmers can repay the loan principal, but hardly the interest portion.

Farmers interested in the project are largely small companies (1 or 2 dunums) are heterogeneous and have different needs. It is important to identify the various sub-organizations of small owners and to evaluate their needs and constraints. In addition, small farmers do not only need credit

for agricultural activities, but also need credit for other family / needs, savings, payment systems and insurance.

Clearly knowledge of the needs of small farmers makes it possible to identify the real needs, in particular regarding the guarantees for the banking system. On systemic risk, agricultural insurance, catastrophic risk programs, price coverage through exchanges of goods or value chains, banks can provide some innovative solutions.



Agriculture value chain development is strongly influenced by:

<u>Financial services</u> Financial services identify the possibility of providing credit easily to small farmers who can expand their business by investing in more profitable crops, plant and machinery, improving the quality of agricultural production and starting up with other farmers on processing products in order to increase the value added on the farm.

On this point, it is important to develop warranty services, such as a **national guarantee fund** that supports the banking system in lending.

Another example of financial services for farms is the establishment of a **national rotation fund** for investment financing for small farmers.

Agricultural insurance must support farmers with regard to the risks of climate change that pose the greatest risk to agriculture and food security. It is clearly necessary to ensure farmers also for losses due to the contingent difficulties of the neighbouring Israel.

Financing needs are not high and are comprised between 1,000-2,000 ILS/du for new tree plantations, so they do not represent important figures to guarantee - only greenhouse construction requires more important investments around 35,000 ILS/du. Other investments relate to corporate mechanization as possible support for company work for medium-sized farms.

Non-financial services: Non-financial services are fundamental to farmers' training for new technologies, low-impact farming practices and organic farming. In addition, credit counselling services and advisory services for the processing and marketing of the products of their own farm are required.

Public-Private Partnerships (PPPs): Another element that could support the development of new financial management models is based on public-private collaboration.

Public-private partnerships (PPPs) enable the involvement of the private sector in the implementation and development of a programme. Various forms of PPPs can be implemented within the program are:

- Partnership with the private sector for better access of small producers to markets and enhancement of quality of production at grassroots level;
- Partnership with the public sector to enforce the necessary legal framework and to develop the indispensable infrastructure;
- Partnership with financial institutions inclusive of commercial banks, microfinance institutions and leasing companies to finance the needs of different stakeholders within value chains and service providers to the value chains;
- Partnership with insurance companies to develop specific products aiming at mitigating risks for stakeholders and financiers;
- Partnership with communities to strengthen their capacities to gradually own and operate productive assets and/or specifically created companies;
- Partnership with local SMEs and entrepreneurs to develop services to value chain stakeholders like processing, storage facilities, transport, maintenance and repair, inputs supply.

JOB IMPACTS

The project in its full version creates new employment, the estimate of the level of direct employment is about 150 new employees and the job security for current employees.

Table 19: Job Created

JOB CREATED	DAYS/YEAR
JOB DAYS CREATED AT FARM LEVEL	**23.741**

JOB DAYS CREATED WUAS			4.400
JOB DAYS CREATED O&M			4.840
TOTAL JOB DAYS CREATED			32.981
INCREMENTAL LABOUR	dd	32981	+ 34%
	n.people	150	

The government may provide subsidies for young farmers who undertake to work on the farm in order to reduce youth unemployment.

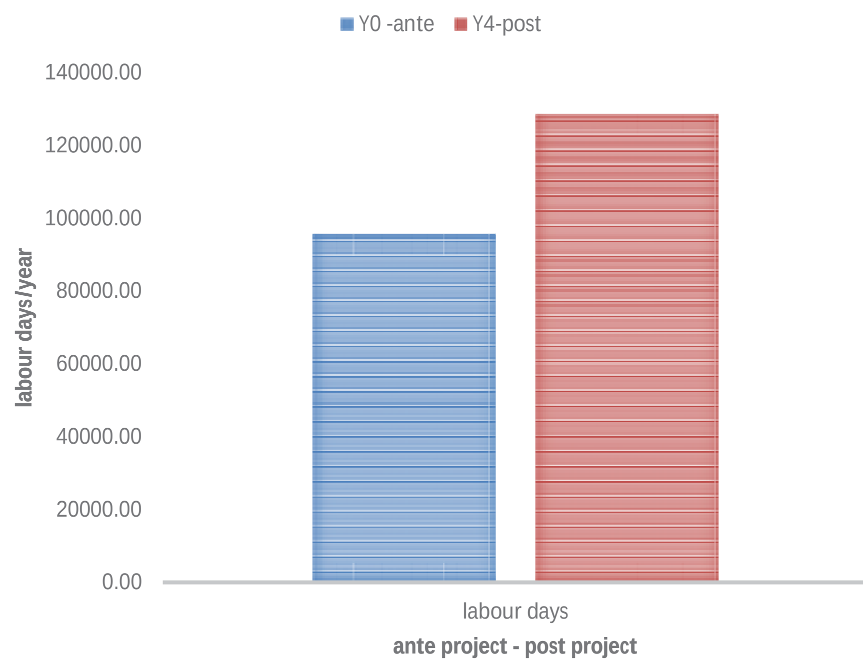


Figure 17: Job created per year before and after the project is implemented

PROJECT IMPLEMENTATION RECOMMENDATIONS

INSTITUTIONAL ARRANGEMENT

BACKGROUND

Traditional irrigation management in Palestine is community-based and informally organized around private wells in Gaza or springs in West Bank. Whereas in the Gaza Strip a small group of farmers share the operation and costs of a private irrigation well and organize the supply of water among themselves on a rotational basis, in the West bank, common irrigation schemes can supply up to a few hundred farmers and thousands of dunums, depending on the size of the spring. The organizational level is thus quite elaborate in West Bank, dealing with O&M, billing, and scheduling for hundreds of farmers in some cases. Still it is mainly informal, the number of WUAs in the Palestinian territories is very limited and the registered ones are very few. Governmental involvement in irrigation, therefore, has been very weak and limited to the licensing of agricultural wells.

INSTITUTIONAL OVERVIEW

Below is a summary of the responsibilities of the institutions that should be involved in the NGEST project, as outlined by the Water Law 2014 and the Draft Water User Association Regulation 2016.[6] It is important to note that the statements below are from the English translation of the laws. If there is a dispute as to the accuracy of a statement, the original Arabic version should be consulted.

As it pertains to this project, the PWA is responsible for (emphasis added):

- Setting a general policy for the planning and evaluation of water and wastewater projects in terms of their economic and social feasibility, setting design and quality control standards, technical specifications, and **monitoring their implementation**.
- Partake in the development of approved **standards of water quality** for various uses, in coordination and cooperation with the competent authorities, and ensure their implementation.

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[6] Because the WUA Regulation is a draft, its provisions (outlined here) may be different in the final version.

- The **establishment of advanced monitoring systems** to monitor precipitation, surface flows, groundwater levels, utilization quantities, and water quality, as well as analysis of data to determine the safe and sustainable yield of Water Resources and improve water resources planning;
- Issue **licenses** for the drilling, exploration, extraction or collection of groundwater;
- Set the general policies for determining the water and wastewater **tariff**;
- Order the suspension of water extraction or water supply in cases of a water source or supply system pollution.

The Water Sector Regulatory Council is responsible for monitoring all matters related to the operation of water Service Providers including production, transportation, distribution, consumption and wastewater management. It has the responsibility and power to:

- Approve of **water prices**, costs of supply networks and other services required for the delivery of water and wastewater services, including setting a unified price for the provision of bulk water supply to Service Providers;
- Issue **licenses to Regional Water Utilities** and any operator that establishes or manages the operation of a facility for the supply, desalination, or treatment of water or the collection and treatment of wastewater, and the levying of license fees;
- **Monitor operation processes** related to the production, transport, and distribution of water and operational processes of wastewater management;
- **Monitor water supply agreements**;
- Setting the basis for regulating the extent and percentage of **local authorities' participation** in the general assemblies of water utilities and ensuring implementation.

The National Water Company is responsible for the production and supply of bulk water at a national level. It is responsible for:

- The **supply and sale of bulk water** to water undertakings, local authorities, joint water councils and associations;
- The **extraction of water** from water resources, desalination of water, and **bulk water transmission** in accordance with a license issued by PWA for this purpose;
- The management, upgrade and development of any assets received from PWA;
- The provision of all the means necessary for the development of all activities and **infrastructure works related to the supply of bulk water**; and

- Propose a water supply tariff and submit to the WSRC for approval.

Service Providers include Regional Water Utilities and Water User Associations.

Regional Water Utilities provide water and wastewater services directly to the consumer, and are responsible for the provision of water and wastewater services within its specified administrative and geographical scope.

Water Users Associations are responsible for managing the service of supplying irrigation water at the local level. More specifically, it is responsible for:

- **Operation, maintenance and management of irrigation and drainage systems** in a fair, efficient and economical manner.
- **Produce or purchase water from its sources** at a certain rate and then redistribute it in a fair and timely manner to all farmers in the irrigation unit according to the criteria agreed with PWA;
- Determine the prices of water sold based on the tariff system in force;
- **Install, dismantle, repair and calibrate the means of measuring water** quantities used by water users.

To create a WUA, (at least) three people representing (at least) twenty farmers owning (at least) 100 dunums may submit an application to the Ministry of Agriculture. The application should contain basic information about the members, including the names and identity cards of the founding members, and the land owned or used by all members along with its agricultural pattern and water usage needs. The application should also include information about the Association, including its address, scope of work, and the water source to be used.

The Ministry of Agriculture will study the application and will then forward it to PWA, which in turn decides whether to grant a license to use the water source. If PWA approves the granting of a license, the Minister of Agriculture shall issue a decision to establish the Association. The application shall then be referred to the WSRC for approval to issue the license.

A WUA will be terminated if its approval to use a water source by PWA is cancelled.

The Ministry of Agriculture shall work with PWA and others in training WUAs on the following subjects:

- General training on participation in associations.

- Specialized training in the fields of financial, administrative and technical affairs necessary for the operation of the Association in accordance with the plans and programs established by PWA;
- Develop the operational plan, management and water distribution operations;
- Develop a maintenance plan for waterways, sockets and pumping mechanisms;
- Directly implement operation and maintenance plans; and
- Evaluation and follow-up.

During the transitionary period while the NWC, WUAs, and other new institutions are created, the relevant governmental authorities, official institutions, civil society organizations, and local authorities should continue to exercise their existing responsibilities and powers.

PUTTING IT ALL TOGETHER

Although it is clear which institutions should be involved in the various aspects of this project, what is not clear is where that authority exactly starts and stops. For example, it is stated that WUAs are responsible for "supplying irrigation water at the local level." But reasonable people may disagree with where that management should start in this project. Does it start at the recovery wells? At the booster station? Or somewhere else?

The main ambiguity, however, is regarding the responsibilities of NWC and the WUA. NWC is responsible for the extraction of water and bulk water transmission. Yet the WUA may "purchase ***or produce***" water, suggesting that the WUA may also be able to extract water itself without purchasing it from NWC. In the new Water Law, NWC is given the responsibility to sell to "associations", including WUAs. That statement alone, however, does not logically necessitate that associations *must* buy from NWC.

Moreover, the WUA is responsible for the irrigation system, which in the case of the NGEST project, coincides with the bulk water transmission system. In other words, the recovery wells extracting water and the pipes bringing the water to the farm gate can be characterized in one of two ways: 1) as bulk water supply (and therefore under the purview of NWC) or 2) as an irrigation system (and therefore under the purview of the WUA), or some combination thereof.

Below are three scenarios for O&M, which are meant to provide a starting point for discussions by Palestinian stakeholders on how best to run the project.

TERMS

Before introducing the scenarios, there should be some clarification of terms:

"**Recovery System**" includes the 27 recovery wells and 42 monitoring wells.

“**Reuse System**” includes all connecting pipes, two 4,000 m^3 water storage tanks, a booster station with 10 pumps, and an irrigation network of 126km of pipelines, which transports the water from the recovery wells to the farm gate and the water metering system.

“**On-Farm System**” is the infrastructure on each individual farm, including the tertiary pipe network to bring the water from the farm gate to the crops.

INSTITUTIONAL SCENARIOS

For the management of irrigation systems, world experience has generally followed three basic arrangements:

1) the government officials continue to manage the systems after completion;
2) the government turns the systems over to farmers to manage them; or
3) the government and farmers manage the systems jointly, meaning some parts of the physical system (generally the larger elements) are managed by governmental agencies while the smaller ones are the farmers' responsibility.

These scenarios are put into the NGEST context and discussed below.

It should be noted that during this transitionary period, neither NWC nor the WUA exist. It is envisioned, therefore, that CMWU will handle the responsibilities of NWC until it is created and able to function. The WUA, which should be created as soon as practicable, will also be assisted by CMWU until it is ready.

Scenario 1 – Governmental Management

1. In this scenario, the Recovery and Reuse Systems would be owned and operated by the NWC.
2. This would mean:
    a. NWC will own and operate the Recovery System;
    b. NWC will own and operate the Reuse System;
    c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it is a simple, straightforward arrangement, whereby the governmental body that specializes in water distribution handles the supply.

The main detriments of this scenario are that it seems to contradict the spirit (if not the letter) of the law, which envisions a greater role for the WUA, and may perpetuate some of the problems with a centralized, governmental approach.

Countries have historically entrusted the management of their irrigation systems to government agencies, on the assumption that they will have the capacity and motivation to achieve high performance standards. The opposite has proven true, as documented reports and literature have shown the performance deficiencies of many government-managed irrigation systems has increased (see, *e.g.*, World Bank, 1997).

The deteriorated performance of irrigation systems under government agencies is generally the resultant of the following:

- the failure to operate and maintain systems adequately;
- the financial burden of subsidizing agencies to manage the system has become more onerous for many governments due to the low fee recovery rates from farmers;
- major difficulties in maintaining subsidies for irrigation systems that perform sub-optimally;
- difficulties in implementing water pricing and cost recovery as a traditional economic solution of "getting the prices right";
- local information constraints and inappropriate incentives for government employees.

Many of the issues delineated above have been problems in the Gaza Strip, and so significant consideration should be given to whether a governmental approach will achieve the goals of this project.

Scenario 2 – Water User Association Management

1. In this scenario, the Recovery and Reuse Systems are owned and operated by the WUA.
2. This would mean:
    a. WUA will own and operate the Recovery System;
    b. WUA will own and operate the Reuse System;
    c. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it firmly places control and management into the hands of the WUA. As mentioned above, several benefits are expected to accrue from involving the WUA in owning and managing the network, including greater overall sustainability of the project.

The greatest detriment of this scenario is that NWC (CMWU) is much more knowledgeable and much better positioned to handle the system than the WUA. The WUA will need significant capacity building and technical assistance to step into this role, as discussed below.

For this approach, governments have followed two different methods to hand over irrigation systems to farmers. Some have favored the quick establishment of the WUA and a rapid transfer of responsibilities to it. Most countries, however, have favored a phased handing over, accompanied by training programs for the leaders of the WUA. The general belief is that a phased program has better chance of success and provides more opportunities to change course, if required.

Scenario 3: Joint Management

1. In this scenario, NWC would own (and for the first few years, also operate) the Recovery and Reuse Systems with the ultimate goal of transferring operation and management to the WUA.
2. This would mean:
   a) NWC would own the Recovery System, and operate it for the first three years of the project.
   b) NWC would own the Reuse System, and operate it for the first three years of the project.
   c) During the first three years, the WUA would receive intensive capacity building.
   d) After the first three years of the project, the WUA would assume operation and management of the Recovery and Reuse Systems.
   e) NWC would continue to own the Recovery and Reuse Systems but would lease them to the WUA.
3. The farmers will own and be responsible for operation of the On-Farm System, with the WUA helping to coordinate farmers for technical assistance and capacity building with modern irrigation techniques and the proposed cropping pattern.

The main benefit of this scenario is that it blends the resources and knowledge of the NWC (CMWU) with the appropriate level of input and phased-in management by the users (WUA).

This scenario also dovetails nicely with the recommended **Investment Scenario 3**, where the capital investments necessary to build both Phase I and Phase II of the Recovery and Reuse schemes would be paid by the government (or by a donor), and the O&M of the Recovery and Reuse schemes and the capital expenditures and O&M of the On-Farm development would be paid by the farmers.

The main detriment of this scenario is that it is a more complex arrangement, necessitating various agreements and contracts between parties to delineate roles and responsibilities.

If this Scenario is chosen, the WUA could contract CMWU to manage the Recovery and Reuse Systems for a limited period of time, say 3 years. Also during that time, the WUA could contract the Union of Agricultural Work Committees (UAWC) to manage the training and extension services to the farmers to establish the executive capacity needed within the WUA.

Complete governmental or complete farmer management are both relatively rare in the world. The in-between option of joint management has become the norm, albeit with different variations. The Consultant recommends that PWA take advantage of world experience and select a joint management model.

WATER USER ASSOCIATIONS

WUAS IN GAZA

Groundwater is the sole source of water for irrigation farming in the target area. Water is abstracted from private wells evenly distributed throughout the project area. Typically, the same well is shared by more farmers – a "collective well". Namely, a farmer owns one well and other neighboring farmers share the operation and maintenance costs for using the pumping system and the water. Each farmer of the group has his own pipeline connecting the well to his farm. The baseline survey of this Complementary Feasibility Study shows that 92% of the farmers depend on the "collective well" system, owned by the remaining 8%.

Usually, the farmers using a collective well do not sign any formal agreement, neither are they linked by an association or a cooperative. Each farmer provides the fuel necessary for his own shift, while maintenance and administrative costs are equally shared among the group. However, conflicts may arise because some farmers do not pay his share in due time, thus undermining the efficient operation of the well.

The few existing WUAs in Gaza are generally small and loosely organized. This low level of organization makes it difficult to initiate joint actions. They are also faced with harsh economic and financial circumstances, including limited access to the international market for agricultural products. Greater farmer cooperation under the umbrella of a WUA could yield significant gains.

COMMON TASKS OF WUAS

The main tasks and activities commonly found in WUAs include:

- Choose and specify the water source and take part in the planning, designing and implementation.
- Define the roles and responsibilities to manage, operate and maintain the water source and its structures.
- Solve conflicts among water users by achieving a fair water distribution among the users.
- By mutual control and increased sense of ownership and responsibility, reduce violations over water.
- Take part in the tasks and functions for the management of irrigation projects.
- Help to develop irrigation efficiency at a field and network level, also by facilitating the spread of modern irrigation techniques.

TRAINING NEEDS AND CAPACITY BUILDING

A capacity building program should be carried out to enable the WUA to achieve its mandate.

On-farm technical assistance and training on irrigation topics, in conjunction with best agricultural practice, will be handled by the Ministry of Agriculture and the non-profit organization Union of Agricultural Workers Committees (UAWC).

Table 20: WUA capacity building and training needs; estimated costs for 20 farmers

TOPIC	NO. PARTICIPANTS	DURATION (DAYS)	ESTIMATED COST (US$)
FACILITATION AND TRAINING SKILLS	10	30	$120,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN IRRIGATION TECHNOLOGIES, SUCH AS ON-FARM LOW PRESSURE SYSTEMS, LOCALIZED IRRIGATION, ETC. BASIC LEVEL.	20	15	$120,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN IRRIGATION TECHNOLOGIES, SUCH AS ON-FARM LOW PRESSURE SYSTEMS, LOCALIZED IRRIGATION, ETC. ADVANCED LEVEL.	20	10	$80,000.00
DESIGN, OPERATION AND MAINTENANCE OF MODERN ON-FARM SURFACE IRRIGATION SYSTEMS.	20	5	$40,000.00

DESIGN, OPERATION AND MAINTENANCE OF ON-FARM DRAINAGE SYSTEMS.	20	7	$55,000.00
ON FARM DRAINAGE, DRAINAGE WATER REMOVAL AND CONVEYANCE OUT OF THE IRRIGATION AREAS TOWARDS THE DRAINAGE OUTFALLS	20	10	$80,000.00
SOIL SCIENCE, SALT LEACHING, LAND RECLAMATION	20	5	$40,000.00
COMPUTER MODELS APPLICATION IN I&D	5	5	$10,000.00
GIS AND REMOTE SENSING APPLICATION FOR IMPROVED WATER MANAGEMENT IN I&D	5	5	$10,000.00
I&D MANAGEMENT TRANSFER (INCLUDING PARTICIPATORY IRRIGATION MANAGEMENT/WUAS FORMATION PROCESS AND BACKSTOPPING)	5	15	$30,000.00
STUDY TOUR TO ABROAD (TO BE SELECTED)	5	7	$52,500.00
USE OF THE AGRO-METEO STATIONS NETWORK. INTERPRETATION OF WEATHER FORECASTING AND RECOMMENDATION FOR FARMERS	5	15	$112,500.00
IRRIGATION METHODS AND SCHEDULE FOR EFFECTIVE PEST AND DISEASE CONTROL	20	7	$56,000.00
		Total	**$806,000.00**

ECONOMIC SUSTAINABILITY OF WUAS AND COSTS

While they may be entitled to claim subsidies or state assistance, WUAs are usually largely self-financing, the bulk of their income being provided by their participants. For NGEST, it is presumed that farmers will cover the costs related to the WUA's management and basic activities (e.g. office rent, administration staff salaries etc.) from the beginning of the organization. Additionally, farmers are expected to pay the OPEX costs of the recovery and reuse scheme, and any on-farm development. The proposed water tariff options in this Report have been made with these expenditures in mind.

It should be noted that, because they are non-profit, WUA-specific legislation could confer powers on WUAs to take and impose compulsory measures. These can include: the right to impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; the right to make binding operational rules concerning, for example, the use and allocation of irrigation water; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts (FAO, 2007). None of these powers are currently in the Draft WUA Regulation. If they are not included in the final version, some aspect of these concerns must be addressed in whatever contractual agreement is brokered between the WUA and either CMWU or PWA.

Table 21 shows an estimated cost breakdown for the establishment and operation of a WUA (gathering approximately 20 farmers) for the NGEST Water Reuse Scheme.

Table 21: Estimated costs for the establishment and operation of one WUA, for 1 year

ITEM	UNIT	COST (USD)
4X4 CAR	1	25,000 USD
OFFICE AUTOMATION EQUIPMENT FOR ADMINISTRATIVE AFFAIRS	Forfeit	25,000 USD
SALARY FOR ADMINISTRATIVE STAFF	1	30,000 USD
RUNNING COSTS	Forfeit	20,000 USD
	Total	100,000 US$

COST SHARING MECHANISMS

Typically, WUA costs include some, or all, of the following:

- The cost of obtaining a permit to abstract and use water and/or to drain water or to dispose of wastewater together with any water use and wastewater disposal charges payable pursuant to such permit;
- Charges in respect of water supplied to the WUA on a contractual basis by a state agency or some other bulk water supplier;
- The WUA's own costs of operating and maintaining the infrastructure under its authority, which may include staff salaries, office expenses (including the costs of rent, utilities and

communication), operation costs including the costs of electricity if pumps are used, system maintenance including routine and annual maintenance, the maintenance of an emergency reserve fund, small replacement fund, transport expenses, purchase of equipment, social charges and taxes; and

- Investment costs for the construction, rehabilitation or reconstruction of infrastructure.

As mentioned above, a key feature of WUAs across the world is that they are usually self-funding, at least as far as operating costs are concerned. The typical sources of WUAs finance include fees and charges for services provided by WUAs to its participants as well as loans, grants and subsidies, income from assets or capital owned by WUAs, and fines from participants who have breached its operating rules.

The way in which the level of fees is determined can be left up to WUAs or specified in the relevant legislation. The amounts payable by individual WUA participants can be based on, for example, the volume of water supplied (if the main WUA service is water provision), flat rate charged per hectare of land (in case of a range of different and not easily measurable services provided by WUA), or value of possessed agricultural land. For the NGEST project, a proposal is made to charge the farmers based on the water delivered to their farms at a rate that ranges between 0.9 and 1.5 ILS/m^3. This fee would cover the expenses of the O&M of the Recovery and Reuse Systems and running the WUA organization.

If farmers are not able to pay the fee until after the irrigation season is over and they have harvested their crops, a range of solutions can be applied, such as: participants can pay deposits, the WUAs can borrow money by way of a loan or bank overdraft or issuing bonds, or receiving governmental or other grants.

Ideally, a WUA fund would be established to provide support for the creation and early administration of the WUA (an initial capital of, say, US$ 1 million). Otherwise the WUA may fail due to low membership fees from the farmers in the NGEST project area, most of whom own small plots of land.

RECOMMENDATIONS

- **Immediately pass enabling legislation for the creation of WUAs**

The Draft WUA Regulation from 2016 should be finalized, promulgated and implemented as quickly as possible. The draft Regulation sets out the basic parameters within which the design of each individual WUA can be crafted. Several important legal rights, however, have not been addressed.

One of those legal rights is the long-term right to abstract water from a natural source or, depending on which Scenario is chosen, a long term contractual right with a bulk water supplier

(e.g. NWC). As written, the Draft WUA Regulation states that PWA may cancel a WUA's right to use a water source; it does not say what process or justification would be required for PWA to do so. Moreover, if PWA cancels a WUA's right to use a source, the Regulation states that the WUA will be terminated by the Ministry of Agriculture. This prospect may have a chilling effect in WUA members' willingness to contribute to the long-term investment needs of the system. Although PWA's cancellation may be appealed, if the Association and its work may be terminated at the whim of a ministry, that creates an impression of a less secure institution overall.

Additionally, as mentioned above, WUAs will very often need to have express legal rights to do things like impose compulsory membership/participation on those who benefit from the WUA's activity; the right to levy compulsory charges regarding, for example, the costs of maintaining an irrigation system; compulsory access rights over land for the purpose of operation and maintenance and if necessary the rights to compulsorily acquire land; and the right to recover outstanding fees and charges on the basis of direct execution (for example by imposing a lien over the land of a debtor) without needing first to obtain a judgment in the civil courts. Without this authority, the work of the WUA may be significantly hampered.

- **International Norms**

To mitigate health and environmental risks, common international norms and standards for the quality of irrigation water should be followed.

STAFFING REQUIREMENTS OF THE PIU

The Project Implementation Unit (PIU) should have a multi-disciplinary technical team. Table 22 illustrates the proposed PIU composition.

The PIU shall assist field activities, and act as coordination unit for related on-farm initiatives. The PIU shall be directly linked with the future WUA that will be established to manage irrigation water distribution.

Table 22: PIU Staff Composition

NO.	AREA OF EXPERTISE	INSTITUTION	QUALIFICATION
1	On farm irrigation technology and water distribution	CMWU	Eng.
2	Land reclamation	CMWU	Eng.
3	Information Technology	CMWU	Eng.

4	Plant Production and Soil Fertility	MoAg	MSc
5	Plant Protection	MoAg	MSc
6	Agro-meteorology	MoAg	MSc
7	Rural Extension	MoAg	MSc
8	Administration		

Expert on On-farm irrigation technology and water distribution

Duties / Responsibilities:

- Review the irrigation requirements and water balance analysis performed and recommend further detailed studies as needed;
- Assist relevant team members in the preparation of work programs and schedules;
- Develop a quality assurance program for civil works for the irrigation component, and train staff on the in implementation of the quality control program;
- Operates power equipment and hand tools to install, maintain and repair irrigation systems and related components including irrigation lines, sprinkler heads, control panels, valves, pumps, etc.;
- Checks system for proper operation and timing. May participate in the design or modification of new or existing systems. Performs seasonal maintenance such as system charging and draining;
- Maintains inventory of related parts and supplies. May lead workers on irrigation projects and work on other grounds related assignments as needed.

Expert on Land reclamation

Duties / Responsibilities:

- Advise farmers about appropriate land management and conservation practices, adapted to the project environment;
- Advise other experts about environmental management and conservation;
- Design specific plans to reclaim non-cultivated areas in the project zone;
- Apply knowledge or research findings to address environmental problems;
- Train personnel in technical or scientific procedures;

- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Information Technology

Duties / Responsibilities:

- Design, program, and maintain IAS website using HTML5/JavaScript/CSS. Interface with SQL databases as required;
- Maintain Microsoft SharePoint site layout and permissions. Develop custom SharePoint lists and libraries;
- Contribute to Social Media system including creating original content, assisting users in content generation, and account management;
- Interact with and provide services to the other members of the staff in a highly dynamic and occasionally time-critical environment.
- Perform other duties as required.

Expert on Plant Production and Soil Fertility

Duties / Responsibilities:

- Support farmers in designing sustainable and productive cropping patterns;
- Help in crop budgeting & planning;
- Take soil samples, prepare and submit them for testing;
- Review soil test results and provide advice to farmers;
- Inspect crops in accordance with guidance;
- Record crop outcomes as requested;
- Manage required field services such as fertility, soil amendments, crop
- production, and more;
- Maintain crop and financial data in accordance with requirements;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Plant Protection

Duties / Responsibilities:

- Identify plant protection problems in the project area and provide technical support for the promotion of safe and sustainable plant protection activities, based on IPM solutions;

- Design and conduct periodic reviews and appraisals of the situation of plant pest and pesticide problems in the project area and advise farmers on necessary actions to implement pest and pesticide management programmes;
- Provide advice to IAS in training technical personnel through targeted training programmes, workshops and seminars related to plant protection and maintain close relations with international and national research institutions for the transfer of research findings;
- Perform other related duties as required;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Agro-meteorology

Duties / Responsibilities:

- Mainstreaming agro-met advisory services into the agricultural extension system;
- Developing and engaging in the delivery of a training plan to improve skills within the extension system for interpretation and analysis of climate information to inform agronomic advice;
- Developing and engaging in education programs for farmers regarding benefits of agro-met advisory services.
- Supporting integration of agro-met within extension packages.
- Reviewing proposed approaches for dissemination and communication of climate information and feedback.

Expert on Rural Extension

Duties / Responsibilities:

- Encourage farmers to adopt best practice techniques by providing exposure to new knowledge, information, skills, inputs and processes;
- Assess individual farms and making technical recommendations for improved production and sustainability;
- Collaborate with farmers in developing processing and post-harvest schemes;
- Suggest research priorities to research committees;
- Organise and manage field days, speak at grower groups, write fact sheets and publications, present courses;
- Interact with the other technical staff and maintain a positive relationship with farmers.

Expert on Administration

Duties / Responsibilities:

- Support team leader in ensuring effective and efficient financial management system;
- Maintain efficient and effective financial system;
- Support in periodic financial planning, including Annual Plan and Budget (APB);
- Supervise general administration of IAS;
- Perform other duties as required.

INSTITUTIONAL CAPACITY ASSESSMENT

There are a number of particular skills that need to be developed for the successful implementation of the NGEST project, including management of MAR and sludge as well as the design, operation and maintenance of modern irrigation technologies. Communication and cooperative approaches should also be fostered through trainings on developing the WUA or community awareness to bolster support for the project.

In order to adequately assess the specific capacity development needs for each aspect of the project, this *Report* has interwoven capacity building throughout each section: Managed Aquifer Recharge; Farmer Assistance; WUAs; and Operation and Maintenance of the Irrigation System. Therefore, although there are recommendations below for Institutional Capacity Building, overall capacity development should be viewed through the context of the entire *Report*.

RECOMMENDATIONS

A capacity development system for the Water Sector in Palestine already exists and a substantial amount of resources are being invested to enhance capacities in this sector (PWA, 2016). Compared to some other countries, where capacity development efforts have to be developed from scratch, Palestine boasts a substantial foundation of sufficiently developed institutions and a high number of human resources investments. Palestinian Universities, polytechnics, industrial secondary schools and vocational training schools produce a constant inflow of trained professionals for the water sector, and international donors have expended considerable sums for training of water sector stakeholders.

However, there needs to be better coordination of capacity development initiatives with policies and strategies so that there is a more efficient utilization of resources and the training better meets the needs of the sector. In particular, PWA, NWC, CMWU and the WUA need targeted capacity building to implement the water law, to make effective and efficient use of increased investments, and to maintain the existing and new infrastructure.

In addition, work needs to be done to create an environment in which skill and knowledge acquisition can take place, including, for example, fostering a professional atmosphere in which technical growth is rewarded and there are incentives for participation, allocating a sufficient budget for on-going development, and ensuring monitoring and follow-up of capacity development efforts.

Below is a truncated list of institutional capacity building recommendations. As mentioned above, for a more detailed analysis of capacity development needs, see the other relevant sections of this *Report*.

Capacity Development Coordination. There is a need for sector-wide monitoring and evaluation of capacity development interventions. The current lack of the monitoring and evaluation is directly correlated with the need for coordination, but also lends itself to the mismanagement of limited resources, decline in performance and loss of value for money spent. It is expected that the newly created Capacity Development Directorate of PWA will lead this coordination as well as execute the recommendations contained in PWA's Water Sector Capacity Development Policy and Strategy of 2016.

Focus on Practical Skills. There should be increased focus on the development of practical knowledge and competencies to address existing and emerging water sector challenges, for example negotiation with the Joint Water Committee, and how to build, manage, repair and renew a modern irrigation system.

Encourage On-going Capacity Development. Water professionals need to refresh and expand their knowledge base in a number of training days each year to be able to excel in their work. Organizational Capacity Development Action plans, covering a 3-5 year period, should be prepared by the relevant units and persons within the respective organizations. These plans should be approved by the organization itself, endorsed at national level, and updates should be made annually.

Help Prepare CMWU. Because CMWU will likely handle the operation and management of the NGEST Recovery and Reuse schemes until the creation of the NWC and WUA, the capacity of CMWU should be expanded to provide this service. Additionally, there may be the need to modify the current mandate of the CMWU to reflect this change.

Sludge Management. Training is needed that tackles sludge collection, treatment, or dumping and sludge management. Sludge represents a completely new sector, which should be organized and well regulated in order to benefit from it.

MAR Training. A simplistic view that treating water to near drinking standards before recharge will protect the aquifer and recovered water is incorrect. For example chlorination, to remove

pathogens that would be removed in the aquifer anyway can result in water recovered from some aquifers containing excessive chloroform. In some locations, drinking water injected into potable aquifers has resulted in excessive arsenic concentrations on recovery due to reactions between injected water and pyrite containing arsenic. Source water that has been desalinated to a high purity dissolves more minerals within the aquifer than water that has been less treated (Dillon, 2009).

Therefore, PWA (and any other ministry that will be responsible for the MAR scheme) needs to understand how this aquifer will interact with the recharged water. More specifically, it should have hydrogeological and geotechnical knowledge, as well as knowledge on water storage and treatment design, water quality management, hydrology and modelling, monitoring and reporting. It needs to understand pathogen inactivation and biodegradation. The response of an aquifer to any water quality hazard depends on specific conditions within the aquifer, including temperature, presence of oxygen, nitrate, organic carbon and other nutrients and minerals, and prior exposure to the hazard, so the Authority should receive adequate training on these subjects.

Additionally, PWA (and any other ministry that will regulate the MAR scheme) should acquire basic stratigraphic and hydrogeological information for each well drilled. This information should be stored in departmental data bases, which would ideally be publically accessible on the web.

Create a MAR Unit. The human resources at PWA are limited as the number of staff is already not sufficient to perform all needed tasks (e.g. data evaluation, quality control) let alone to fulfil new tasks related to MAR. Therefore, it is recommended to create a MAR unit to handle strategic planning and the oversight of MAR activities.

FARMER CAPACITY BUILDING

PRESENT FARMERS' ORGANIZATIONS

The Union of Agricultural Work Committees (UAWC) is the main organization[7] active in the project area, already working with a few farmers. UAWC is a non-profit organization founded by a group of volunteers and agronomists in response to the vulnerable socio-political circumstance of farmers that resulted from occupation policies in confiscating lands and water in the early eighties. The Union aims to help Palestinian farmers to market their produce and provides

[7] Other smaller organizations operating in the area: Ma'an Development Center and Cooperative associations (Beit Hanoon Association- farmers union association)

agricultural employment opportunities through a framework of cooperation with domestic, Arab, and international agricultural development institutions.

Since year 1993, UAWC developed its organizational structure, consisting of a general assembly, board of trustees, general director, and two executive directors, in the West Bank and Gaza Strip. UAWC initially focused on forming Agricultural Cooperatives and Committees in different Palestinian rural areas. UAWC receives funding from numerous western governments and aid organizations including the European Commission, World Vision Australia, AusAID, and FAO. UAWC is also in partnership with many international and local organizations like Action Against Hunger, Oxfam, NARC and LRC.

There is a continuous cooperation between the Union and governmental bodies, like MoAg. Relationships are also established with international development agencies, like FAO.

The activities carried out by UAWC with farmers of the target area include development and revamping of the agricultural sector, such as land reclamation; building greenhouses; products quality enhancement and new crops introduction. Depending on the kind of project, farmers may get financial support depending on the type of crop. There may also be special technical, logistical and financial support for exporting goods such as strawberries and medical herbs, which usually ensure a good revenue.

IMPROVING FARMERS TECHNICAL SKILLS

The farmers interviewed during the baseline survey stated they need technical assistance to better manage their farm. Specifically, about 83% of the respondents declared they would like to improve their knowledge on farm mechanization, with a specific focus on irrigation practices and methods. Know-how on greenhouse management and soil amelioration are the two other topics mostly demanded by the farmers (17%). Plant protection and fertilization techniques seem well known by the farmers, as only 1% of the respondents stated the need for more assistance on this subject.

According to the outcomes of the baseline survey and the agronomic characteristics of the new proposed irrigated cropping system, the following training and technical assistance needs have been identified for the farmers:

Training on appropriate use of irrigation. So far, the irrigation practice has been left in the domain of individual farmers without any technical assistance. Underground water is being managed without considering the actual water requirements of crops, after computing the water balance of the area. Without an appropriate approach to irrigation, the amount of water supplied to crops is often under- or overestimated hence causing low yields and problems of uncontrollable pests and diseases on the cultivated crops. The envisaged training program has

the objective to make the farmers fully capable to design an irrigation plan suitable for their cropping pattern for various irrigation methods (e.g. surface, sprinkle or drip irrigation).

Training on integrated pest management (IPM). It has been observed that use of pesticides on crops is often high in north Gaza, although these products are quite expensive since imported from Israel. Pests outbreaks are common in the target area, probably because of irrigation misuse (see above). However, farmers lack specific knowledge on effective methods for preventing pests and diseases, which should allow them to drastically reduce the amount of sprayed pesticides, so saving money and making the farming environment healthier. The IPM method has been conceived in the '70. It is a pest control strategy that uses a variety of complementary strategies including: mechanical devices, physical devices, genetic, biological, cultural management, and chemical management. These methods are done in three stages: prevention, observation, and intervention. It is an ecological approach with a main goal of significantly reducing or eliminating the use of pesticides while at the same time managing pest populations at an acceptable level. IPM practices have been so far successfully implemented on vegetables and fruit tree crops in the Middle East. These crop groups represent 65% of the new cropping pattern proposed for the project.

Training on Integrated Plant Nutrient Management (IPNM). This methodology has been devised by the Food and Agriculture Organization of the UN. It allows to match crop nutrient needs with sufficient accuracy to prevent surplus of fertilization. This in turn limits soil and water chemical pollution which usually is a consequence of the use of mineral fertilizers. The purpose is to maintain or enhance soil productivity through a balanced use of mineral fertilizers combined with organic sources of plant nutrients, including biological nitrogen fixation. IPNM focuses first on the seasonal or annual cropping system (namely, the entire crop rotation applied by a farm), rather than on an individual crop; secondly, on the management of plant nutrients in the whole farming system; and, thirdly, on the concept of village or community areas rather than individual fields. The proper application of IPNM, among others, allows to minimize the use of mineral fertilizers which are particularly costly in Gaza, because imported from Israel.

Farming field schools (FFS) for effective training on IPM and IPNM. The Farmer Field School is a form of adult education, which evolved from the concept that farmers learn optimally from field observation and experimentation. It was initially developed to help farmers tailor their IPM practices to diverse and dynamic ecological conditions, but subsequently the method has embraced also other relevant topics for improving farmers' technical skills. In regular sessions from planting till harvest, groups of neighboring farmers observe and discuss dynamics of the crop's ecosystem, under the guidance of a facilitator (usually an agricultural extensionist, well trained on running a FFS). Simple experimentation helps farmers further improve their

understanding of functional relationships within the agro-ecosystem (e.g. pests-natural enemy population dynamics and crop damage-yield relationships). In this cyclical learning process, farmers develop the expertise that enables them to make their own crop management decisions. Special group activities encourage learning from peers, and strengthen communicative skills and group building. Farmer Field Schools for vegetable crops have been successfully implemented by FAO in Egypt, Jordan, Syria, Iraq and in Palestine (West Bank).

BUILDING FARMERS' CAPACITY ALONG THE VALUE CHAIN

Supporting farmers in establishing organizations. Collective action can create a more effective market chain that is more stable and can produce the products required at the time needed and of the quality wanted. As a group, producers can provide a more stable and higher quality supply of raw material, which also improves the economic efficiency of the value chain. The higher bargaining power and improved access to markets for group members are made possible by creating a link with other actors along the chain (retailers, traders and processors). However, a farmer organisation cannot be simply created by a top-down approach from the government (for example, by providing strong subsidies to farmers if they join an organisation; or providing inputs for free). Many worldwide experiences clearly show that farmers organisations (under the shape of cooperatives, associations, etc.) fail when members are not fully convinced that collective action is really an opportunity for them to grow and improve their lives. Farmer organisations also fail when their members do not firmly aim at economic independence, but rather rely on external aid. The survey carried out in the project area highlighted that farmers work on individual basis. Even when they share collectively the same private well, everybody keeps on working on his own. It is also noted that only one organisation is existing in the project area, joining a small number of farmers.

To cope with this reluctance toward cooperation, farmers should be invited - through a tailored training programme - to progressively share their activities. For instance, an initial stage of farmer collective action may be started just by purchasing the farming inputs together, which will allow a discount from the seller. Then, farmer collective action can further evolve in growing crops together, according to a cropping plan that has been specifically designed to meet the market needs in a certain period of the year. When collective crop production is finally carried out relationships with the merchants (wholesalers, traders at any level of the supply chain) can be strengthened and options of contract farming may become feasible. Furthermore, associated farmers may start processing the raw materials and their marketing action will become more targeted and complex. By following this progressive process, the farmers' organisation purchasing power and its share of added value along the supply chain will increase.

Training on post-harvest operations and food processing and establishing suitable physical structures. This training programme requires high investments and well established farmer's organisations, which will handle the operations and run the post-harvest and processing structures. The survey carried out by the consultant highlighted that in northern Gaza the existing food industries do not buy raw food materials from the local farmers but they rather import it from Israel, probably because the industry cannot find the required amounts according to its needs. While this specific demand from the industry could be properly satisfied by an organised group of farmers (see above), on the other hand organised and well trained farmers could start simple post-harvest processing activities, such as sorting and packing fresh fruit and vegetables; preparing plant preserves, purée, jams, etc. Another option would be processing dairy products, considering the good milk production from cows, sheep and goats which are being reared in the project area.

All the above-mentioned activities will improve products quality and introduce new products into the local market which will increase the farmers' earnings.

However most of the farmers seem they cannot afford the cost of the initial investment (e.g. purchasing a refrigerator unit, packaging materials, other equipment for processing), nor bank loans seem available in north Gaza. Therefore, external aid should be foreseen together with sound training sessions.

MANAGED AQUIFER RECHARGE

Managed aquifer recharge (MAR), also known as enhanced recharge, water banking and sustainable underground storage, is the purposeful recharge of water to aquifers for subsequent recovery or environmental benefit. MAR can be used to store water from various sources, such as stormwater, reclaimed water, mains water, desalinated seawater, rainwater or even groundwater from other aquifers. With appropriate pre-treatment before recharge and sometimes post-treatment on recovery of the water, it may be used for drinking water supplies, industrial water, irrigation, toilet flushing, and sustaining ecosystems. The figure below shows the basic MAR process for an unconfined aquifer.

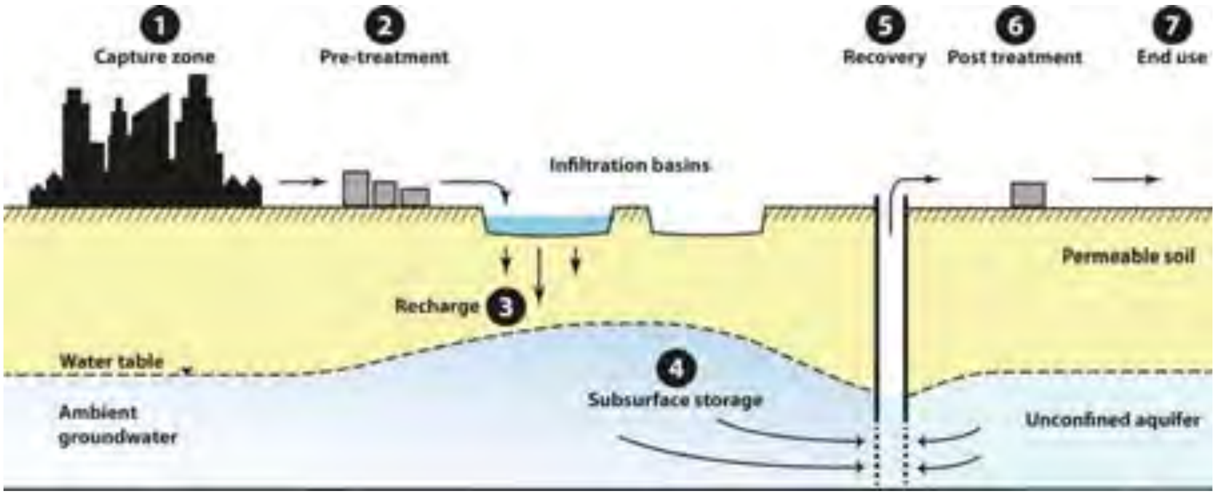


Figure 18: Schematization of Managed Aquifer Recharge System (Source: Dillon, 2009)

Several past documents describe the NGEST Project as if it is a treated-wastewater-for-irrigation project. It is not. Rather, it is a treated-wastewater-for-managed-aquifer-recharge project, where the recovered water will be used for irrigation. The difference is significant and has considerable implications for the feasibility and sustainability of the project. Outlined below are some of the central considerations and concerns for managing this segment of the project.

REGULATORY ISSUES

The main objectives of MAR regulations should be the protection of groundwater from pollution and the assurance of public health. Topics covered in a regulatory framework often include technical issues, water quality requirements to protect groundwater and human health, regulations on the authorization to recharge and to recover water, and institutional arrangements (NRC, 2008).

The quality of the water extracted from the aquifer should meet the most stringent standards related to the intended water use. The quality of the water of a recharged aquifer is a function of multiple factors, including:

- the quality of the recharge water;
- the recharge method used;
- the physical characteristics of the vadose zone and the aquifer layers;
- the water residence time;
- the amount of blending with other sources;
- the history of the recharge.

Setting requirements for indirect recharge is not an easy task. The quality of infiltrated water may be dramatically improved when percolating through the vadose zone, thanks to retention and oxidation processes. These processes affect organic matter, nutrients, microorganisms, heavy

metals and trace organic pollutants. However, though much is known about these processes (Bouwer, 1996; Drewes & Jekel, 1996), forecasting the efficiency of the treatment provided by infiltration through the vadose zone and lateral transfer in the saturated zone is complex. Performances depend on a number of factors such as depth of the unsaturated zone, physical and mineralogical characteristics of the soil layers, heterogeneity, hydraulic load, infiltration schedule and infiltrated water quality (Dillon, 2009).

Therefore, particularly when transfer through the vadose zone is part of the treatment intended to bring the water up to the required water quality, pollutant removal tests should be performed, at the laboratory and onsite, to ensure the water achieves the desired quality. The example of the Dan Project in Israel shows that submitting secondary effluents to a Soil Aquifer Treatment system in a dune sand aquifer can result in the production of a nearly potable water (Sack, Icekson-Tal & Cikurel, 2001).

The complexity of reactive transport processes in the unsaturated zone highlights two of the main stumbling blocks that must be taken into consideration if treated wastewater is being considered for MAR: one specific challenge is to have numerical models that can include all of the hydro-biogeochemical processes involved in reactive transport, while a second, more operational, is the need to have a complete biogeochemical and hydrogeological characterisation specific to each MAR site. These should be taken into consideration in assessing the capacity building needs of PWA and other stakeholders involved in managing the NGEST project.

Several countries (the United States and Australia, for example) have developed guidelines for the use of treated wastewater for recharge (USEPA 2004, 2012; WHO 2006a, b). These guidelines focus mainly on the health and environmental risks that result from the presence of pathogenic microorganisms, suspended solids and dissolved organic carbon in this water. There are few recommendations concerning trace element contents in water (e.g. USEPA 2012), except as concerns five trace metals. These are: (i) arsenic; (ii) nickel, which is only weakly toxic but which accumulates in plants; (iii) cadmium, which is considered to be the metallic pollutant of greatest concern due to its rapid accumulation in plants and its proven toxicity even at low concentrations (acceptable daily intake (ADI) 0.057 mg/day/individual); (iv) mercury, which can be highly mobile; and (v) lead, the injection of which, even at low doses, can cause neurotoxic and hepatotoxic disturbances (Dillon et al. 2009a).

Although these guidelines exist, no country has yet adopted a specific set of legal provisions on MAR, rather regulating the different stages of MAR-related activities through existing legislation on groundwater abstraction, wastewater discharge and treated wastewater reuse. Land use planning and environmental impact assessment legislation add to the complexity of the regulatory frameworks currently available for MAR schemes.

Under many countries prevailing water resources legislation (e.g. Israel, South Africa, Spain, USA, Australia), groundwater which has been recharged with TWW is subject to the extraction and management rules of native groundwater, and is regulated accordingly through abstraction licenses or concessions from the un-differentiated groundwater pool.

IMPLICATIONS FOR THE APPLICATION OF PALESTINIAN WASTEWATER REGULATIONS

The Palestinian Wastewater Regulations (PS 742/2003) lay out the water quality standards that must be met for various uses of treated wastewater. As has been discussed in past NGEST documents, the Palestinian standards are stricter than most international guidelines for wastewater reuse because they prohibit the use of treated wastewater for irrigating any type of vegetable, regardless of the quality of water produced. There has been some expressed concern whether this regulation applies to the NGEST irrigation scheme, which would significantly restrict the types of crops farmers could grow in the project area and, as a result, have severe implications for the financial sustainability of the project.

But the concern of whether the regulation applies to the irrigation scheme stems from the misunderstanding of the nature of this project highlighted at the beginning of this section. The NGEST project does not entail using treated wastewater for irrigation *directly*. Instead, it uses treated wastewater for managed aquifer recharge. Later, after the wastewater has infiltrated through the soil and mixed with the native groundwater, it will be recovered and used for irrigation. The recovered water, therefore, is no longer "treated wastewater," and so the restrictions set out in the regulation for the use of treated wastewater for irrigation do not apply.

That being said, the regulation also covers the water quality standards that must be met for using treated wastewater *for aquifer recharge*. The regulation states, first, that direct injection into the aquifer is prohibited. Second, it states that the use of poor quality water ("D") is prohibited. The quality of water used must be either moderate ("C"), good ("B"), or high ("A"). See the below Table 23 for the basic parameters for each category.

Table 23: Palestinian reuse standards (PS 742/2003)

CLASS	QUALITY	BOD MG/L	TSS MG/L	FEACAL COLIFORM MPN/100ML
A	High	20	30	200
B	Good	20	30	1,000
C	Medium	40	50	1,000

D	Low	60	90	1,000

The NGEST reuse and recovery scheme will utilize the Soil Aquifer Treatment (SAT) infiltration methodology, not direct injection. Additionally, the quality of water expected to be infiltrated is high ("A"). Not only is the water coming out of the NGEST WWTP anticipated to be of a high quality but as the water moves through the unsaturated zone during SAT, the water quality is expected to improve even further.

The project, therefore, is in complete compliance with the Palestinian regulation, so long as the water quality parameters for aquifer recharge are met.

OPERATION AND MAINTENANCE

Clogging is the most limiting technical problem in artificial recharge and can only be managed with regular maintenance and pretreatment. Clogging can be caused by various mechanisms like physical clogging by suspended solids, chemical clogging due to precipitation or clay dispersion, mechanical clogging due to entrapped air or biological clogging due to microbial growth (Bouwer, 2002). Clogging leads to the decrease in porosity and hydraulic conductivity and is experienced at the bottom of infiltration basins as well as around injection wells. There are two basic principles for the management of clogging: (a) pretreatment of recharge water and (b) redevelopment (Brown et al., 2006).

Apart from maintenance related to clogging, regular inspections of the facility are needed to assess if any repair works or cleaning is needed. This could include the cleaning of any screens, change of batteries, lubrication or replacement for equipment prone to wear and tear, repair of damage done by natural forces or vandalism. If mechanical or electrical parts are involved their proper functioning needs to be tested.

RECOMMENDATIONS

REGULATING EXTRACTION

MAR is one of the measures that can be implemented to secure water supply, compensate for some effects of climate change and, more generally, handle the quantity and quality of groundwater bodies. It is not, however, a substitute for groundwater management based on decreasing abstraction and adapting withdrawal to resource availability.

There are a number of private wells in the Gaza Strip, only some of which are officially registered. Thousands of wells are estimated to have been drilled without authorization, which has contributed to more rapid deterioration of the aquifer. (UNEP, 2014) To protect the aquifer and

for the success of the NGEST project, both the authorized and unauthorized agricultural wells should cease operation.

In order to do that, PWA, which is the institution responsible for issuing and renewing licenses for agricultural wells, plans to include a new clause in the next annual renewal of licenses that specifies that the operation of an agricultural well should be stopped when reuse water is available. At the same time, the voluntary adhesion to the new irrigation scheme shall be pursued.

There are several challenges in getting people to adhere to the new scheme. First, the cost of wastewater needs to be equal or less than the cost of extracting the groundwater. So long as it is cheaper to extract from a private well, that is likely where people will get their water from. Second, the water quality and availability from the new irrigation network needs to equal or exceed the existing system. If the new system is of a poor quality or unreliable, farmers will be unlikely to switch. Finally, there is the challenge of overcoming the local tradition of private wells to switch to a collective irrigation scheme. This will likely take awareness raising and perhaps even financial incentives to change the engrained practices of local users.

MAR TRAINING

There are various institutes within the Gaza Strip that currently provide training regarding water and wastewater management. These institutes should be encouraged to establish short courses for MAR operators and regulators. These could also help ensure risk management plans are designed and implemented effectively and management issues are understood and addressed.

More is said on the needs of MAR training in the section on Institutional Capacity Building.

AQUIFER PROTECTION

It is recommended to develop a holistic MAR strategy and to implement transparent and comprehensive regulations specifying maintenance, monitoring and reporting requirements. Regulations should also address water allocation, ownership issues and demand management.

GROUNDWATER MONITORING

OVERALL MONITORING STRATEGY

Before preparing a groundwater monitoring plan, the overall strategy of the groundwater monitoring program should be defined to guide the development of the plan. In this sense, "strategy" refers to the manner in which a hypothetical release from a regulated unit will be detected or measured. Examples of issues that should be addressed when developing a monitoring strategy include:

- The type of monitoring data needed;
- The locations (both horizontal and vertical) from which the samples are to be collected (i.e., definition of "target monitoring zones");
- The manner in which the samples will be obtained; and
- The ability of the monitoring features to rapidly detect a change in groundwater quality.

Development of a groundwater monitoring strategy is illustrated in Figure 19 and Figure 20. As shown in these figures, the potential sources of contamination and the aquifer of concern should be characterized before developing a groundwater monitoring strategy because selection of target monitoring zones cannot be made until the source and the aquifer have been evaluated, usually through a detailed hydrogeological evaluation of the site. When evaluating the ability of a monitoring system to rapidly detect a release from a potential source, the impact of preferential flow paths and vertical gradients should be carefully evaluated; a two-dimensional analysis of groundwater elevation may not reveal actual upgradient or down gradient locations of groundwater flow. The presence of vertical gradients may significantly effect the selection of monitoring locations.

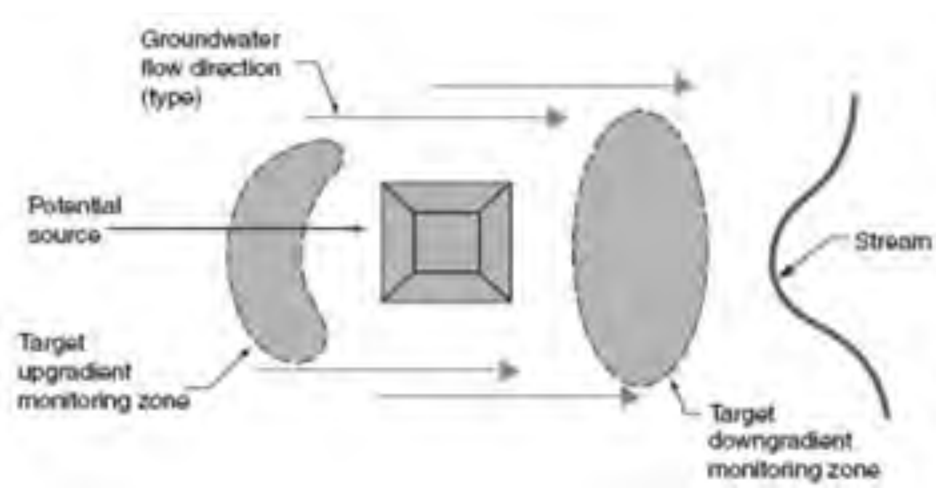


Figure 19: Plan view of typical unconfined aquifer groundwater monitoring system

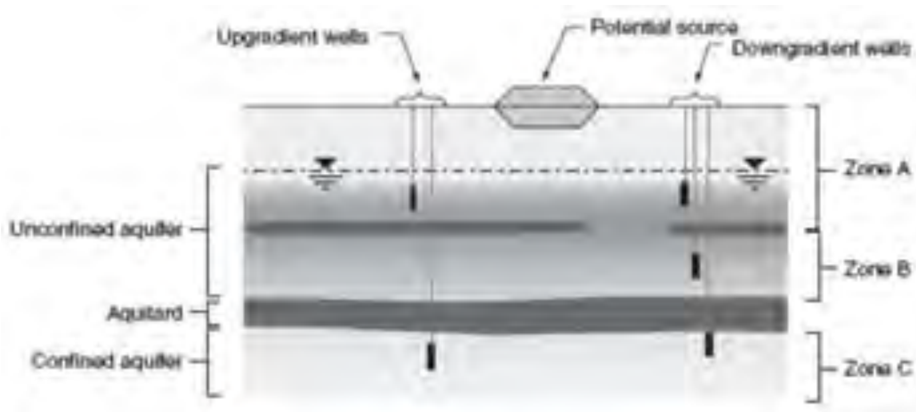


Figure 20: Vertical cross section of target monitoring zones.

MONITORING LOCATIONS AND PARAMETERS

Locating the appropriate monitoring point locations is essential in designing a monitoring network capable of providing data of adequate quality. Selected monitoring locations should provide the most reliable data needed to detect or assess a groundwater contaminant plume. To verify that the monitoring network can accomplish this goal, target monitoring zones must be selected based on the site hydrogeologic conditions and anticipated contaminant pathways. Figure 21 shows the recommended locations of the monitoring wells which was set up based on the location of the recovery wells.

The groundwater monitoring program in the NGEST Project is designed to evaluate the status of the groundwater quality after infiltration of partially treated and treated wastewater. The monitoring wells are distributed in two rows: around 400 to 500 m from the infiltration basin and the second row will be of 1100 to 1200 m from the basin. The first monitoring well row should be located before the first row of the recovery wells in the direction of the infiltration basin, and the second row of the monitoring wells should be located after the second row of the recovery wells to check the quality of groundwater outside the recovery wells areas. The monitoring network will also use the existing 5 monitoring wells constructed recently by PWA and used to monitor the infiltration basin. In addition, the recovery wells will be part of the monitoring network as shown in Figure 21.

Figure 21: Monitoring wells location

The main objective of monitoring is to check the groundwater quality after infiltration and check the operation of SAT process. The consultant made extensive reviews of similar projects such Gosh Dan Project where several parameters are monitored. Among these parameters, the consultant proposed in Table 24 some parameters which would reflect the status of groundwater after infiltration and could be analysed in Gaza Strip laboratories.

Table 24: Monitored Parameters and Frequency of Monitoring

WATER LEVEL	Monthly
PH	Four Times a year
TDS	Four Times a year
BOD	Four Times a year
COD	Four Times a year
DOC	Four Times a year
TC	Four Times a year
AMMONIA AS N	Four Times a year
NO_3	Four Times a year
NO_2	Four Times a year
T.N	Four Times a year
CL	Four Times a year
DETERGENT	Four Times a year
F.C	Four Times a year
PHOSPHORUS	Four Times a year
HEAVY METALS	Four Times a year
O_2	Four Times a year
NITROGEN AND OXYGEN ISOTOPES	Four Times a year

MG	Four Times a year

Samples will be collected from the monitoring wells to characterize the geochemistry of groundwater. The nitrogen and oxygen isotopes of groundwater nitrate will be used in conjunction with other geochemical data to place constraints on potential nitrate sources.

CONCLUSION

This *Complementary Feasibility Report* brings mostly good news. By reworking the original design, the project can save 21.5% of the water use while using 15% less energy, and can operate with a less complex irrigation schedule. It was determined that the project is in full compliance with Palestinian law, and should be financially sustainable by farmers. The review resulted in a new cropping pattern and design network, and offered a range of scenarios for the water tariff and O&M of the Recovery and Reuse Systems.

This *Report* also confirmed the validity of the original design for the recovery scheme and of the original design for the reuse scheme, confirming the selection of materials, the general layout and the selection of the pumping system. The newly proposed system fixes design inconsistencies of the original so that a minimum water pressure of 2.5 bars is provided to every farm gate.

The good news, however, is contingent. The water and energy savings, simplified irrigation schedule, and farmer profitability are contingent on improving the original design of the reuse scheme, introducing modernized irrigation methods and adopting the newly proposed cropping pattern. The project's compliance with Palestinian law is contingent on a minimum level quality of water coming from the WWTP and being disposed of in the infiltration basins. And the project's feasibility overall is contingent on carrying out robust capacity building for ministerial and farmer stakeholders, and of adequately monitoring the Managed Aquifer Recharge component of the project.

Ultimately, therefore, the feasibility and success of the project hinge on whether all the essential stakeholders cooperate to fulfill their role.

ANNEXES

ANNEX 1: DRAFT MOU

A Memorandum of understanding (MOU) is a document describing a bilateral or multilateral agreement between parties. It expresses a convergence of will between the parties, indicating an intended common line of action. It is often used to establish a clear understanding of how common activities will practically function and each party's role and compensation. The contents of an MOU must (a) identify the contracting parties (b) spell out the subject matter of the agreement and its objectives (c) summarize the essential terms of the agreement, and (d) must be signed by the contracting parties.

Similar to a contract, a memorandum of understanding is an agreement between two or more parties. Unlike a contract, however, an MOU need not contain legally enforceable promises. While the parties to a contract must intend to create a legally binding agreement, the parties to an MOU may intend otherwise. For example, an MOU may recite that the parties "agree to promote and support the joint use of facilities." This type of provision establishes an important public statement of cooperation, but it does not constitute a legally enforceable obligation. Alternatively, an MOU may outline the terms of an agreement but state that each party's responsibilities are only enforceable "in the event that the parties' decide to enter a joint use agreement." Additionally, a non-legally binding MOU may be useful to serve as an agreement between two or more departments within a single public entity where a contract may not be legally appropriate.

Although there can be legal distinctions between contracts and MOUs, there may be no legal or practical difference if they are written with similar language. The key is whether the parties intend to be legally bound by the terms of the agreement. If so, they have likely created a legally enforceable contract regardless of whether they call it a contract or an MOU. Therefore, parties should address the legal status of their agreement early in the negotiation process.

Successful MOUs require a lot of thought, effort, and cooperation to reach agreement on a range of issues. In addition to the subjects listed above, an MOU can also cover issues such as: (a) who bears responsibility for the costs of maintenance and repairs, (b) insurance and liability, (c) staffing and communications, and (d) conflict resolution. Below is a sample MOU which lays out the basic provisions of an agreement. To agree on any specifics, however, it is highly advised that the parties meet to discuss the terms of the MOU, ideally with a mediator, facilitator or other neutral third party.

Sample

MEMORANDUM OF UNDERSTANDING

BETWEEN [AGENCY]

AND [AGENCY]

1. **Parties.** This Memorandum of Understanding (hereinafter referred to as "MOU") is made and entered into by and between the [agency name], whose address is ______ , and the [agency name], whose address is ______ .

2. **Purpose.** The purpose of this MOU is to establish the terms and conditions under which the NGEST Project partners will coordinate and function.

3. **Duration of MOU.** This MOU shall become effective upon the last signature by the authorized officials from the (list partners) and will remain in effect until modified or terminated by any one of the partners by mutual consent. In the absence of mutual agreement by the authorized officials from (list partners), this MOU shall end on (end date of partnership).

4. **Responsibilities of [agencies]**. [Delineate all obligations of the first party listed above. Include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, beneficial use of equipment belonging to other agencies while acting pursuant to this MOU.]

5. **Responsibilities of [other agencies].** [Delineate all obligations of the other agencies listed above. Identify the agency covered by this MOU, and include the agency's responsibilities for costs and expenses related to NGEST, including the cost of wages, salaries, benefits and use of equipment belonging to an agency while acting pursuant to this MOU.]

6. **General Provisions**
    A. Each Party pledges in good faith to go forward with this MOU and to further the goals and purposes of this MOU, subject to the terms and

conditions of this MOU. The Parties shall attempt to resolve disputes through good faith discussions.

B. Either Party may unilaterally withdraw at any time from this MOU by transmitting a signed writing to that effect to the other Party. This MOU and the public/private partnership created thereby shall be considered terminated sixty (60) days from the date the non-withdrawing Party actually receives the notice of withdrawal from the withdrawing Party.

C. By mutual agreement, which may be either formal or informal, the Parties may modify the list of intended activities set forth in Paragraph 4.0 above and/or determine the practical manner by which the goals, purposes and activities of this MOU will be accomplished. However, any modification to any other written part of this MOU must be made in writing and signed by both Parties or their designees. Applicable Law. The construction, interpretation and enforcement of this MOU shall be governed by the laws of the State of Palestine. The courts of the State of Palestine shall have jurisdiction over any action arising out of this MOU and over the parties.

D. Entirety of Agreement. This MOU, consisting of [insert number], pages, represents the entire and integrated agreement between the parties and supersedes all prior negotiations, representations and agreements, whether written or oral.

E. Severability. Should any portion of this MOU be judicially determined to be illegal or unenforceable, the remainder of the MOU shall continue in full force and effect, and either party may renegotiate the terms affected by the severance.

F. Third Party Beneficiary Rights. The parties do not intend to create in any other individual or entity the status of a third party beneficiary, and this MOU shall not be construed so as to create such status. The rights, duties and obligations contained in this MOU shall operate only between the parties to this MOU, and shall inure solely to the benefit of the parties to this MOU. The provisions of this MOU are intended only to assist the parties in determining and performing their obligations under this MOU.

The parties to this MOU intend and expressly agree that only parties signatory to this MOU shall have any legal or equitable right to seek to enforce this MOU, to seek any remedy arising out of a party's performance or failure to perform any term or condition of this MOU, or to bring an action for the breach of this MOU.

Partner name

Partner representative

Position

Address

Telephone

E-mail

Partner name

Partner representative

Position

Address

Telephone

E-mail

Date:

(Partner signature)

(Partner name, organization, position)

Date:

(Partner signature)

(Partner name, organization, position)

ANNEX 2: WATER SUPPLY CONTRACT COMPONENTS

Either CMWU or NWC will need to sign a bulk water supply agreement with the WUA. Given the complexity and legal sensitivity of such an agreement, an actual contract is not included here. Instead, below is a list of thirteen areas that should be covered in any future water supply contract. This list is not exhaustive (it doesn't include boilerplate contract components, for example) but it does cover the items most needed for a comprehensive agreement.

1. Price and non-price terms

A bulk supply agreement should include both price and non-price terms so that the parties know what services are being provided at what price.

The price terms could include:

- a standing charge and volumetric rate for each water supply;
- charges for any volumes of water the WUA takes that are above the maximum amount allowed in the agreement;
- a minimum charge that the WUA pays whether it takes any water or not;
- a capital contribution to the connection cost;
- charges for the provision of information; and
- rules about the periodic adjustment of charges.

The non-price terms could include the ownership and responsibility for the assets used in the supply (discussed below), how charges are to be paid and how the parties are to operate the bulk supply.

2. Ownership of and responsibility for the assets

The agreement should be clear about who owns and who is responsible for operating the assets that are used to provide the bulk supply (which will depend on which Scenario is chosen). One way of doing this would be to include a detailed operational plan, which, as well as defining ownership and operating responsibilities, could include details such as maximum flow rate. This information will help in resolving any operational problems and will have a bearing on the price terms of the contract.

3. Measuring the water supplied

A bulk supply agreement should specify how the water supplied is to be objectively quantified. In this case, a meter will likely be used, which will need to measure the water supplied to the

degree of accuracy specified in the agreement. To ensure the accuracy of meter readings, meters should be tested (ideally, the type of test should also be specified in the agreement). Even with testing, there can be occasions when a meter is found to be faulty. To prevent a possible impasse between the parties the bulk supply agreement could specify the mechanism for determining the volume of water supplied in this case.

4. **Quality of the water supplied**

The agreement usually states the quality of the water to be provided and how it is to be assessed. This could be done by specifying the water quality parameters the non-potable water should meet. It is the WUA receiving the bulk supply that is responsible for the quality of water supplied to its customers (the farmers) but NWC (CMWU) must inform the WUA of any events that might lead to harmful water being supplied.

5. **Adjusting prices**

Price terms can be set in different ways. For example, some bulk supply agreements include volumetric charges for the supply of water. Other bulk supply agreements include contributions to the capital costs of building the bulk supply assets or the ongoing costs of operating the bulk supply.

As well as setting out the price terms, the bulk supply agreement might also explain how those price terms are to be adjusted to allow for inflation. Typically, bulk supply agreements include provisions for annual adjustments to the price terms to allow for inflation, although the parties could agree different frequencies of adjustment. The adjustments could be by set amounts, percentages or linked to measures of specific costs or general inflation. If the parties agree that no adjustment is to be made to the price, they could set this out for clarity.

6. **Interruptible or firm supply**

The bulk supply agreement should include details of any allowed interruptions. It would need to explain the number and duration of interruptions that NWC could make and under what conditions interruptions could happen. There might be a link between when NWC can make interruptions and interruptions for planned maintenance, emergencies and water shortages.

7. **Interruptions of supply to carry out planned maintenance**

Planned maintenance can disrupt the flow of water from NWC to the WUA. The WUA will want to know when maintenance will happen so that it can make alternative arrangements to supply the farmers.

The bulk supply agreement could put a requirement on NWC to minimize the frequency and length of any disruption to the bulk supply as a result of planned maintenance work. The agreement would need to define what is meant by 'planned maintenance'.

The agreement might set out the process by which NWC would consult the WUA over the timing of planned maintenance. It could specify how far in advance NWC should notify the WUA of the planned maintenance. The agreement might also allow a reasonable period for the WUA to express its views and could require NWC to consider them before making a final decision on the timing and duration of the maintenance.

8. **Co-operation in emergency situations**

Emergency situations could arise during the period of a bulk supply agreement that affect the quality of the water supplied, the volumes of the water supplied or some other aspect of the bulk supply agreement. It would be helpful if the agreement defined what is meant by an 'emergency' and explained how the parties would deal with one.

Obligations on parties to cooperate in an emergency could include:

- cooperating to prevent an emergency from occurring;
- notifying the other party of the existence and cause, if known, of the
- emergency;
- ensuring, as far as is reasonably practicable, that any emergency has the minimum possible effect on the supply of water;
- agreeing reductions in supply where this is reasonable to prevent or mitigate the effects of an emergency;
- ensuring that priority is given to vulnerable customers if a supply of water is restricted because of an emergency, and co-operate in agreeing categories of vulnerable customers;
- using all reasonable endeavors to restore the supply;
- investigating the cause of an emergency that has occurred; and
- sharing any lessons learned to prevent a recurrence of the emergency.

9. **Co-operation at times of water shortage**

The agreement could specify what is to happen during a time of water shortage. It might also place an obligation on both parties to cooperate in such situations.

The terms relating to water shortages could include:

- a definition of the circumstances under which NWC may limit the water it supplies under the agreement;
- an obligation for NWC to notify the WUA if it intends to impose a temporary ban on the use of water by some or all of its customers; and
- provisions relating to the actions the WUA should take to reduce water taken from the bulk supply in the event of a water shortage.

10. Liability for planned and unplanned interruptions

To give the WUA comfort that it would be adequately compensated for losses arising due to unplanned non-emergency interruptions, the agreement might include categories of costs such as:

- costs incurred in securing alternative sources of supply. The parties may wish to include a non-exhaustive list of potential alternative sources that would need to be deployed – for example, tankered water supplies; and
- GSS (guaranteed standards scheme) payments to customers.

To provide greater certainty, the agreement might allow for liquidated damages, that is, an estimate in advance of the losses the WUA might incur if the supply was not made available. To limit NWC's risk exposure, the liabilities in the agreement might be capped.

11. Duration

It might take many years for the revenues from the bulk supply to cover the cost of the dedicated bulk supply assets. A bulk supply agreement might therefore need to be long enough to allow for the parties to recover the costs of the assets. On the other hand, a long duration agreement can create problems if circumstances change and the agreement is no longer beneficial for one or both parties.

12. Dispute resolution

Disputes might arise from time to time with regard to the bulk supply agreement. It would be sensible for the agreement to include a provision to resolve disputes. It is best if this is comprised of an internal escalation process that must be followed before a matter may be referred to arbitration, the courts or some other form of formal adjudication.

Some energy contracts specify a time limit after which a party cannot raise a dispute about the other party's previous performance of the contract. For example, the contract might specify that parties must raise a dispute about an incorrect payment within a year of the payment being made.

13. Termination

The agreement should set out how it can be terminated by either or both parties. Ways in which a bulk supply agreement could be terminated include:

- on a date specified in the agreement;
- on either party giving a specified period of notice;
- by mutual agreement;
- if the WUA is terminated;
- if there is a material breach of the contract that is not remedied. A material breach could include repeated failure to pay on time or a one-off failure to pay on time which was not corrected within a specified period, or a persistent failure to supply.

ANNEX 3: SOCIAL AND ENVIRONMENTAL IMPACT ASSESSMENT

INTRODUCTION

The summary below was prepared as part of the deliverable "Supplementary Environmental and Social Impact Assessment (SESIA)", which involved the preparation of an independent ESIA of the North Gaza Emergency Sewage Treatment Project (NGESTP), Effluent Recovery & Reuse System and Remediation Works.

The specific objectives related of this SESIA were as follow:

- Highlight the legislation under which the project will be implemented. Besides the Palestinian Laws and Regulations, the study also highlighted the Regional Laws and Regulations, especially from Jordan, Israel and Egypt, associated with wastewater reuse and sludge management and reuse. In addition, the International Standard and Guidelines, including World Bank (WB) procedures and FAO and WHO Guidelines were highlighted.
- Provide baseline environment and socio economic conditions of the project components.
- Identify of the possible positive and negative social impacts, permanent or temporary, of the project components. In addition, the analysis and mitigation measures will be developed to reduce the negative impacts resulted from the project component.
- Identify of any potential temporary or permanent land acquisition requirements associated with civil works. In addition, develop the outline of the vulnerable groups that might be affected by the project and identify the appropriate mitigation measures
- Develop an Environmental and Social Management Plan (ESMP) and monitoring plan to manage, mitigate and monitor any possible negative impacts. Moreover, a capacity assessment of the implementing party to implement the ESMP and recommendations for any capacity-building needs

In addition, as assessment was made for sludge management for the sludge resulting from the North Gaza Wastewater Treatment Plant (NGWWTP) and intended to be used in agriculture as part in the effluent recovery and reuse scheme or in emergency cases to be dumped to landfill.

The study was undertaken throughout July - October 2012. The team developed a cross-sectional study that used a multi-data source approach including site visits, primary data, secondary data, surveys and site measurements.

ENVIRONMENTAL BASELINE CONDITION OF THE PROJECT COMPONENTS

a. General Characteristics of the Project areas

Beit Lahia Wastewater Treatment Plant (BLWWTP) and Effluent Lake

- BLWWTP was constructed in 1976. It is located some 1.5 km east of the town center of the Beit Lahia, northern part of Gaza Strip.
- BLWWTP was built in sand dunes overlying a clay layer of variable thickness with un-continuous impermeable clay layer. It was constructed in stages and modification and rehabilitation activities were performed in order to increase capacity of the plant.

  • During the past few years the situation escalated. With the increase of wastewater network connection, the volume of wastewater inflow had far exceeded the plant's treatment capacity that have led to deterioration of the effluent quality and have led to clogging effects in the neighboring sand dune areas. The ongoing decrease of the infiltration capacity of the flooded areas and the increasing wastewater volumes have resulted in the formation of enduring ponds and finally a lake.
- Over the years the effluent lake had a volume of about 2 million m3 of foul wastewater, which covers around 300 dunums and continued to rise and was threatening to flood the whole sewage collection system and the neighboring communities.
- Starting in 2007 (NGESTP was starting to be implemented), almost 90% of the effluent lake had been dried due to weathering and limited discharge to the lake. Currently the wet area occupies around 10% of the total lake.

Agriculture Land Proposed for irrigation/Sludge use

- The area in the vicinity of NGWWTP is assigned designated to benefit from the recovery water and the treated sewage sludge in the agricultural activities.
- The proposed area is divided into two zones according to its location from NGWWTP. Zone A (northern part of NGWWTP) with about 10,100 dunums whereas, Zone B (southern part of NGWWTP) with about 5,000 dunums. Most of the area is considered as under rain-fed conditions.
- Citrus, Olives, fruits and vegetables are among the crops grown in the proposed agriculture land for reuse scheme.

b. Physical and Biological Environment of the project areas

- The project sites have a typical semi-arid Mediterranean climate with long hot and dry summer (from 25^{o}C in summer and 13oC in winter with maximum daily temperature can reach 29-30^{o}C and the minimum temperature is around 9^{o}C). The proximity of the Mediterranean Sea has a moderating effect on temperatures and promotes high humidity throughout the year. The prevailing wind direction is South West with an average speed of 4.2 m/s (winter) and from North West (summer).

- The average annual evaporation rate is around 1,900 mm/y (5.2 mm/day). The maximum evaporation rate increases during the summer and may reach over 6 mm/day between June and August.
- Ambient air and noise quality at the project sites are consider normal with a slightly high on BLWWTP due to more rapid population surrounding the area.
- The dominate soil type in the irrigation area can be considered as heavy soil with a deep soil profile, which means will not limit root penetration for deep rooted crops. The irrigation scheme assessment was done with taking into account the climate change through the mentioned 10 years by increase the air temperature of 1.5oC.
- The soil at different locations of the effluent lake has a normal pH range and Organic Matter content with negative and low Fecal Coliform. In addition, the Electrical Conductivity at the wet part indicates the higher number due to remaining heavy metal from the stabilized sludge that is present in the top layers of the effluent lake.
- No major fault type formations have been observed in Gaza Strip area.
- Mainly aquatic birds and the reptiles (rats, snake, crows, barn owl and other wild species) are present at the BLWWTP and the Effluent Lake. The effluent lake provides breeding, nesting, roosting and feeding habitats for different birds' species. Typical effluent lake landscape consists of sand dunes covered with Acacia shrubs.
- In the proposed agriculture land for effluent recovery reuse, many Olive, Plum, Almond, Citrus or Orchards have been encountered at agriculture land allocated for irrigation of recovered water and sludge reuse. Many wildlife species; particularly birds were found to inhabit these agro-ecosystems.

c. Water (groundwater quality) of the project components

- The water quality in this study focused on chloride and nitrate concentrations (the most important contamination indicators in the groundwater in the Northern Gaza aquifer).
- The highest chloride sources are expected in the areas affected by seawater intrusion and the deeper groundwater layer (generally exceed 250 mg/l). The seawater intrusion zone covers the western part with 2 to 3 km inland the aquifer. Most of the municipal wells were concentrated in this zone and due the high pumping rate of these wells resulted in accelerating the seawater intrusion.
- NO3 concentration exceeds the WHO drinking water guidelines in most of the Northern Gaza aquifer. In 2003 at the infiltration site (adjacent to NGWWTP), the maximum nitrate concentration in the groundwater was about 30 mg/l due to the operation of the infiltration basin using partially treated wastewater.

- Cl concentration in the wells close to the infiltration basin ranges between 350 to 650 mg/l (till the middle of 2012). The trend of the chloride concentration recorded is steady since 2011 in some wells. In addition, Nitrate concentration for the same period ranges between 20 to 120mg/l.
- From the analysis it found that the groundwater is free of Salmonella, Nematodes and Amoeba & Gardia. However, the total Bacteria ranges between 30 to 395 cfu/ml and the total coliform ranges between 6 to 50 cfu/100 ml in some wells.
- The heavy metals concentrations in all analyzed wells were less than the Palestinian standard values for irrigation. However, there were some wells that have concentrations of Boron and Mercury higher than the standard values.
- The groundwater quality under the effluent lake and the BLWWTP sites is improving after drying the lake.
- According to the groundwater modeling result, the recovered water is not expected to have bacteria, including fecal coliform due to the infiltration process (treated by the soil). In fact, the water quality, especially after the NGWWTP will have better quality than the wastewater reuse. However, to ensure the public health concern related to wastewater and sludge reuse, the monitoring plan is determined in the monitoring plan (including the mitigation measures for epidemiology).
- There is no archeological or historical site as well as the protectorate areas nearby the project component sites. The only site consider important and respected (psychologically important) by the community is the El Shuhada Cemetery, which is nearby the location of storage tanks and booster pumps (water distribution network).

POSITIVE ENVIRONMENTAL AND SOCIAL IMPACTS

The positive environmental and social impacts of the project are:

1. The recovered effluent from the groundwater will be an important source of irrigation water, as water resources in the Gaza Strip are scarce; especially during summer time, as a source of water will be continuously available.
2. The groundwater quality is suitable for Unrestricted Use. The only restriction is for the Total-N, which is higher than 15 mg/l. This could be considered as an advantage for agricultural use. However, it is advisable to restrict the use the recovered water for uncooked vegetables at least for the first year of implementation.
3. The recovery scheme will limit the horizontal dispersion and the vertical building up of the water table, which without recovery will have a negative impact on current land use.
4. Effluent reuse of the recovered water will solve the problem of the disposal of wastewater, as it will be treated and injected for agricultural use.

5. The groundwater quality after drying the lake is improving.
6. Sludge has a high content of organic matter that can help conserving soil organic matter, and sludge stimulates biological activity in the soil.
7. The sludge reuse brings possibility for farmers to supply their lands with organic fertilizer at low costs and reliably available. It is expected that the sludge will cost as low as the transport cost of around 1 ILS/50 kg (compare with 50 ILS/50 kg for Israeli imported fertilizer). Another level of competition reported was with the Palestinian organic fertilizers (each dunum needs about 8 cubic meter from this fertilizer. That cost around 850 ILS per ton which is relatively expensive). Thus, the produced sludge will be a competitive product if it cost less than 300 ILS/T.
8. The sludge reuse is environmentally the best solution compared to disposal inland fills or incineration plants and appealing solution for sustainable sludge management.
9. Sludge is one of the outputs of the project, and will increase the income for those who work in sludge trading,
10. Sludge reuse will work for reduction of chemical fertilizers.
11. Reduction of health risks associated with exposure of villagers or inhabitant surrounding the effluent lake and BLWWTP to environmental risks and nuisance released from the BLWWTP, such as effluent lake flooding and the risk of water borne disease, will be seen. In addition, the project will protect the livelihood status of people who suffered due to the flooding of BLWWTP,
12. The provision of recovered water will reduce the cost of water needed for irrigation in the area. The utilization of the recovered water of high quality and of less price might work for the benefit of the farmers (increase their profits)
13. The new lands gained due to the decommissioning of BLWWTP will be used in agriculture activities or as a recreational or residential place.
14. Potential increase of the price of lands and dwellings due to the implementation of the project,
15. Provision of jobs due to the implementation of the project components, both during construction and operation phase.
16. After decommissioning of BLWWRP, it will considerably reduce odor, mosquitoes and flies.
17. As soon as the NGWWTP is completed and starts its operation (2013) the infiltration of a high-quality effluent in the infiltration ponds will begin to compensate the negative effects on groundwater.
18. The construction of the site and the carrier line will improve the road network connecting the existing and the emergency area.

NEGATIVE ENVIRONMENTAL IMPACT ANALYSIS AND THEIR MITIGATION

a) During Construction Phase

i. Air Quality and Noise Pollution (low impact and temporary)

It is concluded that the air quality impacts associated with dust generation will be of "low" significance. However, whenever the dust emission becomes higher than normal and create disturbance to the workers and project activities, it is recommended to spray the location with water to reduce the impact.

ii. Gaseous Emissions (low impact and temporary)

Air emission impacts associated with the proposed project will be of "low" significance. However, to reduce and minimize the impact, it is recommended to check the vehicles regularly for the exhaust gas and minimize the vehicles and heavy equipment movement at the same time.

iii. Noise (low impact and temporary)

The noise generation is not expected to represent a significant issue to local residents (due to distance from the residential area, only during the day time and on a short period). The most affected people from noise impacts are the construction workers. The mitigation measures recommended in the ESMP and Monitoring Plan for control of noise and air emissions, especially to the workers are based on compliance with the Palestinian Outdoor Noise Standards.

iv. Vibration (low to medium impact and temporary for the water distribution networks and low impact and temporary for other project components)

The closest sensitive structure to the site of the booster pumps (due to psychological perspective of the respected site according to the people in Gaza) is El Shuhada Cemetery (around 10 m away). Consequently, medium vibration impacts could be anticipated to occur. The mitigation measures proposed during the construction of water distribution network component (storage tank and booster pump), near the El Shuhada Cemetery area are as follows:

- The base camp (workers site camp) and place for storage of equipment have to be on the future land dedicated for future expansion (pumps and the storage tanks).
- The construction of the storage tank and the booster pumps room including the generators and the electrical rooms have to be separated and not overlapped.
- The ready mix concrete is preferred to be used instead of onsite concrete mix. Beside the reduction of the dust transmitted to the agricultural land due to mixing onsite and

reduction of the hazardous wastes and other solid wastes on site, the vibrational load will be also reduced significantly (use of concrete pumps will be advantageous).

- In addition, due to the sensitivity of the groundwater, the vibration around the wells construction site should be minimized in order to avoid groundwater contamination due to potential spills.

v. Construction Waste and Handling of Hazardous Waste (low to medium impacts)

Based on the expected waste generation associated with the proposed NGESTP project activities, the impact will be of "low to medium" significance. The following mitigation measures are proposed:

- Onsite domestic sewage collection and disposal (adequate sanitation facilities) shall be provided by the contractor for construction workers' needs.
- Site waste management plan should be developed by the contractor prior to commencement of construction works.
- The burning of any type of wastes should be avoided.
- The reused clay or excavated sand should be stockpiled and stored away from
- Nearby sanitary landfill should be notified to receive the unusable non-hazardous construction wastes or damaged construction materials.

vi. Soil Contamination during Decommissioning of BLWWTP (medium impacts)

Soil may be exposed to contamination due to the movement of construction vehicles and equipment. The contamination will occur due to oil and fuel spills from the engines of machines, and also due to polluted wheels (importing pollutants from outside of the site). It is concluded, based on the above, impacts associated with soil contamination will be of "medium" significance. Mitigation measures proposed during the decommissioning of the treatment plant are as follows:

- The decanting activities should be done with a care and the pipe should be have sufficient length to prevent the spillage to the ground
- Preventive maintenance for any vehicle or equipment that has an engine that leaks oil or fuel.
- Preparing a special fuelling and oil change station on site to contain any possible fuel or engine oil spill. Otherwise fuelling and oil change should be conduct in the private oil stations out of site (concrete paved station on site).
- If any machine is broken on site, a containment system should be used to prevent the spill of oil or fuel on the soil.

- The vehicles moving in and out of site should be checked at the inlet gates of BLWWTP to assure that they are not importing pollutants through the wheels.
- The paved path / concrete paved parking or loading and uploading sites can be made to ensure that the vehicle will not transport the pollutant from the site.

vii. Remediation Works at the Effluent Lake

The best options for financially and technically feasible options (excluded the land investment cost) are the Phytoremediation, clay placement and three layers clay placement. The most sensitive criteria for the remediation selection is the land investment. As the land is being rented and the longer term of the remediation activities will affect the initial cost, in addition, the three layers of clay cap is not necessary as the contamination does not need deep soil replacement, the clay cap placement is the most suitable option, financially and technically.

Heavy machinery and vehicles might be used are excavators and heavy trucks. Impacts associated with remediation works will be of "medium" significance. Mitigation measures proposed during the remediation works of the effluent lake are as follows:

- Standard protection to the workers during the overall remediation activities
- Special tools for handling the dangerous wildlife found
- On site sanitation should be established for the workers
- Avoid the disturbance of the existing plants and wildlife as much as possible during the site preparation
- Handle with care found wildlife (catchment dangerous wildlife). It is recommended to seek the assistance from Ministry of Health and Ministry of Agriculture for the best practice for handling the catch dangerous wildlife
- Minimize the soil contamination by site management plan (place for temporary storage, handling, transportation and disposal)
- Replanting the affected plant that has to be displaced. If the replanting is not feasible, planting 2 new trees to compensate 1 removed tree has to be done by the contractor
- Notification to the designated landfill should be done prior to the soil disposal.

viii. Changes in Hydrology and Groundwater Quantity and Quality (low impact)

During the construction of the recovery scheme, remediation of effluent lake and decommissioning of BLWWTP there will be no impact on groundwater. It is expected the depth of the excavation will not significantly impact the groundwater but the wells construction. It is recommended to hire the highly qualified contractor for wells establishment. Therefore, the

impact negligible for decommissioning and remediation activities and low impact on the water distribution networks (only for wells construction).

The mitigation measures to avoid the hydrology of groundwater quantity and quality are similar to the general wells construction. To reduce the impact on wells construction, highly qualified contractor has to be contracted, isolate the access and the site area to avoid outside disturbance that can make the land fallen down to the wells.

ix. Health and Safety (low to medium impacts)

During the construction phase, as the proposed project are at a large distance from the nearest population or residential area and on the agriculture land, the health of the population is not expected to be significant and considered minimal.

Negative impacts will mainly concern the works for construction of new facilities, which are mainly within water distribution networks. It will have few limited negative impacts such as temporary discomfort and localized pollution to the communities caused by worksites (noise, exhaust fumes, dust and vibration, risk of accidents due to increased traffic in the project impact area, the presence of workers, very limited disruption of wildlife and vegetation, poor management of handled products: fuels and lubricants as well as worksite waste, etc.).

However, although the impact is considered low and temporary for the communities, the mitigation measures are developed to minimize the impact. In addition, due to the health and safety of the workers, which accidents might occur on site in various construction project activities, mitigation measures are as well developed to mitigate the risk of health and injuries to the workers. Mitigation measures developed to minimize the risk related to health and safety, both for community and workers are:

- Raising awareness campaigns to workers and community members to promote safety, and health and safety monitor should be appointed. The monitor can be chosen from among community members who accepted to work in the project.
- Workers should wear standard protection especially due to the dangerous wildlife on BLWWTP and effluent lake sites.
- Workers should be trained to cover the completed parts and keep their work areas safe. In case of causing an accidents, the workers should be penalized either by deduction of salaries or dismissal.
- Existing utilities (especially at BLWWTP and water distribution network), if exist, would be located and staked before construction begins, including and at intersections of other pipes and crossings. This would confirm the location and depth to ensure new construction does not impact the existing utilities.

5. The identification of the existing infrastructure (other pipelines, cables, etc) has to be identified prior to the construction phase.

- Heavy equipment would not normally be operating over the existing utilities during construction of the new line. If heavy equipment or trucks must cross the existing utilities, thus additional soil cover is needed to protect the existing pipe.
- Onsite inspectors would be present during construction to verify that the construction contractor is following engineering specifications and meeting regulatory requirements.
- Workers should take the following steps to protect themselves from falls during high construction:
    - Use 100% fall protection when working on higher construction site
    - Participate in all training programs offered by the employer (contractor).

      c) Follow safe work practices identified by worker training programs.
    - Inspect equipment daily and report any damage or deficiencies

As a mitigation measure, safety measures should be put into consideration and addressed with the workers. The contractor and the PMU are mainly responsible for any safety procedures to be applied

x. Archaeological Disturbance (low impact)

Surveys in the area of the BLWWTP and Effluent Lake concluded that there is no archaeological sites were identified. The confirmation letter was sent to the Archaeological Authority for assurance and clarification of the assessment and the replied letter indicating that the project components (including the irrigation lands) have non-existence of the archaeological site.

Although the sites do not have any archaeological importance, the Jordanian Antiquities Law still applicable and can be applied if there is any archaeological and valuable objects is found.

xi. Ecological Disturbance (medium impacts)

Wetland ecosystem and vertebrates living at the area surrounding the BLWWTP and the effluent lake might be affected during the decommissioning of the treatment plant and the remediation works of the effluent lake.

Although the biodiversity, especially fauna identified within the vicinity of the project sites (effluent lake and BLWWTP), are commonly found, it is not belong to endanger wildlife and in fact it could cause a vertebrate pest outbreak or other health impact, the mitigation measures have to be developed to avoid the ecological disturbance and provide safe and adequate

relocation for found wildlife and re-plantation for the fauna. Based on the ecological disturbance impact, the project at BLWWTP and effluent lake will have significant medium impacts.

However, due to the decommissioning activity and the remediation of the effluent lake, after the finalization of the works activities, the site will provide a permanent positive impact. The biodiversity disturbance of the site due to the remediation works and decommissioning activities, either by relocation, temporary shelter or re-plantation to another site or still within the project site area, will be compensated with the long term positive impact. In addition, as the fauna and flora found in the project site is a local and not belong to the endanger species, they will easily adapted and continue their life cycle.

Mitigation measures to reduce and minimize the impact of the existing wildlife and plantation within the BLWWTP and effluent lake are as follow:

- Standard procedure for health and safety of the workers at the site, especially the equipment that protect them from the wildlife.
- Equipment to handle the vertebrates should be prepared (this includes cages, snake sticks, net, etc.) in case of the found vertebrate during the activities.
- Assistance from the staff of Ministry of Health and Ministry of Agriculture is needed to advice the contractor for temporary relocation of the found wildlife.
- Re-plantation of the trees, if needed, should be done by the contractor, if it is needed. The re-plantation can be done within the area of the effluent lake.
- Avoid the disturbance of the nesting, breeding site. The found nesting or breeding found has to be handled with care and replace it to the safe site.

Regarding the water distribution network site, there is an opportunity that the networks will be laid in agricultural land and impose on the existing crops and local animals around the site. Mitigation measures shall be developed to limit and to reduce the impacts. Based on the ecological assessment, the project will have low to medium impacts.

Mitigation measures develop to avoid the crop and animal disturbances in the vicinity are as follow:

- Temporary construction fences have to be installed prior to the construction of the water networks and other components for recovery water distribution to avoid the fallen of the local animal and to localize the site from the local animals.
- In case the destruction of the crops or plants at the farms near the construction of the recovery water distribution network, compensation has to be settled.
- If it is needed, the replanting or trees relocation (temporary or permanently) has to be done. If the relocation or replanting of the existing trees is not feasible, the

compensation of planting 2 trees (for removal of one tree) has to be done in the other area. It is advisable to plant locally trees.

xii. Land Use and Accessibility (medium impacts)

During the decommissioning and remediation activities, the impact on land use and accessibility is considered "low". Regarding the land use and accessibility of the water distribution networks for the recovery reuse scheme, the main impact on roads traffic will be during possible lying of water distribution networks along or across main roads. In addition to the limited access road for the community during construction, this access difficulty will have more impacts on elderly people, handicapped and children, who may accidentally fall in open trenches or make tedious long cycles before they reach their targeted locations.

Mitigation measures proposed are as follow:

- Selection of suitable location for temporary storage of construction materials, equipment, tools and machinery prior to starting construction, especially on the site that is close to El Shuhada Cemetery.
- The employed machinery drivers should receive training on safe utilization of their machines to minimize accidents risks.
- Clear signs indicating the project site and temporary fences shall be installed prior to the preparation of the site, especially the water distribution networks area.
- Avoid the side of the road for all the temporary storage materials and the place for standby equipment.
- All the activities have to be during the daytime and have to be scheduled to avoid conjunction with the school and working peak hours (morning and afternoon).
- The traffic department should be informed and involved to manage the traffic during the congested time. In addition, the preferred route and an alternative road have to be recommended by the traffic department.
- If the digging (open trenches) is not completed within a day period, the clear sign (by light or fluorescence lights) has to be considered to determine and identify the site during the night.
- When the land use and accessibility is disturbed and the safety of the communities passing by the project location is triggered (especially to the children, handicapped or the elderly who might use the access road), the temporary access road has to be considered with the traffic department assistance.
- Temporary resettlement that might occur during the preparation and the construction phase has to be defined and accordingly has to be compensated.

b) During Operation Phase

i. Air Emissions and Noise Pollution (low to medium impacts)

The impact of such air emissions are considered minor, because the diesel generators are only expected to operate temporarily during power cut-offs. The compliance of generator emissions with Palestinian Standard for Ambient Air will be sufficient to safeguard against unacceptable air emissions impacts to the neighboring areas.

A relatively higher impact will be on the Pumping Station staff, which may be exposed to intermittent pumping noise. The standard protection of the workers, including earmuffs, has to be practiced all the time, especially at the Pumping Station area.

ii. Odor

The operation of the water distribution network system is not expected to have significant impacts on odor. However, due to the remaining pond #7 that will be used as the emergency pond, the operation of anaerobic ponds will have significant impact associated with generation of odor (mainly H_2S) and vectors that mostly generated from raw sewage storage. The mitigation measures proposed for Pond #7 is as follows:

- Minimum standard is set to consider as an emergency (monitoring plan is presented at ESMP section). Maximum permissible level of the overflow or raw wastewater discharge in the pond is 2 m height.
- Maintaining high performance of biological treatment of wastewater. In addition, to be as far as possible from odor recipients and keeping buffer zones between odorous units and neighbors.
- The aerator from the aeration tank can be installed on the pond to maintain reasonable dissolved oxygen in the water to avoid anaerobic conditions.

iii. Vibration

Concerning the vibration at the effluent lake and the decommissioning site (including remaining pond #7 and the PS adjacent to pond #7), the impacts is considered negligible. The main impact (medium impact) expected during the operation of the water distribution network is on the site of booster pump (special attention has to be made to reduce the vibration impact at the pumping station and the generator to minimize the impact due to the close distance with the El Shuhada Cemetery). The mitigation measures to minimize the vibration impacts of the machines are:

- Tree plantation, heavy leaf trees to absorb the vibration and noise generated, is recommended to be planted at the Cemetery area along the proposed main road at the other side of the pumping station.
- Maintenance of the machines and equipment has to be maximized (less than the standard period required).

iv. Water Resource Contamination

The impacts on groundwater is one of the most important issues associated with the reuse project, as part of the project has been designed to prevent impacts on the groundwater from infiltrating partially treated sewage. To identify the impact of the groundwater, the verification of the available water quality monitoring (four rounds from PWA) has been analyzed and the groundwater modeling with different scenarios has been run (with and without recovery schemes and different scenarios of recovery wells implemented (12 wells and 25 wells) and during the different year of implementations; 12 wells implemented on the year 2013 and 2015). Based on the modeling results, the groundwater monitoring plan has been developed.

The groundwater monitoring programme is the key mitigation measures to indicate the water resource contamination. The groundwater monitoring programme will be explained in detailed on the following section, ESMP.

v. Impacts on Local Agriculture, Public Health and Water Resources

Based on the design project report three scenarios that considered the expected water quality recommended are as follows:

- Scenario I: It is more advisable to cultivate orchards on the available area to the west of the project along Al Karama Road. Based on crops water requirements, the available reclaimed water is just enough to irrigate 5,375 dunums divided into citrus, olives, fruit trees, alfalfa and grains (water quality does not have impact on the crops selection)
- Scenario II: Wastewater will be treated more effectively and consequently the effluent will be of better quality in general. The quantity of effluent diverted to the infiltration basin will increase to approximately 23,100 m3 daily. This reclaimed water will be used to irrigate additional land to 7,525 dunums in total.
- Scenario III: This Scenario assumes that the planned WWTP in East Jabalia will work with its full capacity by year 2025. The quality of reclaimed water (39,160m3/day) is expected for unrestricted use. The quantity of reclaimed water will be enough to irrigate about 12,577 dunums. In this scenario vegetable crops will be introduced with an area of 1,258 dunums.

vi. Decommissioning of BLWWTP on Groundwater Quality (positive impacts)

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

vii. Recovery Water Quantity and Quality (medium impacts)

Based on the groundwater modeling and analyses, the recovery water quantity and quality is expected to be acceptable for agricultural irrigation for unrestricted crops, but unacceptable to be used for drinking water. Besides continuous groundwater monitoring, public awareness is needed to ensure that the community is not using the recovery water as a drinking water.

Although the NGWWTP is located nearby the Israeli border, the flood risk is not expected to cross the fence to Israeli border due to the topographical nature of the project site. In addition, as the groundwater modeling result from different scenarios, the plume will not be significantly crossed the Israeli border as the infiltration basins are located more than 300 m downstream of the border and with the recovery wells implementation, the wells will accelerate the flow in the downstream direction away from the Israeli border.

After decommissioning the lake and BWWTP, a positive impact will be clearly found on the groundwater quality in the aquifer under the lake.

viii. Land Use of Effluent Lake Remediate and Decommission of Beit Lahia Wastewater Treatment Plant (medium impacts)

In one year period, the remediation activities will be finalized. Afterward, the remediated effluent lake can be used for agriculture purposes or residential, depending on the Urban Planning of the area and El Awqaf future plan.

After the completion of the remediation works, depending on the urban planning of the area and the future plan of Ministry El Awqaf, the land use of the effluent lake will be mitigated. Based on the soil assessment prior to the completion of the remediation works, there are two options of land use which can be applied:

- To be used as an agriculture land. Although the area will not need additional filling or leveling, but due to the huge amount of the soil excavated at the nearby landfill site (Johr Eldeek) that will be implemented during 2018, if needed, the excavated soil can be transported to the effluent lake site as far as the soil is considered good. The soil quality has to be determined (soil analysis done at the landfill site, by the landfill management), before transporting it to another area.

The agreement between Ministry of Awqaf and the Land Authority or the Ministry of Economic in addition to the agreement of the Landfill management shall be reached prior to transferring the soil to the effluent lake. According to the capacity analysis during the EA of NGESTP, a maximum of 1.5 million m3 of soil can be transferred to fill the effluent lake

- To be used for residential purposes. Additional soil for leveling and soil conditioning, if needed, at the effluent lake site when the urban planning of the area is dedicated for residential area. The soil analysis will not be crucial as the option 1 and the agreement shall be reached only between Ministry El Awqaf and the Ministry of Economic and Land Authority in addition to the agreement of the landfill management for transporting the soil to the remediated effluent lake.

Due to the remaining pond # 7, the mitigation measures are developed to minimize the impacts due to the operation of pond # 7. The impact on the land use and accessibility of the decommissioning land and remaining pond #7 is of "medium" significance. Mitigation measures developed to reduce the impacts are as follows:

- Fences surrounding pond # 7 have to be constructed to reduce the accessibility of the community to the pond area. During the Public consultation, Beit Lahia Mayor announced that there is a budget allocated to build the permanent fence around the pond #7. The agreement between PWA and Beit Lahia Municipality can be reached on the construction procedures.
- There should be 10-15 m distance between the pond area and the fences to be constructed on the surrounding pond.
- The trees shall be planted nearby the fences, in order to reduce the odor or nuisance and separate the pond site from the surrounding neighboring area and future land use of the other decommissioning ponds. Planted trees will also bring positive impact on the visual impact.
- The site is only connected to one main gate and the access road to the neighboring site in addition the pond site should be connected with the pumping station at the vicinity for ease access

ix. Public Health related to Using Recovery Water for Irrigation (medium impacts)

Health protection measures which can be applied to the agricultural use are:

- Crop restriction
- Human exposure control and promotion of hygiene

Adopting crop restriction as a means of health protection in reuse schemes will require a strong institutional framework and the capacity to monitor and control compliance with regulations and to enforce them. Farmers must be advised why such crop restriction is necessary and be assisted in developing a balanced mix of crops so that production of surplus of a specific crop is avoided.

Control measures aimed at protecting agricultural field workers and crop handlers include:

- The provision (and insistence on the wearing) of protective clothing, the maintenance of high levels of hygiene and immunization against (or chemotherapeutic control) selected infections.
- Risks to consumers can be reduced through cooking the agricultural products before consumption and by high standards of food hygiene, which should be emphasized in the health education associated with irrigation schemes.
- Local residents should be kept fully informed on the use of recovery water in agriculture so that they, and their children, can avoid these areas.
- Special care must always be taken to ensure that agricultural workers or the public do not use irrigation water for drinking or domestic purposes by accident or for lack of an alternative.

All measures should be coordinated with the awareness campaign of using treated wastewater and pilot projects of using treated wastewater for irrigation. According to the clarification from the PWA team responsible for the effluent reuse study and pilot projects in Gaza, currently there are ongoing projects related to the awareness and the pilot projects, i.e. awareness workshops carried out for farmers, operators and managers of recovered wastewater (and more awareness will be carried out during the operationalization of the pilot projects).

Recovered water reuse, as it is demonstrated on the groundwater modeling concluded that there is no indication of bacteria or viruses, including the Fecal Coliform. The combination use of recovered water and the sludge for the same area proposed will not have significant impact to the soil, as only the nitrate is considered higher than standard (in this regard, it is not recommended to be used as a drinking but is considered an advantage for the agriculture).

Concerning the epidemiology due to the reuse of the recovered water and sludge for irrigation and soil at the irrigated land, based on the expected water quality, there will be no bacteria, viruses and other related pathogens that lead to the waterborne diseases, i.e. cholera, hookworm, diarrheal diseases or other helminthic infections is expected. However, the monitoring of the epidemiological diseases shall be done by the Ministry of Health through the health centers, especially the health centers within the area of the irrigated land using the recovered water and sludge. Once there is indication of patient with symptom of the diseases mentioned above, the Ministry of Health shall report the case to PWA to investigate the water quality of the water

distribution network and sludge quality. The investigation should conclude the source of the infections or diseases.

When the source is due to the recovered water or sludge reuse, the emergency procedure shall be prepared by the PWA in coordination with CMWU to stop the distribution for further investigation. When the infections or diseases resulted from other source, the standard procedure of the Ministry of Health concerning the outbreak or endemic should be followed.

x. Contamination from Reuse and Disposal of Sludge (medium impacts)

When the sewage sludge fails to meet Rule 503 Class-A on sludge use requirements, it will pose hazardous health and environmental impacts if applied to the lands for agriculture use. The potential contamination will affect soil, air, groundwater and crops. If for some reason the sludge fails to meet Class-A requirements, it will be disposed in a landfill. The most probable impact is high concentration of pathogens (over 1000 cells/100 ml). High concentrations of heavy metals (higher than those in Class- A standards) are not expected as verified by the sludge analysis results.

Concerning the reuse of the recovered water and the reuse of the sludge at the same area proposed, according to the groundwater analysis and current measurement, the recovered water does not contain any possible health risk as well as heavy metal that could have a significant effect on crops. In addition, based on the sludge analysis and the treatment technology at NGWWTP and low content of heavy metal found, the sludge is already stabilized and predicted to meet the Class A rules for sludge reuse.

However, the importance parameter to be ensured for recovered water is the pH and for the sludge is the stability of the sludge. Using the combination of the recovered water and the sludge are not expected to have high significant negative impacts on crop and soil. In addition, with the sludge reuse implementation schedule, sludge monitoring plan and the groundwater monitoring plan implemented during the operation phase, the impact associated is considered low. The importance of the monitoring plan for sludge and recovered water are highly significant. Accordingly, with the possibility of lack of enforcement, the trained qualified personnel for management and monitoring plan has to be taken into consideration. The good management monitoring practice, documentations and reporting has to be well defined and prepared accordingly

Proposed mitigation measures for emergency situation when the sludge is not meeting the requirement of Rule 503 Class A include:

- Sludge not meeting these requirements should not be used for agricultural purposes and should be disposed to landfills.

- As a protection measure in this project, is limiting the sludge application for vegetables that are eaten uncooked despite the fact that Rule 503 Class A sludge allows sludge application for all types of vegetables.
- Adhering to the monitoring and testing requirements
- If the sludge does not meet the Class-A requirements especially with respect to pathogen concentration it should be mixed with lime (the same way that floating sludge is treated) and disposed to landfills.
- Training and guidance for farmers and sludge transporters regarding healthy handling and usage of sludge in agriculture.
- Some precautions to protect farmers are to wear suitable clothes, gloves and boots; washing before eating; and using a facemask if the sludge is dusty.
- Vehicles should be carefully selected for their local suitability and transport routes chosen so as to minimize inconvenience to the public. Special care must be taken to prevent vehicles carrying mud onto the highway.
- Enclosed trucks should be used for transporting treated sludge to prevent sludge spill and to avoid any odor release.
- Keeping good communication between customer, regulator, public and stakeholders including landowners and retailers.

NEGATIVE SOCIO ECONOMIC IMPACTS AND THEIR MITIGATIONS

- Decommission of the BLWWTP will reduce water that some of the farmers relied upon to water their plants. Indicating that their income might be affected that will be mitigated through: i) Provision of recovered water of a competitive price to minimize the potential impacts. ii) Due to the fact that the sewage untreated water should be banned, appropriate laws shall be developed to criminalize the use of untreated water
- Potential risk for the people in the adjacent areas due to having no fence around Pond #7 that might affect children. Mitigation measures will be through constructing fences.
- The use of lands might be limited due to the pond as having recreational activities; especially in case of not having a fence surrounding the pond #7. In addition, the construction of residential compounds in decommissioned area will be limited due to the existence of the pond. Again, the fence will be the most appropriate mitigation.
  - The construction of the carrier pipes will have negative impact due to noise and obstruction of traffic and use of agricultural land during the construction stages.

The project should reduce the disturbance to community using most appropriate environmental mitigation measures in addition to information sharing.

- Due to the unfavorable odor, mosquitoes and flies might affect the health of the adjacent communities. The flies should be combated using hygienic and environmentally friendly procedures.
- The sludge reuse for fertilizer might affect those who work in the chemical fertilizers sector in Gaza Strip, especially, those who import fertilizers. Integrating laborers in the new market could be an appropriate mitigation measure.
- Negative impact on the livelihood status of those who operate wells. Potential loss of income for those who own and operate the wells that will be closed due to project implementation. The laborers and the well owners might be affected severely. It could be mitigated by provision of appropriate compensation i.e. jobs or monetary.
- Put limitation to the plantation of certain crops in the beneficiaries who will use the recovered water. Orientation sessions should be presented to raise farmers awareness regarding the type of crops that should be planted using recovered water
- Expropriation for the areas of lands needed to construct the recovery well and lands needed for the project. The 27 well and the expansion of the treatment plant need about 18,175 m2 (please note, during the social investigation, the wells implementation considered was 27, as it was stated on the design report). Mitigation measures include protective procedures should be applied to limit the resettlements; avoiding small plots in order not to raise poverty and compensation should be paid in a full market price.

POTENTIALLY AFFECTED PARTIES

According to the ranking for the most affected groups who has no alternative livelihood approach were ranked and recognized as follow:

1. The Operators of wells (who are uneducated, untrained) might suffer due the termination of wells. They are maximum 10 people. The magnitude of their vulnerability shall be mitigated

2. The Owners of wells (who might be terminated) will be badly affected due to losing a valuable asset (the well), as well as, being in critical need for alternative source of water, which will cost a lot. In addition, some of them used to gain his income through selling water which will not be available (indicating that his income will be badly affected)
3. Those who Rent Lands from Awqaf for a few amount of money that includes the cost of water. They will be affected in sense of losing their lands and paying for water.
4. The Owners of small plots of lands who will be expropriated during the construction of the recovery wells. Some of them have small plot of lands that don't exceed one dunum. The wells will pass in the middle of such plots of lands and the remaining land will be too small for any use.
5. Other Project Affected Persons due to the implementation of the project during the construction activities

The mitigation of impacts described in detailed in the mitigation measures section. However the discussion of mitigation measures with the above mentioned affected groups based on the entitlement characteristics, any one that might be affected due to expropriation should be compensated. It is recommended to develop a Resettlement Action Plan in order to identify accurately the Project Affected Persons (PAPs), their entitlement, compensation valuation and mechanisms proposed for compensation.

Residual Impacts and Costs of Applying Mitigation Measure

This discussion will cover the whole potential impacts resulted due to land acquisition and expropriation during the preparation, construction and operation phase.

The estimated cost for applying the different activities related to the potential expropriation and land acquisition will be mainly based on:

- Cooperation with the municipalities and other organizations Negotiation with the Awqaf
- Negotiation with the affected people

Therefore, any budget estimations for such activities is based on non-solid rationale

Willingness to Pay, Cost Analysis and Tariff Survey

Surveys have been conducted for willingness to pay for the wastewater and sludge reuse, water distribution network and cost analysis including proposed tariffs for the effluent recovery. The result is a stand-alone report that is presented in Annex 8.

Regarding the increment cost of the reuse system, the draft vision toward the reuse system is under developed. The study includes tariff assessment; cost analysis for water reuse as well as the sludge reuse. However, the tariff survey and willingness to pay conducted under this study should be taken into consideration.

Resettlement Action Plan (RAP)

Based on findings and the consultant's recommendation in addition to the WB approval, the RAP should be prepared as a document due to the certainty of the OP 4.12 triggered.

Once the RAP ToR is cleared (by the donors), work towards the RAP is underway. In specific, the RAP should provide details on how the affected parties are identified, consulted on the project and the adverse impacts they will experience, the compensation, and the modes of grievance redress that is available to them. More specifically, detailed information on the operators of the wells (license or unlicensed), owners of wells, those who rent lands from the Awqaf should be developed, and owners of small plots of lands who will be affected /expropriated; permanently or temporary (due to the disturbances; i.e. land use and accessibility, traffic, etc) should be identified.

Project Alternative

Basically, the objectives of the Effluent Recovery and Reuse, in addition of decommissioning of BLLWTP and remediation works of Effluent Lake adjacent to BLWWTP is to improve the environmental, socio economic and public health conditions in Gaza Strip, especially at the project areas. Accordingly it is expected, by definition, that the environmental and social benefits will overweigh the impacts.

All the environmental and social negative impacts discussed are mainly site-specific and could be managed / minimized through implementing the proposed mitigation measures as described earlier. Comparing the benefits to the impacts in a strategic level, it could concluded that the "no project alternative" is not supported from the environmental and social perspective, given that the project impacts will be controlled as recommended in this ESIA.

In addition, the implementation shall be implemented and start to be operated before 2015, otherwise the recovery scheme will not be able to catch the pollution and they will affect the irrigation wells around the recovery wells.

Environmental and Social Management Plan (ESMP)

ESMP was developed to reduce or eliminate the negative impacts of the project component. The table of the ESMP both during construction and operation phase (environmental and social perspectives) are presented at the following tables (Table 1 – Table 3). The tables also include the monitoring plan, the institutional responsibility for inspection and monitoring including the budget proposed for management and monitoring proposed. The Institutional set up and the roles and responsibility for implementation and supervision during the construction and operation phase of the project components is presented on detailed on the main report of SESIA.

Grievances and Compensation

All grievances received verbally or in written shall be documented in a grievance register and handled by the PMU (PWA). It is of importance to react as quickly as possible to the grievance of the citizens. A best practice standard is to acknowledge all complaints within 10 days. Due to the different character of the complaints, some of them cannot be resolved immediately. In this case medium or long-term corrective actions are required, which need a formal procedure recommended to be implemented within 30 days:

1. The petitioner has to be informed of the proposed corrective measure.

2. In case if a corrective action is not required, the petitioner has also to be informed accordingly.

3. Implementation of the corrective measure and its follow up has to be communicated to the complainant and recorded in the grievance register

The comprehensive grievance mechanism including the institutional responsibility, monitoring, responses procedure and disclosure of the grievance is presented at the main report of the SESIA.

Cash flow, and their respective representations in the financial statements, represent the best explanatory force in providing the reader strong information related to the project performance to create a positive cash flow resulting from the current management processes and/or investment/financing processes. The analysis of cash flow also allows the analyst to verify the existence of proper financial balance between sources of raising investment and the use of the same.

A cash flow statement is a listing of the flows of cash into and out of the project: Revenues and subsidies/grant are the cash inflow, Investments and the costs are the cash outflows. The balance is net cash flow at a specific point in time.

Scenario 3 considers a situation where the construction costs relating to the work of recovery of the waters and of the wastewater reuse projects, provided both in Phase 1 and in 2 are paid in full by funds provided by Donors or the government. The other operating costs of the plant and the maintenance are, however, by paying a water tariff by farms benefiting from irrigation.

The basic aspects of financial and economic analysis, which Scenario 3 has been submitted, are summarized below.

A) Financial analysis

Farm-level investments for an estimated total of about 18.7 million ILS (orchard plants, plant irrigation adjustments etc.) have been graduated over a period of four years.

Staff training activities, much smaller in scope, were instead paid on the first year.

The civil works and the equipment of the recovery wells - tank and booster system, (30,83 million ILS) based on the executive design, were planned to be carried out between the first and the second year of the twenty-five years of the analysis. The 24th year will require procedures for the rebuilding of some of the equipment at the end of useful life, with an estimated cost of 10 mln ILS.

Investments for the implementation of the consortium irrigation network (99,33 million ILS) , to be carried out as a result of the progress of the previous work, are attributed to the second and third year, at the end of which can be considered the final construction stage.

So the project management phase begins. Even for the irrigation network, after twenty-five years, it will be necessary to partially reconstruct the less durable components of the plant.

In the gradual phase of the investment, the irrigation management phase begins with the project.

In the first 4 years, farmers will increase their costs due to the progressive introduction of orchards and greenhouses. From the 4th year, with the full production of orchards and greenhouses, costs and revenues are estimated constant for the remaining 21 years.

It should be considered that farm management costs include, of course, irrigation costs (in the net income statement the cost of irrigation on farms is calculated as the water tariff multiplied by cubic meters of irrigated water).

The water tariff includes the general costs of recover, distribution and control of the irrigation network.

With regard to the investments and the related management costs, the revenues of the project consist of:

- Farm revenues: are calculated on the basis of surveys and estimates carried out in the early months of the year even at project farms;
- Water tariff paid by Industry: 70,000 cubic meters of water per year, consumed by industrial activities in the area at a tariff of 2ILS / CM;
- From the time saving of the farmers, for the lack of irrigation water coming from private wells; These time savings have been prudently estimated, and the hours saved by farmers can be dedicated to the farm, or to other, paid jobs;
- Last but not least, payments by Government / Donors, after one year, come to cover the investments already made for the project under consideration.

The cash flow balance, obtained from the costs and revenues just described, leads to a highly positive result in financial terms. The result holds high values even during the simulations; These were carried out by applying incremental interest rates, at which two financial indicators (Financial Net Present Value and Benefit Cost Ratio), maintains full performance.

B) Economic Analysis

The components of economic analysis include investment and management costs, as highlighted in the previous chapter.

To these have been added:

- Correction of labour cost from financial to economic, consisting of the attribution of labour costs, linked to social costs, such as payroll & social security tax rate;
- VAT Investment Adjustment;
- VAT Revenues / Costs Adjustment.

From the sum of these amounts to the financial ones, an economic flow has been estimated, which, according to the present, shows a good robustness of the project. In fact, by performing

simulations with incremental interest rates, even economic analysis after the financial one keeps values steadily positive.

A cash flow statement is a listing of future flows of cash that occurred during the life of the project. A cash flow statement is not only concerned with the amount of the cash flows but also the timing of the flows. In this analysis, a forecast of expected flows and outflows for the next 25 years of project has been made.

ANNEX 5: BALANCE SHEET FOR INDIVIDUAL CROPS

Table 25: Balance sheet for Citrus

Citrus	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,800.00	1.72	***3,096.00***	
	Costs	**Q.ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	80.00	5.00	400.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.				
Plant Protection*	kg.	4.00	100.00	400.00	
irrigation	m3	827.20	1.50	1,240.80	
Harvesting Labour	dd	14.00	40.00	560.00	
Harvesting machinery	h				
Depreciation of the plant	**1,380**	duration yrs	35.00	39.43	
TOTAL				***2,990.23***	***105.77***
Labour & Enterprise					665.77

Table 26: Balance sheet for Olive

Olive	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
olive oil 50%		45.00	16.00		
tables olive %		300.00	4.00	***1,920.00***	
	Costs	**Q.ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	450.00	0.50	225.00	
Soil Disinfection	kg.				
Plant Protection	kg.	3.00	40.00	120.00	
irrigation	m3	705.10	1.50	1,057.65	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h	5.00	6.00	30.00	
Olive's milling	kg.	45.00	3.50	157.50	
Depreciation of the plant	**1,780**	duration yrs	40.00	44.50	
TOTAL				***2,274.65***	***-354.65***
Labour & Enterprise					-34.65

Table 27: Balance sheet for Peaches

Peaches	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		1,100.00	2.50	*2,750.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.				
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	628.60	1.50	942.90	
Harvesting Labour	dd	4.00	40.00	160.00	
Harvesting machinery	h				
Depreciation of the plant	1,980.00	duration yrs	35.00	56.57	
TOTAL				*2,129.47*	***620.53***
Labour & Enterprise					*780.53*

Table 28: Balance sheet for Grains

Grains	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		450.00	1.50	*675.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.33	60.00	79.80	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	100.00	0.50	50.00	
Irrigation pipes (/5 y)	ml	1400.00	0.70	196.00	
Plant Protection	kg.	4.00	15.00	60.00	
irrigation	m3	309.90	1.50	464.85	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h				
Seedings	kg.	20.00	2.25	45.00	
TOTAL				*1,415.65*	***-740.65***
Labour & Enterprise					*-420.65*

Table 29: Balance sheet for Other fruit crop

Other fruit crops	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		750.00	3.35	*2,512.50*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	2.50	60.00	150.00	
Chemical Fertilizers	kg.	60.00	5.00	300.00	
Organic Fertilizers	kg.	250.00	0.50	125.00	
Soil Disinfection	kg.				
Plant Protection	kg.	5.00	80.00	400.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting Labour	dd	8.00	40.00	320.00	
Harvesting machinery	h	5.00	6.00	30.00	
Depreciation of the plant	1,800.00	duration yrs	20.00	90.00	
TOTAL				*2,348.45*	**164.05**
Labour & Enterprise					**484.05**

Table 30: Balance sheet for Summer vegetables

Summer vegetables	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		5,000.00	0.80	*4,000.00*	
	Costs	Q,ty/du	NIS/unit.	NIS/dun	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	500.00	0.50	250.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	15.00	25.00	375.00	
irrigation	m3	650.10	1.50	975.15	
Harvesting Labour	dd	15.00	40.00	600.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				*2,822.15*	***1,177.85***
Labour & Enterprise					***1,777.85***

Table 31: Balance sheet for winter vegetables

Winter vegetables p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		3,000.00	1.30	***3,900.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	50.00	5.00	250.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	12.00	25.00	300.00	
irrigation	kg.	293.90	1.50	440.85	
Harvesting - Labour	dd	20.00	40.00	800.00	
Irrigation pipes (/5 y)	ml	800.00	0.70	112.00	
Seedings	kg.	1.00	60.00	60.00	
TOTAL				***2,412.85***	***1,487.15***
Labour & Enterprise					2,287.15

Table 32: Balance sheet for winter tomato greenhouses

winter tomato greenhouses p	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		7,000.00	1.50	***10,500.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	1.50	100.00	150.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	400.00	0.50	200.00	
Soil Disinfection	kg.	1.00	100.00	100.00	
Plant Protection	kg.	25.00	25.00	625.00	
irrigation	m3	141.80	1.50	212.70	
Harvesting - Labour	dd	30.00	40.00	1,200.00	
Harvesting - machinery	h				
Seedings	kg.	0.02	8,000.00	120.00	
Depreciation of greenhouse	mq	750.00	50.00	1,875.00	** 20 year*
TOTAL				***4,682.70***	***5,817.30***
Labour & Enterprise					7,017.30

Table 33: Balance sheet for Almond

Almond	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		180.00	8.00	***1,440.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	2.00	60.00	120.00	
Chemical Fertilizers	kg.	40.00	5.00	200.00	
Organic Fertilizers	kg.	300.00	0.50	150.00	
Soil Disinfection	kg.				
Plant Protection	kg.	8.00	25.00	200.00	
irrigation	m3	622.30	1.50	933.45	
Harvesting Labour	dd	3.00	40.00	120.00	
Harvesting machinery	h				
Depreciation of the plant	2,180.00	duration yrs	25.00	87.20	
TOTAL				***1,810.65***	***-370.65***
Labour & Enterprise					-250.65

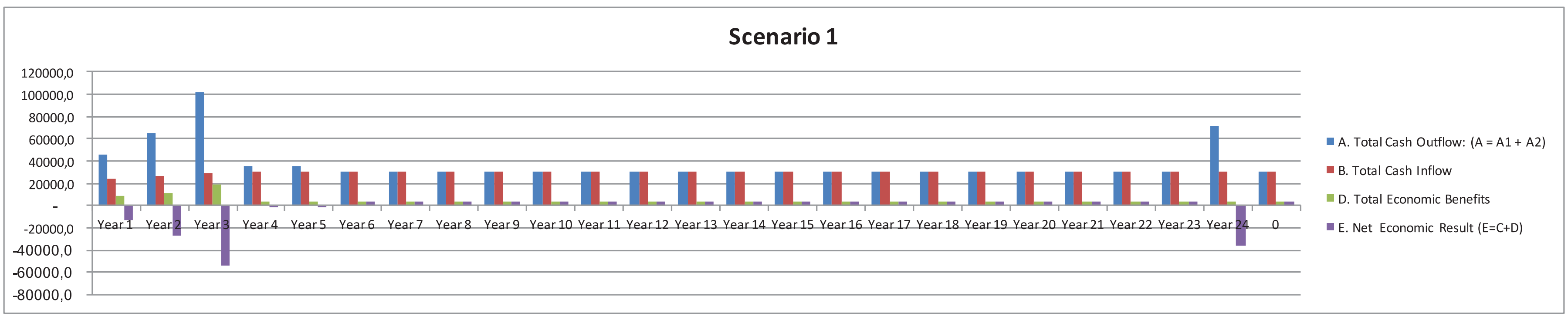
Table 34: Balance sheet for Alpha-Alpha

alpha-alpha	Revenues	Q.ty kg/du	NIS/kg	NIS/dun	*Margin*
		4,500.00	0.35	***1,575.00***	
	Costs	**Q,ty/du**	**NIS/unit.**	**NIS/dun**	
Tillage	n.	0.00	100.00		
Chemical Fertilizers	kg.	0.00	5.00		
Organic Fertilizers	kg.	0.00	0.50		
Soil Disinfection	kg.				
Plant Protection	kg.	0.00	25.00		
irrigation	m3	878.50	1.50	1,317.75	
Harvesting Labour	dd	6.00	40.00	240.00	
Harvesting machinery	h				
Depreciation of the plant	1,360.00	duration yrs	4.00	340.00	
TOTAL				***1,897.75***	***-322.75***
Labour & Enterprise					-82.75

ANNEX 6: DETAILS OF THE FINANCIAL AND ECONOMIC ANALYSES

SCENARIO 1 – FULL COST/SOLUTION 1

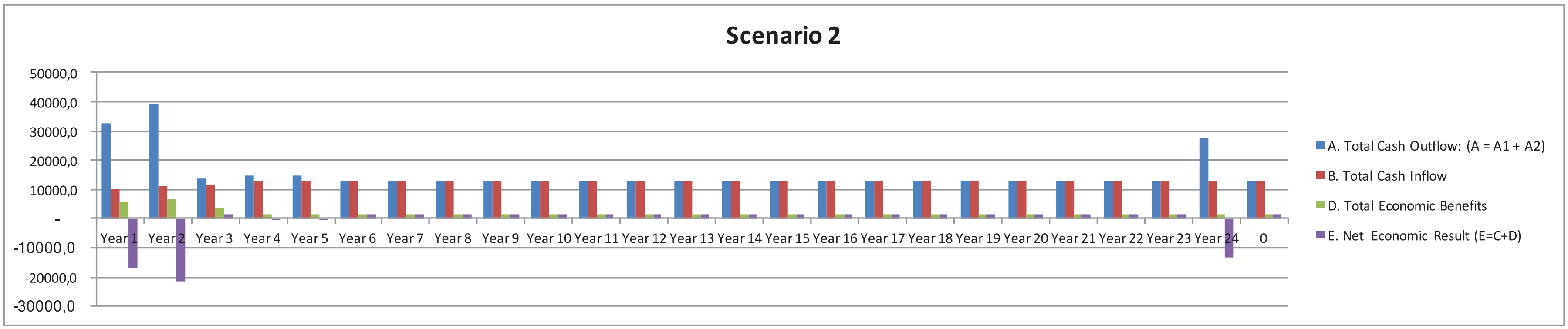
Value in ILS*000									=>																	
Details			**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (NIS)																											
A1. Capital Cost																											
Investment cost at Farm level				4,695	4,695	4,695	4,695																				
Training activities			1,456	1,456																							
Recovery wells tank ans booster			22,997	7,838																						10,000	
Irrigation network				27,161	72,169																					30,000	
A2. Operating Cost (Recurrent Expenses)																											
Farmers pay off the investment						3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742	3742
Cost at Farm level (including	1.50	ILS/CM)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment	*147,162*																										
A. Total Cash Outflow: (A = A1 + A2)	944,282		46,266	64,771	102,295	35,675	35,675	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	30,980	70,980	30,980
B. Benefit: Cash inflow: (NIS)																											
Direct & indirect benefit																											
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 cr *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors																											
Subsidies			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Total Cash Inflow	757,216		24,695	26,721	28,748	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-187,067		-21,572	-38,050	-73,547	-4,900	-4,900	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-205	-40,205	-205
Financial Internal Rate of Return	#NUM!		FNPV@3%	-155,002	BCR@3%	0.772																					
Scenario 1 full stage investment			FNPV@5%	-140,864	BCR@5%	0.750																					
			FNPV@7%	-130,096	BCR@7%	0.728																					
D. Economic Valuation																											
Economic benefit																											
Correction of labour cost from financial to economic			2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement			3680	5600	11547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement			1729	1871	2012	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits			8,238	11,138	19,552	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)			-13,333	-26,912	-53,994	-996	-996	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	3,700	-36,300	3,700
Economic Internal Rate of Return	#NUM!		ENPV@3%	-61,667	BCR@3%	0.909																					
Scenario 1 full stage investment			ENPV@5%	-61,628	BCR@5%	0.891																					
			ENPV@7%	-61,454	BCR@7%	0.871																					



SCENARIO 2 – FULL COST/SOLUTION 2

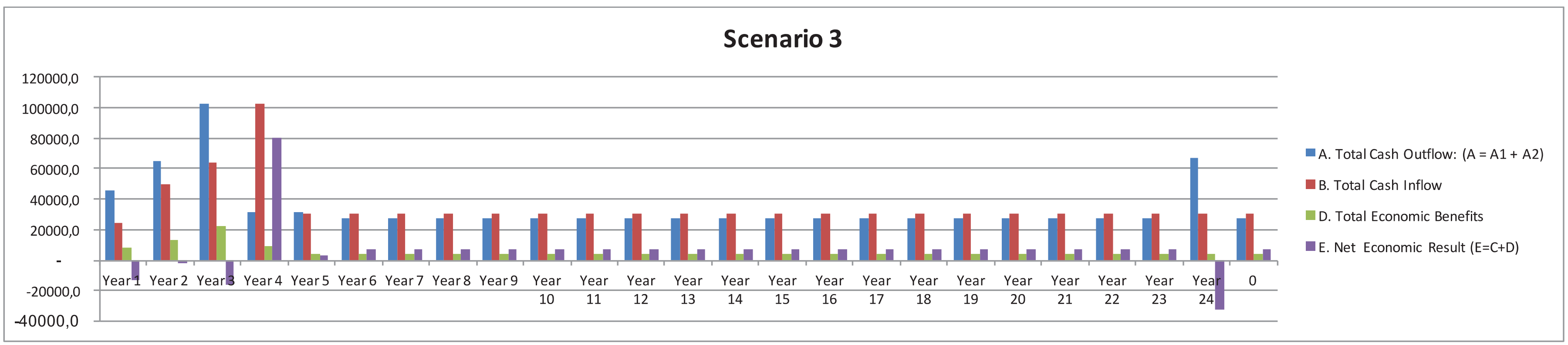
Details			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6
Value in ILS*000									=>
A. Cost: Cash outflow: (ILS)									
A1. Capital Cost									
Investment cost at Farm level				1,925	1,925	1,925	1,925		
Training activities			597	597					
Recovery wells - tank ans booster system			22,997						
Irrigation network				27,161					
A2. Operating Cost (Recurrent Expenses)									
Farmers pay off the investment					1492	1492	1492	1492	1492
Cost at Farm level (including water tariff	1.50	ILS/CM)	8,944	9,685	10,426	11,168	11,168	11,168	11,168
Total investment	57,126								
A. Total Cash Outflow: (A = A1 + A2)	383,109		32,537	39,367	13,843	14,585	14,585	12,660	12,660
B. Benefit: Cash inflow: (NIS)									
Direct & indirect benefit									
Revenue at Farm level			9,798	10,629	11,460	12,291	12,291	12,291	12,291
Water tariff paid by industry 40,000 cm *	2.0	ILS/CM	80	80	80	80	80	80	80
Time saved for non management of private wells			269	269	269	269	269	269	269
Paid by Government/Donors									
Subsidies			0	0	0	0	0	0	0
B. Total Cash Inflow	311,023		10,147	10,978	11,809	12,640	12,640	12,640	12,640
C. Cash Flow Results: (C=B-A)	-72,085		-22,390	-28,389	-2,034	-1,944	-1,944	-19	-19
Financial Internal Rate of Return	#NUM!		FNPV@3%	-61,389	BCR@3%	0.778			
Scenario 2 only Phase I investment			FNPV@5%	-56,792	BCR@5%	0.753			
			FNPV@7%	-53,353	BCR@7%	0.728			
D. Economic Valuation									
Economic benefit									
Correction of labour cost from financial to economic			1160	1504	2457	718	718	718	718
VAT Investment Adjustement			3680	4346	0	0	0	0	0
VAT Revenues/Costs Adjustement			710	768	827	885	885	885	885
D. Total Economic Benefits			5,550	6,618	3,284	1,602	1,602	1,602	1,602
E. Net Economic Result (E=C+D)			-16,840	-21,771	1,250	-342	-342	1,583	1,583
Economic Internal Rate of Return	#NUM!		ENPV@3%	-23,386	BCR@3%	0.915			
Scenario 2 only Phase I investment			ENPV@5%	-24,446	BCR@5%	0.894			
			ENPV@7%	-25,237	BCR@7%	0.871			

Details	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Recovery wells - tank ans booster system																	5,000	
Irrigation network																	10,000	
Farmers pay off the investment	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492	1492
Cost at Farm level (including water tariff	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168	11,168
A. Total Cash Outflow: (A = A1 + A2)	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	12,660	27,660	12,660
Revenue at Farm level	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291	12,291
Water tariff paid by industry 40,000 cm *	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80
Time saved for non management of private wells	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269	269
Subsidies	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
B. Total Cash Inflow	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640	12,640
C. Cash Flow Results: (C=B-A)	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-19	-15,019	-19
Correction of labour cost from financial to economic	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718	718
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885	885
D. Total Economic Benefits	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602	1,602
E. Net Economic Result (E=C+D)	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	1,583	-13,417	1,583



SCENARIO 3: CAPITAL SUBSIDIES

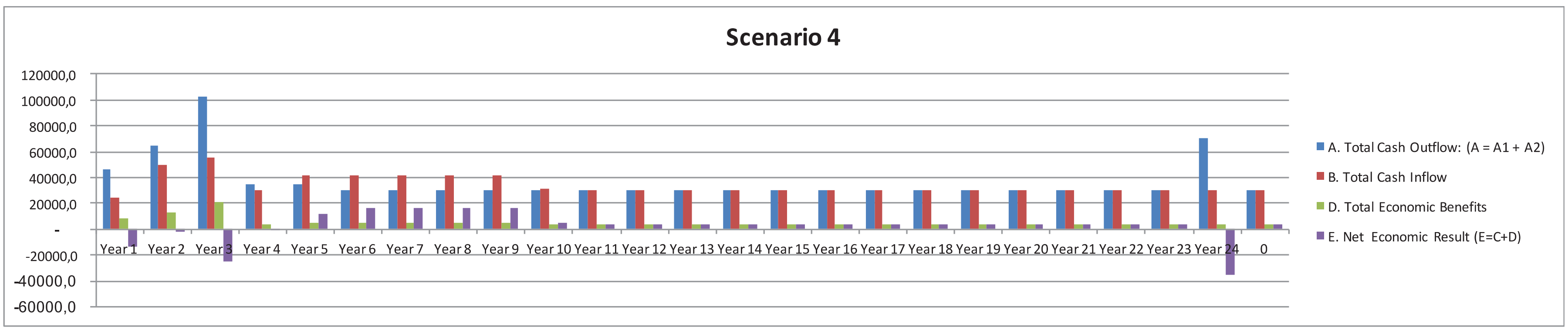
Value in ILS*000										=>																	
Details			**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)																											
A1. Capital Cost																											
Investment cost at Farm level				4,695	4,695	4,695	4,695																				
Training activities			1,456	1,456																							
Recovery wells tank ans booster system			22,997	7,838																						10,000	
Irrigation network				27,161	72,169																					30,000	
A2. Operating Cost (Recurrent Expenses)																											
Cost at Farm level (including water tariff= 1.50	ILS/CM	)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total Investment	*147,162*																										
A. Total Cash Outflow: (A = A1 + A2)	**861,958**		46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
B. Benefit: Cash inflow: (NIS)																											
Direct & indirect benefit																											
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by Industry 70,000 cm *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors				22,997	34,999	72,169																					
Subsidies																											
B. Total Cash Inflow	**887,381**		24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**40,663**		-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
Financial Internal Rate of Return	**10.82%**		FNPV@3%	**17,400**	BCR@3%	**1.028**																					
Scenario 3 Capital cost payd by Donors			FNPV@5%	**12,152**	BCR@5%	**1.023**																					
			FNPV@7%	**7,405**	BCR@7%	**1.017**																					
D. Economic Valuation																											
Economic benefit																											
Correction of labour cost from financial to economic			2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement			3680	5600	11547	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement			1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits			8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)			-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442
Economic Internal Rate of Return	**61.68%**		ENPV@3%	**118,983**	BCR@3%	**1.190**																					
Scenario 3 Capital cost payd by Donors			ENPV@5%	**99,119**	BCR@5%	**1.190**																					
			ENPV@7%	**83,307**	BCR@7%	**1.188**																					



SCENARIO 4 - CAPITAL AND O&M SUBSIDIES/SOLUTION 1

Value in ILS*000										=>						
Details			Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12
A. Cost: Cash outflow: (ILS)															
A2. Operating Cost (Recurrent Expenses)															
Farmers pay off the investment						3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta	1.50	ILS/CM)	21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment	147,162														
A. Total Cash Outflow: (A = A1 + A2)	931,258		46,266	64,771	102,295	35,083	35,083	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388
B. Benefit: Cash inflow: (NIS)															
Direct & indirect benefit															
Revenue at Farm level			23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 m³ *	2.0	ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells			657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors				22,997	27,161										
Subsidies				3,433	6,866	11,443	11,443	11,443	11,443	11,443	11,443	1,047			
B. Total Cash Inflow	865,637		24,695	49,718	55,909	30,775	42,218	42,218	42,218	42,218	42,218	31,822	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	-28,331		-21,572	-15,053	-46,386	-4,308	7,135	11,831	11,831	11,831	11,831	1,434	387	387	387
Financial Internal Rate of Return	#NUM!		FNPV@3%	-52,493	BCR@3%	0.922		investm. Phase II	80,007						
Scenario 4 Capital cost phase 1 paid by government subsidies for 9 years to farmer payd capital cost pha			FNPV@5%	-48,408	BCR@5%	0.913		subsidies	80,007						
			FNPV@7%	-46,166	BCR@7%	0.902		9 year of subsidies							
D. Economic Valuation															
Economic benefit															
Correction of labour cost from financial to economic			2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement			3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement			1729	3480	3914	2154	2955	2955	2955	2955	2955	2228	2154	2154	2154
D. Total Economic Benefits			8,238	12,748	21,454	3,904	4,705	4,705	4,705	4,705	4,705	3,978	3,904	3,904	3,904
E. Net Economic Result (E=C+D)			-13,333	-2,305	-24,932	-404	11,841	16,536	16,536	16,536	16,536	5,412	4,292	4,292	4,292
Economic Internal Rate of Return	18.55%		ENPV@3%	47,413	BCR@3%	1.071									
Scenario 4 Capital cost phase 1 paid by government subsidies for 9 years to farmer payd capital cost pha			ENPV@5%	36,828	BCR@5%	1.066									
			ENPV@7%	27,978	BCR@7%	1.059									

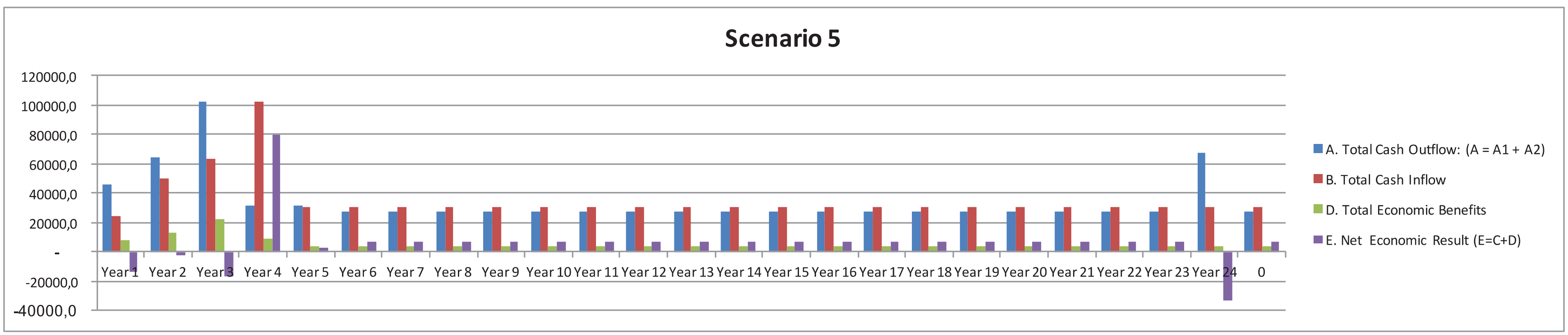
Details	Year 13	Year 14	Year 15	Year 16	Year 17	Year 18	Year 19	Year 20	Year 21	Year 22	Year 23	Year 24
Farmers pay off the investment	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150	3150
Cost at Farm level (including water ta	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
A. Total Cash Outflow: (A = A1 + A2)	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	30,388	70,388	30,388
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 m³ *	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Subsidies				0								
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	387	387	387	387	387	387	387	387	387	387	-39,613	387
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	4,292	-35,708	4,292



SCENARIO 5 - CAPITAL AND O&M SUBSIDIES/SOLUTION 2

Value in ILS*000								=>						
Details		**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**	**Year 7**	**Year 8**	**Year 9**	**Year 10**	**Year 11**	**Year 12**
A. Cost: Cash outflow: (ILS)														
A1. Capital Cost														
Investment cost at Farm level			4,695	4,695	4,695	4,695								
Training activities		1,456	1,456											
Recovery wells tank ans booster system		22,997	7,838											
Irrigation network			27,161	72,169										
A2. Operating Cost (Recurrent Expenses)														
Cost at Farm level (including water tariff= 1.50 ILS/CM)		21,814	23,622	25,430	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment	*147,162*													
A. Total Cash Outflow: (A = A1 + A2)	**861,958**	46,266	64,771	102,295	31,933	31,933	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
B. Benefit: Cash inflow: (NIS)														
Direct & indirect benefit														
Revenue at Farm level		23,898	25,924	27,951	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 m³ * 2.0 ILS/CM		140	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells		657	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors			22,997	34,999	72,169									
Subsidies			3,433	6,866	8,483					0	0	0	0	0
B. Total Cash Inflow	**887,381**	24,695	49,718	63,747	102,945	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	**40,663**	-21,572	-15,053	-38,548	71,011	-1,158	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537
Financial Internal Rate of Return	**10.82%**	FNPV@3%	**17,400**	BCR@3%	**1.028**	investm. Fram level		8,782						
Scenario 5 Capital cost payd by government and and O&M payd by government until repa		FNPV@5%	**12,152**	BCR@5%	**1.023**	subsidies		8,782						
		FNPV@7%	**7,405**	BCR@7%	**1.017**	3 year of subsidies								
D. Economic Valuation														
Economic benefit														
Correction of labour cost from financial to economic		2830	3668	5993	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement		3680	5600	11547	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement		1729	3480	4462	7206	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits		8,238	12,748	22,002	8,956	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)		-13,333	-2,305	-16,546	79,967	2,746	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442
Economic Internal Rate of Return	**61.68%**	ENPV@3%	**118,983**	BCR@3%	**1.190**									
Scenario 5 Capital cost payd by government and and O&M payd by government until repa		ENPV@5%	**99,119**	BCR@5%	**1.190**									
		ENPV@7%	**83,307**	BCR@7%	**1.188**									

Details	**Year 13**	**Year 14**	**Year 15**	**Year 16**	**Year 17**	**Year 18**	**Year 19**	**Year 20**	**Year 21**	**Year 22**	**Year 23**	**Year 24**
A. Cost: Cash outflow: (ILS)												
A1. Capital Cost												
Investment cost at Farm level												
Training activities												
Recovery wells tank ans booster system											10,000	
Irrigation network											30,000	
A2. Operating Cost (Recurrent Expenses)												
Cost at Farm level (including water tariff= 1.50 ILS/CM)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238
Total investment												
A. Total Cash Outflow: (A = A1 + A2)	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	27,238	67,238	27,238
B. Benefit: Cash inflow: (NIS)												
Direct & indirect benefit												
Revenue at Farm level	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978	29,978
Water tariff paid by industry 70,000 m³ * 2.0 ILS/CM	140	140	140	140	140	140	140	140	140	140	140	140
Time saved for non management of private wells	657	657	657	657	657	657	657	657	657	657	657	657
Paid by Government/Donors												
Subsidies	0	0	0	0	0	0	0	0	0	0		
B. Total Cash Inflow	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775	30,775
C. Cash Flow Results: (C=B-A)	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	3,537	-36,463	3,537
D. Economic Valuation												
Economic benefit												
Correction of labour cost from financial to economic	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750	1750
VAT Investment Adjustement	0	0	0	0	0	0	0	0	0	0	0	0
VAT Revenues/Costs Adjustement	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154	2154
D. Total Economic Benefits	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904	3,904
E. Net Economic Result (E=C+D)	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	7,442	-32,558	7,442



IRRIGATION NETWORK BILL OF QUANTITIES ZONE A.1	
Bill. No. 1 - General items	$51,000.00
Bill. No. 2 - Pipeline	$8,233,180.00
Bill. No. 3 - Spareparts	$5,000.00
Bill. No. 4 - Design. Test Runs, Training Works	$13,300.00
Bill. No. 5 - Design and Build fire fighting network and alarm system	$140,000.00
TOTAL COST OF THE PROJECT - PHASE A.1	**$8,442,480.00**

IRRIGATION NETWORK BILL OF QUANTITIES ZONE A.2	
Bill. No. 1 - General items	$51,000.00
Bill. No. 2 - Pipeline	$6,557,160.00
Bill. No. 3 - Spareparts	$5,000.00
Bill. No. 4 - Design. Test Runs, Training Works	$10,800.00
Bill. No. 5 - Design and Build fire fighting network and alarm system	$80,000.00
TOTAL COST OF THE PROJECT - PHASE A.2	**$6,703,960.00**

IRRIGATION NETWORK BILL OF QUANTITIES ZONE B.1	
Bill. No. 1 - General items	$51,000.00
Bill. No. 2 - Pipeline	$5,078,715.00
Bill. No. 3 - Spareparts	$7,000.00
Bill. No. 4 - Design. Test Runs, Training Works	$11,000.00
Bill. No. 5 - Design and Build fire fighting network and alarm system	$90,000.00
TOTAL COST OF THE PROJECT - PHASE B.1	**$5,237,715.00**

IRRIGATION NETWORK BILL OF QUANTITIES ZONE B.2	
Bill. No. 1 - General items	$49,000.00
Bill. No. 2 - Pipeline	$310,340.00
Bill. No. 3 - Spareparts	$3,000.00
Bill. No. 4 - Design. Test Runs, Training Works	$5,000.00
TOTAL COST OF THE PROJECT - PHASE B.2	**$367,340.00**

TOTAL COST OF PROJECT (A)	**$15,146,440.00**
TOTAL COST OF PROJECT (B)	**$5,605,055.00**
TOTAL COST OF PROJECT (A+B)	**$20,751,495.00**