SUB-ASSESSMENT REPORT:

WATER STORAGE AND IRRIGATION

TABLE OF CONTENT

List of figures

List of tables

1. SUB-ASSESSMENT SCOPE AND METHODOLOGY

1.1 Introduction [1]

Viet Nam is located in the eastern part of the Southeast-Asian peninsula, bordered by China in the north, the East Sea in the east and south, the Gulf of Thailand in the southwest, and Cambodia and Lao People's Democratic Republic in the west. The total area of the country is 330,967km2, including 21,140km2 of water. The land border is 4,616km long and the coastline (excluding islands) 3,444km. The narrowest point is only 50km wide. The country has two major deltas; the Red River Delta in the North and the Mekong Delta in the South. Together with the coastal areas, these deltas have the largest concentration of people and arable land. Mountains, hills and plateaus cover more than three-quarters of the country, although over 70 percent of the country lies below 500m above sea level. About 25 percent of the total land area is covered by lowlands or plains.

Administratively, the country is divided into 64 provinces including the capital Hanoi and the main economic hubs of Ho Chi Minh City, Hai Phong, Da Nang and Can Tho. Based on topographic, climatic and socio-economic conditions, the country is sub-divided into eight regions: North-West, North-East, Red River Delta, North Central Coast, South Central Coast, Central Highlands, the South-East and the Mekong River Delta (figure 1). Each of these has its distinct climate, agro-ecological and socio-economic profile, with large spatial differences.

30.9 percent of the total land or 102,317km2 is agricultural production land for annual crops, rice, perennial and other crops; 40.4 percent or 137,965km2 is forestry land (with 101,002km2 natural forest and 36,963km2 planted forest) and 3.2 percent or 10,682km2 are rivers and water bodies. Most agricultural land is located in the two major deltas, coastal areas and the Central Highlands plateaus.

Project target areas are focused on five provinces in two regions: the Central Highlands and the South Central Coast (figure 1). The Central Highlands consists of five provinces, including Dak Lak, Dak Nong, Gia Lai, Kon Tum and Lam Dong – with the project targeting Dak Lak and Dak Nong. The total land area of the Highlands region is 54,659.6km2, and of the two provinces 1,954km2. In terms of topography, the region forms the eastern part of a series of contiguous plateaus located 500m up to 1,500m above sea level, expanding to the south of Lao People's Democratic Republic and north-east of Cambodia. The plateaus are surrounded by the South Annamite mountain range. Around 44.4 percent of the land is agricultural land, with Gia Lai and Dak Lak having the largest agricultural land area. Around 45.8 percent of the total land area is forestry land.

The South Central Coast consists of one major city, Da Nang, and seven provinces, including Quang Nam, Quang Ngai, Binh Dinh, Phu Yen, Khanh Hoa, Ninh Thuan and Binh Thuan – with the project targeting the latter three provinces which form the most southern part of this region. The total land area of the region is 44,367km2, with the total for the three provinces 1,643.7km2. This region has a complex topography with different upland and lowland areas, forests, dunes, and sandy and rocky soils. The highest mountains in the southern part of this region, bordering the Central Highlands, can reach up to 1000m. Around 24.9 percent of the land in the entire region is agricultural land, with Binh Thuan having the largest agricultural land area. Around 53.3 percent of the total land area is forestry land.

1.2 Weather and climate

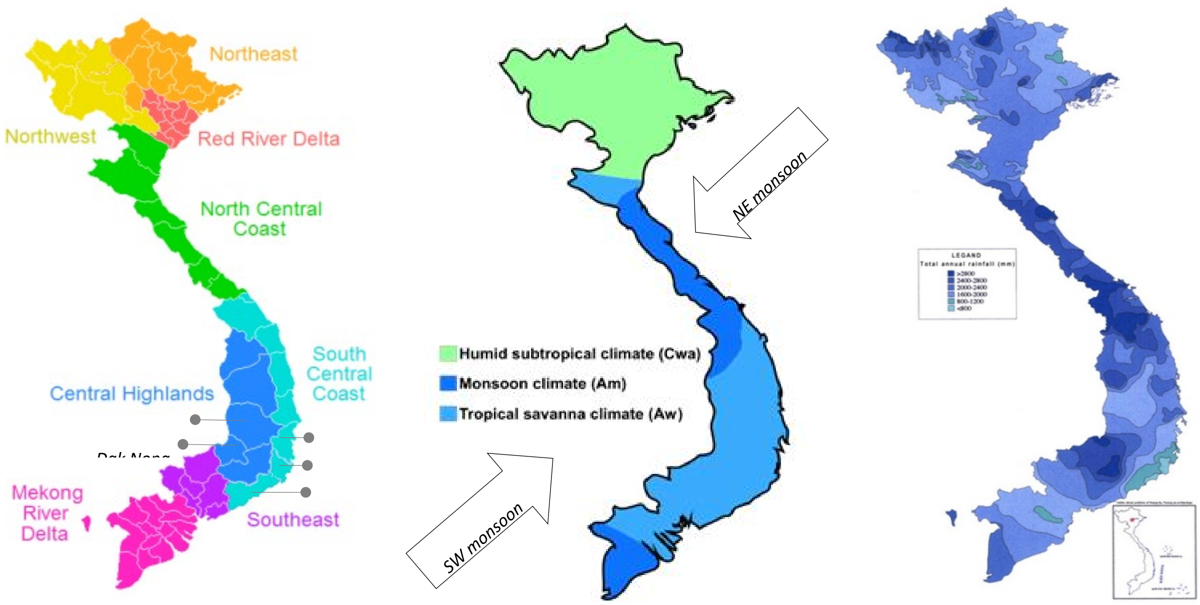
Viet Nam is characterized by a humid subtropical climate with four separate seasons – spring, summer, autumn and winter – in the north and a tropical savanna climate with only two seasons – dry and wet – in the south. The climate is strongly affected by two monsoons, the North-East 'winter' monsoon (December-March) and the South-West 'summer' monsoon (June-September) (figure 2), bringing strong winds, enhanced precipitation and heavy rainfall events.

The complex topography of the country results in strong spatial variations in temperature and rainfall, particularly during the monsoon seasons. Average annual precipitation is around 1,820mm. It varies from an average 1,600-2,200mm in the midlands and plains to 2,000-2,500mm in the mountainous areas. The rainy season lasts from April-May to October-November. The dry season lasts either from December to February or from January to March depending on the specific location. The driest area is in the southern region of the South Central Coast (figure 2). Average temperature varies from 15°C in winter to 25°C in summer. Temperature during the hottest days is 38-40°C and during the coldest days 11-14°C, in the north. Humidity level varies from 80 to 100 percent.

1 Data source: General Statistics Office (GSO) of Viet Nam. Statistical Yearbook 2015. http://www.gso.gov.vn.

Figure 1: Project target areas in Central and Central Highlands

Figure 2: Regions of Viet Nam – indicating target provinces[2] (left), Climate zones in Viet Nam[3] (center) and Average annual precipitation in Viet Nam[4] (right)



2 Map based on GSO classification: https://commons.wikimedia.org/wiki/File:VietnameseRegions.png.

3 https://commons.wikimedia.org/wiki/File:Vietnam_map_of_K%C3%B6ppen_climate_classification.svg.

4 http://www.apipnm.org/swlwpnr/reports/y_ta/z_vn/vnmp131.htm.

Viet Nam's weather and climate are also influenced by the El Niño Southern Oscillation (ENSO) climate system. During El Niño years, the monsoon influence weakens and the central and southern regions of Viet Nam deal with 10 to 30 percent less rainfall than usual and an increased drought risk. Conversely, during La Niña years the monsoon is strengthened and the total rainfall for the same regions increases by about 10 percent compared to usual, increasing flood and landslide risks.[5] In addition, storm frequency and intensity increases in the year after an El Niño as oceans have warmed up more than usual. The strongest El Niño episodes so far – in order of intensity - have been in 2015-16, 1997-98 and 1982-83, while the strongest La Niña episodes in 1973-74, 1988-89 and 1975-76.[6]

Central Highlands and South Central Coast

Both the Central Highlands and South Central Coast are located in the tropical climate zone, but have several local sub-climate zones due to the varied topography: upland or mountainous areas are on average wetter, lowland and coastal areas are drier, and the plateau regions of the Highlands are in between.[7]

The annual rainfall in the Central Highlands ranges from 1400mm to 2000mm. Monthly rainfall is highest from May to October, accounting for about 80 percent of the annual amount. The average monthly rainfall during the rainy season exceeds 200mm and reaches its peak in August and September. The air temperature is lower in comparison with other regions, ranging from 21°C to 24°C. The maximum temperatures are in April and May and can reach up to 27°C to 31°C.

Figure 3: Average monthly temperature and rainfall over the period 1901-2015, Krong Buk Ha reservoir, Krong Pak district, Dak Lak province 8

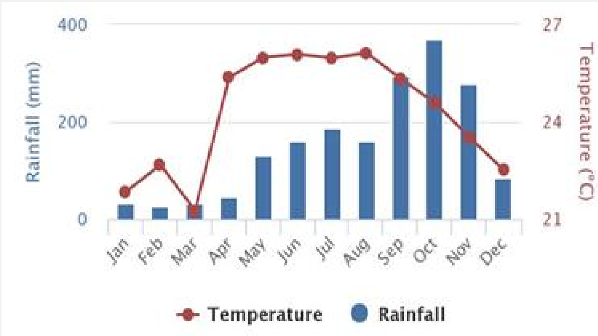
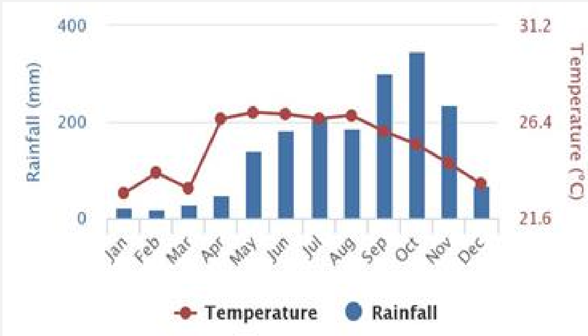


Figure 4: Average monthly temperature and rainfall over the period 1901-2015, Dak Rong reservoir, Cu Jut zdistrict, Dak Nong province



The annual rainfall in the South-Central Coast ranges from 700 to 800mm in the lowlands to 1,300mm in the upland areas, with 90 percent of it provided during the wet season. The most northern part of the region is one of the wettest in Viet Nam, while the southern part – with Khanh Hoa, Ninh Thuan and Binh Thuan – the driest. Monthly rainfall in the three provinces is highest from May to November. The average monthly rainfall during the rainy season is around 200-350mm and reaches its peak in September-October. Some of the driest areas having six to nine dry months a year with less than 500mm annual rainfall. The average air temperature is between 22°C and 26°C, with highest in April and May, from 26°C to 28°C.

5 Thang Van Vu, Hieu Trong Nguyen Thang Van Nguyen, Hiep Van Nguyen, Huong Thi Thanh Pham, and Lan Thi Nguyen (2015). Effects of ENSO on Autumn Rainfall in Central Vietnam, and Thang Van Vu (2016). Characteristics of moisture transport in ENSO events in Vietnam. Vietnam Institute of Meteorology, Hydrology and Climate Change, Ministry of Natural Resources and Environment.

6 El Niño Theme Page, https://www.pmel.noaa.gov/elnino/status.

7 FAO (2016). Viet Nam Country Profile.

8 Source for all temperature and rainfall graphs: World Bank Climate Change Knowledge Portal, http://sdwebx.worldbank.org/climateportal/.

Figure 5: Average monthly temperature and rainfall over the period 1901-2015, Duc Linh district, Binh Thuan province

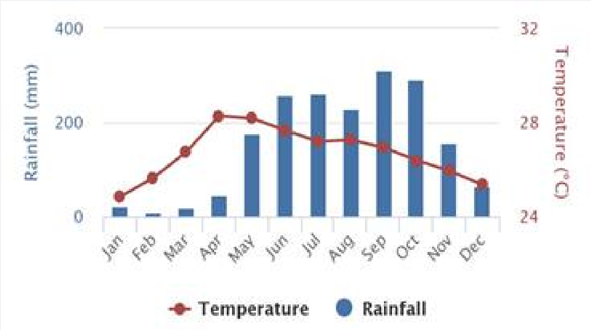


Figure 6: Average monthly temperature and rainfall over the period 1901-2015, southern part of Bac Ai district, Ninh Thuan province

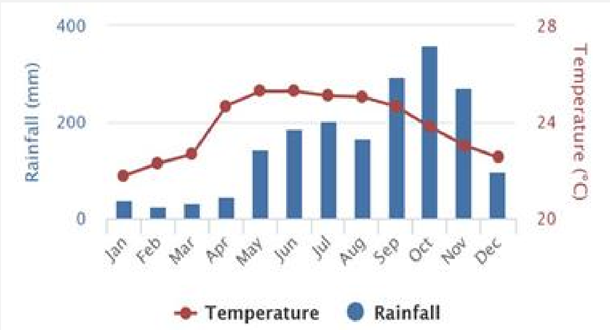
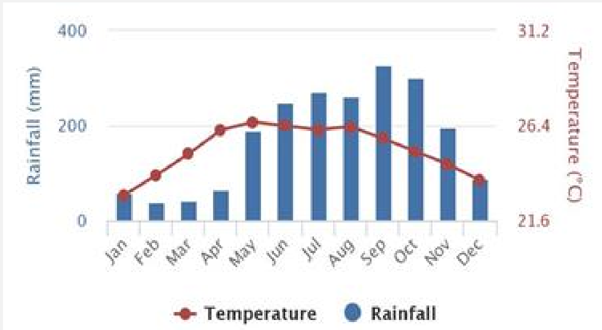


Figure 7: Average monthly temperature and rainfall over the period 1901-2015, Cam Ranh district, Khanh Hoa province



1.3 Observed and projected climate variability and change

1.3.1 Viet Nam

Viet Nam is one of the countries in the world most at risk of damage and loss from weather-related hazards. Germanwatch' Climate Risk Index 2017 identifies Viet Nam as the eight most affected country based on loss from weather-related events from 1996 to 2015.[9] Every year the country is affected by a range of hydro-meteorological and climatological hazards: droughts and forest fires during January-April; (tropical, hail and wind) storms, (coastal, riverine, flash) floods, heavy rainfall and landslides in June-December and extreme temperatures (cold and heat waves) throughout the year.[10]

According to the Government of Viet Nam (GoV)'s Central Committee for Natural Disaster Prevention and Control (CCNDPC), disasters have caused an average of 313 deaths, 1.7 million affected people and US$872 million economic loss per year over the past decade, with floods and storms causing the most damage to human health, livelihoods and infrastructure. Overall, the number of deaths is decreasing while the economic losses from disasters increasing, but with large spatial and inter-annual variability. Increased exposure of people and economic assets has been the major cause of long-term increases in economic losses from weather- and climate-related disasters.[11]

The year 2016 was particularly severe, with an acute El Niño-induced drought and saline intrusion affecting a third of the country, followed by a sequence of typhoons, tropical depressions and heavy rainfall events causing flooding in the North and South Central Coast and Central Highlands regions. In 2016 alone, more than 2.2 million people were affected, 230 people lost their lives, and an estimated US$1.7 billion of damage and loss occurred, or approximately 0.83 percent of the country's Gross Domestic Product.[12]

---

9 Sonke Kreft, David Eckstein and Inga Melchior (November 2016). Global Climate Risk Index 2017. Who Suffers Most From Extreme Weather Events? Weather-related Loss Events in 2015 and 1996 to 2015. Briefing Paper. www.germanwatch.org/en/cri.

10 Classification by the Centre for Research on the Epidemiology of Disasters's Emergency Events Database, http://www.emdat.be/classification.

11 Institute of Meteorology, Hydrology and Climate Change (IMHEN) and UNDP (February 2015). Viet Nam Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptaton. Summary for Policymakers.

12 Central Committee for Natural Disaster Prevention and Control (2017). Annual Disaster Report 2016.

In addition to disaster risks, Viet Nam is also particularly vulnerable to climate change and already impacted by more irregular and intense climate variability and change. When considering climate change exposure, sensitivity and the capacity to adapt, the country is consistently classified as under 'very high risk' or 'extreme risk'.[13]

The most recent GoV Climate Change and Sea Level Rise Scenarios developed by the Ministry of Natural Resources and Environment (MoNRE) in 2016, describe the **already observed changes** in climate and weather-related events as follows: [14]

1.3.2 Central Highlands

Current observed changes in climate and weather-related events in the Central Highlands, based on available data for the period 1960-2010, show the following trends and patterns: [15]

TEMPERATURE INCREASE

A significant trend of about 0.04 to 0.35°C temperature increase per decade (figure 13). While maximum daily temperature has not shown any changes, minimum daily temperature has shown significant increases. Minimum temperature increased from approximately 0.18°C per decade in Da Lat (South Central Highlands) to 0.65°C per decade in Kon Tum (North Central Highlands).

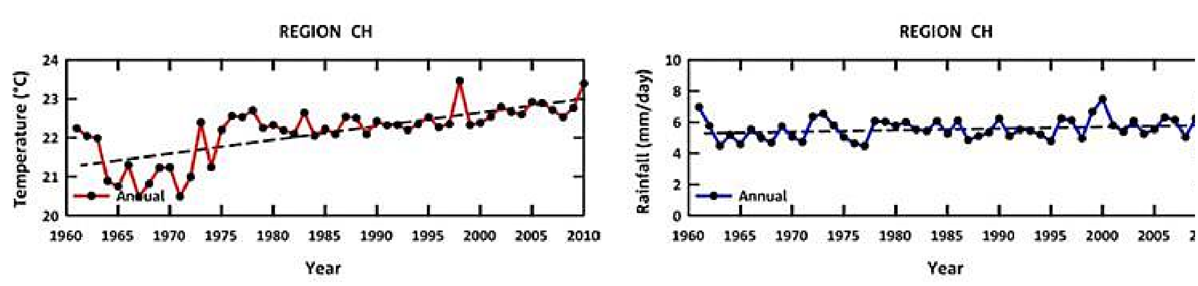
More hot days and fewer cool nights. While the maximum daily temperature has no increasing trend, the number of extreme hot days has increased by about nine days per decade, and the number of extreme cool days decreased by about eight days per decade.

CHANGING PRECIPITATION PATTERNS

Overall slight increase in annual rainfall but with variations per location, with some showing significant increase while others little change or even no decrease (figure 13).

Increased extreme rainfall amounts. Annual maxima of 1-day and 5-day rainfall amounts have increased by around 12 and 9 percent respectively. The number of very wet days has also increased significantly by up to 2 days per decade.

Figure 8: Mean surface air temperature and rainfall trends from 1961 to 2011, Central Highlands [16]



DROUGHT AND FLOOD RISK

For the entire Central Highlands region, the most frequent disaster events have been heavy rainfall with floods, storms, landslides and drought.

Over the period 1989-2010, Dak Lak has been affected by 19 heavy rainfall and flood events, 4 storms, 7 hailstorms and 1 landslide; while Dak Nong has been affected by 4 floods, 2 hailstorms and 1 storm.[17]

Droughts are becoming more severe and are impacting a larger area than before (figure 14 and 15). For example, the area most severely impacted by the recent drought in 2015-2016 was 2.1 to 2.5 times

13 The World Risk Index ranks Viet Nam as 18th most at-risk in the world, under the category of 'very high risk', see: Alliance Development Works, United Nations University Institute for Environment and Human Security (2016). World Risk Report 2016. Focus: Logistics and Infrastructure. www.WorldRiskReport.org. The Climate Change Vulnerability Index ranks Viet Nam 13th, under the category of 'extreme risk', see: Maplecroft (2011). Climate Change Risk Atlas 2011. maplecroft.com/about/news/ccvi.html.

14 MoNRE (2016). Climate Change and Sea Level Rise Scenarios for Viet Nam. Summary for Policy Makers. Triangulated with: IMHEN, UNDP (Ibid.), and J.J. Katzfey, J.L. McGregor, and R. Suppiah (2014). High-resolution Climate Projections for Vietnam. Technical Report. IMHEN, CSIRO.

15 IMHEN, CSIRO (2014). High-resolution Climate Projections for Vietnam. Regional Summary Central Highlands.

16 J.J. Katzfey, J.L. McGregor, and R. Suppiah (2014) (Ibid.)

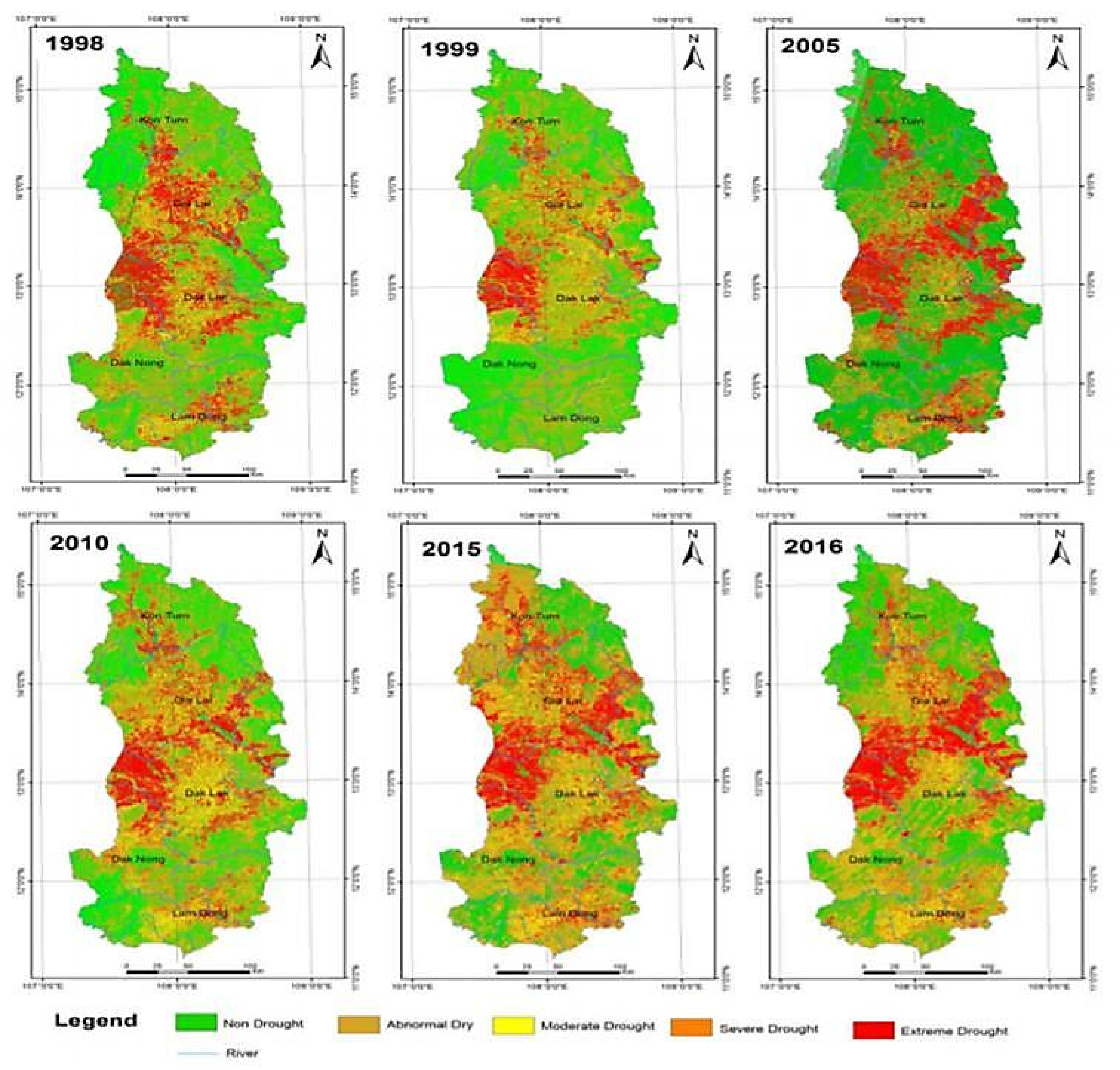
17 http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=vnm larger than in 2010. In addition, areas that have never experienced drought are now also increasingly affected. The main factor causing droughts in this region is reduced dry season rainfall and a longer than usual dry season.[18]

The most drought-prone areas in the Central Highlands are the western districts of Gia Lai (Chu Prong), Dak Lak (Ea Sup and Buon Don) and Dak Nong (Cu Jut and Dak Mil) provinces.

The recent drought damaged or destroyed 90,744ha of crops, mainly perennial, in Dak Lak; and 18,525ha of crops, mainly perennial, in Dak Nong.[19]

The recent drought, with 40 percent less rainfall than normal in Dak Nong and 49 percent less than normal in Dak Lak for June-September, can be considered as a 1 in 100 years event. However, for the coming 25 years, there is a 22 percent chance that a similar event will occur.[20]

Figure 9: Map of the most severe droughts in the Central Highlands over 1998-2016 [21]



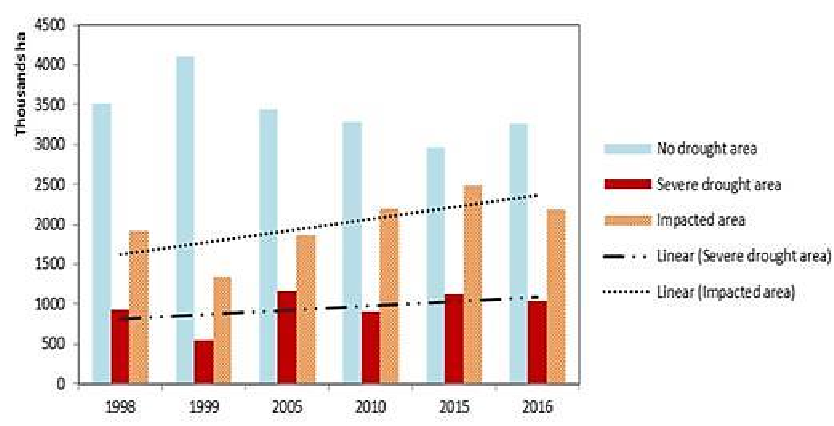
18 *Including source of graph and maps; Nguyen Thi Thu Ha, Mai Trong Nhuan, Bui Dinh Canh, Nguyen Thien Phuong Thao (November 2016). Mapping Droughts over the Central Highlands of Vietnam in El Niño Years Using Landsat Imageries.*

19 *CCNDPC damage and loss data.*

20 *Steven Wade, Francis Colledge, Nguyen Van Manh, John Hall and Donald Parker (June 2017). SC 108211 VIE: Water Efficiency Improvement in Drought Affected Provinces: Climate Change Risk and Vulnerability Assessment. UK Met Office, ADB, p.9.*

21 *Nguyen Thi Thu Ha, Mai Trong Nhuan, Bui Dinh Canh, Nguyen Thien Phuong Thao (November 2016) (Ibid.)*

Figure 10: Trends in drought severity and impact in the Central Highlands over 1998-2016 [22]



Future climate scenarios for the Central Highlands [23]

TEMPERATURE INCREASE

An increase in overall temperatures; of about 1.2 to 2.6°C by mid-century and 2.2 to 4.5°C by end-of-century for the higher (RCP8.5) greenhouse gas scenario. Less warming is evident in the lower (RCP4.5) greenhouse gas scenario.

The number of hot days (days with maximum temperatures above 35°C) is projected to increase by 15 to 20 days a year in the lower lying parts of this region, except in the mountainous areas. In some years, the maximum temperature will exceed 40°C.

The number of heat waves is projected to increase with a range of 3 to 6 days by end-of-century, especially for the southern part of this region. In addition, the average length of heat waves is also projected to increase slightly throughout the region.

CHANGING PRECIPITATION PATTERNS

A 15 to 20 percent increase in rainfall in the wet season - which will start earlier and end later -, and 10 percent decrease and more irregular rainfall in the dry season. Larger variations between minimum and maximum amounts will occur. Likely more intense extreme rainfall events for southern parts of the Central Highlands but little change in the northern parts.

In addition to a delayed onset, the length and intensity of the southwest monsoon are both expected to decrease slightly by mid-century and continue to decrease further by end-of-century, bringing less overall rainfall to the region.

DROUGHT AND FLOOD RISK

The magnitude and frequency of floods during wet season increases due to increased intense rainfall linked to longer and wetter monsoon conditions.

Droughts will become more severe due to rising temperatures and rainfall deficits in the dry season, particularly in the northern part of the region. Short duration droughts will increase, while long duration droughts decrease.

The number of typhoons is likely decreasing, but the number of strong to very strong ones shows an increasing trend, increasing the risk of floods and landslides.

---

22 Nguyen Thi Thu Ha, Mai Trong Nhuan, Bui Dinh Canh, Nguyen Thien Phuong Thao (November 2016) (Ibid.)

23 IMHEN, CSIRO (2014) (Ibid.), MoNRE (2016) (Ibid.) and USAID Mekong ARCC Program (2013). Vietnam Climate Change Vulnerability Profile.

figure 11: *climate models on rainfall and temperature for dak lak province*[24]

RCP4.5 'warm and wet' (blue line), RCP8.5 'hotter and wet' (green line), and RCP8.5 'hotter' (red line) scenarios. The bar and line plot shows the monthly average of daily precipitation and median estimated PET mid-century (2041 to 2070) percentage changes applied to the models (grey line) baseline period (1976 to 2005) for each scenario.

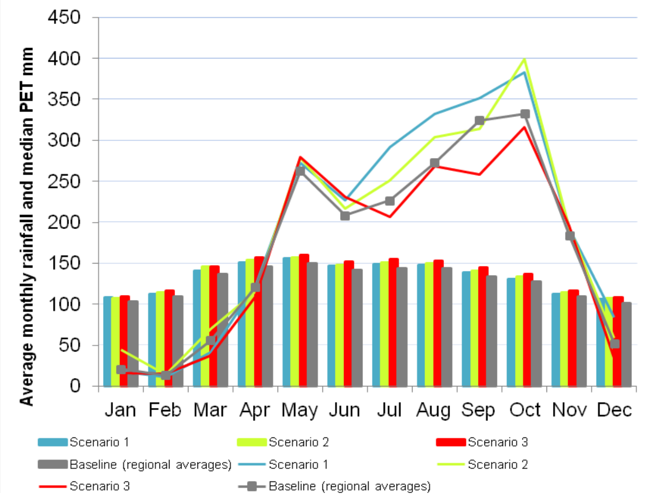
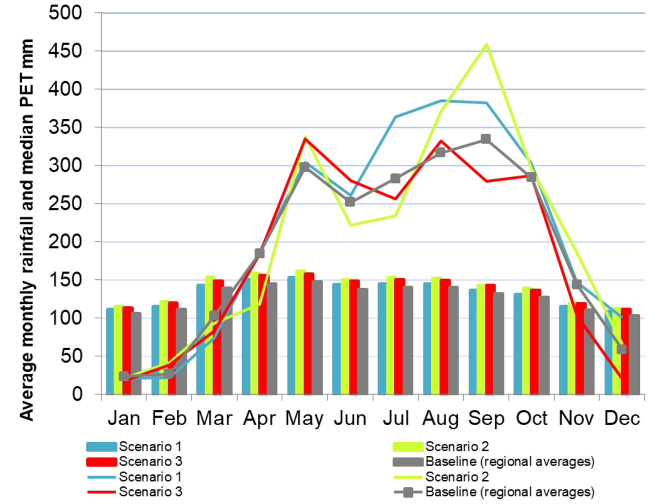


Figure 12: *Climate models on rainfall and temperature for Dak Nong province*

RCP4.5 'warm and wet' (blue line), RCP8.5 'hotter and wet' (green line), and RCP8.5 'hotter' (red line) scenarios. The bar and line plot shows the monthly average of daily precipitation and median estimated PET mid-century (2041 to 2070) percentage changes applied to the models (grey line) baseline period (1976 to 2005) for each scenario.



1.3.3 South Central Coast

Current observed changes in climate and weather-related events in the South Central Coast, based on available data for the period 1960-2010, show the following trends and patterns: [25]

TEMPERATURE INCREASE

Annual temperature has slightly increased, with a trend of about 0.08 to 0.16°C increase per decade (figure 18). While minimum daily temperature has increased significantly by up to approximately 0.36°C per decade, the change in maximum daily temperature is small and not significant for most parts of this region.

More hot days and no changes in cool nights. The number of hot days (days with maximum temperatures above 35°C) has increased significantly by up to 4 days per decade, particularly in the southern part of this region. The number of cold nights remains unchanged.

CHANGING PRECIPITATION PATTERNS

Annual rainfall has increased significantly, with local increases of up to 13 percent particularly in the southern parts of this region (figure 18). However, there are differences between seasons, with the amount of rainfall reducing during the dry season but increasing during the rainy season.[26]

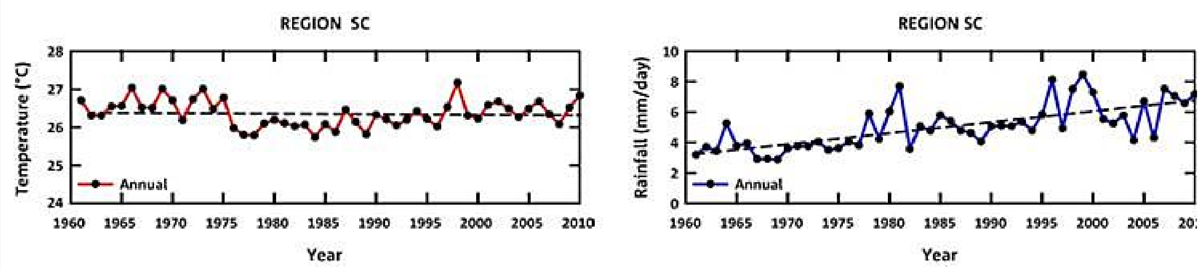
Increased extreme rainfall amounts. Annual maxima of 1-day and 5-day rainfall amounts and the number of very wet days have increased throughout the region, the latter with up to 3 days per decade.

24 Steven Wade, Francis Colledge (June 2017) (Ibid.)

25 IMHEN, CSIRO. (2014) (Ibid.)

26 Hien Thi Thu Le, Thang Nguyen Ngoc and Luc Hens (November 2015). Assessment of the Irrigation Capacity during the Dry Season Using Remote Sensing and Geographical Information (Case Study in Binh Thuan Province, Vietnam).

Figure 13: Mean surface air temperature and rainfall trends from 1961 to 2011, South Central Coast [27]



DROUGHT AND FLOOD RISK

For the entire South Central Coast, the most frequent disaster events have been floods, drought, heat waves and strong winds. Storms are more frequent in the northern part of the region than in the southern part.

Over the period 1989-2010, Binh Thuan has been affected by 21 heavy rainfall and flood events, 4 storms, 6 hailstorms and 2 landslides; Ninh Thuan by 21 heavy rainfall and flood events, 2 storms and 2 hailstorms; and Khanh Hoa by 26 flood events and 5 storms.[28]

The recent El-Niño-induced drought in 2015-2016 damaged or destroyed 12,102ha of crops, mainly fruit trees, in Binh Thuan; 1,215ha of crops, mainly perennial, in Ninh Thuan; and 36,400ha, mainly perennial and rice, in Khanh Hoa.[29]

The recent extreme drought, with 45 percent less rainfall than normal in Binh Thuan and 70 percent less than normal in Ninh Thuan and Khanh Hoa for the period June-September, can be considered as a 1 in 100 years event. However, for the coming 25 years, there is a 22 percent chance that a similar event will occur.[30]

Areas currently most vulnerable to drought and desertification in Binh Thuan are in the semi-arid part of the province: Bac Binh and Tuy Phong districts and the centre of Ham Thuan Bac district.

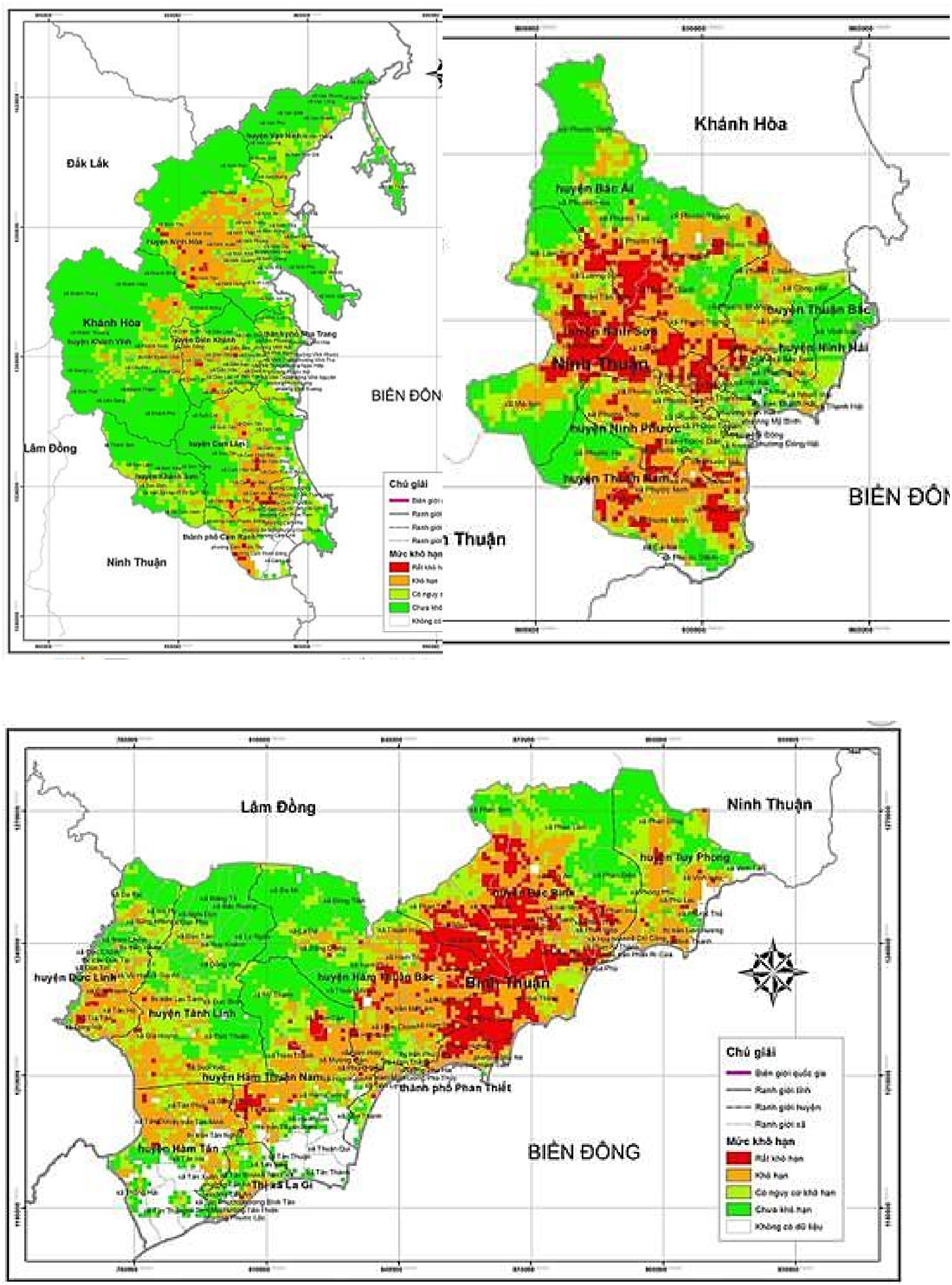
27 J.J. Katzfey, J.L. McGregor, and R. Suppiah (2014) (Ibid.)

28 http://www.desinventar.net/DesInventar/profiletab.jsp?countrycode=vnm

29 CCNDPC damage and loss data.

30 Steven Wade, Francis Colledge, Nguyen Van Manh, John Hall and Donald Parker (June 2017) (Ibid.)

Figure 14: Map of drought affected areas in Khanh Hoa (left), Ninh Thuan (right) and Binh Thuan (bottom) for 2015-2016 [31]



31 Source: Disaster Management Centre, Ministry of Agriculture and Rural Development (2016).

Future climate scenarios for the South Central Coast [32]

TEMPERATURE INCREASE

An increase in annual temperatures of about 1.2 to 2.5°C by mid-century and 2.4 to 4.3°C by end-of century under the higher (RCP8.5) greenhouse gas scenario. Less warming is evident in the lower (RCP4.5) greenhouse gas scenario.

An increase in the number, length and intensity of heat waves and number of hot days (days with maximum temperatures above 35°C) by end-of-century.

CHANGING PRECIPITATION PATTERNS

Overall shorter and higher intensity of monthly rainfall, with large variations in terms of months and amounts. Rainfall in the wet season will increase by 20 percent, particularly in October-November, but rainfall in the monsoon months, June till September, will likely decrease. The wet season will likely be shorter, starting later (up to 15 days) and ending earlier (up to 30 days).[33]

Extreme rainfall events are projected to be less intense.

In addition to a delayed onset, both the length and intensity of the southwest monsoon are expected to decrease significantly. By mid-century, the season length will be reduced by about two weeks and rainfall is reduced by minus 40 percent. This trend continues until end-of-century.

DROUGHT AND FLOOD RISK

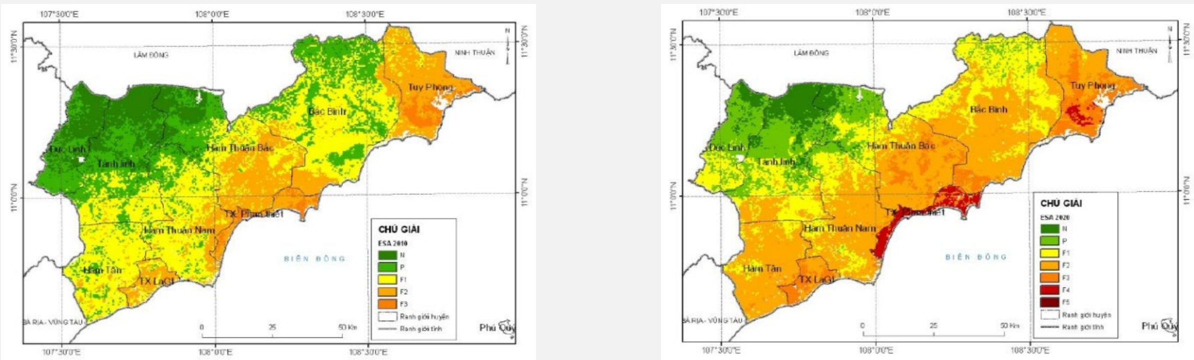
Droughts in general will occur less often, but become more extreme and last longer due to rising temperatures, a changing monsoon and rainfall deficits in the dry season. While small to medium droughts will remain manageable, extreme droughts, similar as in 2015-16, will become a major risk.

Flood risk will also increase, but mainly in the upland areas and the northern part of the region.

The number of typhoons is likely decreasing, but the number of strong to very strong typhoons increasing. Typhoons will also occur later in the year.

Sea level rise will intensify to about 100 to 400mm by mid-century, with further increase by end-of-century and beyond. It will be higher than the global average but with a lower area potentially affected than in the Mekong River Delta. Coastal areas will deal with increased salinity intrusion.

Figure 20: Most drought- and desertification-prone areas in Binh Thuan province, in 2010 and in 2030 [34]



32 IMHEN, CSIRO (2014) (Ibid.) and MoNRE (2016) (Ibid.)

33 Sebastien Doutreloup, Michel Erpicum, Xavier Fettweis and Pierre Ozer (August 2011). Analysis of the past (1970-1999) and future (2046-2065 and 2081-2100) evolutions of precipitation and temperature, in the province of Binh Thuan, South East Vietnam, based on IPCC models.

34 Anne Gobin, Le Trinh Hai, Pham Ha Linh, Luc Hens, Pierre Ozer, Le Thi Thu Hien, Nguyen Thanh Binh and Pham Quang Vinh (July 2012). Impact of global climate change and desertification on the environment and society in the southern centre of Vietnam (case study in Binh Thuan province).

Figure 21: Climate models on rainfall and temperature for Khanh Hoa province[35]

RCP4.5 ‘warm and wet’ (blue line), RCP8.5 ‘hotter and wet’ (green line), and RCP8.5 ‘hotter’ (red line) scenarios. The bar and line plot shows the monthly average of daily precipitation and median estimated PET mid-century (2041 to 2070) percentage changes applied to the models (grey line) baseline period (1976 to 2005) for each scenario.

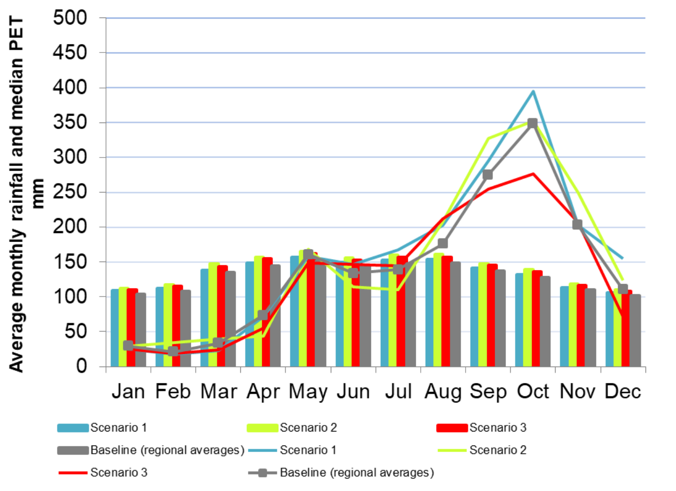


Figure 22: Climate models on rainfall and temperature for Ninh Thuan province

RCP4.5 ‘warm and wet’ (blue line), RCP8.5 ‘hotter and wet’ (green line), and RCP8.5 ‘hotter’ (red line) scenarios. The bar and line plot shows the monthly average of daily precipitation and median estimated PET mid-century (2041 to 2070) percentage changes applied to the models (grey line) baseline period (1976 to 2005) for each scenario.

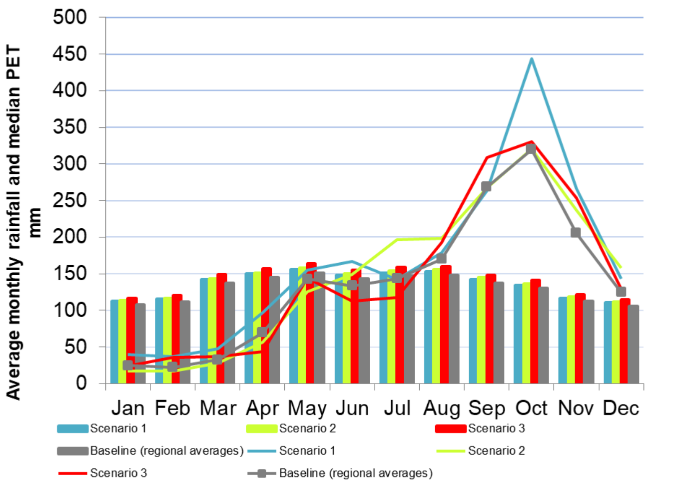
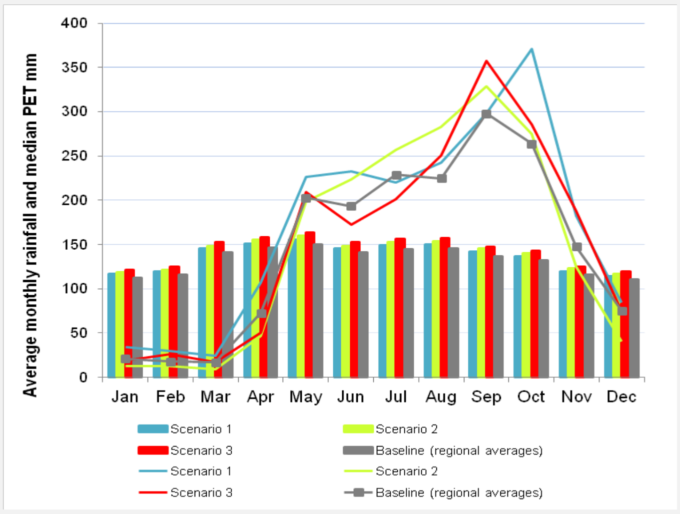


Figure 23: Climate models on rainfall and temperature for Binh Thuan province

RCP4.5 ‘warm and wet’ (blue line), RCP8.5 ‘hotter and wet’ (green line), and RCP8.5 ‘hotter’ (red line) scenarios. The bar and line plot shows the monthly average of daily precipitation and median estimated PET mid-century (2041 to 2070) percentage changes applied to the models (grey line) baseline period (1976 to 2005) for each scenario.



1.4 Climate change impacts on key sectors and socio-economic groups

Overall for Viet Nam, climate exposure and sensitivity will be manifested in the following potential impacts; key impacts for the Central Highlands and South Central Coast are on water resources availability, agricultural productivity, rural infrastructure, local ecosystems and human health: [36]

35 Steven Wade, Francis Colledge (June 2017) (Ibid.)

36 GoV (2012). National Climate Change Strategy, and USAID (2017). Fact sheet. Climate change risk profile. Vietnam.

Agriculture, including fisheries: damage to crops, loss of arable lands, decreased agricultural productivity, shifting production zones, growing cycles and distribution of species, habitat destruction and degradation, animal diseases, increased reproduction and spread of harmful pests, loss of livelihoods and incomes, increased migration

Water resources: increased evaporation, reduced water availability, reduced flows and groundwater levels, degraded water quality, saline intrusion, destruction of water infrastructure

Coastal ecosystems: damage to and destruction of coastal and marine habitats, loss of protection and livelihood value in case of degraded mangroves

Infrastructure: damaged infrastructure and key community assets, increased maintenance costs, reduced mobility of goods and services

Energy: reduced energy production, disruption in service provision

Human health: shifting disease patterns and potential new diseases, decreased labor productivity, psychological stress and trauma

Impacts on water resources

A recent analysis by the United Kingdom Meteorological Office identifies for the two regions the following potential impacts on water resources, for three future climate scenarios: warm and wet; hot and wet; and hotter:

Table 1: Overview of potential climate impacts on water resources in the Central Highlands and South Central Coast, for three simplified climate futures (with yellow: low risk; orange: medium risk; red: high risk; and +/- indicating direction and magnitude of changes) [37]

Potential impact	**Warm and wet**	**Hot and wet**	**Hotter scenario**	**Analysis based on research and expert opinions**
Water resources				
Increase in evaporation; increase in crop water demand and reservoir losses	+3~4%	+5~6%	+7~8%	Estimated based on increase in temperature for each scenario and evapotranspiration
Change in annual average river flows (risk to water availability)	+22~27% (increase)	+10~11% (increase)	+13~14% (increase)	Estimated based on case study modeling on 3 river basins. In hottest scenario, high evapotranspiration and delayed monsoon rains reduce water flow
Decrease in groundwater table due to decrease in groundwater recharge	(increase)	(increase)	(decrease)	Increases under wet scenarios but some reductions in hotter scenario may reduce groundwater levels
Saline intrusion into groundwater, reducing quality	+ (increase)	++ (increase)	++ (increase)	Higher rates of sea level rise with higher rates of warning; up to 0.1% land loss in Binh Thuan for 0.5m sea level rise

Overall, for both regions, when considering average annual water availability, a slight increase in availability of water is expected in the warm-wet and hot-wet scenarios due to an expected increased rainfall. However, inter-seasonal differences will become larger with higher water levels than current in the wet season and less water availability in the dry season, requiring adequate storage options. Under the hotter scenario, water shortages caused by increased demand and higher evaporation will occur.

The highest risk for water availability in both regions is extreme droughts. As these droughts will likely be longer and more severe, farmers are projected to depend on groundwater resources in 15 out of 100 years, with extraction of groundwater in this period expected to increase.[38] Coastal areas, particularly in Binh Thuan, will also be affected by saline intrusion as sea levels gradually rise.

Water availability is very location specific, and is aside from climate variability and change, also influenced by local topography, agricultural practices and the capacity of the irrigation infrastructure. Water availability in upland areas with rain-fed crop systems and limited storage options will remain constrained or worsen, but lowland areas will be better able to deal with incremental climate change, except for extreme droughts and under the hotter scenario. For example, the Trung Tam reservoir in Ea Hleo district in Dak Lak is currently affected by reduced water availability from May to August, but can

37 Steven Wade, Francis Colledge, Nguyen Van Manh, John Hall and Donald Parker (June 2017) (Ibid.)

38 ADB (June 2017). Climate Risk Assessment and Management for the Project 'Water Efficiency Improvement in Drought Affected Province'.

still manage the demand for production. Only once in the past 25 years was the reservoir unable to provide enough water, during the dry season of 1996. With a slight increased annual river flow of 16 percent, the Song Mong reservoir in coastal Ham Thuan Nam district in Binh Thuan can provide the required water supply for the current and planned cultivated crops, within a regular dry season. However, the water balance is under threat during extreme droughts – occurred three times over the past 40 years - and in the hottest scenario when rainfall declines and evaporation increases. [39]

Impacts on agriculture

Climate change is also expected to severely impact agricultural productivity and rural infrastructure in both regions:

Table 2: Overview of potential climate impacts on agriculture and rural infrastructure in the Central Highlands and South Central Coast, for three simplified climate futures (with yellow: low risk; orange: medium risk; red: high risk; and +/- indicating direction and magnitude of changes) [40]

Potential impact	Warm and wet	Hot and wet	Hotter scenario	Analysis based on research and expert opinions
Agriculture				
Crop yield loss and damage to perennial crops due to extreme drought beyond planned irrigation upgrade	-	+	+	By definition water supply will be limited 15% of the time and the chance of an extreme drought like in 2015-16 is high
Reduced crop productivity from loss of arable land due to water logging	+	No change	No change	Under the wettest scenarios, there may be drainage issues
Crop losses due to flood damage	+	+	+	There will be flooding in all scenarios
Reduced crop productivity due to heat waves	No change	No change	-	Some sensitivity to higher temperatures
Shifting of production zones to higher elevations	No change	+/-	+/-	Rising temperatures are not expected to exceed envelop for target crops
Increased reproduction and spread of harmful pests	Unknown	Unknown	Unknown	E.g. rice feeding, ear-cutting caterpillars
Infrastructure				
Destruction of water infrastructure	++	+	+	Risk of flood damage is high; pipe river crossings, weirs and pumping stations in floodplains in highest risk; coastal provinces assets set back from coastline
Damage to roads, disrupting transport of goods	+	+	+	River crossings highest risk
Disruption of energy supply networks	+	+	+	Electricity supply must be resilient to floodS and sufficient during peak demand periods

Crop productivity will be most impacted by reduced water availability in the event of longer dry seasons, extreme droughts and under the hotter scenario. Extreme drought periods can result in 40 to 70 percent less water available for crops, especially affecting perennial crops. Crop yields in upland areas will be negatively impacted by seasonal changes (for example a delayed onset of the rainy season) and more unpredictable precipitation patterns. Extreme rainfall events and related flooding will also cause destruction or damage to crops, particularly in the Central Highlands.

In Binh Thuan, especially Bac Binh, Ham Thuan Bac, Ham Thuan Nam and Ham Tan districts, less and less land is cultivated during the dry season because of more severe weather conditions during the dry season, unpredictable precipitation and limited or unreliable irrigation capacity. Not using or irrigating the land causes more land degradation, which makes it even less attractive for further cultivation.[41] Similar trends are reported for Ninh Thuan and Khanh Hoa.[42]

39 Other sites in the target areas have not been assessed. Steven Wade, Francis Colledge, Nguyen Van Manh, John Hall and Donald Parker (June 2017) (Ibid.), p.33.

40 Steven Wade, Francis Colledge, Nguyen Van Manh, John Hall and Donald Parker (June 2017) (Ibid.)

41 Hien Thi Thu Le, Thang Nguyen Ngoc and Luc Hens (November 2015) (Ibid.)

42 Farmer consultations conducted in Binh Thuan, Ninh Thuan and Khanh Hoa (11-19 September 2017).

For the main crops currently cultivated in both regions, vulnerability for observed and projected climate conditions is as described in the table below, with rice, perennial crops such as coffee and pepper and annual crops such as maize being the most vulnerable.

In addition to crops, farmers also raise livestock, such as cows, goats, pigs and poultry. In most households this is limited to a few heads and as a contingency, but for some households, especially in the South Central Coast, the number is higher and livestock is more sold for additional income. In addition to susceptibility to diseases, livestock is also vulnerable to the observed and projected climate variability and change, mainly temperature and rainfall increases and variability and extreme weather events. The most vulnerable are chickens and pigs. Smallholder cattle are only medium vulnerable, while ducks have a low vulnerability. [43]

Socio-economic groups most vulnerable to climate change impacts

As stated by the GoV-UNDP 'Viet Nam Special Report on Managing the Risks of Extreme Weather Events and Disasters to Advance Climate Change Adaptation', inequalities influence local coping and adaptive capacity, and pose disaster risk management and climate change adaptation challenges from the local to the national level. Socio-economic inequalities and for example health related differences and differences in access to livelihoods or land, and other factors determine vulnerabilities of households and communities in Viet Nam.[44]

A World Bank study looking into the social dimensions of climate change adaptation identifies the main social vulnerabilities for both regions. For the Central Highlands, these include a high number of ethnic minorities, high rates of poverty, many migrants (including the Kinh majority and ethnic minorities from other regions in the country), and a high number of farmers depending on rain-fed and subsistence agriculture. For the South Central Coast, social vulnerability is largely determined by high numbers of poverty, particularly among pockets of ethnic minority groups, and a dependency on rain-fed agriculture in many areas.[45]

The GoV's key laws, strategies and action plans on climate change and disaster risk reduction (see below under section 2) also recognize and prioritize the socio-economic groups most vulnerable to climate change impacts: pregnant women and women nursing under 12-month children, children, the poor, elderly, people with disabilities, and ethnic minorities, especially in upland areas. GoV statistics confirm the higher than average vulnerabilities of these groups in the target provinces (see table 4).

Table 3: Key socio-economic indicators for the target provinces [46]

Indicator	South Central Coast			Central Highlands		Viet Nam
	Khanh Hoa	Ninh Thuan	Binh Thuan	Dak Lak	Dak Nong	
Infant mortality (%)	14	16.4	12.5	24	25.7	14.7
Under five mortality (%)	21	24.6	18.8	36.4	39.1	22.1
Under five prevalence underweight (%)	11.8	18.9	15.1	21.5	22.1	14.5
Literacy rate (15 years and above) (%)	94.8	87.5	93.3	92.9	93.7	94.9
Monthly av. income per capita ('000 VND)	2,670	2,331	2,395	1,988	1,824	2,637
Monthly average income per capita ('000 VND) – for the poorest 20%	873	677	937	550	392	660
Monthly average income per capita ('000 VND) – for the richest 20%	6,384	5,768	5,039	4,658	3,792	6,413
Ethnic minority population (%)	5.7	23.1	7.4	19.6	29	15
Rate of poor households (%) - among the entire population [47]	9.87	14.93	5.81	19.37	19.26	9.88
Rate of poor households (%) - among ethnic minorities	68.6	38.8	19.54	37.17	40.75	23.1

In the Central Highlands, ethnic minorities and smallholders depending on rain-fed agriculture and with lower levels of food security and nutrition were particularly affected during the recent drought in 2015-

43 ICEM (February 2014), Impact and Adaptation Study. Livestock Report. USAID Mekong ARCC Program

44 GoV's Institute of Meteorology, Hydrology and Climate Change, United National Development Program (January 2015). Viet Nam Special Report on Managing the Risks of Extreme Weather Events and Disasters to Advance Climate Change Adaptation

45 Pamela McElwee (December 2010). The Social Dimensions of Adaptation to Climate Change in Vietnam. World Bank Discussion Paper Number 17.

46 Data source: GSO. Statistical Yearbook 2015. http://www.gso.gov.vn.

47 Ministry of Labor, Invalids and Social Affairs, Provincial Departments of Labor, Invalids and Social Affairs, 2016.

2016. When losing their crops and/or animals to climate-related events, they are left with nothing to eat or little to no income to purchase food for their family. This is exacerbated in isolated areas where alternative economic activities are not easily available.[48] Similar patterns occur among ethnic minority groups in the South Central Coast who cultivate rain-fed crops upland.[49]

In terms of gendered impacts of extreme droughts, various inter-agency assessments conducted during the recent drought confirm that women and girls were more severely affected than men and boys:[50]

Women and girls are responsible for domestic work, including ensuring the family has water for drinking and domestic use. This means ensuring the water is clean and living conditions remain sanitary. The drought has put multiple constraints on this for a lengthy period;

Women as the main caregiver in the family also had to deal with the increased risk of diseases and malnutrition induced by the drought, with higher risk among children;

More men than women migrated temporarily during the drought to look for additional income, with women and children remaining behind to take care of the household, as well as the farming land;

Lower mobility of women and women's space constrained to the village, led in a lot of cases to men receiving relief items, training and awareness raising materials at far-away distribution points;

Limited influence of women on household and community decision-making regarding farming or livelihoods as well as financial decision-making.

1.5 Irrigation sector

1.5.1 Irrigation infrastructure development

Irrigation and drainage systems in Vietnam are fairly well developed, which significantly facilitates the expansion of growing areas, increases cropping seasons, stimulates land reclamation, and contributes to ensure food security and exports. By 2015, thousands of irrigation systems had been built in the country, including 6,648 reservoirs of all types, about 10,000 large-scale electric pumping stations, 5,500 large–scale irrigation and drainage sluices, 234,000 km of canals, and 25,960 km of dikes. By 2015, the total irrigated paddy areas were above 7.8 million ha, contributing to a robust and stable increase in food production. In addition, irrigation systems also serve 1.5 million ha of subsistence and industrial crops; provide bulk water sources for 1.3 million ha of cultivated land; supply about 6 billion m^3 of water for domestic and industrial use; prevent salinity intrusion of 0.87 million ha; reclaim 1.6 million ha of alkaline soils, and drain 1.72 million of agricultural land. The irrigation and drainage systems support and facilitate crop diversification and agricultural structural transformation.

Nevertheless, problems exist with the current irrigation and drainage systems: (1) poor management efficiency of hydraulic works, despite considerable investments, the operation and management of hydraulic works show deficiencies such as poor performance, cumbersome organizational structure; increasingly large staff, low labor productivity, low quality governance, fast physical degradation, increasing but unresolved violations, and high rates of unaccounted water; and (2) irrigation and drainage structures do not meet the requirements of a diverse and modern agriculture; the existing irrigation systems mainly focus on providing irrigation water for paddy whilst most upland crops are not yet irrigated or irrigated using backward and water-wasting methods, the areas served by modern and water-saving measures are limited.

As reported by the World Bank,[51] in 2013, more than 50% of the irrigation systems in Vietnam were degraded and/or do not operate at design capacity. In many places, physical efficiency is limited due to inadequate and incomplete investment as designed, lack of on-farm systems, or old structures of low design standards, deterioration of canals and other infrastructure, and in addition, the formulation and implementation of plans has not kept pace with reality. There are shortcomings in management and operation by irrigation management companies (IMCs); irrigation service management does not target needs or support farmers'/water users' participation which leads to low efficiency, inflexibility and unsustainability. Poor maintenance due to lack of funds and the impact of natural disasters degrade the systems, affecting irrigation service provision. Therefore, synchronous improvement of irrigation

[48] *CGIAR Research Centers in Southeast Asia (April 2016). The drought crisis in the Central Highlands of Vietnam. Assessment Report.*

[49] *Farmer consultations conducted in Binh Thuan, Ninh Thuan and Khanh Hoa (11-19 September 2017).*

[50] *GoV-NGO-United Nations joint damage and needs assessments for the drought emergency (April 2016); and UNDP (July 2016), Viet Nam drought and saline water intrusion: transitioning from emergency to recovery. UNDP policy analysis. Verified by field consultations.*

[51] *Appraisal Report of the Vietnam Irrigated Agriculture Improvement Project (WB7).*

systems from head works to fields in parallel with institutional and policy strengthening, management capacity enhancement, amd water efficiency improvement is an urgent requirement of the irrigation sector. It is very critical to invest in improving operation and management efficiency of irrigation systems to facilitate agricultural restructuring towards increasing the value chain; however, the available resources are limited.

According to ADB's study on water productivity[52], Vietnam's average agricultural water productivity is about 0.6 ÷ 0.8 $kg.m^{-3}$, which is much lower than the average of 2 to 2.5 $kg.m^{-3}$ in countries of similar agricultural production patterns. Low water productivity in Viet Nam's agriculture sector undermines national water security, threatens sustained economic growth and increases the country's vulnerability to climate change. Viet Nam is amongst several Asian countries most likely to experience "severe water-stress conditions" due to changes in hydro-climatic conditions and "socioeconomically-driven water requirements."

Vietnam possesses very abundant water resources which, however, are seasonably very changeable, with the dry season flow accounting for 20 ÷ 30% of the total annual flow (about 85% from groundwater). The South Central Region is the country's most arid region, especially in the provinces of Khanh Hoa, Ninh Thuan and Binh Thuan where average rainfall is the lowest in the country and the rainy season lasts for only three months. Water stored in the irrigation systems is very limited and not satisfactory to meet the growing demands of rapid urbanization, industrialization and cropping pattern transformation. Water shortage occurs frequently and constantly from year to year, even in the service areas of the existing irrigation systems. Economic and efficient water use is imperative to adapt to the present drought and water scarce conditions.

According to the latest study climate change impacts, Vietnam is one of the five countries most vulnerable to climate change. Serious watershed deforestation reduces upstream permeable surface layer and increases runoff, which in turn involves landslides, erosion and changing river basin hydrological conditions. The vast coastal plains where happen agricultural production and fishery activities of the provinces, are very sensitive to flooding and saltwater intrusion caused by storms, tropical depressions and other slower types of natural disasters such as sea level rise, plain subsidence resulted by groundwater extraction which also cause groundwater table lowering and increasing downstream water pollution problems. These issues increase the cost and reduce competitiveness of agricultural products. In the South Central and the Central Highlands, the impacts of climate change on weather make drought and water scarce more difficult to predict and heighten the risks of droughts.

Investments in agriculture and rural development were much lower than the development needs in past years. In fact, the total investments in agriculture and rural decreased from 13.8% in 2000 to 6.2% in 2010, and to 5.2% in 2015. Foreign Direct Investment (FDI) was low, the national FDI share of agriculture reduced from 8% in 2001 to 1% in 2010 and tends to slightly increase to about 1.3% in 2015.

The allocation of public investments within the sector was not reasonable, focussing mainly on basic infrastructures of non- or slowly productive nature, notably irrigation and irrigation water fees. Investments from the State budget and government bonds in the irrigation sector accounted for 30% of the total investment budget for agriculture in 2005, and increased to 32% and 42% in 2008 and 2010 respectively. Overall, investments in irrigation increased 7 times whilst the direct investments in agricultural, forestry and fishery production and the producing and profitable national target programs were doubled only in the period from 2005 to 2010. Nevertheless, many irrigation systems have not yet been completed and could only operate at 40 to 75% of their designed capacity. Some irrigation infrastructure has not been properly maintained resulting in low efficiency of public investment.

1.5.2 Water efficiency of irrigation

The percentage of irrigated paddy land accounts for about 23% and 4% of the regional agricultural land in the South Central Coast and Central Highlands respectively, which is lower than the national average of about 30%. Water efficiency of irrigation systems is about 64% and 74% of the designed irrigation area in the South Central Coast and Central Highlands respectively, which is again lower than the same rate in the Northern Region (83%); Southeast Region (82%), and the North Central Region (64%)[53].

---

[52] *Water productivity is a measure of agricultural production per one unit of water used to produce that agricultural production, usually measured in kg/m^3*

[53] *Water Resources Sector Review Report, 2008*

There are different causes to the low water efficiency in the region, specifically, only 10% of the existing canal systems is lined (3,805 km out of 38,010 km of the canal systems); incomplete canal systems cause insufficient water supply for areas far from the water sources that affect water supply of the whole irrigation systems. Hence, the upgrade and lining of the canal systems of the provinces located in the project area will constitute critical solutions to provide enough water sources for different crops as designed of the physical structures and canals in order to stabilize people's production and life, and ensure local food security, especially in remote areas and where inhabit ethnic minority groups.

The project area is located in the region which is frequently affected by droughts with serious damage. The damaged area of the South Central region was 17,277 ha, including 15,627 ha of paddy[54], and 6,376 ha, including 900 ha of paddy[55] in 2012 and 2013, respectively. In the winter-spring crop 2014 - 2015, severe droughts happened across the South Central Region, particularly in the provinces of Ninh Thuan, Binh Thuan and Khanh Hoa. As of June 2015, there is almost active storage, or only dead storage or even no water in some reservoirs such as Song Trau, Song Sat, Suoi Lon reservoirs in Ninh Thuan province. Similarly, in Binh Thuan province, the active storage of reservoirs is only about 21.7% compared to their design. In terms of damages, about 8,621 households lacked drinking water and support was needed; 145 cattles and 1,591 goats and sheep died; about 501 ha of the winter-spring crops lost harvest; 1,578 ha had reduced yields; and about 6,100 ha of the winter-spring crop and 10,200 ha of the summer-autumn crop in 2015 had to stop cultivation due to water shortage in Ninh Thuan province. In Khanh Hoa province, during the winter-spring crop 2014-2015, 571 ha had to stop cultivation and 600 ha had to change the cropping patterns due to water shortage, and 2,988 ha of crops were affected by water shortage (of which 1,735 ha with reduced yields); during the summer-autumn crop, 9,567 ha had to stop production due to droughts, and 1,400 ha were converted from paddy to upland crops due to water shortage. Besides, since the dry season 2015, there have been 31 forest fire events happened damaging 19.7 ha of natural forests in Ninh Thuan province. Similarly, Binh Thuan Province was severely impacted by droughts at unprecedented levels; the number of people faced with drinking water shortage was over 30,000 people; 552 ha of agricultural land totally lost harvest, and 2,167 ha with reduced yields[56]. Thus, it is obvious that continuous and prolonged droughts caused huge damages to the people’s livelihoods and to the whole economy.

In the Central Highlands, severe droughts occurred at the end of April, early of May 2015. The total largest area affected by water shortage and drought was 95,053 ha, including 61,466 ha (4,364 with full harvest lost) in Dak Lak province, 16,760 ha in Dak Nong province, 8,956 ha in Gia Lai province. Moreover, 19,000 households in Dak Lak province faced with lack of drinking water[57].

Many irrigation systems in the region do not perform well at their full capacity because the systems were not completely built with only head works built but the canal network incomplete or not yet built; integrated water use planning was not synchronously implemented for multiple use of the systems. The canal systems are being degraded or fragmented due to their being built with low design standards, or poorly managed and maintained without accountability mechanisms, lack of management decentralization, lack of monitoring and evaluation mechanism to assign management responsibility; lack of adequate and timely maintenance due to limited funding in addition to natural disaster effects that make the systems seriously degraded and affect the service provision capacity consequently.

In many localities, management decentralization is unsmooth with unclear decisions by the managers of each on-farm system due to unavailable suitable mechanisms, policies and regulations in place. Besides, the local resources and capacity to maintain the physical structures are limited. In fact, many structures assigned to local management are quickly found degraded and cannot ensure irrigation and drainage services.

Participatory irrigation management (PIM) is just in a pilot process on small-scale in some localities, because of the following issues: (i) the policy framework of irrigation management decentralization is inadequate; (ii) inconsistent operation and management arrangements; (iii) lack of funds and

54 Drought and salinity intrusion situation and overcoming directions in the South Central and Central Highland provinces, MARD, Directorate of Water Resources, 2013

55 Report on drought and salinity intrusion in the South Central and Central Highland Regions, Directorate of Water Resources, 2014

56 Summary of drought and salinity intrusion situation in the winter-spring crop 2014÷2015, and some judgments on droughts and water shortage in the summer-autumn and autumn crops in the Central, Central Highlands and Southern Regions, Directorate of Water Resources

57 Report on drought and salinity intrusion in the South Central and Central Highland Regions, Directorate of Water Resources, 2014 appropriate financial management mechanisms; (iv) community awareness raising activities on community-based water management and PIM activities are not yet widely deployed; and (v) facilities / canal systems are not satisfactory to meet the demand for irrigation.

Moreover, a number of farmers in the project area have customs of irrigated paddy cultivation and they practice when water is available that consumes lots of water and impacts water availability for other higher-value crops and production plan in the relevant irrigation district. Awareness raising on water-saving and appropriate practices is not effective yet.

On the other hand, awareness raising activities on natural disaster prevention and adaptation in general and drought-adaptation in particular is limited. Currently, those activities mainly focus on "control" rather on management optimization, economic water use, and community adaptation to drought conditions. Complete entrust and awaiting for the government support of part of the local population has exacerbated the already severe situation.

In summary, the development needs and agricultural development potential of the region are huge but the following water resources- and water use-related problems need to be addressed:

i. Drought and extreme weather events have been happening more frequently at higher intensity and severity. The droughts in 1997 - 1998 and 2014 ÷ 2016 due to El Niño are typical examples. El Nino cycles occur every 2-7 years; according to forecasts, the extreme El Nino events, similar to what happened in 1997-1998 and 2014-2016 would occur more often as once in a decade[58]. This will have serious impact with long and negative effects on people’s life and economic activities in the affected areas;
ii. Water resources and arable land are limited, while water demand is rapidly increasing due to urbanization and industrialization
iii. Irrigation systems have not met water supply effectively; water efficiency is still very low.
iv. Management capacity of irrigation operators is weak;
v. Water users waste a lot of water; water productivity is very low compared to the world average.

2 NATIONAL POLICY AND FRAMEWORK

2.1 National framework and priorities on socio-economic development[59]

In Viet Nam, in addition to the constitution, policies and programs on socio-economic development are steered by the ten year Socio-Economic Development Strategy (SEDS) and the five year Socio-Economic Development Plans (SEDPs). The major objective of the current SEDS 2011-2020 is to establish the foundation for Viet Nam to become a modern, industrialized country by 2020. It defines three ‘breakthrough areas’: (i) improving market institutions towards a socialist oriented market economy, (ii) promoting skills development, particularly for modern industry and innovation, and (iii) further infrastructure development.[60] The SEDS acknowledges that rapid development entails sustainable development, so at the same time ensuring economic development, environmental sustainability and social equity. Through the SEDS’ third specific objective, the aim is to mitigate negative environmental impacts of economic development, strive for sustainable management of natural resources, reduce disaster impacts and actively respond to climate change.

Linked to the SEDS, the National Action Plan on the Implementation of the 2030 Agenda for Sustainable Development was approved in May 2017 to advance the Sustainable Development Goals (SDGs) in Viet Nam. The action plan’s main objective is “Sustaining economic growth in parallel with ensuring social progress and justice and environmental and ecological protection, effective management and utilization of natural resources, proactive response to climate change; ensuring that all citizens promote their full potential, equally participate in development and benefit from the results of development; and building a Vietnamese society that is peaceful, prosperous, inclusive, democratic, just, civilized and sustainable.” The plan includes 17 SDGs with 115 specific objectives customized to the Viet Nam context. Of particular relevance for climate change and its impact on water security and agricultural production are: (i) Goal 2 on eliminating hunger, ensuring food security, improving nutrition and promoting sustainable agricultural development; (ii) Goal 11 on promoting sustainable, resilient urban

58 Cai, W. et al. (2014). Increasing frequency of extreme El Nino events due to greenhouse warming. Nature Climate Change, 4, 111-116

59 For a repository of legislation, strategies and plans, see: http://chinhphu.vn/portal/page/portal/English/strategies

60 http://www.economica.vn/Portals/0/Documents/1d3f7ee0400e42152bdcaa439bf62686.pdf and rural development, and (iii) Goal 13 on responding in a timely and effective manner to climate change and natural disasters.

Key cross-cutting socio-economic development target programs

Building on the SEDS and with the aim to improve integration of policies, the GoV has recently developed two major target programs or 'umbrella' programs, combining previous sectoral policies and programs into two integrated programs on new rural development and poverty reduction. Each ministry is responsible for the implementation of the specific sub-programs under these.[61] While the national government has a function in program design and monitoring and evaluation (M&E), all investment decisions and expenditure allocations are made directly at the provincial level, with some devolution to the districts and communes.

The National Targeted Program on New Rural Development (NTP-NRD) 2016-2020, coordinated under the Ministry of Agriculture and Rural Development (MARD), aims to modernize rural areas of Viet Nam and improve living conditions through promoting a model-system of a 'new rural commune'. A commune attains this status when it delivers on 19 economic and social criteria in terms of socio-economic infrastructure, modernized agricultural production systems with links to industrial and services development, income generation and poverty reduction, clean water supply and sanitation, social protection, governance, cultural development, health improvements etc. The objective is for 50 percent of all communes in the country to reach the 'new rural commune' status by 2020. Each set of criteria comes with specific policies and programs to achieve the overall program, the majority a continuation of previous sectoral targeted programs.

The National Targeted Program on Sustainable Poverty Reduction (NTP SPR) 2016-2020, coordinated by the Ministry of Labor, Invalids and Social Affairs (MOLISA), supports infrastructure, livelihoods, basic services and capacity building for the country's poorest districts and communes through five sub-programs. The aim is to reduce the number of poor households by 1.5 percent per year, with more ambitious targets of 3 to 4 percent for disadvantaged and ethnic minority areas. In addition, per capita incomes of poor households will be increased by 150 percent overall and by 200 percent in more disadvantaged areas. The five sub-programs under the NTP-SPR are as follows:

Project 1, also called Program 30a, focused on 64 poor and 23 near-poor districts and coastal areas, with specific sub-components in district infrastructure, coastal infrastructure, production development and labor export.

Project 2, also called Program 135 and being the largest program, is led by the Committee for Ethnic Minority Affairs (CEMA) and focused on 2,240 poorest ethnic minority communes and 33,273 villages, with specific sub-components in infrastructure, support for production and livelihood diversification, and capacity building.

Project 3, on 'Production Development focused on Model Replication', is led by MARD.

Project 4, also called 'Information and Communication for Sustainable Poverty Reduction', is led by the Ministry of Information and Communication.

Project 5, on Capacity Building and M&E, is led by MOLISA.

2.2 Policies and programs on economic development

The key strategy on overall economic development is the Master Plan on Economic Restructuring 2013-2020. The overall target of the Master Plan is to guide the transformation of the country's economy towards a modern socialist-oriented market economy with qualitative and sustainable growth, and improved efficiency and competitiveness. Specifically it aims to improve labor productivity, reorganize state-owned enterprises, develop hi-tech and high value industries – including in the agricultural sector - and accelerate integration into the global economy, through monetary, fiscal and market reforms.

The most recent review of the plan recognizes on-going challenges such as an economic growth still largely based on inputs and low quality and labor productivity, a stable but uncertain macroeconomic environment, slow and inefficient restructuring of the state sector, slow transformation of key sectors

61 Over the period 2011-2015, there were more than sixteen National Targeted Programs, often with significant overlap, limited integration and weak coordination. To improve this, the NTPs were consolidated into two major NTPs for 2016-2020. However, overlap and inefficiencies still continue with the two NTPs "still supporting the same planning process, overlapping in geographical areas, supporting of same types of activities, using the same institutional implementation arrangements, and overlapping of their target groups". See: World Bank (June 2017). Program Appraisal Document on a proposed IDA Credit to Vietnam for the National Target Programs for New Rural Development and Sustainable Poverty Reduction, p.8.

and limited collaboration among institutions. On transforming the agricultural sector, it acknowledges that rural development is slow, lacked integration and is insufficiently adapted to climate change.[62]

The update of the plan includes five targets for the period 2016-2020: (i) developing the domestic private sector and attracting foreign direct investment, (ii) restructuring the state sector: state-owned enterprises, public investment, state budget and the public service sector, (iii) restructuring the finance market, particularly credit institutions and the securities market, (iv) modernizing the economy towards improving productivity, quality, efficiency, while promoting international economic integration, and (v) restructuring major markets, including on land use rights, labor and science and technology.

2.3 Policies and programs on agriculture

The key strategy on agriculture is the Agriculture Restructuring Plan (ARP), developed by MARD in 2013 for the period 2013-2020, and updated in 2016. The ARP aims for the agricultural sector to shift from central planning to become market-led and consumer-driven, with the government's role changing from being the primary investor and service provider to being the facilitator of investments and services provided by others. The ARP calls for equal partnerships among government agencies, the private sector, farmer or community organizations, and the scientific community—the so-called 'four houses' – in progressing the transformation.

MARD's most recent Agricultural Master Plan's priorities are in line with the ARP and focus on:

- Sustaining the growth of the agriculture sector; raising the efficiency and competitiveness by increasing productivity, quality, and added values; satisfying the demands of consumers in Viet Nam and boosting exports.
- Moving from resource-intensive to technology-intensive agricultural growth, from fragmented to consolidated land holdings, and diversify from agriculture to rural non-farm employment.
- Improving income and living standards of rural residents, ensuring food and nutrition security in both the short term and the long term basis, and contributing to the reduction of poverty.
- Enhancing natural resource management, reducing negative impacts on the environment and climate change, utilizing environmental benefits, raising capacity for risk management, enhancing disaster preparedness, increasing forest coverage to 45 percent by 2020, and contributing to the National Green Growth Strategy.

Linked to the ARP, MARD also implements the Scheme of Restructuring of the Irrigation Sector (2014) with the aim to upgrade infrastructure, strengthen management, modernize and improve safety of irrigation systems while protecting against natural disasters. In 2015, MARD also promulgated the Action Plan for the Development of Advanced and Water Saving Irrigation for Upland Crops to Assist Water Resources Sector Restructuring. In addition, the Irrigation Law is currently being updated. Among other provisions, this law requires the adoption of economic efficiency criteria in the allocation of water amongst competing uses including irrigation.

Other agricultural sector laws, policies and strategies linked to the ARP include the Livestock Development Strategy (2008), Strategy on Science and Technology in Agriculture and Rural Development (2012), Law on Cooperatives (2012), revised Land Law (2013), Master Plan for Aquaculture Development (2013), and the Rice Market Development Strategy (2017). In 2008, the Action Plan Framework for Adaptation and Mitigation of Climate Change of the Agriculture and Rural Development Sector for 2008-2020 was issued (see below under section 2.2.7).

2.4 Policies and programs on water resources

In 2006, the National Water Resources Strategy (NWRS) was developed by the Ministry of Natural Resources and Environment (MoNRE). The NWRS' main objective is to strengthen the protection, exploitation, use and development of water resources, as well as the prevention and mitigation of adverse impacts caused by water. The main issues that need to be addressed are identified as: (i) awareness of the importance of water resources in sustainable development; (ii) balance between protection and development of water resources and ensuring adequate supply of water and water security for socio-economic development; (iii) mitigation of adverse impacts caused by water, including floods and droughts; (iv) protection of aquatic ecosystems; and (v) water resources management.

[62] *National Assembly (October 2016). Summary report on economic restructuring plan for period 2016 – 2020. Report No. 460/BC-CP. http://www.mpi.gov.vn/en/Pages/tinbai.aspx?idTin=35701&idcm=273*

Priorities under the NWRS are: river basin planning and management, water storage and transfer, surface- and groundwater protection and sustainable exploitation, pollution control, reservoir upgrading with priority to multipurpose use infrastructure, modernization of weather and hazard monitoring, warning and forecasting system, hazard risk mapping, scientific research and technology development, and consolidation of the legislative and institutional framework.

In 2012, the revised Law on Water Resources was promulgated. It has specific provisions on master planning and policy development, water exploitation, protection and conservation, disaster prevention and control, awareness raising, community consultations in water investments and management, water information systems, prohibited actions, budgeting and international cooperation.[63]

Viet Nam also has a comprehensive National Strategy and Target Program for Rural Water Supply and Sanitation, developed in 2000 and updated in 2011. The latest target program under this strategy are linked to the NTP NRD and NTP SPR objectives and prioritizes investments in poor, remote, ethnic, border and island areas as well as areas where water is polluted or scarce.

2.5 Policies and programs on environmental protection

The National Strategy on Environment Protection (NSEP) to 2020, with vision to 2030 was developed by MoNRE in 2012. The primary objectives of the NSEP are to control and minimize the increase of environmental pollution, resources and biodiversity degradation, further improve the quality of the habitat; and to increase the capacity to respond to climate change, striving for sustainable development. The NSEP recognizes the importance of environmental protection as an integral part of the country's socio-economic development towards a green economy, joint and inter-generational responsibilities and opportunities, and the polluter-pays principle.

In terms of agriculture, it encourages sustainable land use and cultivation, minimizing the use of chemicals and fertilizers, and preventing deforestation, forest degradation, land erosion and deterioration. On water management, it proposes solutions for the inefficient use of water and to overcome seasonal water scarcity: integrated river basin planning, better management of surface and groundwater resources, particularly in dry season, control of water pollution, adjustments of crop systems to less water-intensive ones, modernization of the irrigation system, and payment for forest ecosystem services schemes. Other sectors included in the NSEP are forestry, protected areas, coastal ecosystems, fisheries and biodiversity.

Other relevant laws and policies linked to environmental protection are the Biodiversity Law (2009), the National Strategy and Action Plan on Biodiversity by 2020 (2013) and the Law on Environmental Protection (2014). Section IV of the Law on Environmental Protection specifically addresses climate change with provisions on: mandatory climate risk informed socio-economic development and sectoral planning; greenhouse gas emissions management, including REDD+; management of ozone-depleting substances; renewable energy; eco-friendly production and consumption; waste-to-energy processes; rights and responsibilities of people on climate change information and action; development of technology and science; and international cooperation.

2.6 Policies and programs on forestry

In 2006, the MARD developed the Forestry Development Strategy 2006-2020. The main objective of the strategy is to sustainably establish, manage, protect, develop and use 16.24 million ha of land planned for forestry; to increase the ratio of land with forest up to 42–43 percent by 2010 and 47 percent by 2020; to ensure participation from various economic sectors and social organizations in forest development, to increase their contributions to socioeconomic development, environmental protection, biodiversity conservation and environmental services, to reduce poverty and improve the livelihoods of rural mountainous people, and to contribute to national defense and security. In 2014, the Law on Forest Protection and Development was amended and approved.

The larger part of the strategy focuses on forest resources as a source for economic and agricultural development including for livelihood improvement of people living in or around forests. A smaller section focuses on environmental functions of forests for protection of water resources and watersheds, erosion control, and mitigation of natural disasters.

2.7 Policies and programs on gender equality

The Law on Gender Equality was issued in 2007. One of the key provisions regarding livelihoods is equality between men and women in setting up, carrying out and managing a business and production

[63] *http://extwprlegs1.fao.org/docs/pdf/vie117928.pdf*

activities, and equality in accessing information, capital, markets and labor sources. Rural women are entitled to training and credit support, encouraging them to expand agriculture, forestry and fishery activities in accordance with the law.

The National Strategy and Action Plan on Gender Equality was approved in 2011, with the main aim to achieve substantive equality between men and women in terms of opportunities, participation and benefits in political, economic, cultural and social domains. Specifically, it aims to increase women's political participation and leadership; improve the State's capacity on addressing gender inequality; narrow gaps in the labor market; increase access to labor markets and economic resources for rural poor and ethnic minority women; ensure equal access to education, training and health care; reduce gender stereotyping in cultural and information products; and eliminate gender-based violence. It calls for women's full and equal access to productive resources such as land for cultivation, credit, insurance, markets and other information. It also identifies the need for services such as agricultural extension, vocational training, health and education to be tailored for women from diverse socio-economic backgrounds.

3 PAST AND ONGOING PROGRAMS AND PROJECTS

3.1 Government program

Recognizing the impacts and risks caused by extreme weather events, as well as the shortcomings in agricultural development and the opportunities arisen from the actual needs, the Government has been developig various policies to restructure the economy towards sustainability and resilience to climate change. Among the policies, the agricultural restructuring proposal which was issued enclosed with the Decision No. 899/QD-TTg on June 10, 2013 of the Prime Minister, targets improving the added value and sustainable development as a vital solution. To accomplish the goals mentioned in the Proposal of raising incomes and improving living standards for rural residents, strengthening natural resource management, improving risk management, being proactive in natural disaster mitigation, the Proposal emphasizes: "upgrade of infrastructures associated with improvement of quality of public services and increase of agricultural productivity in contributing to reduce rural poverty rate", "investments in irrigation and drainage shall gradually target multiple objectives, serving both production and increase of urban and rural drinking water supply capacity, to meet the growing demand for water supply and drainage for industrial production and economic development at high growth rates". This proves that irrigation and drainage is very important among the core contents of the restructuring plan. Therefore, investments in irrigation should be synchronized with investments in agricultural support infrastructures, with institutional and management strengthening, and agricultural support service enhancement in order to improve farmer's living standards and contribute to hunger eradication and poverty reduction.

The investment orientations for the irrigation sector in coming years focus on serving the agricultural restructuring program:

- Investments in irrigation towards multifunctionality to serve a variety of crops, aquaculture, and rural and industrial water supply;
- Focusing investments in the head work projects/structures in order to generate the maximal economic benefits; investment priorities given to new projects on dyke systems, dam safety; water supply for aquaculture; larger funding to upgrade, maintenance of structures after investment rather than new investments; construction of reservoirs in the areas affected by droughts, small-scale irrigation and hydropower development in mountain areas; support on technology and consulting services on water-saving methods (public private partnership -PPP).
- Implementation of investment projects in association with the irrigation management decentralization and reform (PPP).

Water Sector Development Strategy by 2020 gives particular attention to irrigation development in order to facilitate agricultural and forestry restructuring and crop diversification, ensure food security under the pressure of population growth, adverse weather changes and global instability, and secure water sources for domestic, industrial, fishery, tourism services, environment and ecological maintenance and improvement, and hydropower development. The main objectives of the Strategy include: ensuring water supply for people and economic sectors; raising safety levels in prevention and resilience in order to minimize flood damages; well managing river basins; rationally exploiting and using water resources; sustaining development, controlling water pollution and depletion in the main river basins and all the national river basins; and improving water management capabilities from the central to local levels.

Ministry of Agriculture and Rural Development (MARD) acts as the leading and directing the implementation of the Water Sector Development Strategy. According to the Strategy Implementation Plan, the following tasks are set forth: (i) developing irrigation and drainage, water supply for economic restructuring, agricultural and rural industrialization and modernization, and socio-economic development, particularly focus on upgrading and modernization of existing irrigation systems for their performance at full design capacity; continued investments in building new facilities, including large and medium scale integrated hydraulic works in river basins and water supply for agriculture, fishery, domestic, industry, flood control and hydropower generation; developing small and medium irrigation projects in the mountains to serve agricultural and forestry production, drinking water supply, hydropower generation in contributing to the rural and agricultural modernization; building hydraulic works for water supply and salinity prevention serving peoples and agricultural, fishery and salt production in the coastal areas; and developing innovative and water-saving irrigation solutions for upland crops, including industrial crops and fruit trees in the midlands and mountains, etc; (ii) consolidating and developing measures to prevent and mitigate flood disasters; (iii) strengthening water resources and hydraulic work management; and (iv) intensifying investments in scientific and technological research in the field of irrigation and drainage.

In recent years, MARD has focused their investments in upgrading and completing irrigation systems using ODA funds and counterpart funds. Along with the development and improvement of irrigation infrastructure, many other different approaches are also being studied and applied, including participatory irrigation management, integrated water resources management, etc to enhance investment efficiency, transforming from “command” to "services" in order to improve the beneficial use of water resources and irrigation works and mobilize maximum institutional participation in water management for the sake of better quality services towards water users. The activities aiming to strengthen irrigation management entities, finalize and complete the legal and policy framework, improve the irrigation management efficiency are being implemented to overcome those difficulties.

Among the ODA projects on irrigation and drainage managed by MARD, there are 10 projects completed and put into operation (excluding the investment projects for Laos), nine projects are ongoing, one project is awaiting for the agreement signing, and one project is under technical preparation. The practical operation of the completed projects show that the irrigation and drainage systems funded in the ODA loan projects have been performing well in facilitating socio-economic development in the project area, especially for agricultural and rural development along with the development and integration process of the country. Among those projects, some projects funded by ADB and WB to upgrade and modernize irrigation and drainage, support agricultural production and rural development, and reduce poverty have been and are being carried out successfully and serve as premise for the proposal of this WEIDAP, some examples are as follows:

The Vietnam Water Resources Assistance Project (VWRAP/WB3: US$ 176.5 million, completed on 31 December 2012): the project aims to (i) foster agricultural diversification and gains in productivity through irrigation system modernization, and thereby raise farm household incomes and reduce rural poverty; (ii) establish effective systems of dam safety management and lower the risks associated with dams; and (iii) promote the environmentally sustainable development and management of water resources in the Thu Bon River Basin. The project invested in upgrading part of the main canals, some primary and secondary canals of the Phu Ninh system (Quang Nam province), the headwork and some primary and secondary canals of the Ke Go system (Ha Tinh province).

The "*Development of Northern Chu and Southern Ma Rivers Irrigation System Project* (ADB6)" and "*Central Region Water Resources Project*" used ADB loans to invest in the construction of irrigation infrastructure in the Central Region. The WEIDAP will inherit experiences in developing business plan and restructuring of the IMCs towards financial autonomy for enhanced viability in management and operation of the structures in the post-investment stage.

The "*North Nghe An Irrigation System Upgrading Project", "Phan Ri - Phan Thiet Irrigation Project*", and "*Irrigated Agriculture Improvement Project*" employed JICA and WB loans to improve irrigated agricultural production in some selected provinces in the Central and Northern Mountains Regions in order to enhance the added value of agricultural production and adaptation to climate change on the basis of improvement of irrigation and drainage systems and institutions, irrigation management policies in line with the orientations of the National Target Program on New Rural Development and the Agricultural Restructuring Proposal.

The previous ODA projects targeted multiple objectives and addressing various problems through main activities such as building and upgrading irrigation infrastructure; strengthening management;

community development, etc. Many projects aimed to address pressing and localized issues by applying the centralized investment approach but without adequate resources allocated. The recently arisen issues mentioned in the objectives of the Sustainable Development Strategy and the National Target Program are of critical significance for the country's development but has not been thoroughly addressed, especially the "Agriculture, Rural and Farmers" Program (tam nong), the New Rural Development Program, the Agricultural Restructuring Proposal, and the Water Resources Development Strategy by 2020 which require synchronous and completed investment projects to fully resolve the problems from the head work to on-farm system levels. It is necessary to combine investments in upgrading physical works and strengthening system management aiming to improve the efficiency of irrigation and drainage services provided by the irrigation managers and encourage community participation in irrigation management. It is also required to complete and modernize the head works of reservoirs and conveyance canals together with introduction of water-saving and efficient irrigation methods for each type of crops and other water user’s needs; and to increase water efficiency, reduce input costs together with increasing the added value of agricultural production, transferring irrigation management along with improved farm and land use management. The lessons learned from the previous projects are summarized below and will be considered during the preparation and implementation of ADB8 Project:

- Only investing in irrigation in the areas with high economic value and less water-intensive crops in order to increase the value produced per unit of water used.
- It is important that technical designs of the subprojects should be prepared immediately upon the approval of the Feasibility Study Report for the sake of timely implementation of the project, well being prepared with sufficient capability to minimize the impact of the next El Niño cycle, and reducing the commitment fee of the loan. This could provide the basis for bidding arrangement immediately after the loan agreement takes effect.

Given the challenges posed by multi-purpose water management, flexibility in agricultural production support (cropping patterns and crops can be changed in a short period as required by the markets), and convenience and economy of water resources exploitation as well as irrigation and drainage management and operation, the design of this project should aim to: (i) not only meet the water supply against droughts but be able to cope with other extreme weather events (such as floods and storms) which are increasingly occurring abnormally under impacts of climate change; (ii) be flexible in providing irrigation services for various types of crops; (iii) apply scientific and technological solutions in construction and management, gradually modernize to improve water efficiency through water supply monitoring, appropriate management and decision making; and (iv) implement measures for asset inventory, evaluation, and management for the structures and systems, this is useful for the maintenance and fund allocation as well as for water valuation in order to enhance sustainability of the invested structures

MARD should directly perform the complicated tasks, the inter-provincial tasks or those assigned by the Government only. Other tasks should be decentralized to the local governments for direct investment management.

The powers, responsibilities and autonomy of the implementing agencies should be clearly defined before the start of the project. The Water User’s Organizations and Irrigation Management Company should be trained in accounting and financial management in order to ensure the project effectiveness. It is necessary to transfer irrigation management to Water User’s Organizations and the transferring process should be closely monitored to ensure the transparency and fairness.

In summary, many ODA projects have been implemented in Vietnam and contributed significantly to the completion and capacity enhancement of the irrigation and drainage systems, and strengthening of integrated water resources management capacity to facilitate the achievement of the objectives of agricultural development, living condition improvement in the context of climate change adaptation. Among them, those projects with obvious objectives of upgrade and completion of irrigation systems, improving irrigation management capacity are the Vietnam Water Resources Assistance Project, Irrigated Agriculture Improvement Project, Central Region Water Resources Project, and North Nghe An Irrigation System Improvement Project, which will serve as basis for MARD to inherit and propose the Water Efficiency Improvement for the Drought Affected Province Project, and then submit the Ministry of Planning and Investment (MPI) and the Government for consideration and approval.

3.2 Socio-economic development programs and projects

3.2.1 Poverty reduction

Since 1998, provincial PPCs, with technical support from MPI, CEMA and development partners, are implementing the ethnic minority poverty reduction program '*Socio-Economic Development of the Most Vulnerable Communes in Ethnic Minority and Mountainous Areas in Vietnam'*, also called Program 135. Initially approved for a period of seven years, the program was extended for a second phase from 2005 to 2010, and a third phase from 2011 to 2015. The initial objective and main objective until today is to implement government policies targeting the most vulnerable communes, promoting production and access to basic infrastructure, improving education, training local officials and raising people's awareness for better living standards and quality of life. Initially focused on infrastructure, it shifted to a focus on livelihood improvement and rural development.

Linked to Program 135, from 2006 to 2008, provincial PPCs also implemented the regional '*Program 134'* which provided housing, land for resettlement and/or agricultural production, clean water, water supply for irrigation and legal aid to poor ethnic minorities in the Central Highlands. Since 2002, through '*Program 139'* ethnic minorities across Viet Nam are also provided free health insurance, and through '*Program 168'* exemption of school fees, and support with textbooks and school supplies.

Since 2014 and until 2019, MPI is implementing the '*Central Highlands Poverty Reduction Project'*, in all five Central Highlands provinces, through a US$ 150million loan from the World Bank. The overall objective is to enhance living standards by improving livelihood opportunities in upland areas. The project has the following components: village and commune infrastructure development; sustainable livelihoods development through linking farmer groups and agricultural enterprises for investment in commercial agriculture or agroforestry; connective infrastructure development, capacity building and communication.

Since 2016 and until 2023, MPI, the Ministry of Transport and the provincial PPCs are implementing the '*Support to Border Areas Development Project'* in Kon Tum, Gia Lai, Dak Lak, Dak Nong and Binh Phuoc, through a US$ 106.5million loan from the Asian Development Bank (ADB). The project supports the socio-economic development of the border area between Viet Nam, Cambodia and Lao PDR through institutional capacity building support and the construction of transport and other basic infrastructure, including irrigation, water supply and wastewater treatment, and rural roads.

3.2.2 Agriculture and livelihoods

From 2014 to 2017, the Food and Agricultural Organization (FAO) (lead), UNIDO, UNESCO, IOM and UNV, in partnership with MARD implemented the joint program '*Support to the National Target Programme on the New Rural Development*', funded through a US$ 1.1million grant from the One UN fund and US$ 290,000 GoV contribution. The program was implemented at national level and in Son La and Quang Nam. The components were: (i) rural residents and producers' knowledge enhanced for modernizing agro-production, rural livelihoods and social development; (ii) capacity building in policy, strategy and public investment for creating new incentives for the new rural development process; and (iii) coordination and M&E of the NRP NRD. Activities included: development of new agricultural technologies, commune learning centres and cultural houses, value chain improvement, capacity building, policy advisory task force, participatory planning, and results-based M&E.

Since 2014 and until 2019, MARD is implementing the project '*Productive Rural Infrastructure Sector Project in the Central Highlands*' in all five Central Highlands provinces, through a US$ 80million loan from the ADB Asian Development Fund.[64] The objective is to increase rural and agricultural productivity, increase rural incomes and sustain livelihoods through regenerating and upgrading underdeveloped or outdated productive rural infrastructure, targeting areas with good potential for agricultural production with existing irrigation schemes. It hereby directly supports the implementation of the NTP NRD.

Starting from 2017, MARD will implement the project '*Enhancing Agricultural Competitiveness in Viet Nam'* in Khanh Hoa, Can Tho and Thai Binh, with a US$ 1.8 million grant from the Japan Fund for Poverty Reduction, administered by ADB. Supporting the implementation of the GoV ARP, the project aims to establish public-private collaboration arrangements in agriculture value chains and strengthen public investment planning and expenditure management for agriculture commercialization. Activities include: value chain assessments, climate-responsive financing for agribusiness development and investment, public-private partnership establishment, policy and institutional analysis, provincial agribusiness value chain strategies and plans, and capacity building.

64 The districts covered by this project in Dak Lak are: Ea Sup, Krong Nang, Lak, M'Drak and Buon Ma Thuot city.

Between 2010 and 2016, the International Fund for Agricultural Development (IFAD) has supported Dak Nong through the '*Sustainable Economic Empowerment of Ethnic Minorities*' project. The project was funded through a US$ 12.8million loan from IFAD, a US$ 0.3million grant from IFAD, a US$ 2.3million Government contribution, including US$ 0.9million from the Vietnam Bank for Agriculture & Rural Development, and an estimated US$ 0.7million as beneficiary contribution. The main objective was to contribute to the sustainable improvement of the livelihoods of poor and ethnic minority households, with particular focus on women. The project had two components: (i) ethnic minority livelihood development; and (ii) rural financial services, with activities such as: development and promotion of livelihood models, enterprise-to-farmer and farmer-to-farmer extension services, training programs, set up of farmer interest groups, a loan program based on joint liability, a Women's Union managed credit program, construction or upgrading of roads, bridge, drainage and waste management systems, irrigation canals and dams, water supply systems, and drying yards.

Between 2011 and 2017, IFAD has also supported Ninh Thuan, Gia Lai and Tuyen Quang through the '*Agriculture, Farmers and Rural Areas Support Project*'. The project in Ninh Thuan was funded through a US$ 12.8million loan from IFAD, a US$ 3.3million Government contribution and an estimated US$ 1.5million as beneficiary contribution. The objective of the project was to sustainably improve livelihoods among ethnic minority and rural poor households, with the following three major components: (i) institutional strengthening for implementation of pro-poor initiatives; (ii) pro-poor value chain development; and (iii) commune market-oriented socio-economic development planning and implementation. Activities included: value chain mapping and assessment, set up of farmer interest groups, development and promotion of livelihood models, competitive grant schemes for farmer groups and rural enterprises, a Women's Union managed credit program, training for farmers, extension workers, planners and other local authorities, construction or upgrading of roads, bridges, irrigation, water supply systems, electricity lines and markets.[65]

From 2015 to 2020, MARD is implementing the '*Vietnam Sustainable Agriculture Transformation Project'* or VnSAT project, mainly funded through a US$ 238million loan from the World Bank. The aim is to improve farming practices and value chains and promote institutional strengthening for the effective implementation of the ARP. For the Central Highlands, the project focuses on an intensive coffee rejuvenation, replanting and sustainable production program, and capacity building of national and local Government and value chain partners to support agricultural transformation. The beneficiary target is 62,000 coffee producing households. Activities include: training programs, farmer field schools, demonstration models, support to farmer group establishment, preferential loans for coffee replanting and rejuvenation, loans for farmers to invest in water efficiency technologies such as drip irrigation and roots watering, technical support on coffee certification, a virtual call center linked to mobile applications etc. [66]

Over the period 2004-2015, Oxfam implemented four projects in Thuan Bac and Bac Ai districts in Ninh Thuan aimed at improving the livelihoods of Raglai ethnic minority communities. From 2004 to 2007, the '*Food Security and Income Generation for poor Raglai ethnic men and women in Bac Ai district, Ninh Thuan province'* project; from 2007 to 2010 the *'Community Empowerment for Raglai people through livelihoods and market interventions'* project and a community-based forestry project (see below), and from from 2011 to 2015, the '*Enhancing Market Access and Promoting Economic Leadership for Raglai Women in Ninh Thuan'* project (US$ 337,000 grant). Activities across all projects were similar and included: gendered market mapping and selection of products, production inputs and support for market development, capacity building for producer group members on market skills, improved extension and veterinary services, advocacy for supportive policies and support by Government and the private sector, and cross-cutting actions aimed at improving the role of women in the household and community.

From 2012 to 2015, the SNV Netherlands Development Organisation in partnership with the Vietnam Chamber of Commerce and Industry managed the *'Vietnam Business Challenge Fund'*, with US$ 4.6million grant funding from the United Kingdom Department for International Development. The fund supported the private sector in Viet Nam to develop innovative business models that deliver both commercial benefits for the company and social impact for the low income population through 'inclusive business' models. The project has supported 16 models in three sectors: agriculture, low carbon growth and infrastructure and basic services, with one of the projects implemented in Binh Thuan, focusing on sustainable fishing and restoration of marine resources. A similar program called the '*Inclusive Business Accelerator*' ran from 2014 to 2016, with funding from the Netherlands.

65 Currently, MPI, PPCs and IFAD are designing an extension of this program for Ninh Thuan. This next phase will replicate good practice from the previous project but specifically focus on climate resilient agriculture. The project is intended to start in 2019.

66 The districts selected in Dak Lak are: Cu Kuin, Cu Mgar, Buon Ho, Krong Buk, Krong Nang, Krong Pak and Ea H'Leo.

Since 2016 and until 2020, the SNV Netherlands Development Organisation in partnership with MARD, the Viet Nam Chamber of Commerce and Industry and the local Women's Union, is implementing the '*Enhancing Opportunities for Women's Enterprises*' project, with funding from the Dutch Government. The project is implemented in Binh Thuan, Ninh Thuan, Binh Dinh and Quang Binh and focuses on strengthening women entrepreneurship, improving access to inputs and business assets, and increasing women leadership at all levels of the value chain.[67]

3.2.3 Water

From 2005 to 2008, the Ninh Thuan PPC implemented the project '*Harnessing water resources in Ninh Thuan Province*', with a US$ 27million loan and US$ 327,000 grant from the French development agency AFD. The project repaired or constructed new irrigation and water storage infrastructure for 2,500ha of farm land alongside the Cai river basin. Operation and management was organized through an irrigation fees system.

From 2008 to 2014, the Italian Development Cooperation has supported Binh Thuan with the '*Binh Thuan Water Sector Project'*, funded through a US$ 18million loan provided by the Italian Government. The project supported the construction of irrigation infrastructure for 1,500ha of farms cultivated by ethnic minority farmers in Bac Binh district and drinking water facilities for 135,000 people in Ham Thuan Bac district.

From 2007 to 2015, the provincial PPCs implemented the project '*Central Region Small and Medium Towns Development*' in 8 towns in Binh Thuan (Phan Thiet), Ninh Thuan (Ca Na and Thap Cham), Khanh Hoa (Cam Ranh and Ninh Hoa), Dak Nong (Gia Nghia) and Phu Yen (Song Cau and Tuy Hoa), through a US$ 53million loan from the ADB Asian Development Fund. The project improved: access to safe and sustainable water supply, drainage and wastewater treatment, reduced flooding and ponding, and improved solid waste management systems; behavioral change towards environmental hygiene and sanitation; and sustainable management and delivery capacities of water supply and sanitation service providers.

From 2015 to 2020, Dak Lak PPC is implementing the project *'Irrigation development in sustainable coffee areas in Dak Lak'* under PPC Resolution 153/2015/NQ-HĐND, with a planned budget of US$ 296.3million. The project is focused on irrigation infrastructure and water efficiency, aiming to increase the area of irrigated coffee by 16 percent – or 30,646ha - by 2020. The Resolution also includes a vision for 2025 to expand the irrigated area by 40 percent, or equivalent to 74,247ha, from the current situation.[68]

From 2011 to 2014, with US$ 4.5million grant funding from the Korea International Cooperation Agency, the provincial PPC of Dak Lak constructed a clean water supply system benefiting 80,000 households in Buon Ho town.

From 2016 to 2021, the MARD Center for Rural Water Supply and Sanitation is implementing the '*Results-based Scaling up of Rural Sanitation and Water Supply Program'*, with a US$ 200million loan from the World Bank and US$ 25.5million GoV co-financing. The overall objective is to improve hygiene behavior, and increase and sustain access to rural sanitation and water supply in rural areas, in line with the National Strategy and Target Program for Rural Water Supply and Sanitation and the NTP NRD. The project is implemented in 25 provinces, including in Dak Lak, Dak Nong, Binh Thuan and Ninh Thuan.

From 2012 to 2014, a research project called '*Linking increases in water use efficiency for food production at the farm scale to global projections*' was implemented in Ninh Thuan, by the Leibniz Institute for Agricultural Engineering Potsdam-Bornim, in partnership with the International Food Policy Research Institute and Southern Institute for Water Resource Planning. Funding was provided by the German Government. The research combined a local farm scale approach with a global modeling approach to further develop a methodology for estimating agricultural water flows, costs of production factors that affect farmers at the farm scale and to improve projections for agricultural water use.

From 2009 to 2016, the NGO International Development Enterprises implemented the project '*Introducing Low-cost Micro Irrigation Technology for Poor Farmers in South Central Vietnam'* in six

---

67 A similar project is implemented by SNV, CARE International and Oxfam in North Viet Nam (Lao Cai and Bac Kan), called 'Women's Economic Empowerment through Agriculture Value Chain Enhancement', from 2016 to 2019, with funding from the Australian Government.

68 82% of the planned budget is for building new reservoirs. 19% of the budget is sourced from the national government, 34% from Government bonds, 6% or US$ 17.6million from the provincial budget, 23% from Overseas Development Aid, and 18% from enterprises and beneficiaries. https://thuvienphapluat.vn/van-ban/Linh-vuc-khac/Nghi-quyet-153-2015-NQ-HDND-phat-trien-thuy-loi-vung-ca-phe-ben-vung-Dak-Lak-giai-doan-2015-2020-285454.aspx districts in Ninh Thuan, with funding from the Swiss Government. With locally adapted sprinkler and drip irrigation, the project covered 650ha and reached 2,100 households, including 200 very poor households. The overall aim of the project was to promote low cost technologies and practices through a pro-poor market based approach and farmer-driven innovation. Project activities included: engagement of farmers and retailers in product research and development, market development with set-up of a technology supply chain network, marketing campaigns in collaboration with local authorities and mass organizations for technology replication.

Since 2014, the Vietnamese start-up Mimosatek is promoting so-called '*precision-agriculture'* technology to smallholder farmers and agricultural business across the country, but mainly in the Central Highlands. Currently focused on on-farm irrigation, the 'MGreen' system comprises of small-scale weather stations, soil sensors, automated measurement and data processing devices and a smartphone application, that help the farmer to know when, where and how much to irrigate ensuring reduced costs for agricultural inputs and maximum yield outcomes. The system currently operates best for a mono-cropped farm, but the company intends to develop alternative systems for inter-cropped farms. Mimosatek aims to reach 1 million farmers with their technology by 2022.

From 2015 to 2018, Electricity Viet Nam is upgrading hydropower facilities in Ninh Son district of Ninh Thuan through the project '*Da Nhim Hydropower Plan Expansion Project'*, with a US$ 85million loan from the Government of Japan. Once finished, the project will have expanded electricity supply with an additional 100million kilo watt per hour, as well as increase water supply in dry seasons.

From 2018 to 2023, MARD with provincial PPCs will implement the '*Dam Rehabilitation and Safety Improvement Program'*, with a US$ 420million loan from the World Bank and a US$ 40million GoV contribution. The focus is on priority repair and upgrading of multipurpose dams and reservoirs in more than 31 provinces in Viet Nam, to ensure safety of downstream infrastructure and long term viability and operational efficiency. [69]

3.3 Projects and programs on climate resilience

Under the climate finance investment mechanism of the SP RCC, provinces, including Dak Lak, Khanh Hoa, Ninh Thuan and Binh Thuan were requested to submit projects for strengthening climate resilience. In 2012, more than 64 projects have been approved, with 16 projects implemented over 2013-2014.

3.3.1 Water security in the context of climate variability and change

From 2005 to 2008, the Australian Centre for International Agricultural Research in collaboration with the Tay Nguyen University, Ho Chi Minh City University of Economics and MoNRE implemented the research project '*Managing groundwater access in Tay Nguyen (Central Highlands) Vietnam'* in Dak Lak, with a US$ 402,912 grant from the Australian Government. The aim was to better understand the groundwater flows and use, and recommend appropriate policy incentives for more sustainable management.

From 2007 to 2009, Partners Voor Water in collaboration with MoNRE implemented the pilot project '*Re-hydrating the earth by sustainable, small scale sub-surface water retention techniques*' in Ninh Thuan. The project demonstrated a system for runoff harvesting and water retention to improve soil moisture availability and recharge shallow groundwater levels.

From 2004 to 2010, UNESCO implemented the pilot project '*Augmenting groundwater resources by artificial recharge in Binh Thuan province, Viet Nam'*, in partnership with the Vietnamese Academy of Science and Technology, the local DARD and DoNRE, and the Sapienza University in Italy. The project was funded by the Italian Government, the International Council for Science and UNESCO. The project conducted hydro-geological and hydrological studies, aquifer mapping and water testing, groundwater modeling, and capacity building on aquifer management.

From 2013 and until 2019, the provincial PPCs of Ninh Thuan, Binh Thuan and Ha Tinh with technical support from the Belgian Bilateral Cooperation are implementing the project '*Integrated Water Management and Urban Development in Relation to Climate Change*', funded through a US$ 28.5million grant from the Belgian Government. The project's main objective is to strengthen the capacities on integrated water resource management and urban development in the context of climate change. It includes activities such as downscaled climate, hazard and hydrology modeling, provincial climate change action planning, urban master planning, institutional capacity building, and urban water supply, drainage and other green infrastructure investments. Two studies are currently in the pipeline: one on water demand versus availability within a climate change context; and the other on irrigation

69 Sites selected in Dak Lak are: 10 reservoirs in Krong Pak, Krong Nang, Krong Buk, M'Drak, Ea Kar districts and Buon Ho town management practices, from farm to company level. The project does not plan any specific infrastructure or other support to farmers directly.

From 2018 to 2022, MARD and provincial PPCs will implement the project '*Water Efficiency Improvement in Drought Affected Provinces'* (WEIDAP) in five provinces: Dak Lak, Dak Nong, Binh Thuan, Ninh Thuan and Khanh Hoa. The project is funded through a US$ 100million loan from ADB's Asian Development Fund, a US$ 300,000 grant from the ADB Climate Change Fund, a US$ 750million grant from the Water Partnership Fund, Government contributions equalizing US$ 16million and farmer contributions equalizing US$ 1.6million. The project aims to improve agriculture water productivity ('crop per drop') and climate resilience by increasing water use efficiency in irrigated agriculture in provinces affected by the 2015-2016 drought. The project has three major outputs and areas of interventions as follows:[70]

1. Modernized irrigation management services adopted: irrigation water resources allocation and delivery, maintenance of irrigation infrastructure, piloting of a water delivery charging mechanisms, and policy and institutional arrangements for management, operations and maintenance.
2. Modernized irrigation systems developed and upgraded: rehabilitation and development of modern irrigation infrastructure
3. On-farm water distribution, application and management practices for high value crops improved: promote adoption of on-farm water efficiency agricultural techniques, and support the development of high tech agricultural production zones.

3.3.2 Strengthening agricultural resilience

Since 2006, ADB, FAO and IFAD are supporting the countries in the Greater Mekong Subregion through the regional '*Core Agriculture Support Program'*, with phase I running from 2006 to 2010, and phase II from 2011 to 2020. In Viet Nam the project is mainly implemented at the national level, with pilot activities in Northern provinces. Phase I of the program focused on facilitating cross-border agricultural trade and investment, promoting public-private partnerships, enhancing capacity in agricultural science and technology, establishing emergency response mechanisms for agricultural and natural resources crises and strengthening institutional linkages and mechanisms for cooperation. Phase II focuses on promoting food safety and modernizing agricultural trade, promoting climate-friendly agriculture via market-based strategies (including carbon financing, climate-resilient farming systems, weather-based insurance) and promoting agriculture as a source for clean rural renewable energy.

From 2014 to 2017, FAO in partnership with MARD has implemented the national level project '*Enhancing NAMA Readiness: building capacity in integrated food and energy systems in Vietnam*', funded through a US$ 770,000 FAO grant. The project aimed to improve institutional capacity for the development of a framework for NAMA in the agricultural sector, through capacity building, policy dialogue and policy development support.

From 2007 to 2011, the Australian Centre for International Agricultural Research in partnership with the Vietnam Academy of Agricultural Sciences and the local DARD, conducted a research-for-development project in Ninh Thuan and Binh Dinh called '*Improving the utilisation of water and soil resources for tree crop production in coastal areas of Vietnam'*, with a US$ 666,198 grant from the Australian Government. The research looked into efficient irrigation and nutrient management practices for horticultural crops grown in wet and dry seasonal climates with limited water and highly permeable soils.

Since 2014 and until 2019, the International Water Management Institute and E.D.E. Consulting, with US$ 2.2million funding from the multinational Nestlé and the Swiss Agency for Development and Cooperation, partnered with the Hanoi University of Science and the local DARDs for the program '*More coffee with less water – towards a reduction of the blue water footprint in coffee production'*. The program targets 50,000 coffee farmers in all the Central Highlands provinces, and includes a large training program on irrigation management and application of good agricultural practices, an online and SMS based weather information system[71] and policy support on water management.

Since 2016 and until 2018, Atlantic Commodities Vietnam Ltd. or ACOM, a Vietnamese coffee and cocoa exporter[72], with funding from the multinational Jacobs Douwe Egberts/Mondelez International, and in partnership with DARD, is implementing the '*Cultivation Soil Management and Water*

70 ADB, MARD (April 2017). Water efficiency improvement in drought-affected provinces (WEIDAP), Viet Nam (TA 9147-VIE): project preparation consultancy services. Mid Term Report.

71 See http://thoitiet.hus.vnu.edu.vn/

72 ACOM was established in 2002 as a subsidiary of ECOM Agroindustrial, one of the world's top three community trading and processing companies, mainly in coffee, cocoa and cotton.

Conservation project' in Dak Lak and Lam Dong. Through demonstration farms and farmer groups, the project aims to promote the adoption of agroforestry farming, improved soil and nutrient management, terrace farming, water conservation, coffee rejuvenation and certified coffee production, targeting over 2,000 farmers and 3,500ha. The above project builds on a previous project implemented by ACOM in 2013-2015 in Lam Dong, with co-funding from the Sustainable Trade Initiative or IDH and Mondelez International through their '*Coffee Made Happy'* program. The project provided trainings to 1,500 farmers on good agricultural practices, record keeping and business planning; seedlings, shade trees and other inputs; soil testing and fertilizer recommendations; and support on obtaining and sustaining coffee certification.[73]

From 2016 to 2018, SIMEXCO, a large state-owned coffee bean exporter, in partnership with UTZ, E.D.E. Consulting and the Western Highlands Agriculture and Forestry Science Institute, implements the '*Sustainable Coffee Landscape'* project in Dak Lak. The project aims to raise awareness of 5,362 farmers (with 7,604ha of farm land) about; climate change impacts on coffee production and possible adaptation options, the need to reduce water consumption through more efficient technologies, improve the use of fertilizers without harming the environment, and the advantages of farmer groups. The project will conduct Farmer Field Schools, demonstration plots and extensive data gathering through Farmer Field Books.

All the above public-private partnerships are closely linked to the IDH flagship programs the '*Initiative for Sustainable Landscapes'* and the '*Sustainable Coffee Program'*. The landscape initiative aims to bring the public, private and civil society sector together to co-invest in farm landscape improvement and sustainable production, for example through inter-cropping, agroforestry, improved fertilizer and water management etc. The Coffee Program operates more at the national level by providing a platform for dialogue between public, private and civil society partners. In Viet Nam, the platform is called the Vietnam Coffee Coordination Board, chaired by MARD.[74] Recently, the Board approved a coffee sustainability curriculum to be used as training material by extension services, businesses and other partners.

From 2017 to 2021, a research partnership led by the French Agricultural Research Centre for International Development, and including ICRAF World Agroforestry Centre, SNV, international and local universities and private sector partners such as the international coffee company Illy, is implementing the '*Breeding Coffee for AgroForestry Systems'* project. The project is running in Viet Nam (including the Central Highlands), Nicaragua, El Salvador and Cameroon and is funded through a US$ 5.4million grant from the European Union *Horizon 2020* research and innovation programme. It aims to diversify the range of varieties available and cropping practices integrated into agroforestry systems for a more sustainable coffee production.

Since 2003, MARD with support from the SNV Netherlands Development Organisation is implementing the '*Biogas Program for the Animal Husbandry Sector in Vietnam*', with funding from the Dutch Government. The main objectives are to improve the livelihood and quality of life of rural farmers in Vietnam through exploiting economic and non-economic benefits of domestic biogas, and to develop a commercially viable domestic biogas sector. By mid-2016, the program has facilitated the construction of 157,583 small-scale bio-digesters in 55 provinces, including Dak Lak and Khanh Hoa, benefiting more than 800,000 people.

3.3.3 Climate information services, for agriculture, water and early warning early action

Since 2015 and until 2018, CARE and the ICRAF World Agroforestry Centre, in partnership with the MoNRE IMHEN and local DARDs, are implementing the research-for-development project '*Agro-Climate Information Services for Women and Ethnic Minority farmers in South-East Asia'* targeting 200,000 farmers in Viet Nam (Dien Bien and Ha Tinh), Cambodia and Lao PDR. The project is funded through a US$ 1.6million grant from the Research Program on Climate Change, Agriculture and Food Security led by the Consultative Group for International Agricultural Research (CGIAR). The project has five major components: co-development of seasonal agro-climate forecasts and advisories, set-up of gender empowering farmer learning networks, an action-oriented capacity building program for agricultural planners and farmers, a knowledge generation platform, and policy dialogue for scaling agro-climate information services. The project is building on earlier work by CARE from 2012 to 2014 piloting agro-climate information services in Thanh Hoa and Bac Kan.

---

73 For more details, see https://www.idhsustainabletrade.com/uploaded/2016/10/151209-6-pager-ACOM.pdf

74 Members include the Vietnam Coffee and Cacao Association (VICOFA), the organization with the largest number of producers and traders in the coffee sector, with the large majority being Vietnamese producers and traders.

Between 2013 and 2016, Oxfam in partnership with IMHEN implemented the project '*Agro-climate forecast and information system for enhanced resilience of poor farmers*' in Quang Tri. The overall objective was for poor women and men, particularly ethnic minorities to claim and receive the required information and services to adapt their crop calendar and farming system to consequences of climate change. Activities included: assessment of the existing agro-climate forecasting system, introduction of crop calendar and forecast development software, development and dissemination of agro-climate forecast bulletins, formation of farmer interest groups, farmer learning events, and capacity building of hydro-met and agricultural staff.

Since 2013, the Norwegian Meteorological Institute in collaboration with the Asian Disaster Preparedness Center is delivering a capacity building program to the national hydro-meteorological services in Viet Nam as part of the project '*Strengthening Weather and Climate Services of Myanmar, Bangladesh and Vietnam to Deal With Hydro-Meteorological Hazards'*, funded by the Norwegian Ministry of Foreign Affairs. Trainings are delivered twice a year and focus on digital tools for daily and seasonal weather monitoring and forecasting, climate services for early warning and disaster risk reduction, ocean modeling etc.

Since 2016, and until 2019, the NGO ICCO, in partnership with MARD and a number of private sector organizations, is implementing the '*Information services for coffee farmers in Vietnam'* or GREENcoffee project, in Dak Lak, Gia Lai, Kon Tum and Lam Dong provinces. It is funded through the '*Geodata for Agriculture and Water'* or G4AW Program from the Netherlands Government. Targeting more than 100,000 coffee farmers, the project is providing an SMS and mobile app-based information system that delivers information on daily weather and weather forecasts, extreme weather conditions, daily prices and price forecasts for coffee, basic advice on farming techniques, pests and diseases etc. The system integrates a question-and-answer hotline manned by technical experts. It was launched in August 2017.

Since 2015, the Vietnamese enterprise AgriMedia is offering SMS-based weather and market information services to farmers, agricultural enterprises, reservoir operators and agricultural planners through its iMetos system. The system includes the installation of small-scale weather stations operated at the local level, but linked through a server managed in Hanoi. Currently 60 weather stations have been installed across the country, including in Dak Lak, and 500,000 farmers have signed up to the SMS service, paying a monthly subscription fee. By 2018, the company aims to install up to 200 to 300 weather stations to cover the entire country. In addition to iMetos, in August 2017, AgriMedia in partnership with VinaPhone also launched a call-center, manned by more than ten technical experts to provide advice to farmers.

Starting in 2017, the Institute for Water and Environment and the Vietnam Academy of Water Resources, both under MARD, are implementing the research project '*Application of Satellite Data to Strengthen the Capacity of Reservoir Operation and Management for Increasing Resilience to Drought and Ensuring Water and Food Security for Ninh Thuan'*, with grant funding from the USAID-NASA SERVIR-Mekong program.[75] Activities included are: field surveys to collect data, development of a data system to support reservoir operation, field surveys to assess the accuracy of the system, and stakeholder engagement.

Starting in 2017, FAO in partnership with MARD have initiated the pilot application of a drought risk index through the project '*Strengthening the agro-climatic information system to improve the agricultural drought monitoring and early warning system in Vietnam, pilot study in Ninh Thuan province*', funded through a US$ 200,000 FAO grant. The risk index is based on FAO's Agriculture Stress Index System, which is a component of their Global Information and Early Warning System and will focus on rice, maize, fruit and other crops. Rather than using rainfall data, the index is based on vegetation health collected via satellite imagery and historical data spanning thirty years. Seasonal and ten days outlooks are then produced to disseminate to farmers and agricultural planners. In a next step, the aim is to expand the pilot to seven other most drought affected provinces including in the Central Highlands, and integrate the index into Viet Nam's multi-hazard warning system.

---

[75] A five-year (2014-2019) data-for-development program, SERVIR-Mekong works in partnership with leading regional organizations to help countries in the Lower Mekong Region - Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam - use information provided by Earth observing satellites and geospatial technologies to manage climate risks. The program has the following objectives: (i) build and institutionalize the technical capacity of government decision makers and key civil society groups to integrate geospatial information into their decision-making, planning, and communication; (ii) improve the sharing of user-tailored geospatial data, products and services; (iii) develop new high quality user-tailored data, tools, applications, and models to address on-the ground priorities; and (iv) SERVIR-Mekong hub strengthened as a regional provider of geospatial data, analyses, and capacity building services. The Asian Disaster Preparedness Center is the prime implementer, with three other consortium partners, Spatial Informatics Group, Stockholm Environment Institute and Deltares, assisting in the implementation.

in Gia Lai and Ca Mau, with a US$ 950,000 funding from the European Civil Protection and Humanitarian Aid Operations program. The aim of the project is to pilot a forecast-based financing (FbF) system[76] for drought early warning and early action on food security and livelihoods, and water, sanitation and hygiene. Activities include: development of scientific thresholds for drought occurrence with levels of severity and probabilities, linking of thresholds to preparedness actions via drought early action plans, community dissemination and learning through women's groups, cost benefit analysis for scaling, and advocacy at national level through an FbF working group. The project follows a drought emergency livelihood recovery program implemented by FAO and Action Aid in 2016 that delivered vouchers and unconditional cash transfers to more than 6,000 farmers in Gia Lai, Dak Lak and Dak Nong.

Starting in 2017, the International Center for Tropical Agriculture in partnership with the World Meteorological Organization, University of Southern Queensland and the insurance company Willis Ltd. is implementing the project '*Applying seasonal climate forecasting and innovative insurance solutions to climate risk management in the agriculture sector in South-East Asia*'. The total funding is US$ 16.1million, including US$ 9.5million funding from the German Government's International Climate Initiative and US$ 2.6million from Willis Ltd. The objective of the project is to develop resilient climate risk management systems, best practices and insurance products, to shield smallholder farmers and businesses engaged in coffee, sugar, rice, cassava, rubber, and grazing across the agricultural value chain, from physical and financial disaster associated with climate variability and change. Activities include: expansion of the current data collection network, climate, agricultural and hydrological modeling, seasonal-to-yearly climate forecasts, demonstration of index-based insurance products, policy development on risk insurance and capacity building.

3.3.4 Disaster risk reduction

From 2003 to 2006, the Viet Nam Red Cross, the Netherlands Red Cross and Spanish Red Cross implemented the first CBDRM project '*Preparedness for Disasters Related to Climate Change'* in Ninh Thuan, Binh Thuan, Nghe An, Ha Tinh and Quang Binh, with US$ 460,000 grant funding from the Netherlands. The project implemented structural and non-structural measures for disaster preparedness such as awareness raising, community risk analysis and planning, small-scale mitigation measures, support to disaster response teams and capacity building. A similar project '*Community Based Disaster Preparedness in Viet Nam'* was implemented by the same organizations reaching 61,000 people in Ninh Thuan (Ninh Phuoc and Ninh Hai districts), Binh Thuan (Tuy Phuong district), Quang Tri and Hue from 2007 to 2008, with US$ 415,000 funding, including a US$ 350,000 grant from the European Union Disaster Preparedness fund.

From 2011 to 2014, World Vision implemented the project '*Enhance Community Capacity in Community-Based Disaster Risk Management Planning and Implementation'* in Bac Binh and Ham Thuan Bac districts in Binh Thuan, with funding from the German Government. The project was integrated into its area development program (see under section 3.2.5).

From 2013 to 2015, the Vietnamese NGO Centre for Marinelife Conservation and Community Development or MCD implemented the project '*Improving community livelihood resilience and adaptive management of locally managed marine reserves of Vietnam*' in Khanh Hoa, Binh Dinh and Quang Nam with a US$ 58,000 small-grant from the Mangroves for the Future program. The project targeted coastal districts such as Van Ninh district and supported poor fishermen and women headed households with livelihood support. In addition, technical support was provided for Marine Protected Area-wide adaptation planning.

From 2014 to 2016, under Decision 48, the Ministry of Construction implemented a '*Target Programme to provide support policies and solutions for poor households to build storm and flood resilient houses in Central Region'*, in 14 provinces in Central Vietnam, including Khanh Hoa, Ninh Thuan and Binh Thuan. As part of this program, 688 houses used by poor households in the three latter provinces were made flood and storm proof. A second phase of the program will expand it to an additional 1,629 in the three provinces, and 85,100 for a total of 20 provinces.

From 2008 to 2011, UNDP in partnership with MARD implemented the '*Strengthening Institutional Capacity for Disaster Risk Management in Viet Nam, including Climate Change Related Disasters*' project at the national level and in Binh Thuan, Cao Bang and Can Tho, with US$ 4.3million grant funding

[76] The FbF approach has been developed and promoted by the Red Cross Red Crescent Movement and the World Food Program since 2015. The approach has been successfully demonstrated in Uganda, Zimbabwe, Peru, Guatemala, Bangladesh, Dominican Republic, Haiti, Mozambique, Nepal and the Philippines and is now being replicated across the world. For more information, see http://www.climatecentre.org/programmes-engagement/forecast-based-financing

from UNDP and the Australian Government. The project focused on the implementation of the National Strategy on disaster risk management, including the development of a new law, improvement of the early warning system, institutional capacity strengthening, disaster damage information systems and the set-up of the MARD CBDRM Program. A second phase of the project was implemented through a partnership of UNDP, MARD, Oxfam, the Viet Nam Red Cross and the Vietnam Women's Union from 2012 to 2016 and focused on the dissemination of the new law and the extensive roll-out of the CBDRM Program in 20 provinces, including Binh Thuan.

From 2017 and until 2022, MARD, the Ministry of Construction and PPCs of 28 coastal provinces, including Binh Thuan, Ninh Thuan and Khanh Hoa, in partnership with UNDP are implementing the project '*Improving the resilience of vulnerable coastal communities to climate change related impacts in Viet Nam*', with a US$ 29.5million grant from the Green Climate Fund. The objective of the project is to improve the resilience of vulnerable coastal communities to climate change related impacts in Viet Nam through: safe housing to protect vulnerable communities from increased flooding and storms; robust mangrove coverage to provide a natural buffer between coastal communities and the sea; and enhanced climate risk information to guide climate resilient and risk informed planning.

From 2017 till 2021, provincial PPCs in Ninh Thuan, Binh Dinh, Phu Yen, Ha Tinh and Quang Ngai will implement flood recovery interventions through the '*Emergency Flood Disaster Reconstruction Project for Vietnam*', funded via a US$ 136million loan from the World Bank. Funds will be used to rehabilitate disaster affected infrastructure such as irrigation, dams and reservoirs, roads, bridges etc. An additional component focuses on institutional capacity strengthening on disaster recovery.

3.4 Proposed WEIDAP project

3.4.1 Rationale

In line with the Agricultural Development Strategy of Vietnam, ADB's Country Partnership Strategy 2016 ÷ 2020 aims to "maintain sustainable agriculture growth by improving efficiency and competitiveness, improve rural living conditions and resilience in the context of climate change".

Both ADB's Country Partnership Strategy (CPS) 2012-2016 and the strategy for the agriculture, natural resources and rural development (ANR) sector the strategy for the Agriculture and Natural Resources confirm continuous support to Vietnam in maintaining its sustainable agricultural growth by improving efficiency and competitiveness, improve rural living conditions and resilience in the context of climate change. The "Water Efficiency Improvement for the Drought Affected Province Project" is fully in line with these strategies, and aims to respond to the consequences of climate change associateddroughtand improve the added value of agricultural production, and contributing to build a new rural society.

ADB has extensive experience in supporting integrated water resource development and management, and in natural disaster management in Vietnam. Since 1993, ADB has consistently assisted the irrigation and drainage sector of Vietnam as a foundation for sustainable agricultural development, poverty reduction and adaptation to climate change. Prevoius projects include: the Irrigation and Flood Protection Rehabilitation Project (completed in 2001), the Red River Basin Water Sector Project (completed in 2001), the Flood Remedial Project (completed in 2002), Second Red River Basin Water Sector Project (completed in 2010), Central Region Water Resources Project (completed in 2011), Phuoc Hoa Water Resources Project (ongoing), Strengthening Water Management and Irrigation System Project (ongoing), North Chu and South Ma Rivers Irrigation System Project (ongoing), and Greater Mekong Subregion - Flood and Drought Risk Management and Mitigation Project (ongoing).

Following the severe drought in 2014-2015, an ADB survey conducted in June 2015 proposed the Water Efficiency Improvement for the Drought Affected Province Project to respond to the drought in the South Central and Central Highland Regions. The proposed Project aimed to both realize ADB's and the Government's strategic objectives and to provide emergency support to the provinces seriously affected by drought, based on requests from the affected provinces and under the direction of the Government and Prime Minister.

3.4.2 Objectives and scope of WEIDAP

To support water efficiency improvement in the provinces affected by droughts in 2014-2016 through rational allocation of water resources in order to enhance the added value of agricultural production in contributing to agricultural restructuring, new rural development, and adaptation to climate change.

Specific objectives

To improve irrigation management in the provinces affected by droughts towards service-oriented irrigation management with potential public-private partnership involvement; to develop water tariff and introduce bidding procurement mode in irrigation service provision.

To upgrade, rehabilitate and partially modernize irrigation systems in order to improve water efficiency and resilience to extreme weather events; to apply scientific and technological solutions in water management and distribution for high economic value agricultural production in conditions of water scarcity; and to research and develop PPP in the construction and management of irrigation systems.

To introduce advanced scientific and technological solutions in water-saving irrigation at level in order to encourage application of water saving irrigation at on-farm for water efficiency improvement.

The project also aims to attract private large-scale agricultural production and processing investors to invest in high-tech agricultural zones in 2-3 localities in the project area.

Scope of the Project

Location of the project: According to the provincial selection criteria[77] agreed with ADB and approved by the Prime Minister at the Decision No. 727/QD-TTg dated 28 April 2016, and after screening process, the project will be implemented in Ninh Thuan, Khanh Hoa, Dak Lak, Dak Nong and Binh Thuan provinces.

3.4.3 Expected outputs of the Project

Outputs on irrigation service management improvement

- Strengthened plan preparation, improved regulations and water supply monitoring in the irrigation systems under the Project in order to support effective irrigation management based on periodic water productivity evaluation;
- Strengthened infrastructure management to improve efficiency and sustainability through harmonizing the O&M plan and allocated budgets;
- Improved business plan of the water suppliers to boost up irrigation towards service-oriented and financially autonomous entities, and promote PPP in irrigation management;
- Enhanced WUG’s participation so that they will participate in the irrigation plan development, monitoring and management of on-farm water-saving irrigation systems together with water supply entities (especially with PPP);
- Improved natural disaster risk management capacity (particularly droughts) of the agricultural water users.

Outputs on upgrade, rehabilitation and modernization of irrigation systems

Eight small and medium irrigation systems[78] are expected to be upgraded, rehabilitated and expanded to serve mainly high economic value crops in the five drought-affected provinces towards modernization and resilience to natural disasters risks, especially drought risks. The design of the project will also take into account some other issues such as cropping pattern change to introduce high economic value, less water-consumping crops; available mechanization potential; adaptation to future water scarcity as well as more frequent occurrence extreme weather events (such as floods and droughts); and future water demand rise.

Appropriate water monitoring equipment will be set up and installed in the irrigation systems for enhanced water monitoring and allocation in water-scarce conditions and better operation management. The items in this component should be designed properly based on practical management capacity of the operators, on farmer’s participation awareness, and on economic and environment aspects in order to maximize water efficiency per unit of water used.

PPP forms will be deployed aiming to mobilize social capitals for upgrade, rehabilitation, modernization and O&M management of the irrigation systems under the project. The lessons learned from this will serve as premise for the implementation of PPP forms in the water sector, which is currently very unattractive to private investors.

Outputs on application of on-farm water-saving irrigation

---

[77] *Maximally five provinces most affected by droughts in 2014÷2015 in terms of agricultural losses.*

[78] *The systems are selected using the selection criteria agreed with ADB and submitted to the Prime Minister in the PDO of the PPTA.*

Water-saving irrigation models will be screened, selected and introduced for high economic value crops in the project area. The models will be highly flexible and able to adapt to the changing cropping patterns in line with market demand.

Efficient energy solutions will be suggested for irrigation systems in the project area in order to reduce input costs, thereby increasing the agro-product value and contributing to environmental protection. These results will be replicated outside the project geographical scope;

Scientific and technological solutions will be proposed to improve water efficiency based on water productivity evaluations in the South Central and Central Highland Regions;

Irrigation procedures and modes, and associated implementation guidelines will be developed for high economic value crops in the project area in order to avoid water waste in the drought areas and improve crop productivity through reasonable irrigation regimes.

3.4.4 Estimated total costs and proposed implementation schedule

The project will require investment of US $ 124.3 million equivalent to VND2,808.3 billion. Funds will come from donor capital, non-refundable funds and Vietnamese reciprocal capital as follows:

- ADB Donor Capital : An ADB loan of US $ 100 million, equivalent to VND 2,260 billion focusing is propoposed which will focus on construction and related activities in Components 3 and 3..Non-Refundable Funds: The Water Resources Development Fund (WFP) will provid $ 1.05 million, or $ 23.7 billion, to implement Component 1 activities.
- Vietnamese reciprocal capital: The capital from the central budget and the project's provinces is proposed at USD 23.2 million, equivalent to VND 525 billion. These funds will be used activities including site clearance, community liaison design, project management, taxation and some implementation of Component 2.

According to the loan negotiation plan proposed by ADB for the project, the feasibility study report is expected to be approved early 2018 to enable loan negotiations to be completed within 2018. The project is planned to be implemented in six years, from 2018-2024.

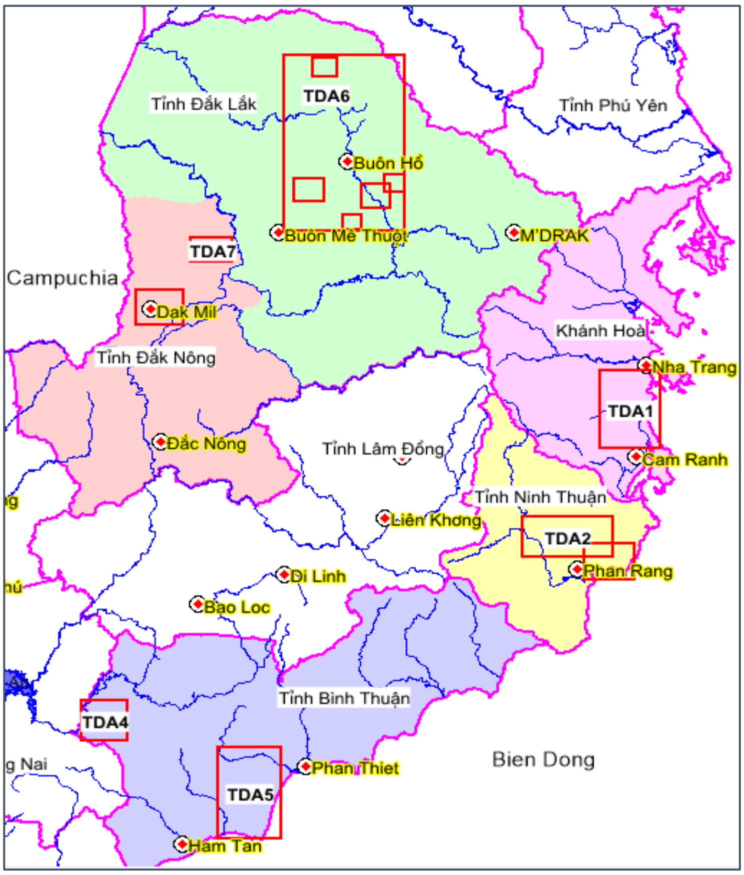


Figure 15: Location of 08 subprojects in WEIDAP (red rectangular)

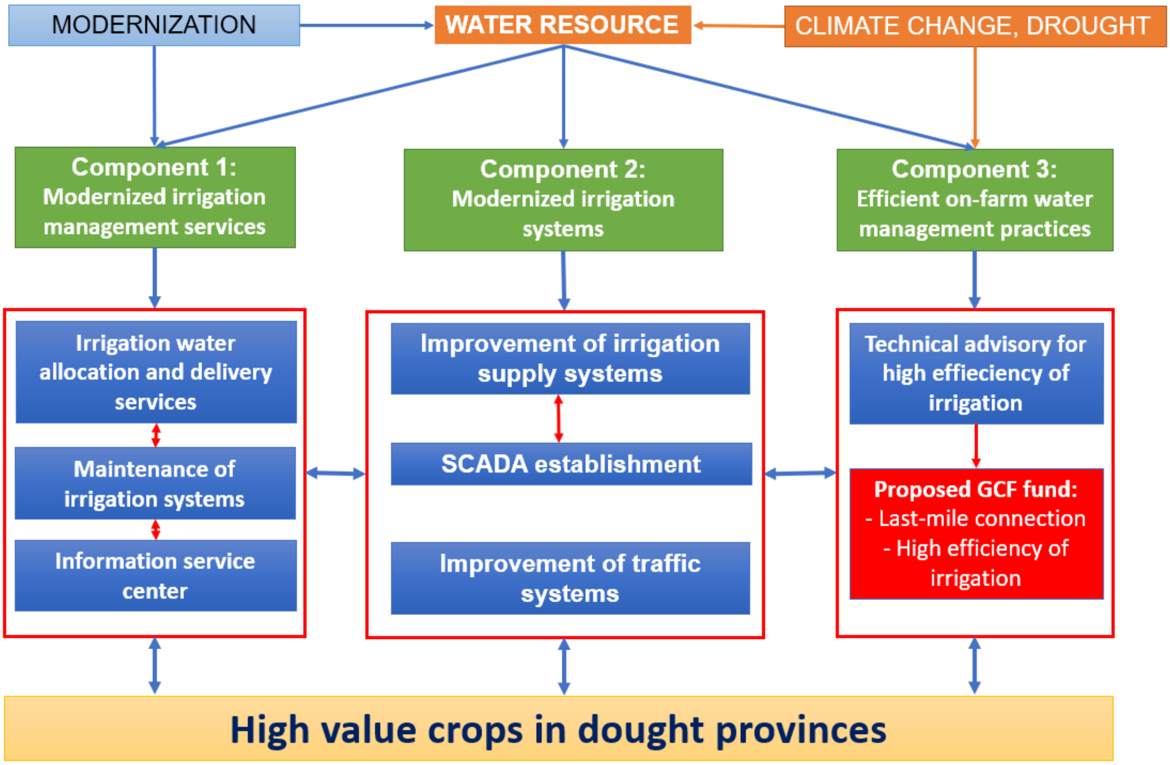


Figure 16: flow chart of Weidap and the proposed GCF fund (red-box)

3.5 Lessons learned and good practices

3.5.1 Water security in the context of climate variability and change

Household level rainwater harvesting tanks, water storage tanks and wells, are commonly used for water storage in Viet Nam. In addition, a number of bioengineered options for improved water storage have been successfully trialed across Viet Nam:

- Compacted clay-bottom ponds, integrating shade trees [79]
- Temporary ponds in flood plains or riverbeds [80]
- Small-scale mobile ponds made of bamboo and plastic sheeting [81]
- Vetiver grass application to combat bank erosion [82]

Small-size, mostly concrete, weirs, trenches and dams have also been installed on small to medium size streams and rivers to temporarily increase water availability, particularly at the end of the wet season or beginning of the dry season. These are combined with trees or plants to fence the contour trenched area and reduce soil evaporation.[83]

Recharge of groundwater has also been promoted via a method called 'Managed Aquifer Recharge'. While it has been applied in other countries for decades, it was only tested for the first time in Viet Nam as part of the UNESCO supported project '*Augmenting groundwater resources by artificial recharge in Binh Thuan province, Viet Nam*', from 2004 to 2010 (see under section 3.3.1).[84] Trials are also about to start in Dak Lak in areas where intensive groundwater pumping for coffee production has led to declining groundwater availability. A new means of implementing Managed Aquifer Recharge - referred to as

[79] *MARD Institute of Water Resources Planning (June 2017). Promoting the Application of Green Water Management in Rain-fed Agriculture in Vietnam. Progress Report.*

[80] *Farmer consultations conducted in Binh Thuan, Ninh Thuan and Khanh Hoa (11-19 September 2017).*

[81] *Expert consultation with ICRAF, 5th September 2017.*

[82] *Paul Truong, Tran Tan Van and Elise Pinners. Vetiver System Applications. Technical Reference Manual.*

[83] *Partners Voor Water (December 2009). Re-hydrating the earth by sustainable, small-scale sub-surface water retention techniques, Vietnam. Final Report, Executive Summary.*

[84] *Nguyen Thi Kim Toa, Nguyen Van Giang, Phan Thi Kim Van, Giuseppe Ardulno, Paolo Bono, Bui Tran Vuong (October 2008). Management of aquifer recharge. Groundwater storage in the sand dunes of Viet Nam. Tech Monitor Special Feature: Water Harvesting Technologies.*

'underground taming of floods for irrigation' - has been proposed by the International Water Management Institute and is being tested in the Ganges Basin. [85]

3.5.2 Strengthening agricultural resilience

Various climate resilient livelihood models or good practices, including for the poor, have been promoted and documented by MARD, research organizations, NGOs and private sector. These include: [86]

i. Rice: Alternate Wetting and Drying, System of Rice Intensification, 1-must-5-reductions (1P5G)
ii. Efficient water management: water and input saving, moisture-preserving practices, mulching
iii. Improved crop varieties, i.e. drought, flood, salt and disease tolerant
iv. Inter-cropping models or rotational cropping
v. Agro-forestry: Sloping Agricultural Land Technology
vi. Other crops: safe and green vegetables, integrated food-energy systems
vii. Integrated farming models: rice-fish, rice-shrimp, rice-duck, vermiculture, Garden-Pond-Shed
viii. Livestock: feed and fodder management, manure management, bio-bedding, biogas
ix. Closed loop agriculture: agricultural waste management, bio-char, bio-fertilizer [87]

The relatively low level of technology use among farmers highlights that several challenges and barriers to adoption of the resilient practices persist. Barriers often relate to low availability of required inputs (such as seeds for improved varieties, or water scarcity during droughts), high costs of installation (e.g. of improved irrigation facilities) with limited access to credit and markets, high labor costs and a limited level of technical knowledge and skills. Addressing those barriers is a key requirement for successful out-scaling of CSA practices.[88]

Recognizing that each context and specific practice are different, ICRAF World Agroforestry Centre developed eight steps or 'features' towards implementing and scaling climate smart agriculture: (i) engage local authorities, communities and technical partners throughout the process; (ii) review local land use, land use plans, policies and support programs; (iii) prepare a portfolio of scalable climate smart agricultural practices; (iv) participatory prioritization of scalable climate smart agricultural practice; (v) awareness raising and information events; (vi) capacity building; (vii) information provision and technical support; and (viii) follow-up, monitor and report.[89] A similar process has been promoted by MARD with technical support from a number of NGOs: (i) learn about local climate risks; (ii) analyze the impacts on people's livelihoods; (iii) identify the most vulnerable; (iv) identify available adaptive livelihood options; (v) review the requirements and conditions to apply each adaptive livelihood solution; (vi) assess the suitability of each to the local context and vulnerable groups; (vii) select options to implement or scale; and (viii) plan, implement and monitor.[90] In addition, CARE in support of MoNRE has developed a user-friendly tool to assess and rank livelihood options for various categories of resilience: climate change adaptation, climate change mitigation, economic feasibility, institutional feasibility, social and cultural feasibility, environmental sustainability and replication potential.[91]

Lessons from successful and sustainable agricultural models in ethnic minority areas show that these models work for the poor and marginalized when they are: easy to do, use less labor and investment, are suitable to local soil conditions and irrigation, produce products that are easy to sell, receive continuous support over the years, receive close monitoring, and promote farmer-to-farmer cooperation in the community. In contrast, models that are difficult to sustain or replicate normally require intensive investment that is unaffordable to ethnic minority households, are not suitable to local soil and irrigation

85 http://utfi.iwmi.org. In: CGIAR Research Program on Climate Change, Agriculture and Food Security- Southeast Asia (2017). Assessment of potential CSA options for future agriculture production in the South Central region of Vietnam.

86 See for example: MARD Action Plan in Response to Climate Change in Agriculture and Rural Development; MARD Extension Services Department (December 2015). Tài liệu hướng dẫn lựa chọn và triển khai sinh kế thích ứng với biến đổi khí hậu (only available in Vietnamese); IPSARD, FAO, GACSA (July 2016) (Ibid.); UTZ (January 2016). Climate Change and Vietnamese Coffee Production. Manual on Climate Change Adaptation and Mitigation in the Coffee Sector for Local Trainers and Coffee Farmers; CCWG (November 2015). Community-based Climate Change Initiatives in Vietnam.

87 Good practices on climate resilient agriculture specific for the different agro-climatic zones in the target provinces needs further detailed assessment, preferably with farmers' involvement.

88 MARD, IPSARD, FAO, USAID, Winrock and CIAT (in preparation). Climate-Smart Agriculture in Viet Nam.

89 Elisabeth Simelton, Tam Thi Le, Bac Viet Dam, Tuan Minh Duong, Hoa Dinh Le (in preparation). 8 features towards scaling Climate-Smart Agriculture. Manual for scaling out climate-smart agriculture on the ground, with experiences from My Loi climate-smart village, Vietnam.

90 MARD Extension Services Department (December 2015) (Ibid.).

91 CARE International in Vietnam (January 2016). Climate Resilient Livelihood Assessment Matrix.

conditions, do not link to markets and receive one time support without close monitoring and evaluation.[92]

In response to the severe drought of 2015-2016, the CGIAR research consortium recommended the replication of the following good practice to improve the resilience of crop systems in the Central Highlands: [93]

Deploy available drought-tolerant crop varieties during the dry season.

Integrate appropriate drought-tolerant and economically useful tree species within existing farming systems and to stabilize slopes. At the farm level, these: (i) provide shade for crops and animals; (ii) ameliorate micro-climate conditions; and (iii) provide additional biomass and income for farmers.

Develop crop-livestock–landscape simulation models that can demonstrate a range of scenarios and conduct landscape modeling with farm profitability scenarios. This helps farmers find optimal strategies for maintaining production and profits in the context of climate change.

Feed crop residues to livestock when feed is scarce and external inputs not accessible.

Establish fodder banks in contour hedgerows. This provides additional biomass for livestock and at the same time helps maintain soil quality through reducing erosion and cushioning the impact of drought and other climate-related events from mono-cropping in the short term.

Develop community-based water availability maps based on the systematic recording of groundwater levels in wells and surface water level by community observation networks.

Promote and incentivize broader private sector involvement. For instance, supply chain initiatives could be utilized as in-setting mechanisms where large buyers of agricultural commodities support farmers in adapting to climate change and reducing their emissions.

For the South Central Coast, recommended good practices are as follows:

Promote crop diversification to market-oriented crops that are suitable for the different drought risk conditions. There is, however, a need to redesign the irrigation system to facilitate crop diversification, for more efficient distribution of water, and for better drainage.

To increase the resilience of the poor, who may have more limited capacity to diversify into commercial crops or are located in less productive degraded areas, integrated farming systems with inclusion of small ruminants can be promoted. Including small livestock for smallholders who have limited land also helps buffer the shocks from extreme weather-related events.

Changing to direct dry seeding with the use of available irrigation facilities, using drought tolerant rice varieties and applying alternate wetting drying method can help optimize water use during the dry season.

Opportunities to reduce demand and increase water productivity can be achieved through improved organic matter management, increasing the water holding capacity and fertility of the root zone soil, and minimizing leaching of water and nitrate to the groundwater. Utilization of organic soil amendments and mulching can increase soil water holding capacity, improve soil physical parameters, and ameliorate soil nutrient deficiencies.

Farmer-managed natural tree regeneration could be promoted to allow for native tree species to regenerate on farmlands. Otherwise, intercropping with high-value tree species for timber, fruits, or fodder is also an option. Tree planting around farm plots should also be promoted to serve as windbreaks, thus protecting crop damage from strong winds, and mitigating wind erosion.

High efficiency irrigation (HEI) technologies, for example drip irrigation, micro-sprinklers, overhead sprinklers or precision irrigation, have also been promoted by local authorities and the private sector, but with a very high investment cost and therefore low uptake, particularly among the poor. An exception to this is an initiative by the NGO International Development Enterprises, that promoted a low-cost technology option affordable for the poor and near-poor, and that was co-designed between farmers, local suppliers and technical facilitators (see above under section 3.2.3). To ensure uptake and benefit among the poorest, it is crucial to engage them throughout the entire process of market and needs

[92] Oxfam (December 2014) (Ibid.)

[93] CGIAR Research Centers in Southeast Asia (April 2016) (Ibid.)

assessment, product design, market development and replication, as potential buyers as well as sellers.[94]

3.5.3 Agro-climate information services

CGIAR has formulated eight key lessons learned in scaling up climate services for farmers, based on 18 case studies in Asia and South Africa: [95]

Rural climate services are enabled and sustained by institutional arrangements, and investment in capacity at multiple levels, that support sustained interaction between climate and agricultural organizations and farmers.

Climate services must be delivered at a local scale to be relevant to farm decision-making.

A seamless suite of forecast, advisory and early warning products, with a range of lead times, enables farmers to manage evolving risks through the season.

Giving farmers an effective voice in the design, production and evaluation of climate services increases uptake, legitimacy, and sustainability.

Integration of meteorological information with local indigenous knowledge may foster trust, local relevance and use.

Face-to-face dialogue between farmers and service providers is an effective way to communicate historic and predicted seasonal climate information.

Information and Communication Technologies, in combination with other communication channels, offer expanding opportunities to reach farmers with relevant information, at scale.

Proactive targeting of women and other socially marginalized groups can help ensure inclusiveness in the design and delivery of climate information services for rural communities.

In Viet Nam,short term weather forecasts are broadcast on television and are also available for free via smartphone applications or the internet, often with animated maps. With smartphone usage increasing, including among the youth from poor communities (see under section 4.5), promotion of these free forecasts and weather apps as integral part of pro-poor agro-climate information services. Experience from North-Central Viet Nam show that with proper mentoring support such tools can be very useful to farmers particularly when combined with investment to improve the GoV's forecasting system.[96]

Farmers and local authorities have also been successfully engaged in managing village-level low-cost automatic weather stations. The village meteorological stations record temperature, rainfall, humidity, air pressure, wind speed and direction at the same intervals as official observations. They help farmers see the difference between the weather forecast, observations from the nearest official weather station and the actual temperature in the village.[97]

3.5.4 Engagement with small-scale farmers

A number of approaches have been applied in Viet Nam to engage farmers in project activities on agriculture, rural development and climate resilience. The most successful approach has been a group-based learning process called the Farmer Field Schools (FFS). FFS are implemented differently in each context, but they follow the same overallprocess: training-of-trainers (usually of the agricultural extension department, by external technical experts from MARD, research organizations or NGOs), followed by a training-of-farmers targeting 'farmer champions', 'lead farmers' or leaders of farmer groups, farmer-led on-site demonstration, testing and learning based on crop cycles, and on-going mentoring support to continue the farmer peer-to-peer learning and sharing. Although FFS clearly have demonstrated their effectiveness and influenced GoV extension services and mass organizations, services still operate based on a traditional top-down farmer education model of lectures, technical

94 Expert consultation with iDE, 6th September 2017.

95 Tall A, Hansen J, Jay A, Campbell B, Kinyangi J, Aggarwal PK and Zougmoré R. (2014). Scaling up climate services for farmers: Mission Possible. Learning from good practice in Africa and South Asia. CCAFS Report No. 13. CGIAR Research Program on Climate Change, Agriculture and Food Security.

96 Roy A, Simelton E, Quinn C. (2017). Which forecast represents the local weather best? Preliminary case study findings from My Loi village, northcentral Vietnam. CCAFS Info Note. CGIAR Research Program on Climate Change, Agriculture and Food Security.

97 blog.worldagroforestry.org/index.php/2016/03/09/better-weather-information-helps-save-animals-during-cold-spells/

training materials, demonstration farms at better-off farms or on public land. Trainings also often have limited to no follow-up at the farmer level.[98]

Farmer groups that have been most sustainable in Viet Nam are pre-existing, self-managed groups that have a shared financial or livelihood interest, for example cooperatives, farmer interest groups or village saving and loan associations. The least effective are groups that are created specifically for project activities, where membership is paid from outside sources rather than voluntary or when there are limited tangible benefits such as groups or clubs centered around information sharing, awareness raising and behavior change.[99]

In neighboring countries, the NGO International Development Enterprises has promoted the 'Farm Business Advisor Approach'. These are individual agents, either entrepreneurs or family businesses, who go door-to-door, field-to-field, supporting small-scale farmers with a variety of services. They provide an essential last-mile market link for farmers located in remote areas far away from commercial centers. Services provided can include: loans (loan broker for microfinance providers), output marketing (access to market information, support with transport), services (advice on land preparation, plant and harvesting, soil nutrients, pest and disease control, operation and maintenance of technologies), inputs and equipment (irrigation kits, pumps, fertilizer, seeds, pest control). Farm Business Advisors earn income from various sources: margins and commissions on sales of inputs, fees for services, increase yield from self-owned demonstration farmers etc. [100]

3.5.5 Mechanisms for financial support to farmers

A variety of options have been used in Viet Nam to deliver financial support to farmers to strengthen agricultural production and climate resilience: these are often combined with technical information and training and have specific conditions per their purpose:

- In-kind support.
- Conditional grants to purchase a certain good, from full coverage to a certain percentage of the total amount ('seed grants'), depending on the farmers' socio-economic background.
- Vouchers, mostly conditional or limited to a list of agricultural input supplies or goods that can be obtained from small to medium-size local suppliers (based on a market assessment), with more options for the farmers to choose from than with the grant system. [101]
- Micro-credit or loans, conditional or non-conditional, often with a lower total amount, lower interest and different repayment schedules than loans provided by private banks.
- Community development funds, combining local state budget, external funds and community contributions, with funds allocated to activities resulting from participatory community based plans. [102]
- Competitive grants for farmer groups, where farmers apply as a group for a grant (full or a percentage) after submitting a brief proposal in response to a call-for-proposals. Often the call has specific conditions in order for the farmer group investment to be eligible for the small grant.[103]
- Competitive grants for small and medium rural enterprises, with the same principles as the farmer group competitive grant. However, co-investment from the private enterprises is considerably higher percentage-wise than what is expected from the farmer group. [104]

---

[98] Elske van de Fliert, Ngo Tien Dung, Ole Henrikse, Jens Peter Tang Dalsgaard (June 2007). From Collectives to Collective Decision-making and Action: Farmer Field Schools in Vietnam; Oxfam (December 2014) (Ibid.); and expert consultation with ICRAF, 5th September 2017.

[99] The exceptions are religious and cultural groups. Farmer consultations conducted in Dak Lak and Dak Nong (9-15 August 2017) and Binh Thuan, Ninh Thuan and Khanh Hoa (11-19 September 2017)

100 iDE (2015). Linking remote farmers to markets. Tactic Report.

[101] See section 3.3.3 for FAO's experience with a voucher-for-drought recovery program in in Gia Lai, Dak Lak and Dak Nong. Expert consultation with FAO, 21st August 2017.

[102] Expert consultation with Oxfam, 25th August 2017.

[103] IFAD has extensive experience in promoting this kind of grants, including in Ninh Thuan and Dak Nong. Expert consultation with IFAD, 28th August 2017.

[104] Both IFAD and SNV have applied these competitive grant schemes in their projects. See: IFAD (2017). Co-Investment with Enterprises and Farmers. Guidance note for investment preparation; and SNV (2015). Vietnam Business Challenge Fund. Final Report.

- Preferential pricing schemes for farmer access to climate-, water- and energy-smart technologies, negotiated with the private sector, to ensure access and encourage entry of the poor into the market. [105]

All the above options have advantages and disadvantages, depending on the purpose of the support and enabling conditions. Mechanisms where farmers have a range of options to choose from or where they can propose themselves what to do with the financial support, are most empowering. Mechanisms for farmer support through engagement with the private sector are more difficult or time consuming to set-up but can potentially reach much more farmers.

3.5.6 Working on gender within climate change programming

Key lessons learned on addressing gender issues within climate change programming have been identified as follows: 106

- Understand gender and other sources of inequality to plan appropriate resilience actions; conduct a gender and power analysis at the beginning of a new project to inform the development of a Gender Action Plan.
- Monitor changes in gender inequality throughout climate change project implementation and act on issues that arise: (i) set up systems to track progress towards gender equality, including the collection of sex disaggregated data, use of indicators that measure changes in gender norms, and inclusion of women and men in project M&E; (ii) consider how activities may impact on a range of gendered dimensions, monitor change such as on workloads, levels of decision-making, roles and responsibilities, rights awareness etc. , and apply 'do no harm' principles in all the work; (iii) allocate budget for gender integration, gender tracking and for specific actions that promote gender equality and women's empowerment
- For lasting change and resilience, address power and resources imbalances in the household and community and transform gendered roles and responsibilities. Implement interventions that support access and agency, not only focusing on the types of livelihood opportunities an intervention creates but also whether the process of creating that opportunity promotes women's increased self-confidence and decision-making abilities.
- Integrated activities that promote improved livelihood security (through diversification as well as resilience), community-based natural resource management and women-led economic development: (i) facilitate equal access to and control over productive resources, markets and services including land, water, inputs, agro-climate information and both financial and extension services; (ii) organise men-only activities as an entry point to talk with them about men and women's roles in resilient livelihoods and how men can support the women apply new techniques; (iii) women's groups, women-only trainings or meetings are a first step to build women's confidence in a safe space. However, it is important that these groups are brought into contact with the broader community to ensure that improvements in confidence are not limited to women-only spaces.

With regards to addressing gender within agro-climate information services, the most recent experience by ICRAF and CARE in the North and Central Viet Nam shows that women and men farmers' needs and preferences must be considered in order to most effectively disseminate agro-climate information. Empowering women and men with access to information that they can understand, act upon, and share, can augment the productivity and resilience of farming systems. Understanding the nuances of unique gendered challenges and opportunities in terms of labor distribution, information dissemination, and collaboration is essential for identifying actionable adaptation strategies. Specifically, opportunities exist to improve intra-household information sharing. Gender factors must be integrated into project design, policy formulation and implementation at all levels.[107]

[105] Applied by the NGO GreenID in their Local Energy Planning project in Thai Binh. See: CCWG (November 2015) (Ibid.), p.78.

[106] CARE International in Vietnam (July 2015) (Ibid.); and USAID, 2014. Women's Economic Empowerment: Pushing the Frontiers of Inclusive Market Development

107 Tuan DM, Smith A, Le TT, Simelton E, Coulier M. (2017). Gender-differences in Agro-Climate Information Services (Findings from ACIS baseline survey in Ha Tinh and Dien Bien provinces, Vietnam). CCAFS Info Note. CGIAR Research Program on Climate Change, Agriculture and Food Security.

4 LAST-MILE CONNECTION TO WEIDAP IRRIGATION SYSTEMS

Under the Water Efficiency Improvement in Drought Affected Provinces (WEIDAP) Project, the climate resilient modernized irrigationdeveloped will provide farmers with efficient, affordable, and flexible irrigation water. Feasibility-level designs were prepared for each 08 subproject. These designs were for largely fixed service areas, (pipeline) layouts, and design discharges. Design options were evaluated and recommendations made for detailed engineering designs.

4.1 Key design principles for subprojects

4.1.1 Existing Farmer Practices and Adopted Level of Service and Layouts

Farmers in all the subprojects cultivate high-value crops, with irrigator flows usually between 1.7 and 4 liter/second (l/s). Indicative irrigation times, stream flows, and irrigation periods are tabulated in Table below. Water is usually conveyed to and within the farm by hose. Some farmers have installed buried polyvinyl chloride (PVC) pipes within the farm to connect drag hoses. Irrigation may be directly onto the plant (dragon fruit) or to basins (mango, coffee, pepper). Furrow irrigation is practiced for some vegetables, while small areas of drip (grape) or sprinkler (dragon fruit, coffee, pepper) have been installed.

Table 4: Field Irrigation Measurements

	Unit	Mango	Dragon Fruit	Coffee	Pepper
Irrigation time per plant	minutes	5-20	2-3	3-5	1-2
Application method	-	Basin	Onto plant	Basin / sprinkler	
Number of trees/vines	no./ ha	180-250	+1,000	+1,100	+2,200
Irrigator flow	l/s	1.7 – 2.5	1.5 – 4.0	2 - 3	2 – 3
Irrigation application	mm	50 – 130	10 – 20	80 - 120	10 – 20
Time to irrigate 0.5-ha farm	hours	+21	5 – 8	20 - 26	5 – 8
Irrigation Interval	days	+10	2 - 5	25-30	2 - 5

The focus for system modernization is buried piped distribution (gravity and pumped), taking water from canals and/or reservoirs, and supplying hydrants, typically 63 millimetre (mm) diameter, with flows of ±5 l/s to which farmers can connect. These hydrants are to be within 500 m of the farmers' fields. The required level of service is illustrated on the figure at the end of Section II.

The flow at each hydrant will ensure that all hydrants can operate at the same time supplying 5 l/s. There will be several farmers connecting to each hydrant, taking water in turns and as per their requirements. Sufficient flexibility is provided so that, generally, all farmers can irrigate within daylight hours.

Basic supervisory control and data acquisition (SCADA) systems will facilitate operations, for example, enabling remote monitoring of flows at hydrants, pressures at key points in pipelines, and linking pump operation to water levels in a controlling header tank, and so on.

4.1.2 Design of Pipe Systems

The design duty is specific for each system. The net area served for each scheme is provided and should not change more than ± 5%. Any variation of the scheme boundary should have prior approval from MARD/ADB otherwise water deficit will occur in the systems.

Maximum velocity limits shall depend on pipe type and class, but will typically be 1.5 (1.7) m/s for polyvinyl chloride (PVC) pipes and 2.0 (2.5) m/s for high-density polyethylene (HDPE) pipes at full flow. Minimum velocity at design flows will be 0.3 m/s to ensure against sedimentation in the pipe. For pumped systems, the optimum flow velocity, from capital and energy cost considerations, is likely to be 0.7-1.2 m/s.

A hydrant flow of 5 l/s should is adopted in pipeline design.

Design (residual) head is a minimum of 2.5 m for gravity systems, where constant flow valves are not required, and a minimum of 10.0 m for pipe-pressured systems, for each hydrant operating at 5 l/s for the system operating at full flow. The operating and residual heads will be higher when the overall system flow is less than the design maximum.

Pipes shall be either HDPE or PVC of appropriate class. HDPE pipes are likely to be adopted for all pipes due to ease of connections and certainly for larger flows and pipe diameters.

Pipe layouts shall observe the level of service adopted for the project (see figure at the end of Section II). For example, a single pipeline is sufficient for service areas <1.0 km wide. For larger areas, ring (loop) systems may be adopted. A combination of ring and branch (dead end) pipe systems may be appropriate.

The main advantage of ring (loop) designs is that they keep more even pressure and operating conditions under various demand/supply conditions, as flow may occur to a hydrant from both directions. They also have redundancy in that flow may be maintained in one arm, while the other is under repair. Ring designs shall be adopted unless shown to be significantly (>5-10%) more expensive. Where ring designs are adopted, each arm of the ring would usually have a similar range of pipe diameters.

4.1.3 Hydrant-Manifold

Hydrant flows shall be 5 l/s±10% at full flow in the pipeline. This is achieved by one of the methods outlined below:

- Adjust the hydrant pipe diameter that connects to the main line according to the available (residual) head under full design flow conditions. This enables farmers at one hydrant to exceed the flow if others are not using their hydrants, however it works by burning off residual head[108]. This option is inexpensive, and it can be well applied in gravity designs.
- Install pressure control valves in main pipeline so that pressures at each hydrant under full flow conditions are similar, however this also works by burning off residual heads at hydrants. This option can be considered for gravity systems where there are large head losses to be burnt off[109].
- Install a constant flow valve to each hydrant[110] – this option can ensure that all hydrants receive the design flow, though it limits the ability of one hydrant to use more water when others are shut. However, it does not burn off residual head, thereby potentially allowing farmers to convey water from the hydrant-manifold to their farms without pumping. This option is suggested for all the pump pipe systems. It could also be adopted for the gravity systems.

The number of hydrants is calculated by dividing the total flow (l/s) by 5 l/s. It should be noted that with this design approachunder no circumstances can the number of hydrants be increased, and the design flow per hydrant be also not be changed. The specifc cost effective hydrant-manifold designs will be identified/agreed with MARD/ADB. It should also be noted that direct fuse connections are envisaged between the main pipeline and the off taking pipe where HDPE pipes are adopted. If PVC pipes are adopted, then T fittings shouldbe used.

Hydrant-manifold head loss for 5 l/s flow would be about 13.1 m for 40 mm pipe, 5.5 m for 50 mm pipe, and 2.5 m for 63 mm pipe due to bends, on-off valve and flow m(s).. Head loss through a constant flow valve is typically 2-4 m depending on the make and model. Typically, 63-mm pipe hydrants are proposed and total head loss through the hydrant- manifold will be about 6.5 m, assuming 4.0 m for the constant flow valve. A general arrangement sketch for a hydrant manifold with indicative head losses is attached at the end of Section II.

4.1.4 Hydrant Location and spacing

The hydrant spacing is to be located proportionally to the area served, so that each hydrant commands the same area.

The hydrants shall connect directly to the main pipeline. There is no need for any intermediate linking pipeline or for the introduction of a distribution hierarchy with parallel running pipelines (as sometime recommended for canal systems) to control water distribution. For large systems, if additional flow control measurement is required, it will be introduced into the main pipeline at intervals.

4.1.5 Manifold

The The manifold is supplied from the hydrant and allows each farmer who uses the hydrant to have his own hose connection, which may be metered for water charging purposes. Each farmer would usually take the full flow in turn.

Hydrants and manifolds are typically constructed from *High-Density Polyethylene* (HDPE) welded to the main line and PVC standard pipe connected with standard fittings. There is no need for steel fittings, except perhaps flanges for valve and meter connections.

---

[108] If residual head is burnt off, then it may be advised for pipeline alignments to follow high land to the extent deemed practical.

[109] None of the WEIDAP subprojects has very large head losses, so this option is not expected to be adopted.

[110] Various constant flow valves are available (e.g., Maric valve from Australia). These valves work with a spring or variable rubber orifice, which adjusts the orifice area depending on pressure. A pressure drop of at least 2 m occurs over the valve. Indicative cost is about US$100 for a 60-mm valve.

Farmers may connect pumps to the manifolds, in which case, these pumps may develop suction heads up to about 5 m. If residual heads are lower than 5 m, then measures may be necessary to ensure each hydrant still receives ±5 l/s under full flow, e.g., by installing flow limiting valves at the hydrants.

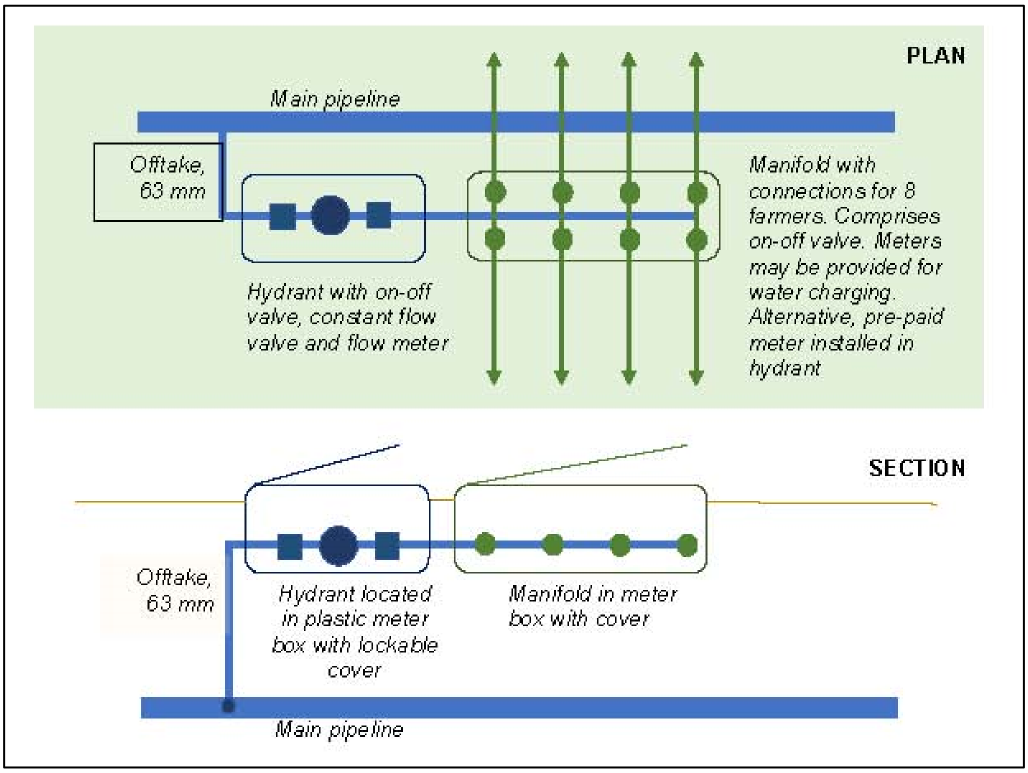


Figure 17: Arrangement of Hydrant-Manifold

4.1.6 Pipe Alignment

The pipeline should be located to minimize the impact on private land and avoid housing areas, wherever possible. Farmers will not be able to take their hose over major highways. Either pipelines shall be provided on both sides of the road (ring design) or branches are provided.

All farm land shall be within 500 m of the pipeline, and the density of pipe shall typically be 15–20 m/ha. Layouts given in this note may be adopted and improved as agreed with MARD/ADB.

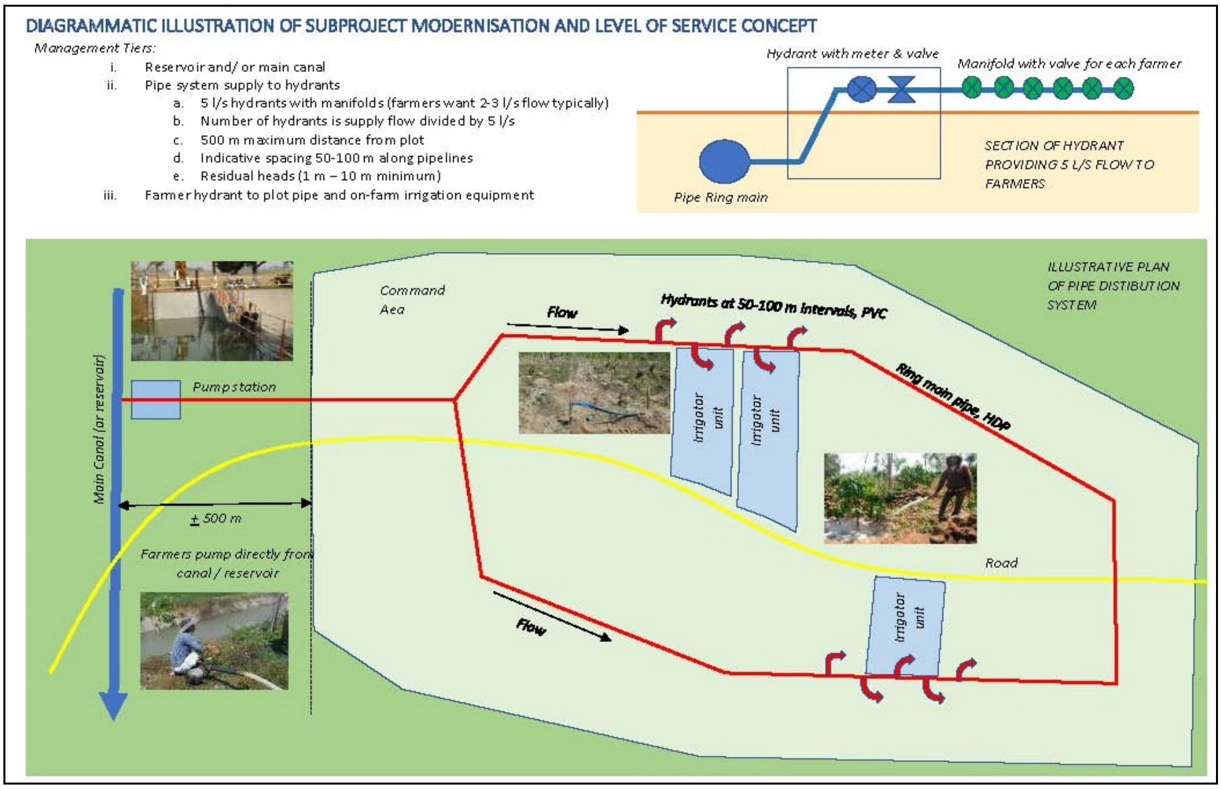


Figure 18: Schematic Diagram of Modernized Piped Irrigation System

4.1.7 Pumping system

The delivery schemes comprise a mix of the following: (i) direct pumping combined with a header (pressure) tank at some high point; (ii) pumping into a header tank with subsequent gravity supply; or (iii) gravity supply.

It is not proposed to have a direct pumping scheme as the intricacies of pumps being able to supply very small flows (i.e., just one or two outlets operating) up to full flow in an efficient and cost-effective way is not deemed practical.

4.1.8 Canal Systems

For improved canal operations and water accounting, balancing (regulating) storage should be provided at the end of the canal systems, usually at the end of the main canal and sometimes at the end of long branch canals. Balancing storage should be provided for Tra Tan.

Balancing storage is not required where rice is the predominant crop at the end of the canal system, as in Cam Ranh, or for very flat (contour) canals, as in Ea Kuang, Dak Lak.

Releases from the main upstream reservoir will be informed by water level sensors in balancing storage and/or from sensors at intakes at pump off takes (see SCADA below).

4.1.9 Inspection Roads

In Viet Nam, land for buried pipe systems is acquired and compensation paid, so that the operator has the right of inspection at any time to check pipeline structures, associated valves and fittings, as well as for any leaks. Paved inspection roads, typically 3.0–5.0 m wide, are ideally provided along the pipelines. For the WEIDAP subprojects, as funds are limited, the following guidance is given for paved inspection roads:

- If the pipeline is aligned along an existing paved road/highway, no additional parallel inspection road is required.
- For pipelines <400 mm in diameter, paved inspection roads need not be provided, unless they are also justified to improve farm to market access.

Inspection roads shall be 3.0 m wide (pavement width) if the sole/major purpose is for inspection. If significant other traffic use is expected, the width may be 5.0 m, or as appropriate.

4.1.10 Control and Measurement

The following control and management system is suggested for valves:

- Main flow control (on/off) valves should be located strategically, for example, at the head of pipeline and separating out each part of a ring main.
- Air valves should be located at high points and at intervals along the pipeline.
- Flushing valves should be located at low points and/or gully or stream crossings.
- Non-return valves are not needed.
- Hydrants must have a simple flow control valve, which could be incorporated with a limiting (constant) flow valve.
- Each individual farmer should have a simple flow control (ball) valves at the manifold.

Pressure gauges may be located at branch pipeline off-takes and at the end of each pipeline, and:

- connected to alarms for breaks or malfunctions;
- connected to continuous read out; and
- connected to pumps, where appropriate.

Flow measurement requirements are as follows:

- For overall pipe system: continuous monitoring relayed to central office/control at the following points: (i) head of main pipeline; and (ii) several strategic points around the system to enable monitoring of water use/distribution and to identify any leaks.
- Hydrants: continuous monitoring relayed to central office is ideal, but if this is too expensive, a few of this remote reading type shall be installed, with locally read meters installed at other locations. This will enable operators to see if some areas are getting more disproportionally more flow and can allow adjustments to be made.
- Individual farmer meters – local read for sharing purposes and post-paid charging is envisaged.

Metering options, indicated below, will be discussed and agreed with MARD/ ADB and concerned provincial authorities. For example, if a prepaid meter were adopted and installed at a hydrant, additional meters would not be required in the manifold, as each farmer using his “smart card” would operate the meter and take the full flow in turn.

4.1.11 SCADA Systems

For each scheme, a basic SCADA system will be installed to monitor operations for both pipe and canal systems. For pipe systems, remote monitoring of pump operations, pressures, and flows is proposed. The decision concerning local or remote read of flows at hydrants will be made following consultations between central and provincial authorities. For canal systems, water levels and flows will be monitored at a few selected points: reservoir, head of main canal, and balancing storage in tail of system.

Adoption of two sensors for important data is recommended, including data that inform reservoir releases and pump operations. Also, the sensor types should be different, e.g., piezometric (pressure) and ultrasonic sensors. An alarm signal shall be transmitted if the level or pressure readings are significantly different from each other.

It is expected that transmission of data from sensors–loggers to central control rooms (offices) will use the mobile communication network (GSM).

4.2 Last-mile connection in Khanh Hoa province

4.2.1 The design of WEIDAP

The proposed subproject will enable increased and sustainable crop production (mainly for mango) through the efficient distribution and use of surface water stored in existing reservoirs using lined canals and pressure-pumped pipe systems. Mango areas will expand with an assured supply of water and some rice areas will convert to crops. Pressure on groundwater use will be reduced. Improved monitoring and management of water through a basic supervisory control and data acquisition (SCADA) system will enable more efficient and productive use of water. Improved supply and direct pumping from canals will encourage farmers to invest in water efficient application technologies (WEATs) as well as reduce their pumping costs.

The subproject consists of two separate storage irrigation systems supplied from existing Suoi Dau and Cam Ranh reservoirs. Both combine rehabilitation of existing gravity canal systems and new pumped pipe systems. The existing gravity canal systems will supply rice and mango areas and the new pumped pipe systems will supply established and expanded mango areas.

The Suoi Dau system will supply 1,000 ha of mango, 592 ha of miscellaneous crops and 1,200 ha of rice while the Cam Ranh system will supply 3,000 ha of mango and 270 ha of rice.

Gravity Canal System

The subproject will demolish 15.3 km of concrete trapezoidal lining and replace it with reinforced concrete flume sections with 150 mm thick walls and with a reinforced concrete cover slab 100 mm thick. Design discharges will also be reduced in line with proposed crop areas. Although bridges are in reasonably good condition, many of them (about 30) would have to be demolished and replaced to fit the new flume canal section. Details are summarized in Table 2. No work will be done for the 59 secondary and smaller canals, other than to provide new turnout gates.

Pumped Pipe systems

The subproject will build five subsystems with pumping stations and ring main distribution pipelines to meet the adopted level of irrigation service. The proposed pumped pipe system layouts are shown in figure below. The associated level of service is presented in Table 3.

Table 5: Levels of Service to Mango Areas

Subsystem		Access to Water (ha)			
Type	Name	< 250 m	Inter	> 500 m	Total
Canal Systems	SD	117	141	337	595
	CR	241	248	950	1,439
	Total	358	389	1287	2,034
Canal	%	18	19	63	100
Piped Systems	SD	223	135	47	405
	CR1	213	184	163	560
	CR2	257	191	52	500
	CR3	173	91	40	304
	CR4	97	67	33	197
	Total	1697	1465	2972	6,134
Piped	%	49	34	17	100
Total	ha	1,321	1,057	1,622	4,000
Total	%	33	26	41	100

Three centrifugal electric pumps are proposed for each pumped pipe system, one being standby. Pump houses shall be provided for pump security, and to house control and monitoring systems. Three-phase electric connections shall be provided, complete with transformers, switches, lightning arrestors and so on. General arrangement drawings of the pump houses, together with intake and small pumping reservoir, have been prepared in Figures 3 and 4 of Annex 3.

Consistent with the modern level of service standards, the project will equip the five piped subsystems with 385 standard hydrant manifolds each with a 5 l/s design discharge. Therefore, the total design discharge of the 385 hydrant manifolds is 385 hydrant manifolds (HM) x 5 l/s/HM = 1,925 l/s, which is the same as the total design discharge of the five pumped pipe irrigation systems serving 1,966 ha x 0.98 l/s/ha for mango = 1,927 l/s.

The unit cost of simple PVC hydrant manifolds is about $435 (80 mm diameter) or $320 (63 mm). Therefore, the maximum total cost of 385 hydrant manifolds will be $167,475, which is only $85 per ha over the service area of 1,966 ha. The average spacing of HMs will be 100 m. Each HM will serve about six households.

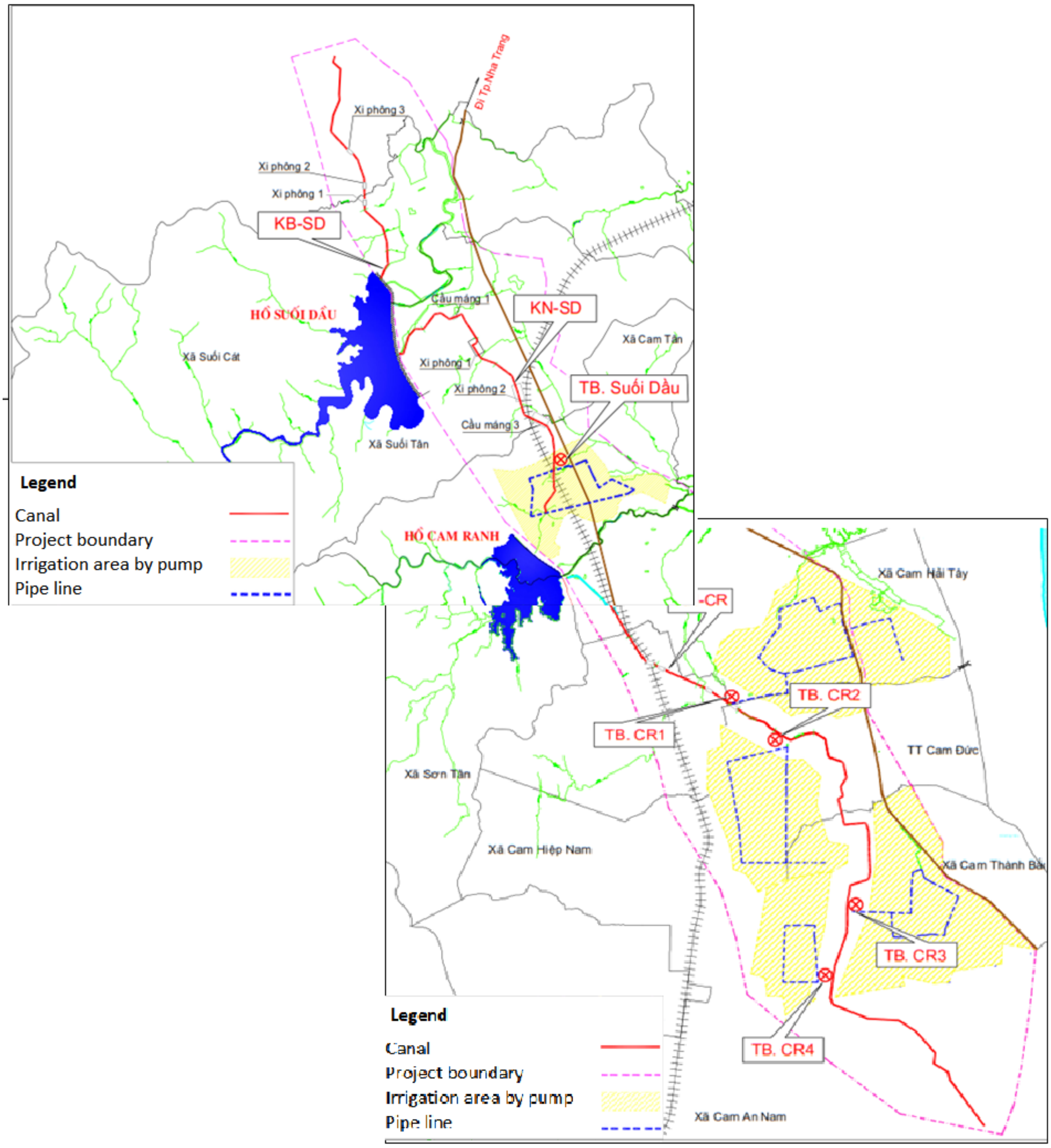


Figure 19: Canal – pump and pipeline system in Khanh Hoa - Subproject

4.2.2 The key gap and proposed last-mile connection to WEIDAP

The WEIDAP project is not addressing issues of connectivity to irrigation schemes. Farmers in the WEIDAP project areas are required to invest their own resources to obtain 'last-mile' connections from the surface canal or pipe irrigation systems to their plots. This presents an overwhelming challenge to poor and near-poor farmers and is therefore a specific need that should be addressed in the proposed UNDP project. Water storage issues in the WEIDAP project or adjacent communes also are not addressed either through this WEIDAP project.

Figure 20: The exist private pumping systems from opened canal in subproject area in Khanh Hoa: the pipe from canal and the electrical pump in canal-bank

4.2.3 Recommended interventions

To holistically address the water security of poor and near-poor smallholders in light of longer and more extreme drought periods and climate related water stress, the proposed project should complement the WEIDAP interventions on irrigation infrastructure and address its gaps. In addition to providingtechnical expertise for design and distribution systems, the project can increase access of poor and near poor farmers to a combination of locally available mobile pipes, pumps, water meters, shifting valves and small-scale on-farm water storage solutions that will enable last-mile connectivity to the GoV invested irrigation schemes. This can better enable reliable water supply during drought periods.

The recommended interventions in Khanh Hoa province are as follows:

- Support group/single poor and near poor households to establish the shared/private pump and pipeline systems to connect to closest manifold or canal for crop irrigation.
- Provide technical support to last-mile connection including survey and design of the system; and development of manual documents for operation and management of their irrigation systems, (especially for the management of shared systems).

For the planted area that will benefit from the improved canal system the project shouldsupport for irrigation system connect to the canal including

1) Estimation of shared pump and shared pipeline networks for a group of beneficiaries HH in appropriate locations,
2) Support for estimation of private pump and pipeline for single beneficiary HH

The maximum connection distance to canal should be no more 2000m with most systems averaging about 1000m.

For the planted areas that will benefitfrom 05 ring main pipeline system support for the irrigation system to connect to the designed hydrants and the water supply in ring main pipeline system should be provided. The system is designed with low water pressure that will require further pumping for high efficiency irrigation (HEI) application so the project should provide:

1) Support for the estimation of water meter, shared pumps and pipeline network for a group of beneficiaries HH in appropriate locations
2) Support for estimation of water meter and private pump storage if it is needed and pipelines for single beneficiary HH if required.

The maximum connection distance to hydrants will be around 500m with most systems averaging about 300m.

4.2.4 The beneficiary of interventions

Data on the total number of households, the poverty rate and near poor households in the project areas are determined based on the latest official sources.

The area and population proportions of the communes covered by the WEIDAP project are determined based on the mapping of the WEIDAP project site map and related administrative maps, area and population ratios inside and outside of the WEIDAP project area (rainfed area), which is defined as in the attached table.

Beneficiary sites are the communes related to WEIDAP command area, including 09 communes: Cam Đức; Cam Tân; Cam Hoà; Cam Hải Tây; Cam Hiệp Bắc; Cam Hiệp Nam; Cam Thành Bắc; Suối Cát; Suối Tân.

Poor and near poor rate without land of 11%[111] is excluded to estimate the number of beneficiary households for Khanh Hoa.

Table 6: Total number of households, rate of beneficiary households in Khanh Hoa

No	Commune	Total household (2017)	Rate of beneficiary HHs	Shared area in Weidap (%)	Shared area in rainfed (%)	Number of beneficiary HHs
I	**Khánh Hòa province**	**22,153**	**6%**	**59%**	**41%**	**1,032**
	Cam Lâm district	**22,153**	**6%**	**59%**	**41%**	**1,032**
1	Cam Đức	4,195	6%	80%	20%	179
2	Cam Tân	2,127	12%	70%	30%	159
3	Cam Hoà	3,589	7%	60%	40%	134
4	Cam Hải Tây	1,421	3%	50%	50%	19
5	Cam Hiệp Bắc	800	7%	70%	30%	35
6	Cam Hiệp Nam	1,375	6%	50%	50%	37
7	Cam Thành Bắc	3,621	6%	50%	50%	97
8	Suối Cát	2,489	21%	50%	50%	229
9	Suối Tân	2,537	13%	50%	50%	143

4.2.5 Operational and implementation modalities

The canal and ring main pipelines will be managed by the local IMC based on a simple SCADA system. This will include monitoring water storage in the Cam Ranh and Suoi Dau reservoirs and monitoring water levels in canals as well as pipe flow and pipe pressures in ring main pipes. The control office will establish a computer based cellular or Global System for Mobile Communications (GSM) network to help adjust flow releases to the main canals and flow to ring main pipe from the reservoirs.

The last-mile connection from WEIDAP to beneficiary HH will be managed by themselves or by farmer groups. The O&Msystem will be supported by Technical group in each commune. O&M functions could include the following actions:

Register farmers using the two pumping systems;

[111] *Committee For Ethnic Minorities Affairs Web Portal: http://csdl53dtts.ubdt.gov.vn/Files/phieuxa/Bieu3.pdf*

Meter and charge farmers according to water use, at least to recover O&M costs;

Flush sediment during the wet season and during the dry season from the weirs; and

Manage water flow releases from the two reservoirs so as to not waste water.

4.3 Last-mile connection in Ninh Thuan province

4.3.1 The design of WEIDAP

The subproject will enable the transformation of dry land, currently most of which is not being cropped and comprises patchily grassed, thorny shrubs and cacti. Much of the land is currently used for grazing of cattle and small ruminants (goats and sheep), but in the recent past, it supported maize and vegetable cropping by small holders when water was available. Unreliable water supplies led to some farmers abandoning crop agriculture, but "with the project," many are expected to return to the area and resume farming. In addition, commercial farming is expected to be attracted to the area given the more reliable water supplies, with private sector companies buying-up land from smallholders to amalgamate larger contiguous plots. Several commercial farms are anticipated, each about 50 ha in size, under the concept of High Tech Agricultural Production Zones. With reliable water supplies, the range of crops that can be grown include grapes, Vietnamese apple, vegetables, maize and grass (fodder).

The larger scale commercial farm(s) are likely invested in high efficient irrigation equipment, drip for grape and perhaps sprinklers for vegetables. Smallholders may have capital constraints but are expected to adopt drag hose and basin/furrow irrigation techniques. Pressures at hydrants may be sufficient for hose irrigation, but on-farm pumping would be required for sprinklers and/ or drip systems.

On completion, Song Cai storage dam is expected to supply 6,800 ha in Tan My irrigation system. In the meantime, completed parts of Tan My irrigation systems, including the Thanh Son-Phuoc Nhon and Nhon Hai-Thanh Hai subprojects, will operate as gravity piped run-of-river irrigation systems supplied by the new Tan My pipeline[112] from the existing Tan My weir to the downstream end of the Thanh Son-Phuoc Nhon service area. The Tan My pipeline will function as the main Thanh Son-Phuoc Nhon subproject pipeline. As it is being financed by the government, it is not included under the sub-projects.

WEIDAP will extend the main Tan My conveyance pipeline from the downstream end of Thanh Son-Phuoc Nhon system to the Nhon Hai-Thanh Hai subproject, and this extension is included in the project cost.

Following discussions between MARD, the province, and ADB, net irrigable areas will be 1,800 ha for Thanh Son-Phuoc Nhon and 1,000 ha for Nhon Hai-Thanh Hai. The water allocation from Tan My pipeline for Nhon Hai-Thanh Hai is 0.87 m^3/s, equivalent to 0.87 l/s/ha.

With limited water, high efficiency distribution and application is required to provide flexible supplies for high value cropping. Over some areas, seasonal crops including grass (fodder) will be cultivated for which flexibility is less important, and would not have such a high priority in case of drought compared to perennial crops such as grape. Groundwater may continue to be used but to a more limited extent. Details of the crop water calculations are presented in Supplementary Appendix 1 (Design Principles for Subprojects).

The new Tan My pipeline will branch at the downstream end of the Thanh Son-Phuoc Nhon service area where (i) the government Tan My project will extend the northern branch pipeline, to supply the existing Song Trau and Ba Rua reservoirs, and (ii) WEIDAP will extend the southern branch to supply the Nhon Hai-Thanh Hai subproject, see Figures attached.

The Thanh Son-Phuoc Nhon sub-project designs require 28.66 km of HDPE pipe, ranging in diameter from 160 mm to 500 mm, and giving average density of 15.9 m/ha. About 1,219 ha (68%) of fields will have access to water within 250 m, 446ha (25%) from 250 m to 500 m and only 135 ha (7%) beyond 500 m as shown in Table 6.

Table 7: Pipe Diameters and Lengths

∅ (mm)	Length (m)	∅ (mm)	Length (m)	∅ (mm)	Length (m)
630	-	400	2,392	200	2,453
550	-	355	5,527	160	1,463
500	1,386	315	5,581		

[112] *The government has constructed the first 31 km of the Tan My pipeline and expects to complete the rest in 2018.*

450	2,149	250	7,710	Total	28,660

∅ Pipeline diameter

Consistent with the modern LOS standards adopted for WEIDAP, the Project will equip the six piped subsystems with about 360 standard hydrant manifolds, each with a 5 l/s design discharge. The total design discharge of the 360 hydrant manifolds is 1.80 m^3/s. The unit cost of simple PVC/ HDP hydrant manifolds is about $435 (80 mm diameter) or $320 (63 mm), giving a total cost of $156,600, equivalent to $87/ ha. The spacing of hydrant manifolds will be about 80 m. Each hydrant manifold will supply about six to 12 households.

Rigid PVC or black HDPE pipe will be adopted. For the larger pipes (>500 mm), glass fiber reinforced plastic (GRP) is a possible alternative to HDPE. However, though very smooth, it vulnerable to damage until placed in the ground. Also, adoption of several different pipe types is not recommended. Each sub-system will connect directly to the Tan My steel pipeline. The one-direction valve, shown on the figure, may not be needed. A volumetric flow meter may be provided.

The high-tech agriculture production zone is expected to be developed in west of the subproject area, in subsystems 14 and 16. To support farm - market access, particularly for the high-tech agriculture production zone, as well as to provide access along the pipeline for inspections and repairs, paved roads are required. In total, 36.64 km of roads are proposed.

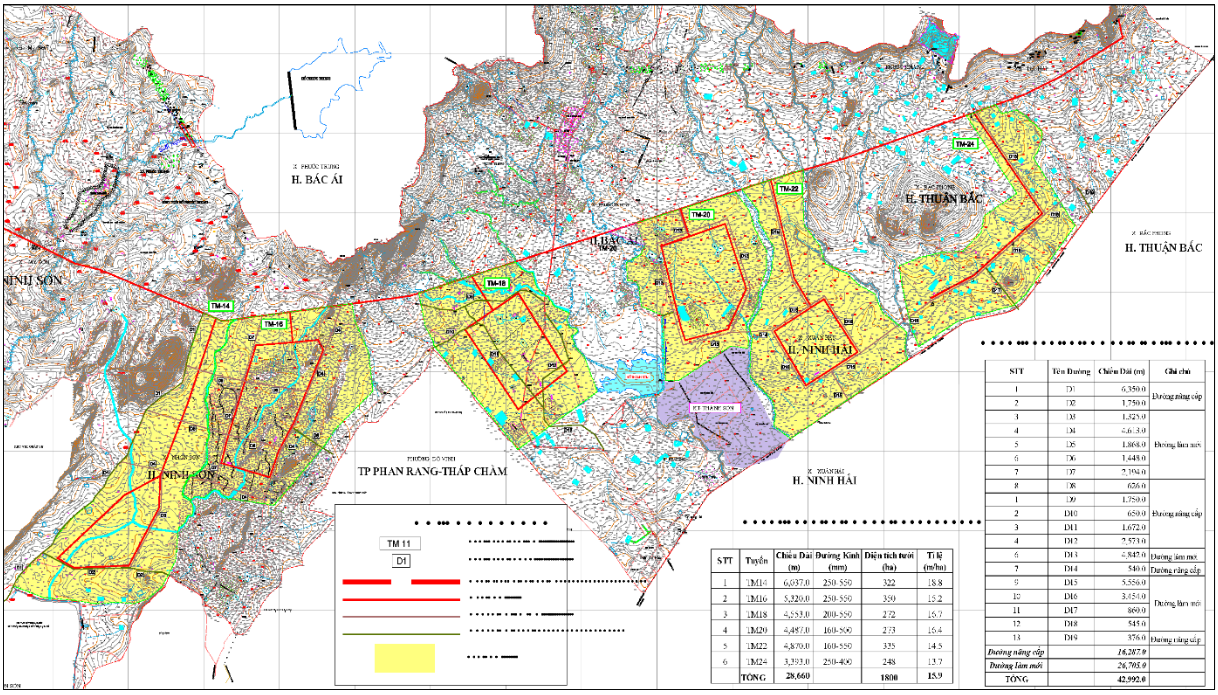


Figure 21: The layout of Thanh Son-Phuoc Nhon sub-project in Ninh Thuan

The Nhon Hai-Thanh Hai subproject: Within the 1,000 ha command area, the total length of pipeline is 15.8 km, giving a pipeline density of 15.8 m/ha, and (i) 531.8 ha (53%) has access to a pipeline within 250 m, (ii) 349.9 ha (35%) is between 250 m and 500 m, and (iii) only 118.3 ha (12%) is further than 500 m. Table 4: Proposed Irrigated Area and Pipe Density.

The Nhon Hai-Thanh Hai subproject comprises the following five pipeline sections designed to meet the level of service (LOS) standards adopted for WEIDAP:

A single conveyance pipeline from the main Tan My pipeline branch, at the downstream end of Thanh Son-Phuoc Nhon service area, to the upstream end of Nhon Hai-Thanh Hai service area. This conveyance pipeline will not serve any irrigation area along its route. Therefore, it will not be equipped with hydrant manifolds and its design discharge will be 0.945 cumec (allocations of 0.87 cumec for irrigation plus 0.075 cumec for domestic water supply) over its entire 9.12 km length.

A single distribution pipeline, along Kien Kien-Vinh Hy provincial road, at the south-west limit of the narrow 94.3 ha upstream service area (max design discharge = 0.87 cumec);

A single distribution pipeline, along Kien Kien-Vinh Hy provincial road, through the middle of the narrow 306.4 ha intermediate sub-service area;

A ring main distribution pipeline to divide the wider 599.3 ha downstream sub-service area into four equal strips, with similar access to water; and

A single branch pipeline to convey water to and from the existing Ong Kinh Reservoir.

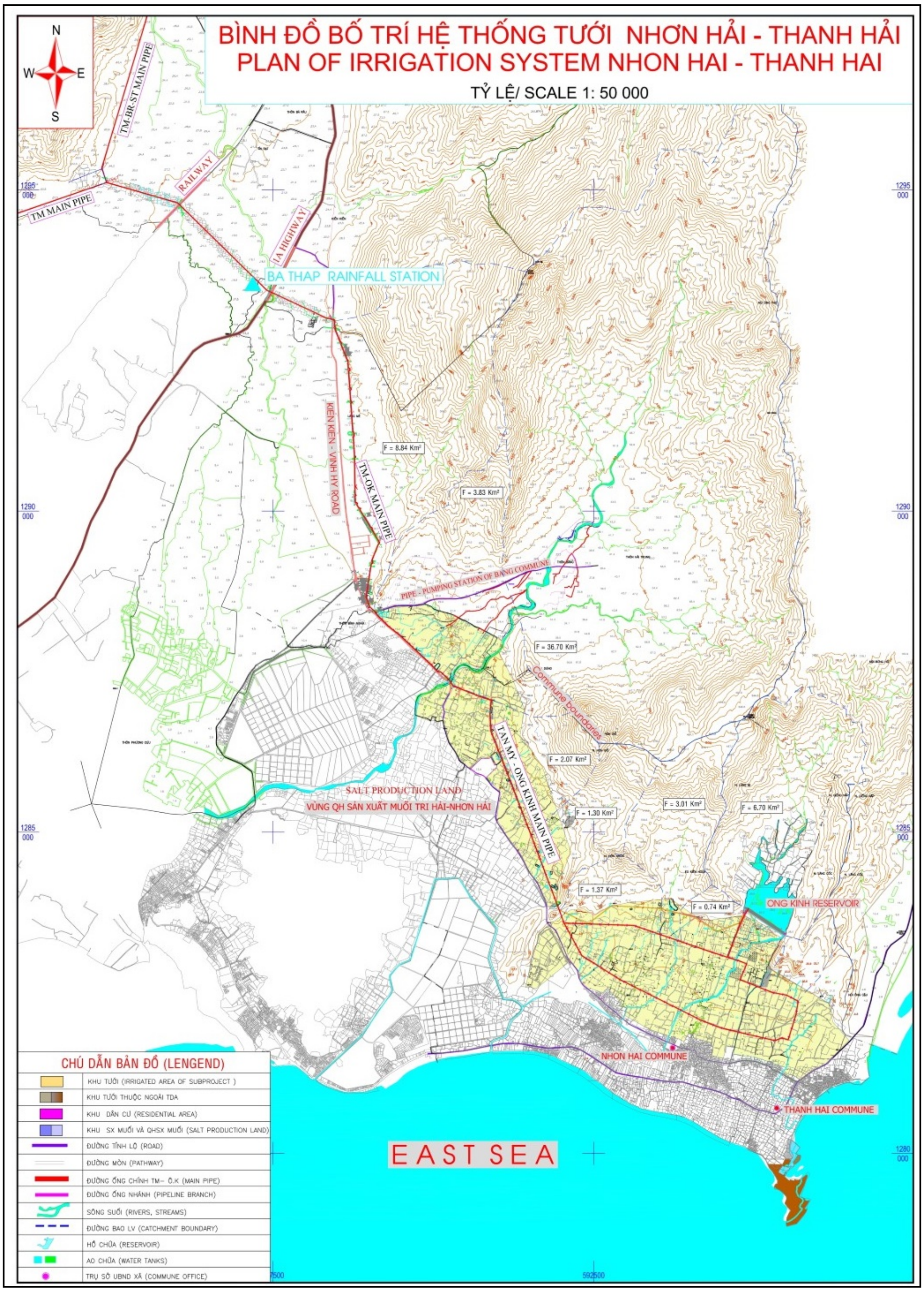


Figure 22: The layout of Nhon Hai-Thanh Hai subproject in Ninh Thuan

4.3.2 The key gap and proposed last-mile connection to WEIDAP

As the same design rule like ring main pipeline systems in Khanh Hoa province, The WEIDAP project is not addressing issues of connectivity to irrigation schemes, the two subprojects in Ninh Thuan also only provide irrigation water up to hydrant manifolds. Farmers in the WEIDAP project areas required to invest their own resources in obtaining 'last-mile' connection of the surface canal or pipe irrigation system to their plots. This presents an overwhelming challenge to poor and near-poor farmers which is recognised high rates in Ninh Thuan and is therefore a specific need that should be addressed in the proposed UNDP project.

The coastal area of Ninh Thuan is a special dry area with the rainfall of only 750mm / year but the potential evaporation is about 1,900mm / year. The irrigation system serving the agricultural production in the area is some small reservoirs with very limited capacity. An example in Ong Kinh reservoir, every year, water storage is always exhausted, people have to exploit the underground water in dried reservoir ground to irrigate (figure). Basically the exist irrigation system can not meet the water demand for existing production area in the area. Damage caused by annual drought disturb the life and production of people in the region.

The planed irrigation area in Thanh Nhon – Phuoc Son subproject is around 2000ha. There is no irrigation system, land is mostly desert or land is a crop due to drought without water production. The main source of income is from agricultural production. At present, irrigation works for water supply for agricultural production in the project area have not been invested. Many places are abandoned. The fruit trees and industrial crops are growing rapidly such as Grapes, apples, peanuts, vegetables, grass areas ... now there is absolutely no irrigation works. Area of aquaculture in the area of water source is mainly dependent on nature, so the impact on productivity and product quality.

Figure 23: Digging within Ong Kinh reservoir to get water for irrigation and private pipeline from the pumps to irrigation area (above)). Excavation wells for groundwater extraction in field plots (black dots) and anti-evaporation shield design for wells in Nhon Hai (below)

4.3.3 Recommended interventions

WEIDAP pipe system take high pressure water from Tan My irrigation main pipe, the designed residual head in each *hydrant manifolds are greater than 10m thus sufficient for any irrigation technology. T*he proposed project should complement the WEIDAP interventions on irrigation infrastructure and address its gaps through provide technical expertise for design and distribution systems for last-mile connection to GoV invested irrigation schemes ensuring reliable water supply during drought periods.

The recommended interventions in Ninh Thuan province are:

Support group/single poor and near poor house holds to establish the shared/private pipeline systems to connect to closest manifold for crop irrigation.

Technical support last-mile connection: survey and design the system; development of manual documents for operation and management of their irrigation system, especially in management of shared systems.

The solution of for the planted area benefitted from 02 subprojects in Ninh Thuan:

1) Support for estimation of water meter, shared pipeline network for a group of beneficiaries HH in appropriate locations
2) Support for estimation of water meter and pipeline for single beneficiary HH

The maximum connection distance to hydrants are around 500m but mainly within 350m.

4.3.4 Beneficiary site selection

Beneficiary sites are the communes related to WEIDAP command area, including 09 following communes:

Ninh Hải district: Phương Hải; Xuân Hải; Tri Hải; Nhơn Hải.

Ninh Sơn district: Nhơn Sơn

Thuận Bắc district: Lợi Hải; Bắc Sơn; Bắc Phong

Bác Ái district: Phước Trung

Poor and near poor rate without land of 24% is excluded to estimate the number of beneficiary households for Ninh Thuan.

Table 8: Total number of households, rate of beneficiary households in Ninh Thuan

No	Commune	Total household (2017)	Rate of beneficiary HHs	Shared area in Weidap (%)	Shared area in rainfed (%)	Number of beneficiary HHs
II	**Ninh Thuận province**	**23,856**				**1,557**
	Ninh Hải district	**12,909**				**381**
1	Phương Hải	1,783	16%	10%	90%	22
2	Xuân Hải	4,245	8%	50%	50%	137
3	Tri Hải	3,130	12%	20%	80%	56
4	Nhơn Hải	3,751	12%	50%	50%	166
	Ninh Sơn district	**3,719**				**284**
6	Nhơn Sơn	3,719	14%	70%	30%	284
	Thuận Bắc district	**6,658**				**743**
10	Lợi Hải	2,974	44%	20%	80%	200
11	Bắc Sơn	1,983	59%	50%	50%	446
12	Bắc Phong	1,701	15%	50%	50%	97
	Bác Ái district	**570**				**149**
16	Phước Trung	570	49%	70%	30%	149

4.3.5 Operational and implementation modalities

The ring main pipeline and pipeline system are managed by local IMC based on a simple SCADA system including monitoring water level in Tan My weir and water storage in Song Cai reservoir in near future, the monitoring system also include the water pressure in pipeline and flow velocity in pipes and discharges in operational valves.

The control office will establish over the cellular network or Global System for Mobile Communications (GSM), stored on a computer, and used to adjust flow releases sub-systems from Tan My pipeline.

The last-mile connection from WEIDAP to beneficiary HH will be managed by themselves or by farmer group. The O&M code of system is supported by Technical group in each commune. O&M functions could include:

Register farmers using the two pumping systems;

Meter and charge farmers according to water use, at least to recover O&M costs;

Flush sediment during the wet season and during the dry season from the weirs; and

Manage water flow releases from the two reservoirs so as not to waste water.

4.4 Last-mile connection in Binh Thuan province

4.4.1 The design of WEIDAP

Du Du-Tan Thanh subproject

The subproject will serve an established dragon fruit area. With subproject area, perennial dragon fruit coverage will increase from 1,460 ha (78%) to 1,960 ha (100%). Most years surface supplies will be sufficient to meet demand. In drought years, if necessary, farmers may supplement surface supply by pumping groundwater. The pressure on groundwater resources will reduce substantially, and the development will be sustainable. The service area consists of two communes and one township that has historically the largest area of dragon fruit in the country.

The subproject will comprise a single new gravity pipe system. It will supply 1,960 ha, mainly of dragon fruit. Estimates have been made regarding actual area irrigated, and about the water requirement and efficiency of the system and the number of hours operated in a day. The Viet Nam national irrigation guidelines have determined that the total flow required is 1.1 m^3/s. The Project Preparatory Technical Assistance (PPTA) also found a similar system water requirement.

The new gravity intake structure will be located at the existing Tan Lap Reservoir. From this intake, the national design consultant (NDC) considered various canal and pipe combinations, including a supply pipeline or canal along the high land to the east of the command area with off-taking downslope canals which would supply private ponds/ tanks located in farmers' fields. These pipe-canal systems would not allow direct farmer hose connection, rely on farmer ponds for flexible supply and would entail significant water losses in these ponds. They were therefore rejected in favor of all pipe solutions.

The option of ring main layout where the two narrow parts of the command area were served by two single pipelines and the two wide parts by two ring mains. To optimize access to water, pipelines were centrally located, down the middle, dividing the service area into two (with single pipelines) or four (with ring main pipelines) strips of approximately equal width.

Table 9: Comparison of the Two Piped System Options

	Ring Main	
Access to Water (m)	ha	%
0 – 250	1,208	62
250 – 500	662	34
500 – 650	90	4
Pipe (km)		34.7
Pipe (m/ha)		17.7

Residual heads or pressures range from a maximum of 9.41 m to a minimum of 1.22 m.

Consistent with the modern irrigation LOS adopted for Water Efficiency Improvement in Drought-Affected Provinces (WEIDAP) the project will equip the ring main distribution pipelines with 220 hydrant manifolds, each with a standard 5 l/s design discharge. The total water delivery capacity of the 220 hydrant manifolds is 1.10 m^3/s, which is the design discharge for the system, so demand cannot exceed supply.

The hydrant manifold arrangements, first proposed for a (i) 63 mm diameter hydrant offtakes from 900 mm to 355 mm diameter pipes, and (ii) for similar offtakes from 315 mm and 200 mm diameter pipes are presented in the layout map. The hydrant manifold unit costs ranged from $1,645, for an offtake from a 900 mm diameter pipe, to $361 for an offtake from a 200 mm diameter pipe. The design has a sleeve or collar fitted around the parent pipe equipped with a 63 mm diameter tapping for the hydrant manifold. The tapping sleeve or collar can be expensive and depends on the diameter of the parent pipe. The remainder of the hydrant manifold consists of standard 63 mm diameter pipe and fittings which have a fixed cost regardless of the diameter of the parent pipe.

Each hydrant manifold will serve about six to 10 households (HHs). The project will provide a standard digital/ mechanical flow meter to record individual farmer water consumption. In ring main sections with low residual heads, farmers would have to provide their own pump to provide sufficient pressure for on-farm pressurized sprinkler or drip irrigation systems.

Paved inspection roads are proposed along the larger, >500 mm diameter, pipelines to facilitate inspection of pipeline structures, and allow access to repair any leaks. However, access roads are not required where pipelines are aligned quite close to existing all weather roads. In total, 13.0 km of paved inspection road are included in the cost estimate.

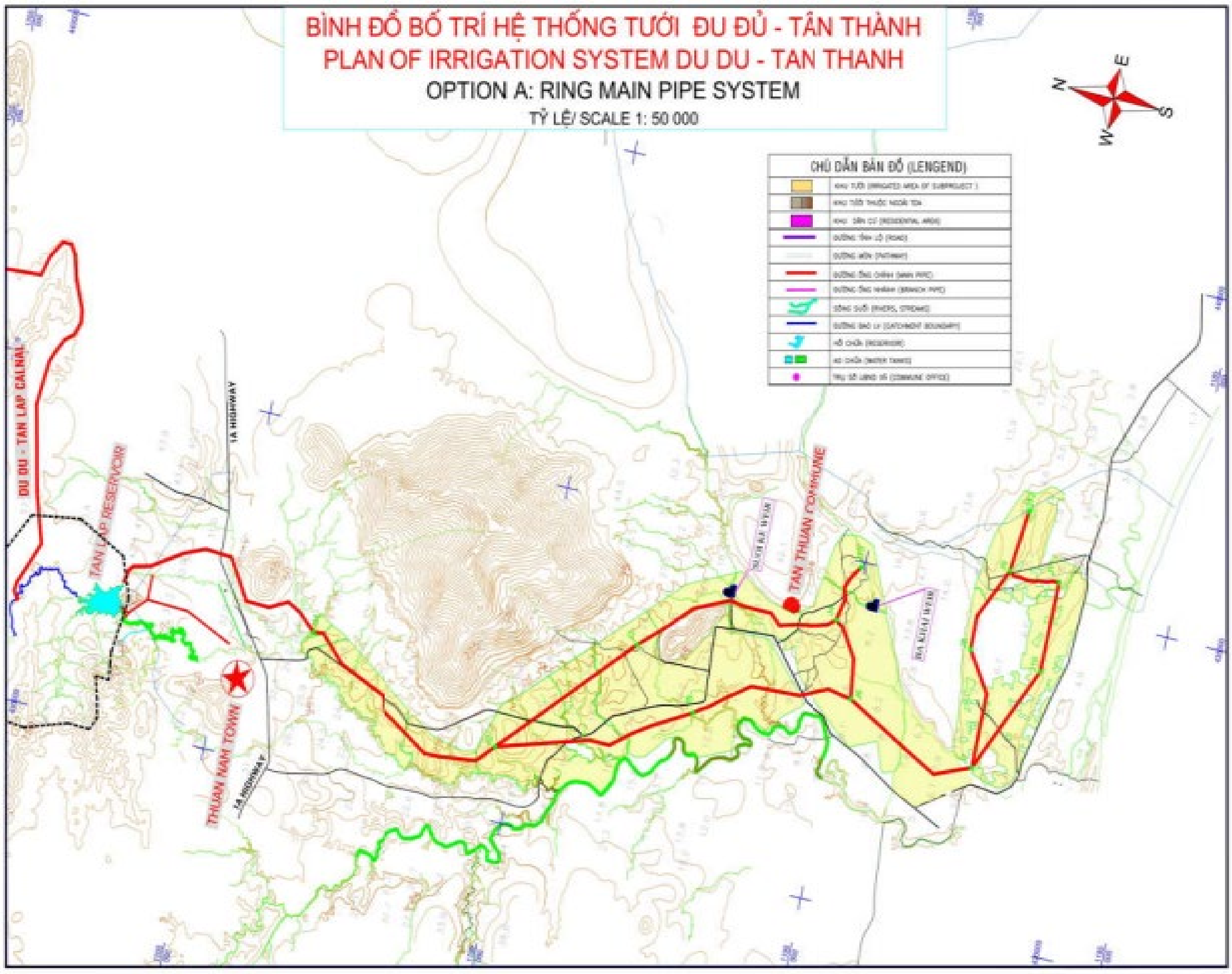


Figure 24: The layout of the irrigation system in Du Du – Tan Thanh subproject

Tra Tan Subproject

The subproject comprises an existing storage reservoir and canal system, and a proposed new pumped pipe system pumping water directly from the reservoir. Modernization will line the main canal system and selected secondary canals, and support direct pumping by famers from these canals for HVC irrigation. Rice areas will continue to be supplied by gravity canal flow. Secondary canals which only supply areas within about 500 meter (m) of the main canal will not be constructed/lined. Small balancing storage tanks are recommended at the tail of the main and the longest secondary canal. The new pipe system will comprise a pumping station supplying water to a hill top header tank, from which a single pipeline will command a strip of land up to about 1.0 km wide. Hydrants at about 50 m intervals will command plots of land either side of the pipeline. To facilitate improved operation of the canal system, water levels shall be remotely monitored in the tail end balancing storage tanks, and inform flow releases from the reservoir. For the new pipe system, pressures and flows at key points shall be monitored - pumps shall turn on/off according to the water level in the hill top header tank.

The Subproject comprises two separate irrigation systems. Both will be supplied from the existing Tra Tan Reservoir. The schemes comprise: (i) modernization of the existing gravity open canal system, and (ii) construction of a new pumped piped system.

The existing canal system comprises the existing storage dam and unlined main and off-taking secondary canals. Farmers have been discouraged from pumping directly from the canal, and water is diverted into nearby ponds from which farmers then pump. Much of the water is used to irrigate about 140 ha of rice in the middle upper part of the system where losses are significant. With the project, farmers will be allowed to pump directly from the canal system to irrigate HVCs.

The system will supply an area of 854 ha, including 714 ha of high value crops (HVCs), pepper and cashew, and 140 ha of rice. Assumptions/ estimates were made regarding water requirement and efficiency of the system and the number of hours operated in a day. The Vietnam national irrigation guidelines have determined that the total flow required for the canal system averages 1.41 l/s/ha for the crops cultivated giving a peak demand of 1.2 m^3/s for the command area.

Of the 854 ha service area, 380 ha (44%) will have access to canal water within 250 m, 322 ha (38%) will have access between 250 m and 500 m and only the remaining 152 ha (18%) will have access of over 500 m.

Rectangular concrete in-situ lining is proposed for the main canal, and precast lining sections for the secondary canals. Canal structures will be repaired/ upgraded. Section sizes vary from 1.8 x 1.7 m to 0.8 x 0.8 m for the main canal, and from 0.8 x 0.8 m to 0.5 x 0.5 m for the secondary canals.

The requirement for downstream storage tanks was considered but has not been included in the feasibility level design costs. Instead it was felt that farmers might provide their own individual farm-level storage tanks or ponds. A basic SCADA system was proposed to monitor and control flows along the canal system.

The pumped piped system will serve a HVC (pepper and cashew) area of 236 ha. Assumptions/ estimates can be made regarding water requirement and efficiency of the system and the number of hours operated in a day. The Vietnam national irrigation guidelines have determined that the total flow required for the pipe distribution system is 0.94 l/s/ha giving 0.222 m^3/s (796 m^3/hr). The PPTA also proposed a similar system design requirement.

The proposed new pipe system comprises an onshore intake, pumping station, rising main, hill top header tank and single distribution pipeline supplying hydrants each with a discharge of about 5 l/s.

The pumping station comprises an on-shore reinforced concrete pump house equipped with three vertical turbine pumps. The intake and pump house floor elevations are +90.9 m and +96.5 m respectively. The minimum reservoir water level is about + 92.0 m. Two centrifugal pumps will operate in parallel 24 hours/ day while the third is on standby. Two pumps have the combined capacity to deliver the required flow of 0.222 m^3/s against a head of 31 m comprising: (i) suction intake losses (1.25 m), (ii) hydrostatic lift (full header tank) (27 m) and (iii) rising main losses (2.88 m).

The distribution pipeline meets the LOS standards developed and adopted for WEIDAP, with fields being within about 500 m from the pipeline. The service area excludes the area that may be irrigated by direct pumping from the canal system. It varies in width from less than 1.0 km to 1.5 km wide, and a single HDPE distribution pipeline 3.96 km long is proposed. The total length of pipeline is 4.39 km and this gives a pipe density of 18.6 m/ha for the 236 ha service area. The hydraulic design of the distribution pipeline, using the Epanet software, give residual heads or pressures at the hydrants range from a maximum of 22.9 m (tank full) to a minimum of 10.1 m (tank empty). The minimum pressure occurs at the downstream end of the distribution pipeline.

Table 5: Distribution Pipe Diameters and Lengths

∅ (mm)	**Length** (m)	∅ (mm)	**Length** (m)	∅ (mm)	**Length** (m)
450	306	300	595	150	170
400	1,190	250	595	100	85
350	765	200	255	**Total**	**3,961**

∅ = pipe diameter

For the design flow of 0.222 m^3/s, 45 hydrant manifolds each with a fixed 5 l/s design discharge will be provided. Each hydrant comprises a ball (or gate) valve and a digital (ultrasonic) flow meter, and supplies a manifold to which each farmer can connect their hoses. Valves and cheap (local) read meters may be provided for each farmer along the manifold offtake for transparent charging of farmers according to volume of water use.

The unit cost of hydrant manifolds is about $435 (80 mm diameter) or $320 (63 mm). Therefore, the total cost of 45 hydrant manifolds will be $19,575, equivalent to $83/ha over the service area of 236 ha. The average spacing of hydrants along the pipeline will be 88 m.

The design also includes for a 2.0 m wide concrete, 160 mm thick, access road to facilitate operations and servicing along the length of the pipeline, about 4.39 km in length.

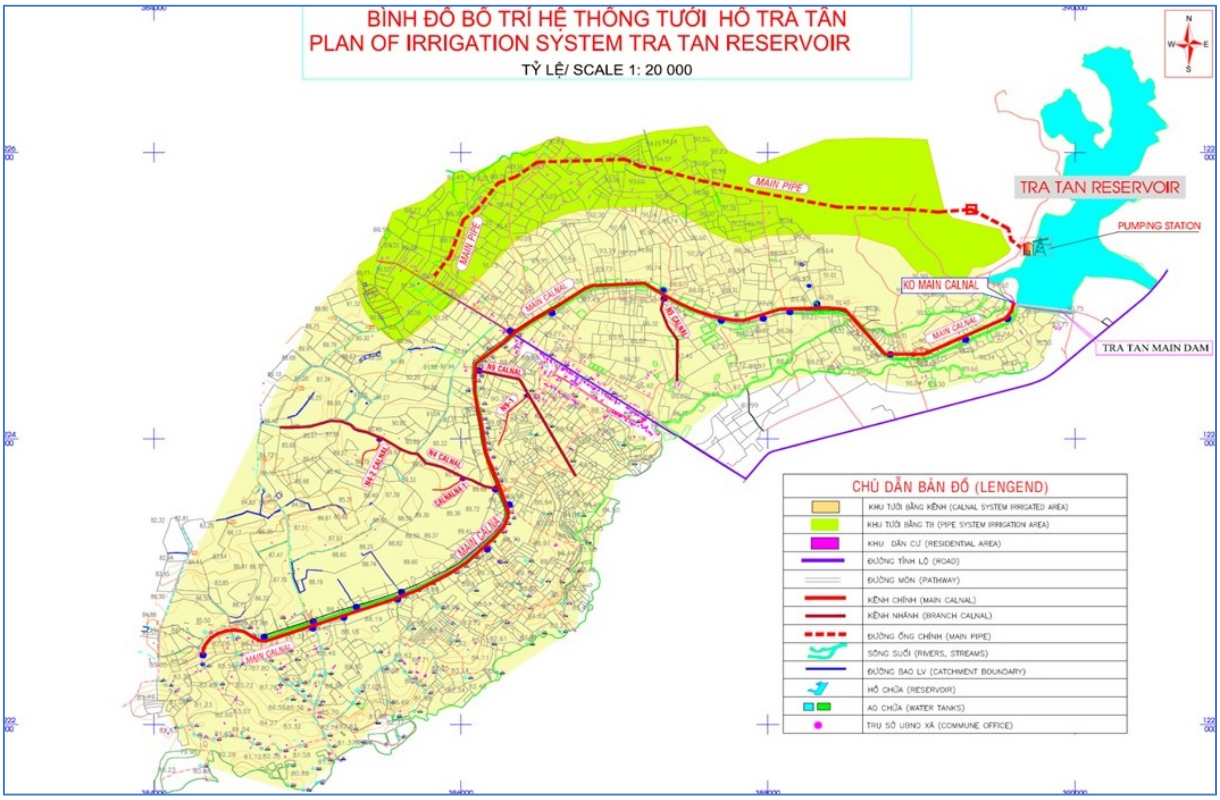


Figure 25: Layout of Tra Tan Subproject

4.4.2 The key gap and proposed last-mile connection to WEIDAP

In Ham Thuan Nam district, specially in Tan Thuan commune and Tan Thanh commune. Severe due to lack of irrigation system for irrigation. In the dry season, when surface water sources in small rivers and streams in the area have dried up, their water sources are mostly underground water from existing wells and dug wells. And it is more difficult when weather in the central provinces in general and in Binh Thuan in particular in the recent years there is a unpredictable transformation, especially the rain regime, causing the imbalance water source. Moreover, in the dry season, the phenomenon of drought also occurs more and more commonly, the drier and hotter climate has made negative impact on the life of the people in the area. In fact, from 2010 up to now, the area of Ham Thuan Nam district has continued to suffer from prolonged and severe dry droughts, which have impacted on the local people's production.

As the same design rule like ring main pipeline systems in Khanh Hoa and Ninh Thuan province, The WEIDAP project is not addressing issues of connectivity to irrigation schemes, the two subprojects in Binh Thuan also only provide irrigation water up to hydrant manifolds. Farmers in the WEIDAP project areas required to invest their own resources in obtaining 'last-mile' connection of the surface canal or pipe irrigation system to their plots. This presents an overwhelming challenge to poor and near-poor farmers and is therefore a specific need that should be addressed in the proposed UNDP project.

4.4.3 Recommended interventions

Support group/single poor and near poor house holds to establish the shared/private pump and pipeline systems to connect to closest manifold or canal for crop irrigation.

Technical support last-mile connection: survey and design the system; development of manual documents for operation and management of their irrigation system, especially in management of shared systems.

WEIDAP solutions in Binh Thuan have 3 types of water supply, the intervention for each type are:

i. Type 1: Gravity branched and ring main pipeline with medium water pressure in 03 communes in Ham Thuan Nam district: Tân Lập; Tân Thuận; Tân Thành
ii. Type 2: Storage pump and gravity branched pipeline system in 02 communes in Duc Linh district: Tân Hà; Trà Tân
iii. Type 3: Gravity canal through 03 communes in Duc Linh district: Tân Hà; Đông Hà; Trà Tân

Type 1 and type 2:

Support for estimation of water meter, shared pipeline network for a group of beneficiaries HH in appropriate locations.

Support for estimation of water meter and pipeline for single beneficiary HH.

The maximum connection distance to hydrants are around 500m but mainly within 300m.

TYPE 3

Support for estimation of shared pump and shared pipeline network for a group of beneficiaries HH in appropriate locations,

Support for estimation of private pump and pipeline for single beneficiary HH.

The maximum connection distance to canal are around 1000m but mainly within 700m.

4.4.4 Beneficiary site selection

Beneficiary sites are the communes related to WEIDAP command area, including the following 06 communes:

Hàm Thuận Nam district: TT Thuận Nam; Tân Thuận; Tân Thành

Đức Linh district: Tân Hà; Đông Hà; Trà Tân

Poor and near poor percentage without land of 15% is excluded to estimate the number of beneficiary households for Binh Thuan.

Table 10: Total number of households, rate of beneficiary households in Binh Thuan

No	Commune	Total household (2017)	Rate of benificaries HH	Shared area in Weidap (%)	Shared area in rainfed (%)	Number of benificeries HH
III	**Bình Thuận province**	**13,820**				**198**
	Hàm Thuận Nam district	**8,322**				**82**
1	TT Thuận Nam	3,329	6%	10%	90%	11
2	Tân Thuận	3,593	4%	50%	50%	61
3	Tân Thành	1,400	4%	20%	80%	10
	Đức Linh district	**5,498**				**116**
4	Tân Hà	1,402	12%	20%	80%	29
5	Đông Hà	2,029	9%	10%	90%	16
6	Trà Tân	2,067	10%	40%	60%	71

4.4.5 Operational and implementation modalities

A simple SCADA system shall be provided for both the canal and pumped pipe systems, with all data transmitted to a central office. Operations will be monitored from a central office, and in the event of problems, including pipeline fracture or leaks, the pumps would automatically shut down. Pipe flows would be metered, most likely using clamp-on ultrasonic digital meters fixed around the pipes upstream of the pump station and downstream of the header tank. These could operate by battery and solar power. Meters will also be installed at each hydrant. Data will be transmitted over the cellular (GSM) network, and stored on computer at the control office.

The last-mile connection from WEIDAP to beneficiary HH will be managed by themselves or by farmer group. The O&M code of system is supported by Technical group in each commune. O&M functions could include:

Register farmers using the two pumping systems;

Meter and charge farmers according to water use, at least to recover O&M costs;

Flush sediment during the wet season and during the dry season from the weirs; and

Manage water flow releases from the two reservoirs so as not to waste water.

4.5 Last-mile connection in Dak Lak province

4.5.1 The design of WEIDAP

The subproject schemes will enable increased and sustainable high value cropping though efficient distribution and use of water from storage reservoirs. Cropped areas will expand and the pressure on groundwater use will be reduced. For farmers in areas where there is no groundwater, or where groundwater is not reliable, preventing investment in perennial crops, will be able to consider high value perennial crops. Improved monitoring and management of supply though a basic supervisory control and data acquisition (SCADA) system will enable more efficient and productive use of water. The schemes, with assured irrigation water supplies, available at appropriate flows (<5 l/s), will encourage farmers to invest in improved on-farm irrigation equipment, sprinkler and drip/ bubbler, allowing irrigation at non-social times, supporting crop production increases, and reducing labor and pumping costs.

The design of the Dak Lak Subproject comprises eight new storage irrigation systems, serving a total of 2,650 ha, to be supplied from five existing reservoirs.

Table 11: Dak Lak Subproject Irrigation Systems

Reservoir	Irrigation System: Supply	Irrigation System: Distribution	Area (ha)	Length (km)	Density (m/ha)
Ea Drang	New pump station	New piped	150	2.70	18.0
Buon Yong	New pump station	New piped	451	8.51	18.9
Ea Kuang	New pump station	New piped	422	15.78	18.7
	Existing open canal	New piped	424		
Krong Buk Ha	New pump station	New piped	200	3.45	17.3
	New pump station	New piped	400	6.86	17.2
	New pump station	New piped	200	3.85	19.3
		New piped	200	3.31	16.5
Doi 500	New pump station	New piped	203	4.07	20.0
Total = 5	8 Systems		2650	48.53	18.3

Source: Design summary table in the English summary of the NDCs revised design report.

Irrigation systems are required to deliver the peak irrigation water requirement (IWR) in the critical month (April). The peak crop water requirement (CWR) for the pump-pipe systems, where coffee and pepper are the dominant crops, is 1.04 l/s/ha, taking into account conveyance-application efficiencies, and proving some operational flexibility.

A typical pumping station is presented in the attached drawing Annex 4. To cope with variations in reservoir water levels, about 8 m for Doi 500 Hill reservoir, and over 10 m for the Krong Buk Ha reservoir: (i) submerged turbine pumps, and (ii) surface motors, located above maximum reservoir water levels, are to be connected by, (iii) long vertical drive shafts. Each of the pumping stations would be provided with two operational pumps and one stand-by pump. Pumping heads range from 16 m to 55 m, motor capacities for 50 kW to 230 kW and transformer station capacities from 180 kVA to 800 kVA.

The total capacity of the 16 operational pumps is 10,880 m^3/hr = 3,022 l/s and their unit design discharge is 3,022 / 2,650 = 1.14 l/s/ha. Therefore, the operational pump capacity includes a factor of safety of 10% as the required flexible system delivery capacity is only 1.04 l/s/ha. This is equivalent to pumping 22 hours/day instead of continuously 24 hours/day.

Piped distribution systems have been designed to meet the modern level of irrigation service adopted for Water Efficiency Improvement in Drought Affected Provinces (WEIDAP. Pipe densities range from 16.5 m/ha to 20.0 m/ha and the average is 18.3 m/ha. Of the total command area, some 1,781 ha (67%) will have access to water within 250 m, 830 ha (31%) from 250 m to 500 m, and only 39 ha (2%) beyond 500 m.

Table 12: Revised Design Pipe Diameters and Lengths

∅ (mm)	Pipe Lengths (m)[113]: Ea Drang	Buon Yong	Ea Kuang	KBH	Doi 500	Total[2]
110	880	1,465	1,337	2,244	467	6,503
140	97	0	0	0	0	237
160	229	2,251	2,047	3,573	827	9,087
225	512	2,274	1,464	2,921	1,303	8,699
280	685	1,135	1,354	2,310	815	6,579
355	295	697	1,719	1,831	352	5,249
400	0	441	1,873	1,120	302	4,136
450	0	120	950	1,405	0	2,925
500	0	0	0	489	0	989
560	0	124	959	833	0	2476

[113] *In the English summary of the NDCs revised design report, there are discrepancies between pipe lengths in the design summary and cost estimate tables for the: Krung Buk Ha (17.46 km versus 16.88 km) and Ea Kuang (15.78 km versus only 11.70 km). The latter large discrepancy may be because the gravity pipeline is not in the cost estimate?*

710	0	0	0	149	0	859
Total	**2698**	**8,507**	**11,703**	**16,875**	**4,066**	**47,739**

Source: Cost estimate table in the English summary of the NDCs revised design report.

The project will equip the piped sub-systems with 550 standard hydrant manifolds each with a 5 l/s design discharge. Therefore, the total design discharge of the 550 hydrant manifolds is 2.75 m^3/s, which is very nearly the system design discharge of 1.04 l/s/ha x 2,650 ha = 2,756 m^3/s.

The unit cost of simple PVC hydrant manifolds is about $435 (80 mm diameter). Therefore, the maximum total cost of 550 hydrant manifolds will be $239,250, which is only $90 per ha over the service area of 2,650 ha. The average spacing of hydrant manifolds will be less than 87 m to be confirmed at detailed design. Each hydrant manifold will serve an area comprising about 6-10 households. Farmers will not pay a connection fee and will have one standard digital flow meter per connecting farmer.

Figure 26: Layout of Ea Kuang irrigation system in Dak Lak province

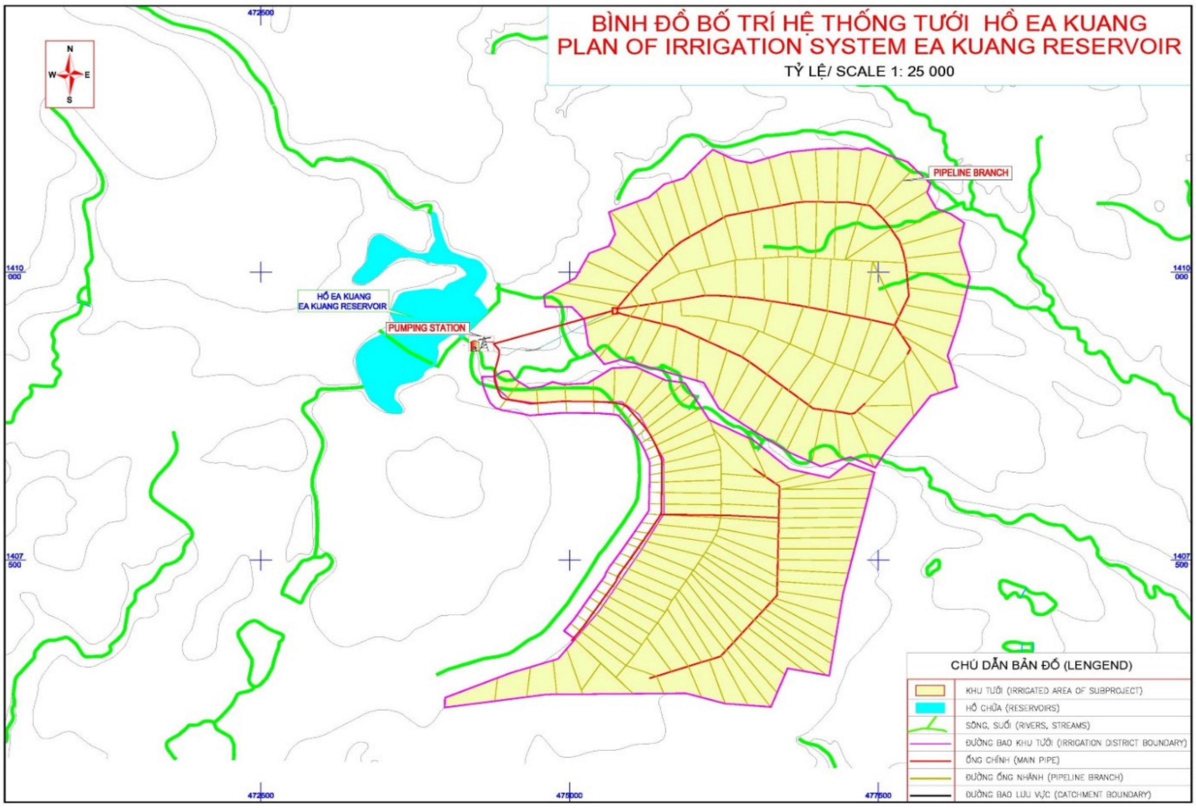


Figure 27: Layout of Krong Buk Ha irrigation system in Dak Lak province

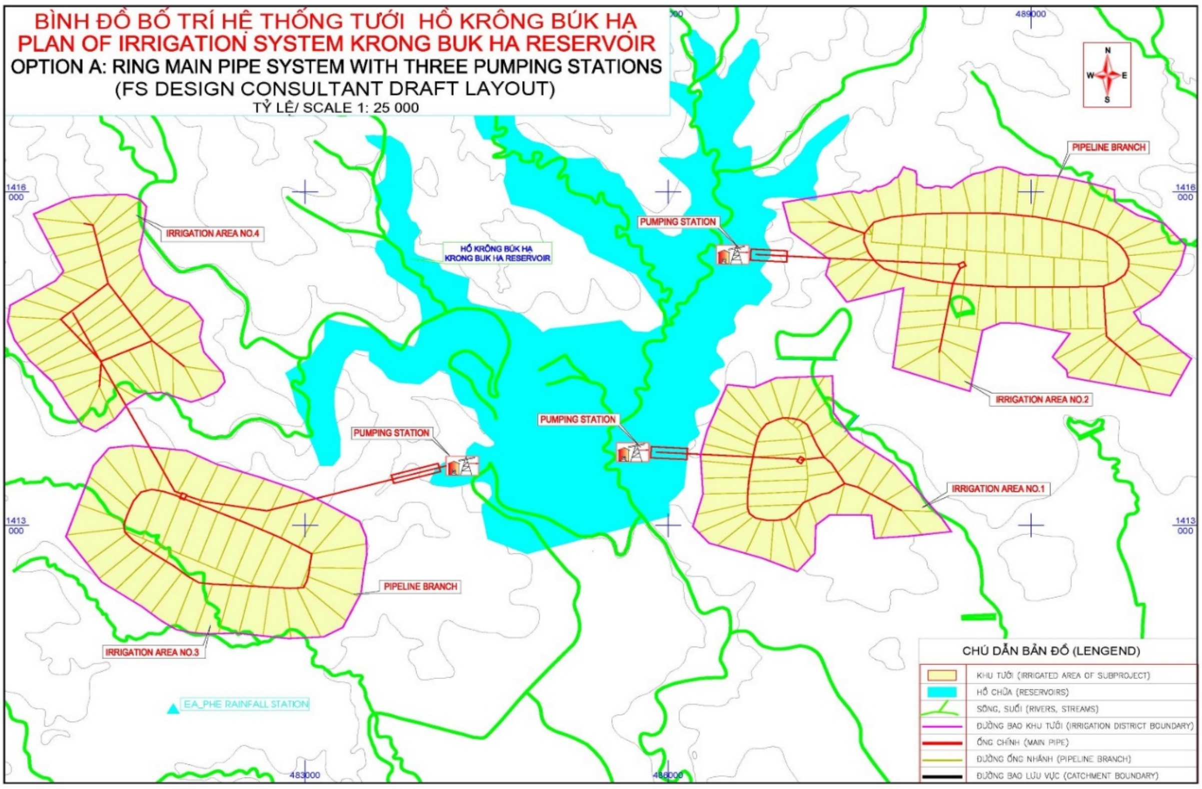


Figure 28: Layout of Doi 500 irrigation system in Dak Lak province

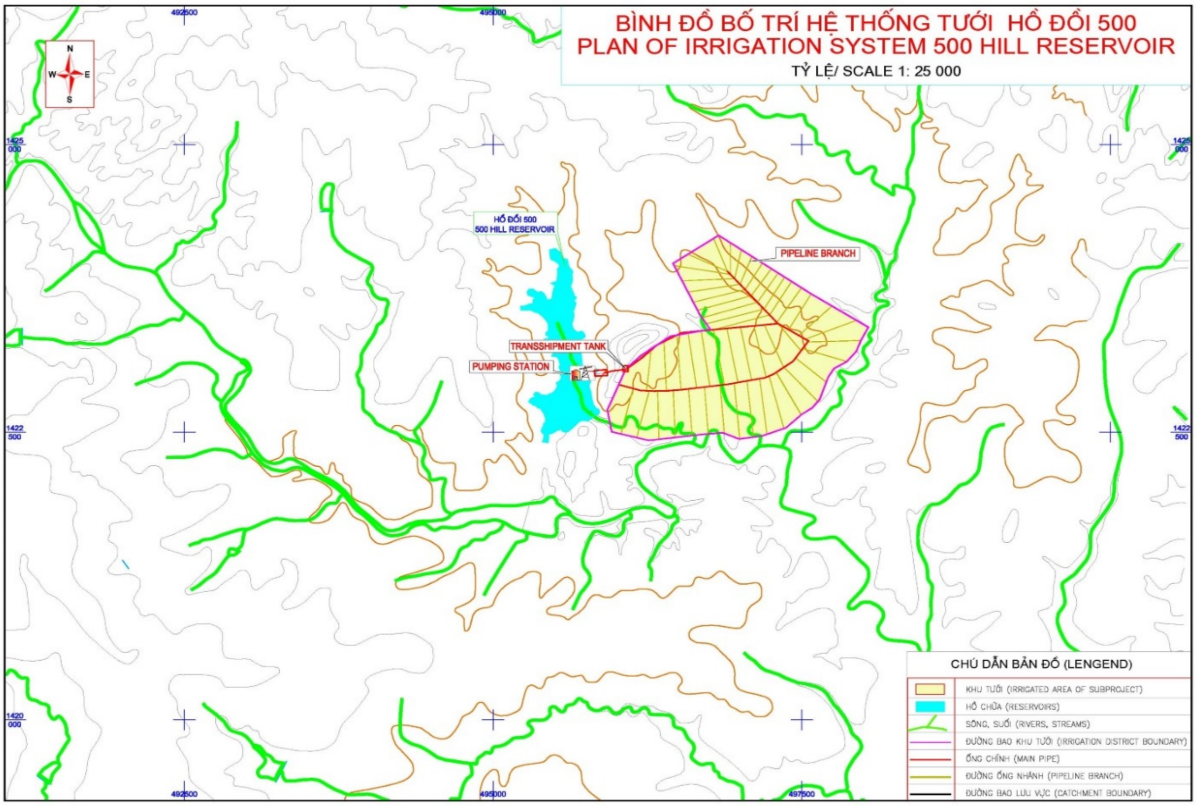
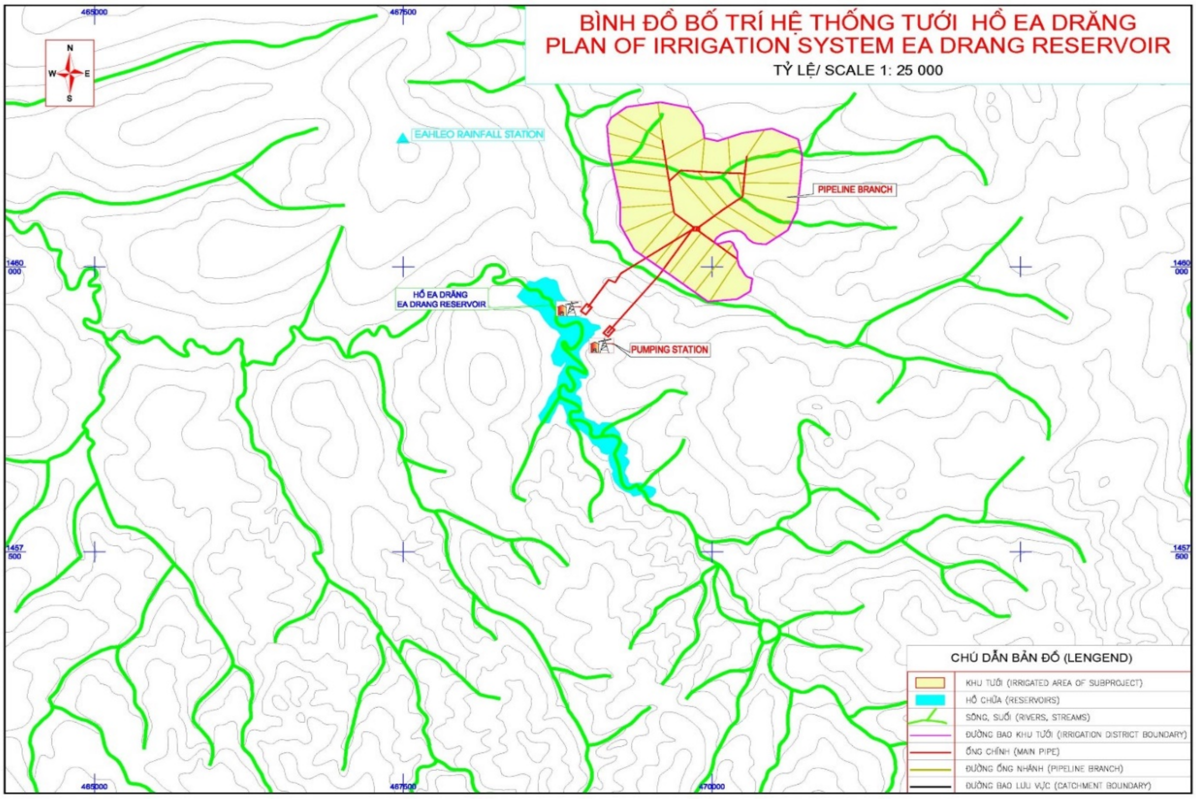


Figure 29: Layout of Ea Drang irrigation system in Dak Lak province



4.5.2 The key gap and proposed last-mile connection to WEIDAP

In Dak Lak, many irrigation reservoirs have invested recently. The efficiency of gravity irrigation works is not high cause of changing crop patterns from high water demand (rice) to lower water demand crop in irrigation area and the gravity irrigation cannot expand due to hilly topography. However, many areas of industrial crops such as coffee and pepper are located upstream of the reservoirs, which have not yet been irrigated or only some households located close to the reservoir for private irrigation to a very small area. This area is often drought, coffee production is very low (1,5 ÷ 1,7 ton / ha), life of people is difficult with an average income of less than 16 million per year. For years, people have used different methods (dig wells, dig small ponds, buy water ...) to irrigate coffee trees, but they are not effective and can not meet the irrigation requirements of their farms.

The WEIDAP is proposed to build electric pump stations in 05 large reservoirs in the province of Dak Lak to irrigate the coffee and pepper cultivation areas in upstream reservoirs there. However, As the same design rule like ring main pipeline systems in the provinces, the WEIDAP project is not addressing issues of connectivity to irrigation schemes, the subprojects in Dak Lak also only provide irrigation water up to hydrant manifolds. Farmers in the WEIDAP project areas required to invest their own resources in obtaining ‘last-mile’ connection pipe irrigation system to their plots. This presents an overwhelming challenge to poor and near-poor farmers which is recognised high rates in Dak Lak and is therefore a specific need that should be addressed in the proposed UNDP project.

4.5.3 Recommended interventions

WEIDAP pump-pipe systems pump water from reservoirs to elevated tanks for gravity irrigation. The designed residual head in each *hydrant manifolds are greater than 10m thus sufficient for any irrigation technology.* The proposed project should complement the WEIDAP interventions on irrigation infrastructure and address its gaps through provide technical expertise for design and distribution systems for last-mile connection to GoV invested irrigation schemes ensuring reliable water supply during drought periods.

The recommended interventions in Dak Lak province are:

Support group/single poor and near poor house holds to establish the shared/private pipeline systems to connect to closest manifold for crop irrigation.

Technical support last-mile connection: survey and design the system; development of manual documents for operation and management of their irrigation system, especially in management of shared systems.

The solution of for the planted area benefitted from 02 subprojects in Ninh Thuan:

Support for estimation of water meter, shared pipeline network for a group of beneficiaries HH in appropriate locations.

Support for estimation of water meter and pipeline for single beneficiary HH.

The maximum connection distance to hydrants are around 500m but mainly within 300m.

4.5.4 Beneficiary site selection

Beneficiary sites are the communes related to WEIDAP command area, including following 08 communes:

Ea Hleo district: EaĐrăng town; Đliê Yang

Cư M'Gar district: Quảng Tiến;

Ea Kar district: Xuân Phú

Krông Păc district: Krông Buk; Ea Phê; Ea Yông; Ea Kênh

Poor and near poor percentage without land of 9% is excluded to estimate the number of beneficiary households for Dak Lak.

Table 13: Total number of households, rate of beneficiary households in Dak Lak

No	Commune	Total household (2017)	Rate of benificaries HH	Shared area in Weidap (%)	Shared area in rainfed (%)	Number of benificieries HH
IV	**Đăk Lăk province**	**24,325**				**1,354**
	Ea Hleo district	**6,567**				**165**
1	EaĐrăng town	4,372	19%	10%	90%	37
2	Đliê Yang	2,195	64%	10%	90%	128
	Cư M'Gar district	**1,601**				**55**
3	Quảng Tiến	1,601	12%	30%	70%	55
	Ea Kar district	**1,463**				**43**
4	Xuân Phú	1,463	16%	20%	80%	43
	Krông Păc district	**14,694**				**1,091**
5	Krông Buk	3,023	41%	30%	70%	338
6	Ea Phê	5,152	12%	10%	90%	56
7	Ea Yông	3,744	35%	50%	50%	596
8	Ea Kênh	2,775	40%	10%	90%	101

4.5.5 Operational and implementation modalities

Remote monitoring of operations is designed for all sub-systems, particularly for the larger pumping stations, with data transmitted over the cellular (GSM) network, and stored on computer at a central management office. The station operator would be able to shut down the pumps remotely, overriding local controls. Monitoring would include reservoir water levels, pumped flows, pump speed and temperatures, and pipeline flows and pressures at a few key locations. Pipelines flow rate and volumes may be metered with clamp-on ultrasonic digital meters. These operate by battery and can link to the GSM network. Meters may also be installed each hydrant. Simple mechanical meters, read locally, are likely to be cheaper, and would most likely be adopted at manifolds.

A simple SCADA system shall be provided to each pumping pipe system to allow one or two operators to monitor and manage all pumping stations. No skilled or specifically trained operator would be required on site (at the pumping station), just a watchman with a mobile ‘phone will suffice. Spare devices (sensors, etc.) should be maintained by the operator, with a trained technician able to replace broken or stolen equipment. Such arrangements require some management oversight and an emergency response mechanism in the event of pressure failure.

Operation and maintenance of pumps and pipelines may best be undertaken by a private operator under a Private-Public Partnership (PPP) arrangement whereby the operator would collect a service fee from beneficiary farmers. Water meters would be installed at hydrants to facilitate charging and to monitor individual water delivery.

Those farmers wishing to use high pressure application technologies (drip or sprinkler) may need to re-pressurize at the offtake point to raise the level of head as required (at the individual cost to the farmer).

The last-mile connection from WEIDAP to beneficiary HH will be managed by themselves or by farmer group. The O&M code of system is supported by Technical group in each commune. O&M functions could include:

Register farmers using the two pumping systems;

Meter and charge farmers according to water use, at least to recover O&M costs;

Flush sediment during the wet season and during the dry season from the weirs; and

Manage water flow releases from the two reservoirs so as not to waste water.

4.6 Last-mile connection in Dak Nong province

4.6.1 The design of WEIDAP

Cu Jut subproject

The subproject design involves: (i) 10 permanent weirs to replace farmers' temporary weirs, supplied from the existing Dak Dier and Dak Drong Reservoirs, (ii) two pump - pipe demonstration irrigation systems, supplied from new weirs 2 and 9, each serving 50 ha, and (iii) upgrading of 10.95 km of access road. The layout of the 10 weirs and their service areas are shown on Table 5 below. The design general arrangement drawing for a typical weir, and drawings for one of the two proposed pumping stations supplying the 50 ha pumped - pressure pipe areas, are included in the Engineering Annex 3.

Table 14: Weir Characteristics

	Weir Design Characteristics				
Weir	CA (km^2)	DF (cumec)	Width (m)	UD ($m^3/s/m$)	Service Area (ha)
1	79	119	20	5.95	203
2	83	122	20	6.10	186
3	90	127	20	6.35	216
4	95	129	20	6.45	226
5	188	239	30	7.97	224
6	195	245	35	7.00	215
7	208	249	40	6.23	218
8	212	257	40	6.43	225
9	216	260	50	5.20	225
10	217	261	50	5.22	225
Total					2163

CA = catchment area, DF = 1-in-50-year design flood, and UD = unit discharge.

Source: English summary of the NDC revised subproject design report.

The national design consultant (NDC) estimates of design floods are tabulated above for each weir, and vary from 119 m^3/s for 'Weir 1' to 261 m^3/s for 'Weir 10,' the furthest downstream.

Natural river channels usually overflow their banks, on to their flood plains, every 2-3 years. Site visits and discussions with local stakeholders confirmed that the Ea Dier River does indeed regularly flood over its river banks. To accommodate the 1 in 50-year design floods, the weirs would need to be as wide as or wider than the natural river channel.

Two weir options were considered: (i) gated weirs, and (ii) ungated weirs. The cost of gated weirs was found to be almost double the cost of ungated structures, and the benefit from the greater in-stream storage cannot justify the addition cost. Operation and Maintenance (O&M) costs would also be higher. Further, there remains a risk that gates would not opened in a time for passage of a flood, with flood damage resulting.

Final designs have, on average, 1.5 m high fixed weir crests, and long crests with no horizontal constriction of flow. Weir widths range from 20m to 50m. Raised embankments upstream of the weirs reduce the likelihood of the weirs being outflanked. However, with extreme floods the weirs could still be outflanked, so flexible protection to the permanent concrete weir structure is proposed and should be included in the designs.

Each scheme will each serve an area of 50 ha and have a capacity of 1.16 x 50 x 3.6 = 210 m^3/hr for continuous 24 hour/day operation. Pumping heads will be 25 m and 34 m head. From the small pumping stations, rising mains will both supply 420 m^3 header tanks.

The two piped distribution system layouts have been designed to meet the modern irrigation level of service adopted for Water Efficiency Improvement in Drought Affected Provinces (WEIDAP), with farmers' fields within 500 m of the pipeline.

The project will equip each of the two systems with 12 standard hydrant manifolds each with a 5 l/s design discharge. Therefore, the total design discharge of the 12 manifolds is 60 l/s, which is nearly the same as the system capacity of 1.16 x 50 = 58 l/s. The unit cost of 80 mm diameter hydrant manifolds is $435 each. Therefore, the total cost of 12 hydrant manifolds is $5,220, or $104 per ha over the service area of 50 ha. The average spacing of hydrant manifolds will be 98 m (Tan Ninh) and 170 m (Village 12).

To improve access, and link to the bridge crossing, 10.95 km of 4.0 m wide concrete paved road is proposed and included in the cost estimates.

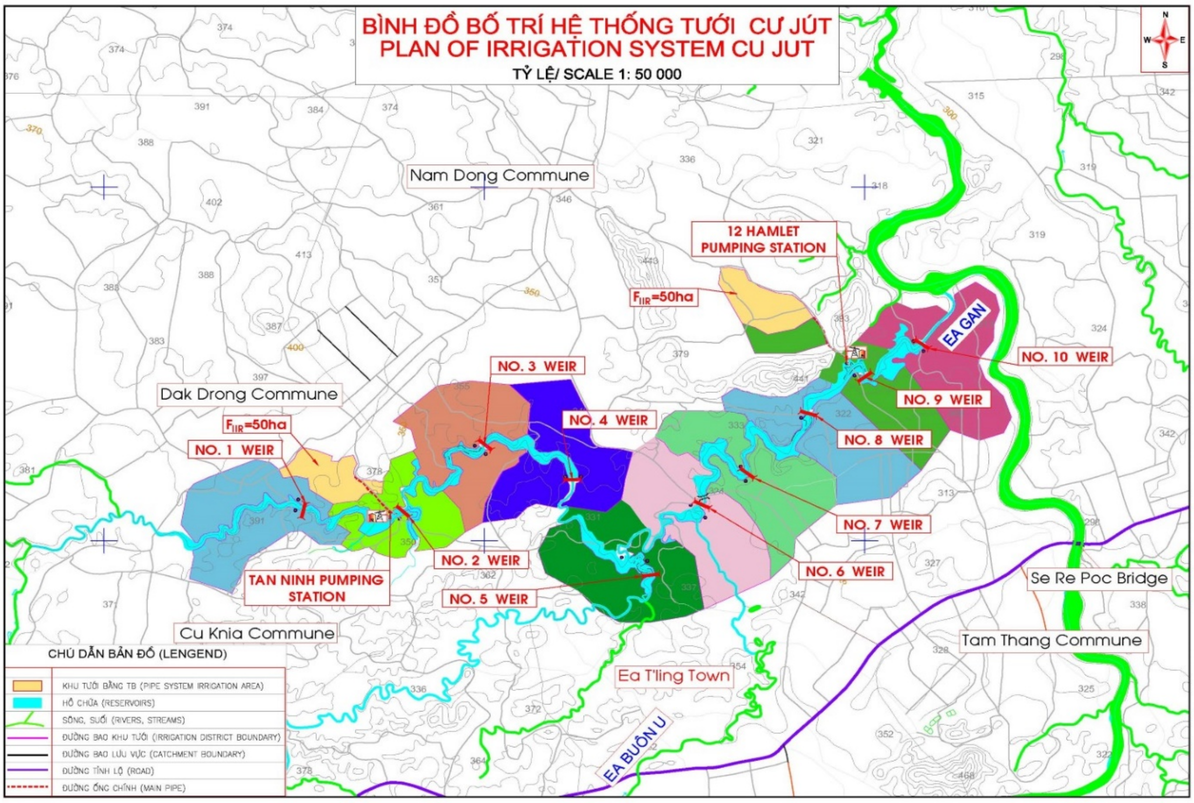


Figure 30: The layout of Cu Jut subproject, Dak Nong

Dak Mil Subproject

The subproject includes: (i) upstream works: rehabilitation of 24 existing structures, including structures on four existing storage reservoirs, five existing diversion weirs, construction of 2.75 km of reinforced concrete box culvert, construction of a new pumping station, to replace a temporary one, on Reservoir #1; (ii) downstream works: replacement of farmers' temporary weirs with three permanent un-gated weir structures; and (iii) road upgrading together with bridge/culvert crossings.

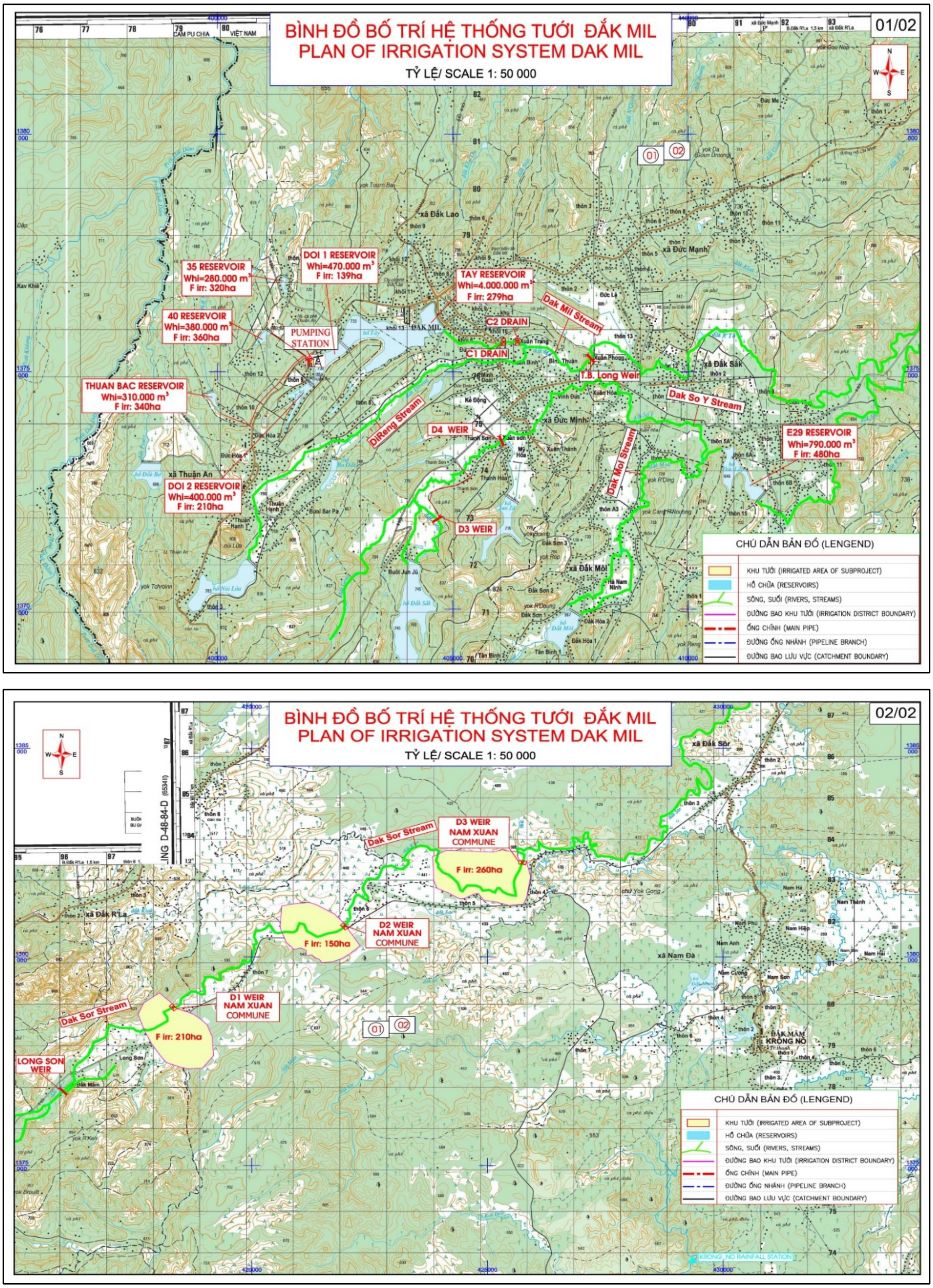


Figure 31: Layout of Dak Mil subproject, Dak Nong

4.6.2 The key gap and proposed last-mile connection to WEIDAP

The water used for agricultural production for the area is mainly taken from the main stream of Ea Diêr (confluence of two streams of Dak Đ'rông and Dak Diêr streams), regulating and regression of 02 reservoirs: Dak Dir reservoir Area of 36 km², total capacity of 6.34x106 m^3; The Dakrong reservoir covers an area of 15.4 km² with a total capacity of 2.47x10^6 m^3. The state of the stream bed is filled up, landslide.

In order to regulate water for production, villagers use paddy soils and timber for temporary dams to pump irrigation water. Temporary dams exist only for a short time in the dry season, when the rainy season lasts, and does not retain water. This leads to the amount of water being regulated from the upper lakes flowing downstream causing losses, lack of irrigation water.

Agricultural production areas of Cu K'nia, Nam Dong and Tam Thang communes: With low mountainous terrain, fertile soil (rich red soil); In Dak Đrong, Cu K'nia, Nam Dong and Tam Thang communes, Cu Jut district has the largest area of coffee and pepper production with an area of 36,100ha, accounting for 52% of the total area of agricultural land.

Figure 32: Temporal dams in Dak Drong stream, Cu Jut district

4.6.3 Recommended interventions

The main recommended intervention for this province is the provision of support to groups or single poor and near poor households to establish the shared/private pump and pipeline systems to connect to closest manifold or weirs - canal system for crop irrigation.

For the planted area benefiting from improved weirs - canal system: support for irrigation system connection to the canal:

1) Support for estimation of shared pump and shared pipeline network for a group of beneficiary HHs in appropriate locations,
2) Support for estimation of private pump and pipeline for single beneficiary HHs

The maximum connection distance to canal is around 1000m with average of 700m.

For the planted area benefiting from the pipeline system: support for irrigation system connection to the designed hydrants; the water supply in ring main pipeline system is designed with high water pressure that does not require further level of pumping for HEI application:

1) Support for estimation of water meters, shared pipeline network for a group of beneficiary HHs in appropriate locations
2) Support for estimation of water meters and pipeline for single beneficiary HH

The maximum connection distance to hydrants are around 1000m but mainly within 700m.

4.6.4 Beneficiary site selection

The selection of target areas is based on the 13 communes in 3 districts included in the WEIDAP area in Dak Nong as follows:

Cư Jut district: Ea T'Ling; Nam Dong; Đăk DRông; Tâm Thắng; Cư Knia; Trúc Sơn

Đăk Mil district: Đắk Lao; Đức Mạnh; Long Sơn; Đắk Sắk; Thuận An; Đức Minh

Krông Nô district: Nam Xuân

The selection of beneficiary households includes poor and near-poor HHs based on local classification in the districts. The total population in the related communes are 290,705 people (72,676 households).

The rate of poor and near-poor in each communes and shared area of each commune are listed in the table below. The average rate of poor and near-poor is 19% based on data on 2017 in which the poorest area is in Krong No district. The selected households exclude the 6% of people without land in Dak Nong province.

Table 15: Total number of households, rate of beneficiary households in Dak Nong

No	Commune	Total household (2017)	Rate of benificaries HH	Shared area in Weidap (%)	Shared area in rainfed (%)	Number of benificeries HH
V	**Dak Nong province**	**34,198**	**18%**	**28%**	**72%**	**1,047**
	Cư Jut district	**16,715**	**17%**	**27%**	**73%**	**704**
1	Ea T'Ling	3,858	20%	20%	80%	145
2	Nam Dong	4,026	15%	20%	80%	114
3	Đăk DRông	3,316	15%	20%	80%	94
4	Tâm Thắng	2,928	18%	20%	80%	99
5	Cư Knia	1,835	20%	70%	30%	241
6	Trúc Sơn	752	16%	10%	90%	11
	Đăk Mil district	**15,925**	**9%**	**18%**	**82%**	**185**
7	Đắk Lao	1,981	5%	10%	90%	9
8	Đức Mạnh	3,653	4%	20%	80%	27
9	Long Sơn	373	26%	20%	80%	18
10	Đắk Sắk	3,559	10%	20%	80%	67
11	Thuận An	2,629	3%	20%	80%	15
12	Đức Minh	3,730	7%	20%	80%	49
	Krông Nô district	**1,558**	**27%**	**40%**	**60%**	**158**
13	Nam Xuân	1,558	27%	40%	60%	158

4.6.5 Operational and implementation modalities

To facilitate operations, informing release of water from the two upstream reservoirs, Ho Dak Dier and Ho Dal Drong, water levels shall be monitored in the reservoirs, as well as in the last weir (No. 10) along the Ea Dier River. During dry season, flow releases shall be managed to maintain a minimum water level in the pond for the last weir.

For the two small pumped pipe systems, devices would be installed so that pump operations are linked to pipeline pressures. Also, devices could be installed to ensure against pipe fracture during pump start-up or shut-down. This function may be performed by gradual opening/closure of values. Control valves would be installed at the pump stations, and possibly at a few key locations in the pipe systems to allow pipe branches to be isolated for maintenance, in case of pipe leak/ burst. Operations would also be monitored, and in the event of problems, including pipeline fracture or leaks, the pumps would automatically shut down. Pipe flows could be metered using clamp-on ultrasonic digital meters fixed around the pipes at the pump stations. Meters will also be installed at each hydrant.

For individual famers wishing to connect to manifolds, additional meters may be installed to the manifolds to monitor usage. These meters would be cheap, possibly simple mechanical meters read manually. Alternatively, pre-paid meters may be installed to the hydrants to facilitate cost recovery.

All data will be transmitted over the cellular (Global System for Mobile communication [GSM]) network, and stored on computer at a system control office.

It is envisaged that a private sector partnership arrangement may be made between the IMC and a private organization to manage the 10 weirs and the two pumped schemes, or possibly just the two pump-pipe schemes. Also, that the private sector could develop additional pumped-pipe systems taking water from the other weirs.

The last-mile connection from WEIDAP to beneficiary HH will be managed by themselves or by farmer group. The O&M code of system is supported by Technical group in each commune. O&M functions could include:

Register farmers using the two pumping systems;

Meter and charge farmers according to water use, at least to recover O&M costs;

Flush sediment during the wet season and during the dry season from the weirs; and

Manage water flow releases from the two reservoirs so as not to waste water.

In overall, there are 4,765 households will be supported to connect to WEIDAP systems in 05 provinces (45 communes).

4.7 Cost for last-mile connection in 05 provinces

4.7.1 Information for costing in Khanh Hoa

The average distances from beneficiary house hold to WEIDAP system is different from the canal and from the ring main pipelines, the average distance from canal to beneficiaries' HH is around 1000 m and from hydrants to beneficiaries' HH is around 500m.

According to the WEIDAP project document, the smallest pipeline size to the fire hydrant is 63mm diameter, which is also commonly used on a household scale, so in this calculation the pipe diameter is chosen in Determination of support costs. Unit cost for HDPE pipe with 63mm diameter is around 320 US $ per 100m.

In addition, since WEIDAP main water supply in the existing irrigation channels has been upgraded and partly from pipeline pumping systems with low pressure water columns, a system of water pumps is required. The project should support the pump that comes with the pipe. Giống đơn tự động cho hp 02 HP (horsepower power) is around 100 US $ per pump

Pumps and pipelines are the main equipment in connection with the WEIDAP project, but auxiliary equipment such as water meters, control valves as well as transit tanks are also essential to complete the system. the system. Other related devices and storage for the estimation of the pump - the pipe system is around 60US $ per system

Beneficiary HHs are required to make in-kind contributions (labour, materials) to co-design, build and maintain the system.

4.7.2 Information for costing in Ninh Thuan

The average distances from beneficiary house hold to WEIDAP system is around 350m.

According to the WEIDAP project document, the smallest pipeline size to the fire hydrant is 63mm diameter, which is also commonly used on a household scale, so in this calculation the pipe diameter is chosen in Determination of support costs. Unit cost for HDPE pipe with 63mm diameter is around 320 US $ per 100m.

WEIDAP irrigation systems in Ninh Thuan are designed for water supply with high pressure water column of more than 10m, so there is no need to support irrigation pumps in this area.

But auxiliary equipment such as water meters, control valves as well as transit tanks are also essential to complete the system. The other cost is around 60US $ per system.

Beneficiary HHs are required to make in-kind contributions (labour, materials) to co-design, build and maintain the system.

4.7.3 Information for costing in Binh Thuan, Dak Nong

The average distances from beneficiary house hold to WEIDAP system is different from the canal and from the ring main pipelines, the average distance from canal to beneficiaries' HH is around 500 m and from hydrants to beneficiaries' HH is around 350m.

According to the WEIDAP project document, the smallest pipeline size to the fire hydrant is 63mm diameter, which is also commonly used on a household scale, so in this calculation the pipe diameter is chosen in Determination of support costs. Unit cost for HDPE pipe with 63mm diameter is around 320 US $ per 100m.

In addition, since WEIDAP main water supply in the existing irrigation channels has been upgraded and partly from pipeline pumping systems with low pressure water columns, a system of water pumps is required. The project should support the pump that comes with the pipe. Price unit for a pump 02 HP (horsepower power) is around 100 US $ per pump.

Pumps and pipelines are the main equipment in connection with the WEIDAP project, but auxiliary equipment such as water meters, control valves as well as transit tanks are also essential to complete the system. the system. Other related devices and storage for the estimation of the pump - the pipe system is around 60US $ per system.

Beneficiary HHs are required to make in-kind contributions (labour, materials) to co-design, build and maintain the system.

4.7.4 Information for costing in Dak Lak

The average distances from beneficiary households to the WEIDAP system is around 350 - 500m depending on the commune and where people have access to a hydrant or an open canal.

According to the WEIDAP project document, the smallest pipeline size for the hydrant is 63mm diameter, which is also the size commonly used on a household scale, so in this calculation the pipe diameter is chosen in Determination of support costs. Unit cost for HDPE pipe with 63mm diameter is around 320 US $ per 100m.

WEIDAP irrigation systems in Dak Lak are mostly designed for water supply with high pressure water columns of more than 10m, so there is no need to support irrigation pumps in this area, except in in Ea Yong commune, where an open canal is upgraded and people are pumping water from the canal for irrigation. The unit cost for an electrical pump 02 HP (horse power) is around 100 US$ per pump.

Auxiliary equipment such as water meters, control valves as well as transit tanks are also essential to complete the system. These costs are around 60US $ per system.

Beneficiary HHs are required to make in-kind contributions (labour, materials) to co-design, build and maintain the system.

Estimated cost for the last mile connectivity support is *5,997* mil USD, including:

Design for last-mile connection

Last-mile connection construction

Training for O&M of last-mile connection

Table 16: Summary of estimated cost for last-mile connection to WEIDAP system

Item	Unit	Amount	Price (USD)	Cost (USD)
Activity 1.2. *Establish last-mile connections to current and planned government irrigation schemes to support smallholders to cope with increasing rainfall variability and droughts*				***5.997.200***
1.2.1 Design for last-mile connection: 08 subprojects in five provinces, 5499 connections, 05 consultation teams,		**4.765**		***104.830***
Khánh Hòa province	*systems*	*1.032*	*20*	*20.640*
Ninh Thuận province	*systems*	*1.557*	*20*	*31.140*
Bình Thuận province	*systems*	*216*	*20*	*4.320*
Đăk Lăk province	*systems*	*917*	*20*	*18.340*
Dak Nong province	*systems*	*1.043*	*20*	*20.860*
Consultantcy cost (05 consultation teams)				*9.530*
1.2.2 Last-mile connection construction: pipes and other related devices: valve, pump		***4.765***		***5.838.320***
Khánh Hòa province: 1032 households	*households*	*1.032*	*1.100*	*1.135.200*
Ninh Thuận province: 1557 household	*households*	*1.557*	*1.000*	*1.557.000*
Bình Thuận province: 216 households	*households*	*216*	*1.000*	*216.000*
Đăk Lăk province: 917 households	*households*	*917*	*1.000*	*917.000*
Dak Nong province: 1043 households	*households*	*1.043*	*1.200*	*1.251.600*
Consultancy 10% and contingency cost 5%				*761.520*
1.2.3 Training for O&M of last-mile connection: 02 days course for each commune		***47***		***54.050***
Khánh Hòa province: 10 workshops in 9 communes, 100 farmers in each workshops	*workshops*	*10*	*150*	*1.500*
Ninh Thuận province: 16 workshops in 9 communes, 100 farmers in each workshops	*workshops*	*16*	*150*	*2.400*
Bình Thuận province: 2 workshops in 6 communes, 100 farmers in each workshops	*workshops*	*2*	*150*	*300*
Đak Lak province: 9 workshops in 8 communes, 100 farmers in each workshops	*workshops*	*9*	*150*	*1.350*
Đak Nông province: 10 workshops in 13 communes, 100 farmers in each workshops	*workshops*	*10*	*150*	*1.500*
Consultantcy cost (material preparation for workshop, refreshements….)	*workshops*	*47*	*1.000*	*47.000*

5 DESIGN THE WATER HARVESTING SYSTEM IN RAINFED REGIONS

5.1 Existing water harvesting systems

There are many type of water harvesting and water storage structures in the five target provinces, and these can be classified into three main types of water harvesting and storage facilities:

1. Harvesting rain water – surface water: ponds
2. Harvesting shallow ground water
3. Harvesting shallow ground water and surface water

Existing bio-engineering solution: At present, bio-engineering solutions for erosion control, bank erosion and protection of highway slopes and irrigation works have been applied widely in the Northern mountainous provinces of Vietnam.

Details of existing rain harvesting systems are in Appendix 1.

5.2 Key gaps

In the South Coastal Region

There are several different type of water harvesting and water storage facitlities existing in the region. Big open wells are very common in sandy areas in Ninh Thuan and the Binh Thuan coastal area, and some seasonal ponds also exist in sandy soil beside rivers and streams during the dry season.

In the upper parts of provinces like Bac Ai and Ninh Son in Ninh THuan, Duc Linh in Binh Thuan or Cam Lam and Cam Ranh, pumping wells or ponds near by water sources like rivers, reservoirs are more common than open big wells.

The opened or pumping wells for exploiting ground water are popular in the region cause of:

Difficulty in surface water (lowest rain area in Vietnam)

Less land occupation than ponds

Cheaper than pond and can be use privately in each house hold

During critical dry time, water in pond ran out earlier than in wells

However, groundwater is unsustainably exploited in the region, given saline intrusion is several areas in Ninh Thuan an Binh Thuan, as reported by DARD in Ninh Thuan and Binh Thuan.

In Highlands

Pumping wells and small ponds are very common in coffee and pepper farming area in Dak Lak and Dak Nong, most of them are privately owned, i.e. for single farms. The wells mainly exploit shallow ground water, though some wells may exploit deep ground water (greater 50m depth of well).

Figure 33: Huge number of pond in coffee and pepper area is constructed in Ea Kar district, Dak Lak

Most poor and near poor households in the area are still too poor to invest in digging ponds:

(1) no money digging pond,

(2) no land for digging ponds,

(3) perception of ineffective digging of ponds by wells and pumping.

Currently, wells are still a convenient and inexpensive system for most households in the region, especially for poor and near poor households with small scale production. However, groundwater extraction, especially deep-water groundwater, is not encouraged due to the depletion of water resources and the fact that there is a shortage of water in the drought period. Therefore, supporting the development of ponds in appropriate locations is a sustainable approach to protecting water resources, stabilizing production and responding to climate change.

At present, most of the ponds and lakes are managed very well by individual households who are the owners of the works. However, public pond, natural or man-made ponds, most are located on public land that is managed by the local government at the commune or village level.

Under normal conditions, almost all people can get water from public ponds for use, however, under drought conditions, the village or commune authorities will stand up for water management.

Dredging of ponds is mainly supported with commune funds or under provincial anti-drought support programs.

5.3 Preliminary water balance for ponds

To determine the extent to which water resources can be extracted and utilized sustainably in each region, as well as the impacts of climate change on water sources and water use in rain-fed production areas, there is a need to assess the availability of water resources for pond solutions and the adaptive capacity of people in daily life and their production. By using appropriate mathematical tools and models, the water balance assessment exercise will include the following:

Water source assessment under climate changes 2050:

Calculate the current and past water evolution in order to evaluate the water source trends over time.

Calculate the potential of water resources under climate change conditions according to the recommended scenarios for the study area.

Water demand assessment under climate changes 2050:

Calculate the current and past water evolution to evaluate water source trends over time.

Calculate the potential of water resources under climate change conditions according to the recommended scenarios for the study area.

Water balance assessment:

Calculate the water balance in terms of space (commune, district) and water balance over time (crop production in the year, fluctuations of production according to market movements).

Assessment of the availability of water resources in the context of climate change in the future

Proposed appropriate response measures in pond design, water use and water use structures in the area.

Capacity requirements for implementation:

This activity requires modeling on a long time series and complete set of data on water resources, production and drought in the project area, the content of which falls outside the capacity of local officials. A consultant with in- deep knowledge and experience of water balance modeling in the project area, which has been carrying out similar works in the area, is a priority.

5.3.1 Pond classification

Classification of ponds based on terrain conditions

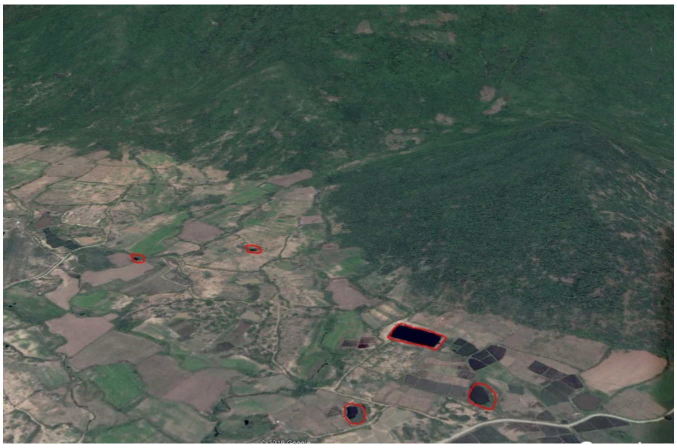
Each region has different terrain conditions resulting in the different capacity of ponds for water collection. In this study, the ponds are classified into three regions based on terrain conditions, including:

i. Ponds on lowland
ii. Ponds on midland areas
iii. Ponds in upland areas

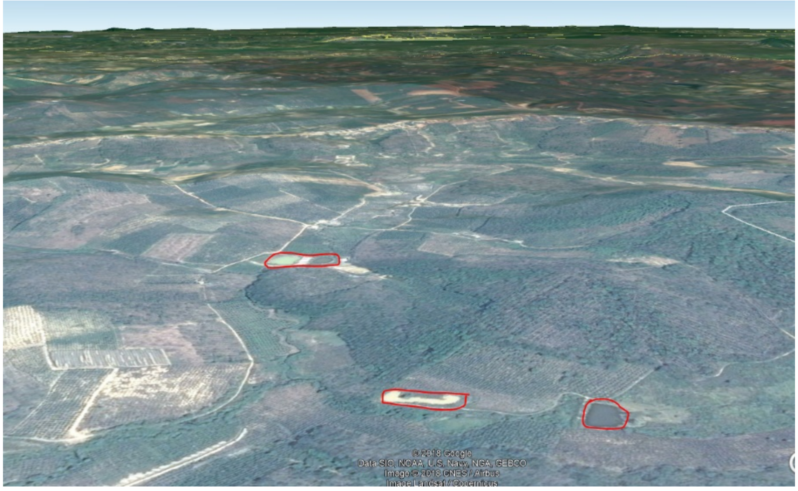
Normally, ponds in the delta area are the smallest and largest in mountainous areas, as follows:

- Ponds in flatland, rainfall collected area: 0.5 -2 ha
- Ponds in the midland, rainfall collected area: 2-10 ha
- Ponds in the upland, rainfall collected area: 5-10 ha

An example of exist pond in lowland area in Cam Lam, Khanh Hoa



An example of exist pond in upland area in Bac Ai, Ninh THuan



An example of exist pond in midland area in Ea Kar, Dak Lak

Ponds classification is base on the area for irrigation. There are two main types of ponds that are classified according to the size of ponds and number of users as follows:

- Households ponds: irrigation for about 0.2-0.3 hectares of non-rice crops (no irrigation for rice)
- Shared ponds: irrigated for about 1-3 ha of non-rice crops.

5.3.2 Rainfall and climate change scenario

Hydrometeorological data and climate change data

Currently, there is a network of meteorological and rainfall gauging stations with relatively complete data in the study areas of the subprojects. The majority of the stations have measurements since 1976 -1980 to date; the data are satisfactory in terms of quality and continuity. The stations are usually located in the downstream of the rivers; the station density in the upstream part is low.

Using effective rainfall with reliability of 85%, based on the time series data of rainfall in stations in the regions (see the listed stations and the location map of stations).

Climate change data: Climate change data is determined according to the "climate change scenario" of the Ministry of Natural Resources and Environment in 2016. The selected scenarios for calculation is scenarios RCP4.5 for 2050 based on recommendation from MONRE that “The RCP4.5 scenarios can be applied to design standards for non-long-term projects and short-term plans.”

Table 17: List of meteorology stations applied in water balance modeling in WEIDAP

No	Location	Station	Measurement period	Element measurement
I	***Khanh Hoa province***			
	Cam Lam district	Cam Ranh	1977-2017	Meteorology, Rainfall
II	***Ninh Thuan province***			
	Ninh Hai district	Phan Rang	1979-2017	Meteorology, Rainfall
	Ninh Son district	Phan Rang	1979-2017	Meteorology, Rainfall
	Thuan Bac district	Nha Ho	1978-2017	Rainfall
	Bac Ai district	Nha Ho	1978-2017	Rainfall
III	***Binh Thuan province***			
	Ham Thuan Nam district	Phan Thiet	1976-2017	Meteorology, Rainfall
	Duc Linh district	Vo Xu	1977-2017	Rainfall
IV	***Đak Lak province***			
	Ea Hleo district	Buon Ho	1977-2017	Meteorology, Rainfall
	Cư M'Gar district	Buon Ho	1977-2017	Meteorology, Rainfall
	Ea Kar district	Krong Buk	1976-2017	Rainfall
	Krong Pac district	Krong Buk	1976-2017	Rainfall

No	Location	Station	Measurement period	Element measurement
V	***Dak Nong province***			
	Cu Jut district	Buon Me Thuot	1977-2017	Meteorology, Rainfall
	Dak Mil district	Dak Mil	1977-2017	Meteorology, Rainfall
	Krong No district	Dak Mil	1977-2017	Meteorology, Rainfall

Figure 34: Location of the eight subproject areas (red rectangulars) and hydrometeorological monitoring network in the 5 provinces in the South Central and Central Highlands.

Table 18: Climate change factors in the South Central region

2050s Rainfall Factors %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
RCP4.5	63,9	64,8	45,8	47,0	11,7	20,4	-3,6	7,9	0,1	40,7	23,3	12,1	
Baseline (regional averages) mm	21	18	17	73	203	194	229	225	298	264	148	75	1763
RCP4.5	34	30	24	107	226	233	220	243	298	371	182	84	2054
2050s T Factors degC increases	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
RCP4.5	1,2	1,1	1,0	1,1	1,2	1,1	1,0	1,0	1,1	1,0	0,9	1,2	
2050s PET Factors %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
RCP4.5	4,1	3,6	3,1	3,3	3,5	3,3	3,2	3,1	3,5	3,3	2,9	3,9	
Baseline (regional averages) mm	113	116	141	146	150	141	144	145	137	132	116	110	1592
RCP4.5	117	120	145	151	156	146	149	150	142	136	119	115	1645

Table 19: Climate change factors in the Central Highlands region

2050s Rainfall Factors %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
RCP4.5	-13,5	-20,9	-25,6	1,2	3,9	8,7	28,5	21,9	8,4	15,1	4,6	59,5	
Baseline (regional averages) mm	21	14	56	121	263	209	227	273	324	332	184	53	2075
RCP4.5	18	11	42	122	273	227	291	333	351	383	192	84	2327
2050s T Factors degC increases	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
RCP4.5	1,5	1,0	0,7	1,1	1,3	1,3	1,1	1,1	1,2	0,9	1,0	1,4	
2050s PET Factors %	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
RCP4.5	5,4	3,5	2,6	3,5	4,0	4,1	3,4	3,5	3,8	2,8	3,6	4,9	
Baseline (regional averages) mm	103	109	137	146	150	142	144	143	134	127	109	101	1544
RCP4.5	109	113	141	151	156	147	149	148	139	131	113	106	1602

5.3.3 Crop water requirement and climate change

There are many types of crops in the project area, of which crops below representing each area to calculate water use requirements.

Table 20: List of crops in the districts of the project area

No	Location	Crop types	Cropping Calendar
I	***Khanh Hoa province***		
	Cam Lam district	Mango	Whole year
II	***Ninh Thuan province***		
	Ninh Hai district	grape	Whole year
	Ninh Son district	grape	Whole year
	Thuan Bac district	grape	Whole year
	Bac Ai district	grape	Whole year
III	***Binh Thuan province***		
	Ham Thuan Nam district	Dragon fruit	Whole year
	Duc Linh district	Pepper	Whole year
IV	***Dak Lak province***		
	Ea Hleo district	Coffee	Whole year
	Cư M'Gar district	Coffee	Whole year
	Ea Kar district	Coffee	Whole year

No	Location	Crop types	Cropping Calendar
	Krong Pac district	Coffee	Whole year
V	***Dak Nong province***		
	Cu Jut district	Coffee	Whole year
	Dak Mil district	Coffee	Whole year
	Krong No district	Coffee	Whole year

For the current situation, crop water requirements are estimated in accordance with the national standards TCXDVN 285-2002 for hydraulic works – Main regulations on design; irrigation calculations are made at probability of 75%.

For the future and climate change conditions, the climate change and sea level rise scenario for Vietnam announced in 2016, so called RCP4.5 scenario serves as basis and water requirements in accordance with the QCVN 04-05:2012/BNNPTNT, Hydraulic works - Main regulations on design; irrigation calculations are made at probability of 85%.

The tool to calculate crop water requirements is CROPWAT developed by the World Food and Agriculture Organization (FAO). To calculate the crop water requirements (CWR), CROPWAT requires data on evapotranspiration (Eto). CROPWAT accepts the manual entry of measured ETo data or values of temperature, humidity, wind speed and hours of sunshine, after which the software will compute ETo using Penman-Monteith formular.

Climatic effects cause different precipitation in each period, and the large variability of topographical conditions results in a wide range of changes to climate factors, especially visible in the yearly rainfall in each region. In addition to the dependence on climatic factors caused by large air masses, rainfall also depends on sub-climate factors caused by localized topographical disturbances, therefore rainfall changes are rather complex spatially. The correlation coefficient is obviousy reduced respective to the distance between the gauging stations, but yearly rainfall is also very different in space and time even between the stations, which are rather close to each other due to topographical effects. The selected stations are summarized in the table below.

Based on the location of the subprojects and estimated effects of the gauging stations on the irrigation command areas of the subprojects, the meteo and rainfall gauging stations are selected to calculate the effective rainfall in the subproject areas. Input data to calculate the rainfall include the followings: (1) measured rainfall data of the rainfall gauging stations in the region, these data have been listed in Section 2.1, and (2) cropping calendars of crops and water supply probability for crops (75% or 85%).

The meteo stations compute evapotranspiration (ETo) in order to calculate irrigation requirements using CROPWAT for each irrigation district; the selected stations are summarized in previous section.

Table 21: Summary of the meteo and rainfall gauging stations referred for calculations of designed rainfall, and the resulted annual average rainfall and rainfall at probabilities of 75% and 85%

No.	Meteo	Rainfall	Xonn	X75%	X85
1	Nha Trang	Dong Trang	1.552	1.225	1.093
2	Cam Ranh	Cam Ranh	1.262	958	865
3	Phan Rang	Tan My	1.165	920	849
4	Phan Rang	Nha Ho	851	653	585
5	Phan Rang	Phan Rang	804	585	534
6	Ham Tan	Vo Xu	2.454	2.182	2.027
7	Ham Tan	Ham Tan	1.617	1.444	1.355
8	Phan Thiet	Phan Thiet	1.149	998	940
9	Buon Ho	Krong Buk	1.430	1.236	1.145
10	Buon Ho	Buon Ho	1.549	1.422	1.328
11	Buon Me Thuot	Buon Me Thuot	1,860	1,647	1.549
12	Dak Mil	Dak Mil	1.798	1.559	1.463

5.3.4 Water balance

Calculation of the amount of water loss in the pond

- Evaporation of free surface: The amount of water evaporated at the pond surface, taken according to measurement data at the meteorological stations in the area.
- Water loss due to infiltration

Calculate water balance to determine pond size

- Principle of calculation: The water volume in the ponds is enough for the area planted in the period of irrigation, balancing to ensure shallow water at the end of the dry season.

Determine the maximum amount of water stored in the pond, as the ponds continuously store water and supply water during the irrigation period; the maximum storage capacity in the calculation period is the design capacity of the pond

Verification of the design under climate change

- Change in monthly rainfall and PET under scenario 4.5 RCP, 2050

5.3.5 Basic pond design under climate changes

Results of pond design in each area by each type of pond are shown as follows:

Table 22: Pond design in Khanh Hoa Province

No	Pond classification	Watershed (ha)	Mango (ha)	Pond storage (m3)	Width (m)	Length (m)	Depth (m)
1	HH pond in flatland	2	0.5	1125	15.0	15.0	5.0
2	Shared pond in flatland	5	2	5400	30.0	30.0	6.0
3	HH pond in midland	2	0.5	1125	15.0	15.0	5.0
4	Shared pond in midland	6	2	4704	28.0	28.0	6.0
5	HH pond in upland area	2	0.5	1125	15.0	15.0	5.0
6	Shared pond in upland area	7	2	3750	25.0	25.0	6.0

Table 23: Pond design in Ninh Thuan province

No	Pond classification	Watershed (ha)	Grape, apple (ha)	Pond storage (m3)	Width (m)	Length (m)	Depth (m)
1	HH pond in flatland	2	0.15	1125	15	15	5
2	Shared pond in flatland	6	0.4	2400	20	20	6
3	HH pond in midland	2	0.2	845	13	13	5
4	Shared pond in midland	8	1	4374	27	27	6
5	HH pond in upland area	2	0.2	845	13	13	5
6	Shared pond in upland area	10	1	3456	24	24	6

Table 24: Pond design in Binh Thuan province

No	Pond classification	Watershed (ha)	Dragon fruit, pepper (ha)	Pond storage (m3)	Width (m)	Length (m)	Depth (m)
1	HH pond in flatland	2	0.4	980	14.0	14.0	5.0
2	Shared pond in flatland	5	1.8	4374	27.0	27.0	6.0
3	HH pond in midland	2	0.7	845	13.0	13.0	5.0
4	Shared pond in midland	6	3	3750	25.0	25.0	6.0
5	HH pond in upland area	2	0.7	845	13.0	13.0	5.0
6	Shared pond in upland area	8	3	3456	24.0	24.0	6.0

Table 25: Pond design in Dak Lak province

No	Pond classification	Watershed (ha)	Coffee (ha)	Pond storage (m3)	Width (m)	Length (m)	Depth (m)
1	HH pond in flatland	2	0.3	1125	15	15	5
2	Shared pond in flatland	6	1	4704	28	28	6
3	HH pond in midland	2	0.4	980	14	14	5
4	Shared pond in midland	6	1.5	3456	24	24	6
5	HH pond in upland area	2	0.38	1125	15	15	5
6	Shared pond in upland area	6	2	4704	28	28	6

Table 26: Pond design in Dak Nong province

No	Pond classification	Watershed (ha)	Coffee (ha)	Pond storage (m3)	Width (m)	Length (m)	Depth (m)
1	HH pond in flatland	2	0.3	676	13	13	4
2	Shared pond in flatland	6	1.5	4056	26	26	6
3	HH pond in midland	2	0.3	845	13	13	5
4	Shared pond in midland	6	1.8	5400	30	30	6
5	HH pond in upland area	2	0.35	676	13	13	4
6	Shared pond in upland area	6	2	2904	22	22	6

The detail water balance modeling will be done during design in the next phase.

5.4 Recommended interventions

There are several ways to collect and storage rainwater, for which digging ponds is the most common solution that is suitable for the people of Vietnam and which helps to increase income for people by combining aquaculture in the pond.

To store water effectively and use water efficiently in the proposed ponds in the projected area, the basic intervention for the activity would include:

Assessment of water balance in the context of climate change

Design and construction of ponds using bio-engineering solutions

High efficiency use of water (described in section 6)

Establishment of sustainable operation and maintenance of ponds

5.4.1 Development of new rain harvesting system

a. Pond site assessment

In this activity, the program will assist villages and communes in detailing the status and potential of water resources development on the basis of exploitation of surface and rainwater sources in the area.

Implementing this task requires a combination of specialist and water resource development and local officials with experience and knowledge of the site.

The results of this activity will provide information for subsequent activities of this subcomponent:

(i) Assessment of current status of existing ponds in terms of capacity and water supply;

(ii) Identification of upgraded ponds to increase irrigation capacity;

(iii) Identification of potential sites where new ponds may be dug, including common ponds for a group of households and ponds for individual households;

(iv) Identification of suitable green solution groups for each region

Process of identifying potential sites for pond construction or upgrading:

The work must be carried out in a specific order from the bottom up, stemming from the needs of the beneficiaries;

The potential sites should be existing ponds for upgrading or areas for new pond construction to save investment costs and contribution to irrigation development in each locality.

The selected sites of upgrading and construction must be in line with the orientation of crop structure in each locality.

A system of rain harvesting pond requires performing some basic and necessary work as shown in the figure below:

Figure 35: Component for rain harvesting pond design and construction

Application condition:

In target area - rainfed irrigation,

Have potential water resource for harvesting

Stable geological condition for construction

Having an area to deposit excavated soil

Selection of pond location:

The location of the pond is arranged in accordance with the overall layout of the water collection system, increasing the ability of gravity irrigation and does not interfere with farming activities.

Selection of pond location is crucial for collecting rain water, spillage water or groundwater to conduct water storage, it can be on a hill slope or lowland location.

The selection is to ensure the ability to recover the largest amount of rain water on farm and adjacent areas. Decisions and factors include: availability of groundwater, the channel, where the water is located, selection of the low-lying position to reduce the volume of digging ponds and reduce losses due to permeability.

The position of the pond should be adjusted to meet the conditions in the low lying area of the farm and facilitate the layout of the water supply system.

b. Design of rain harvesting system

Design of storage pond:

The storage capacity is designed to ensure sufficient supply of water for crops in the dry season. The volume of water supply is dependent on water demand and loss due to storage and distribution of water. The crop water demand is a function of crop types, cultivated area and irrigation method.

Dimension of pond: the size of the pond should be large enough to cover the area based on crop water demand.

Ponds can be any shape but rectangular ponds are simpler to construct and adapt to water supply conditions.

Pond bank slope: m = 0-1. For clay land the minimum coefficient can be m = 0.5; In sandy soil this needs to increase up to 1 – 1.5.

Depth of the pond H = 2-5 m, for ponds with a depth > 3m, it needs to be designed to ensure safety for people and avoid slippage.

Width of the pond B > 10 m and length of the pond L > 10 m

Pond storage: W = f(depth H, width B, length L, slope m) = f(water demand, rain, soil, terrain…)

Estimation of water demand:

The volume of water storage depends on the need for crop irrigation demands. Calculation of water storage capacity is important as it will determine all remaining parameters of the storage system. Inaccurate calculation of volume will lead to waste or insufficient water for irrigation of crops. To calculate storage capacity, it is necessary to consider a number of factors such as the irrigation demand for a unit of planted area, additional water sources, crop seasons and growth stages. The capacity of each ponds will be designed in detail at project initiation. On average, for cultivated crops, the demand for water per year is about 3,000-5,000 m^3 / ha.

Water collection system:

Due to the characteristics of the land and topography, the design will need specific measures for water collection.

- Collect rain falling on waterproof materials like clay soil, HDPE cover or cement yard. This measure is strictly required in the South Central Coast region where sandy soils are strongly permeable, the annual rainfall is lighter so surface flow is very small. There is a need to take measures to strengthen the water collection surface to increase water concentration into storage pond.

- Collect surface flow: small canal following the topo contour; pipeline to collect water from roofs if it's applicable

- Sediment filters: prevent sedimentation and keep waste from running to pond or tank

Dealing with water loss:

Prevention of water loss from pond bottom: priority green solutions can use clay or clay soil to treat the pond bottom to prevent water loss

For ponds in low places with additional groundwater, there is no need to treat the pond bottom

Prevention of landsliding into the green ponds: growing elephant grass or shrubs with extensive root systems to protect the shore.

Prevention of surface water loss of ponds: anti-evaporation of the surface with green solutions such as water-proof anti-evaporation surfaces. Planting trees around the pond to reduce wind and create shade for open air.

Calculation of water distribution system:

If using PVC pipes, they should be buried to the ground to avoid aging. Water distribution occurs through gravity or by using small pumping units in locations where water cannot flow freely.

This network will connect to high efficiency irrigation system in farms.

The sketch of ponds are as pictured below:

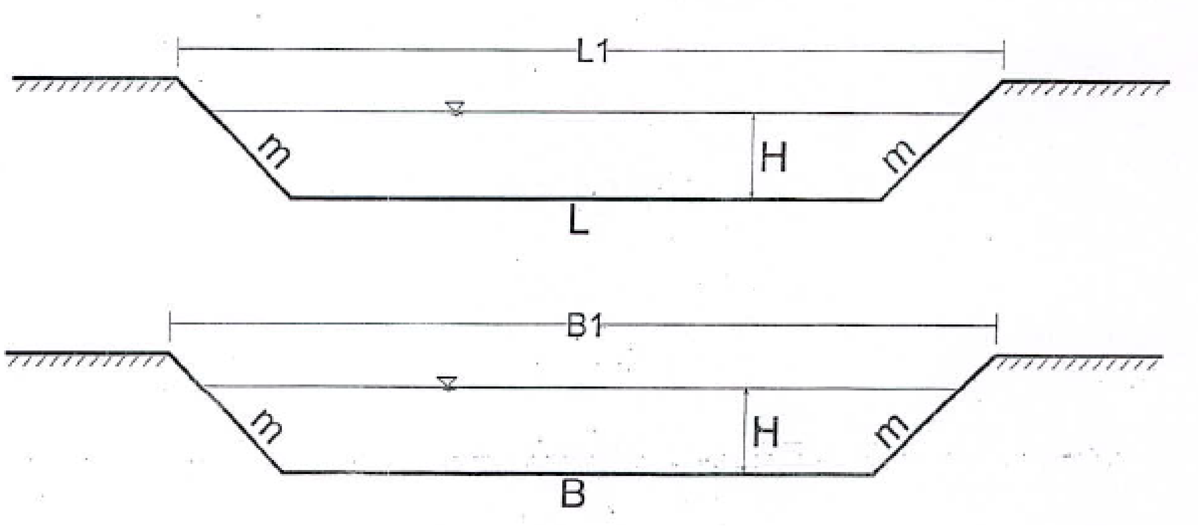


Figure 36: sketch of pond cross sections

Figure 37: A sample of a pond construction and water supply pipeline

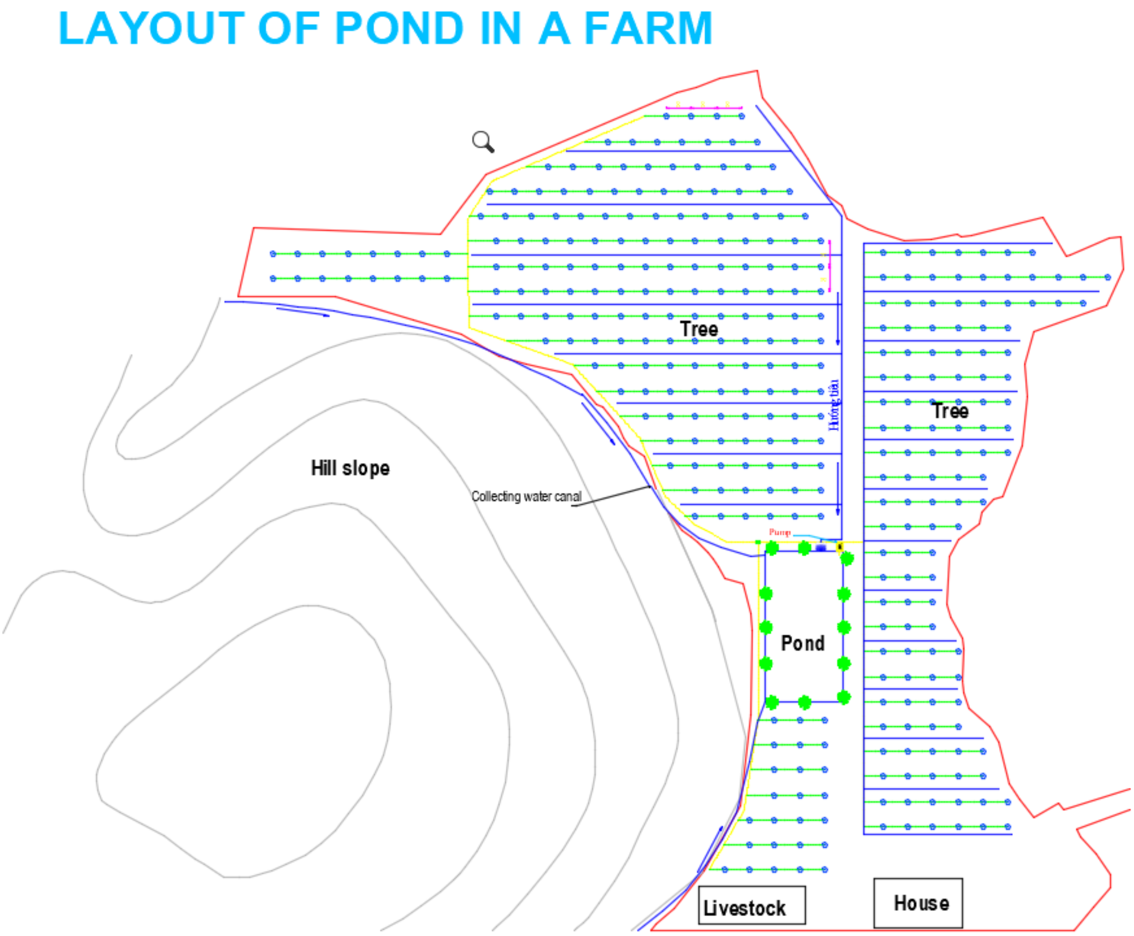


Figure 38: Sample of pond layout in typical non-rice farm

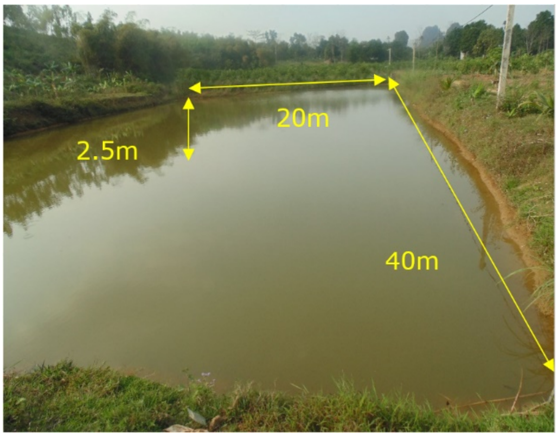


Figure 39: Simple design of a pond for 0.66 ha irrigation of non-rice crop

Figure 40: Simple design of a pond for 0.13 ha irrigation of non-rice crop

5.4.2 Upgrading of existing rain harvesting systems

The upgrading of ponds depends on the current status of the ponds, with the following including but not limited to:

Expansion of pond size to meet irrigation area based on water demand calculations and pond size expansion (depending on available area of each household).

Addition of solutions to water loss due to infiltration and evaporation in ponds.

Upgrading efficient water-gathering systems: making canals, trash collection systems.

Improved water distribution system: replacing irrigation canals with piping systems.

Detailed design and construction steps are provided in section 5.3.2.

5.4.3 Bio-Engineering solutions

In terms of water protection measures, shore bank protection and erosion reduction as well as sedimentation of ponds, green technology solutions are recommended for the items in section 5.3.2. as follows:

Planting grass to protect the pond bank against erosion.

Planting additional trees around the pond to prevent wind and reduce sunlight to reduce evaporation in the pond.

Pretreatment of infiltration in ponds with green solutions such as clay pellets about 10cm below the pond to reduce water loss in sandy areas with high permeability, and there may be additional solutions. like spreading HDPE to waterproof.

The detailed site-specific design for each type of solution, such as how to plant, how to maintain, what type of clay soil to use as waterproofing, as well as reinforcement of ponds, will be identified at project start-up.

5.4.4 Technical support for rain harvesting development

Technical groups will assist communes in establishing shared pond groups (Pond Management Groups). The aim of the group is to improve roles and responsibilities of pond users in the management, exploitation and protection of the pond system, including scheduling use of pond resources to avoid conflict and maximize efficiency of water extraction and use.

The technical group will develop a code to manage shared pond group with some key principles:

- Assignment of pond operations and maintenance to beneficiary households

- Assignment of monitoring of pond management to local authorities through agreement among beneficiaries

- Signature of general use commitments, certified by local authorities

- Written commitments must include the following:

Daily pond management

Guidelines for coordinated dredging ponds, funds for dredging ponds

Mechanism of water use in water scarcity

Dispute resolution mechanism

The technical groups are formed based on the following basic steps:

Step 1: Preparation

- Preliminary agreement: Agreeing the policy of building and developing a water users group with local authorities as well as relevant agencies and representatives of people in the area. Unity of action is expressed in a commitment that affirms the roles and responsibilities of the parties in the establishment and organization of a water users group in a long-term and sustainable manner.

- Consultation with related parties on the preliminary agreement: People's Committees, village heads, water users ... after full dissemination of requirements and purposes for the organization of the group.

Step 2: Field survey - registration - grouping

- Conducting consultations with potention users in the field and then combining with the survey of maps (if any).

- Make a list of users in the area based on pond location.

- Households register to participate in the groups (voluntary).

- Meet with the household to communicate necessary information related to the activities of the group, set up groups and vote for the team leader (possibly head of related village if necessary).

Step 3: Establish the operation rule of the group

The land owner will manage ponds and sell water to neighboring households based on the regulations on operation of ponds. These regulations are developed and confirmed by the People's Committee.

Pond use regulations address:

- Daily management rules and Management rules in water scarcity conditions
- Ownership of ponds, water ownership in ponds
- Pond management, pond protection and safety
- The right to use water
- Priority water use rights
- Obligation to contribute to dredging ponds
- The right to share income in the pond

The rule also establishes the rights of land donors and the form of land donations for ponds

- Estimate the annual benefit/cost for pond maintaince and annual fee for group members

- Maintaince schedule: annual schedule and urgent works, guidelines for coordinated dredging ponds, funds for dredging ponds

- Dispute resolution mechanism

- Finalization of agreement: Prepare documents, sign and submit them to commune People's Committees for certification of agreement.

Technical support for pond management team, 1st training should contain following content:

Technical training on water use planning, irrigation planning, production development plans

Training skills in pond maintenance and operation

Construction and supervision of construction during maintenance

Training on financial management, revenue collection, seeking opportunities to sell water and pond products such as fish, etc.

Evaluation after 1-2 years of operation: the technical team will conduct a second assessment and training for the pond management team on the same content as the first training

5.5 Beneficiary site selection

Beneficiary sites for rainfed interventions consist of 45 WEIDAP communes and expanded to 15 communes, both located in 14 districts of WEIDAP project. For 45 WEIDAP communes, vulnerable households who last-mile connectivity is not feasible (too far from WEIDAP system to be efficient for example) will be targeted. Additional 15 communes are selected given their location in highly climate risk areas (drought) and high presence of poor/ethnic groups. :

The selection of beneficiary households is based on the official list updated every year. It is estimated that 1,159 ponds upgraded/built will benefit a total of 16,463 households out of 139,416 households in the 60 communes. Following table details the number of ponds by communes:

Table 27: Pond number by commune

No	Commune	Total household (2017)	Rate of benificaries HH in all communes	Shared area in rainfed (%)	Number of ponds
	TOTAL	**139,416**			**1,159**
I	**Khánh Hòa province**	**22,153**	**6%**	**41%**	**82**
	Cam Lâm district	**22,153**	**6%**	**41%**	**82**
1	Cam Đức	4,195	6%	20%	5
2	Cam Tân	2,127	12%	30%	7
3	Cam Hoà	3,589	7%	40%	9
4	Cam Hải Tây	1,421	3%	50%	3
5	Cam Hiệp Bắc	800	7%	30%	3
6	Cam Hiệp Nam	1,375	6%	50%	5
7	Cam Thành Bắc	3,621	6%	50%	11
8	Suối Cát	2,489	21%	50%	24
9	Suối Tân	2,537	13%	50%	15
II	**Ninh Thuận province**	**30,980**		**69%**	**357**
	Ninh Hải district	**12,909**	**17%**	**68%**	**39**
1	Phương Hải	1,783	16%	90%	-
2	Xuân Hải	4,245	8%	50%	10
3	Tri Hải	3,130	12%	80%	17
4	Nhơn Hải	3,751	12%	50%	12
	Ninh Sơn district	**6,534**	**32%**	**50%**	**61**
5	Mỹ Sơn	2,815	50%	70%	53
6	Nhơn Sơn	3,719	14%	30%	8
	Thuận Bắc district	**8,427**	54%	**76%**	**159**
7	Phước Chiến	1,155	82%	100%	46
8	Phước Kháng	614	88%	100%	26
9	Lợi Hải	2,974	44%	80%	52
10	Bắc Sơn	1,983	59%	50%	29
11	Bắc Phong	1,701	15%	50%	6
	Bác Ái district	**3,110**	**66%**	**83%**	**98**
12	Phước Tân	743	73%	100%	26
13	Phước Thắng	944	64%	100%	30
14	Phước Thành	853	77%	100%	33
15	Phước Trung	570	49%	30%	9
III	**Bình Thuận province**	**17,125**			**192**
	Hàm Thuận Nam district	**11,627**	**11%**	**85%**	**131**
1	TT Thuận Nam	3,329	5%	80%	21
2	Mỹ Thạnh	227	69%	100%	24
3	Hàm Cần	891	32%	100%	44
4	Tân Lập	2,187	6%	100%	20
5	Tân Thuận	3,593	4%	50%	11
6	Tân Thành	1,400	6%	80%	11
	Đức Linh district	**5,498**	**11%**	**77%**	**61**
7	Tân Hà	1,402	12%	80%	20
8	Đông Hà	2,029	9%	90%	23
9	Trà Tân	2,067	10%	60%	18
IV	**Đăk Lăk province**	**29,980**			**260**
	Ea Hleo district	**9,405**	**27%**	**93%**	56

No	Commune	Total household (2017)	Rate of benificaries HH in all communes	Shared area in rainfed (%)	Number of ponds
1	TT. EaĐRăng	4,372	11%	90%	17
2	EaSol	2,838	19%	100%	26
3	Đliê Yang	2,195	14%	90%	13
	Cư M'Gar district	**1,601**	**16%**	**70%**	**7**
4	Quảng Tiến	1,601	12%	70%	7
	Ea Kar district	**4,280**	35%	93%	**80**
5	Ea Sô	889	61%	100%	26
6	Ea Sar	1,928	48%	100%	46
7	Xuân Phú	1,463	16%	80%	8
	Krông Păc district	**14,694**	**33%**	**75%**	**117**
8	Krông Buk	3,023	41%	70%	43
9	Ea Phê	5,152	14%	90%	32
10	Ea Yông	3,744	17%	50%	16
11	Ea Kênh	2,775	22%	90%	26
V	**Dak Nong province**	**39,177**		**81%**	**268**
	Cư Jut district	**16,715**	**18%**	**73%**	**122**
1	Ea T'Ling	3,858	20%	80%	36
2	Nam Dong	4,026	15%	80%	27
3	Đăk DRông	3,316	15%	80%	21
4	Tâm Thắng	2,928	18%	80%	24
5	Cư Knia	1,835	20%	30%	7
6	Trúc Sơn	752	16%	90%	7
	Đăk Mil district	**15,925**	**10%**	**82%**	**60**
7	Đắk Lao	1,981	5%	90%	6
8	Đức Mạnh	3,653	4%	80%	9
9	Long Sơn	373	26%	80%	6
10	Đắk Sắk	3,559	10%	80%	21
11	Thuận An	2,629	3%	80%	3
12	Đức Minh	3,730	7%	80%	15
	Krông Nô district	**6,537**	**29%**	**87%**	**86**
13	Đăk Sôr	1,124	29%	100%	19
14	Nam Xuân	1,558	27%	60%	15
15	Đăk Drô	2,186	20%	100%	24
16	Nam Nung	1,669	30%	100%	28

5.6 Cost and budget estimates

The unit price for pond digging is calculated based on actual experience in localities where ponds are being developed. In the drought management program in Binh Thuan and Dak Nong, the unit cost is VND 30 - 100 million per pond depending on the size of the pond and the service area (0.5 ha to 05 ha non-rice plant).

The price for upgrading existing ponds does not ensure water supply and replenishment solutions for dehydration, nor evaporation by green methods, the average cost per pond is about 25 million VND.

The cost for the support group to assess the current situation, identify the ponds to be upgraded, build and design ponds in each locality is on average about 75 million (3 months specialist work).

Similarly, the support group for establishing water user groups in shared ponds is also estimated to cost about 3 months of specialist work per commune unit.

Estimated cost requirement for enhancing supplementary irrigation in rainfed areas is approximately US $ 5.964 million. Details are as follows:

Table 28: Cost estimation for development of rain harvesting systems

Item	Unit	Amount	Price (USD)	Cost (USD)
Activity 1.3 Enhance supplementary irrigation of rain fed smallholders to cope with rainfall variability and drought				***5.694.375***
1.3.1 Siting and climate resilient design of ponds and landscaping elements [#s of ponds, types, sizes, locations, prototypes]		**60**		**630.000**
Khánh Hòa province: data collection, survey and design ponds including bio-engineering solutions in 9selected communes	communes	9	10.000	*90.000*
Ninh Thuận province: data collection, survey and design ponds including bio-engineering solutions in 15selected communes	communes	15	10.000	*150.000*
Bình Thuận province: data collection, survey and design ponds including bio-engineering solutions in 9selected communes	communes	9	10.000	*90.000*

Item	Unit	Amount	Price (USD)	Cost (USD)
Đăk Lăk province: data collection, survey and design ponds including bio-engineering solutions in 11selected communes	communes	11	10.000	*110.000*
Đăk Nông province: data collection, survey and design ponds including bio-engineering solutions in 16selected communes	communes	16	10.000	*160.000*
Contingency cost 5%				*30.000*
1.3.2 Upgrade of climate-resilient ponds [ID cofinancing]		**484**		**974.880**
Upgrade of 36 existing ponds including bioengineering solutions in Khánh Hòa province	*existing pond*	*36*	*1.500*	*54.000*
Upgrade of 133 existing ponds including bioengineering solutions in Ninh Thuận province	*existing pond*	*133*	*1.500*	*199.500*
Upgrade of 108 existing ponds including bioengineering solutions in Bình Thuận province	*existing pond*	*108*	*1.500*	*162.000*
Upgrade of 119 existing ponds including bioengineering solutions in Đăk Lăk province	*existing pond*	*119*	*1.500*	*178.500*
Upgrade of 88 existing ponds including bioengineering solutions in Đăk Nông province	*existing pond*	*88*	*1.500*	*132.000*
Cofinancing for land compensation in Khánh Hòa province	*ha*	*0,72*	*10.000*	*7.200*
Cofinancing for land compensation in Ninh Thuận province	*ha*	*2,66*	*15.000*	*39.900*
Cofinancing for land compensation in Bình Thuận province	*ha*	*2,16*	*20.000*	*43.200*
Cofinancing for land compensation in Đăk Lăk province	*ha*	*2,38*	*12.000*	*28.560*
Cofinancing for land compensation in Dak Nong province	*ha*	*1,76*	*12.000*	*21.120*
Consultancy 10% and contingency cost 5%				*108.900*
1.3.3 Construction of climate-resilient HH ponds [ID cofinancing]		**490**		**1.515.100**
Construction of 36 new HH ponds including bioengineering solutions in	*new HH pond*	*36*	*2.200*	*79.200*
Construction of 183 new HH ponds including bioengineering solutions in	*new HH pond*	*183*	*2.200*	*402.600*
Construction of 66 new HH ponds including bioengineering solutions in	*new HH pond*	*66*	*2.200*	*145.200*
Construction of 98 new HH ponds including bioengineering solutions in	*new HH pond*	*98*	*2.200*	*215.600*
Construction of 107 new HH ponds including bioengineering solutions in	*new HH pond*	*107*	*2.200*	*235.400*
Cofinancing for land compensation in Khánh Hòa province	*ha*	*1,44*	*10.000*	*14.400*
Cofinancing for land compensation in Ninh Thuận province	*ha*	*7,32*	*15.000*	*109.800*
Cofinancing for land compensation in Bình Thuận province	*ha*	*2,64*	*20.000*	*52.800*
Cofinancing for land compensation in Đăk Lăk province	*ha*	*3,92*	*12.000*	*47.040*
Cofinancing for land compensation in Dak Nong province	*ha*	*4,28*	*12.000*	*51.360*
Consultancy 10% and contingency cost 5%				*161.700*
1.3.4 Construction of climate-resilient shared ponds [ID cofinancing]		**185**		**1.990.345**
Construction of 10 new HH ponds including bioengineering solutions in	*new shared pond*	*10*	*7.500*	*75.000*
Construction of 41 new HH ponds including bioengineering solutions in	*new shared pond*	*41*	*7.500*	*307.500*
Construction of 18 new HH ponds including bioengineering solutions in	*new shared pond*	*18*	*7.500*	*135.000*
Construction of 43 new HH ponds including bioengineering solutions in	*new shared pond*	*43*	*7.500*	*322.500*
Construction of 73 new HH ponds including bioengineering solutions in	*new shared pond*	*73*	*7.500*	*547.500*
Cofinancing for land compensation in Khánh Hòa province	*ha*	*1,60*	*10.000*	*16.000*
Cofinancing for land compensation in Ninh Thuận province	*ha*	*6,56*	*15.000*	*98.400*
Cofinancing for land compensation in Bình Thuận province	*ha*	*2,88*	*20.000*	*57.600*
Cofinancing for land compensation in Đăk Lăk province	*ha*	*6,88*	*12.000*	*82.560*
Cofinancing for land compensation in Dak Nong province	*ha*	*11,68*	*12.000*	*140.160*
Consultantcy 10% and contingency cost 5%				*208.125*
1.3.5 Training in climate-resilient water resource management to enhance supply. [advisories on WRM link to Output 2.2] [#s of trainees, repeat training yrs 2-5; costs, numbers etc.]		**328**		**278.800**
Khánh Hòa province: 7 workshops in 9 communes, 100 farmers in each workshop, two time	workshops	*14*	*150*	*2.100*
Ninh Thuận province: 55 workshops in 15 communes, 100 farmers in each workshop, two time	workshops	*110*	*150*	*16.500*
Bình Thuận province: 11 workshops in 9 communes, 100 farmers in each workshop, two time	workshops	*22*	*150*	*3.300*
Đăk Lăk province: 49 workshops in 11 communes, 100 farmers in each workshop, two time	workshops	*98*	*150*	*14.700*
Đăk Nông province: 42 workshops in 16 communes, 100 farmers in each workshop, two time	workshops	*84*	*150*	*12.600*
Consultancy cost (Material preparation for workshop, water, meal and other material)	workshops	*328*	*700*	*229.600*
1.3.6 Organization of O&M of communal or shared storage ponds and surrounding landscape, including potential funding		**185**		**305.250**

Item	Unit	Amount	Price (USD)	Cost (USD)
mechanisms [governance and O&M, financing and planning, need O&M plan for this and last mile]				
Khánh Hòa province: setup shared pond user group, governance and O&M plan and planing for 10 ponds, implementation of O&M for the first 2 years	*ponds*	*10*	*1.500*	*15.000*
Ninh Thuận province: setup shared pond user group, governance and O&M plan and planing for 41 ponds, implementation of O&M for the first 2 years	*ponds*	*41*	*1.500*	*61.500*
Bình Thuận province: setup shared pond user group, governance and O&M plan and planing for 18 ponds, implementation of O&M for the first 2 years	*ponds*	*18*	*1.500*	*27.000*
Đăk Lăk province: setup shared pond user group, governance and O&M plan and planing for 43 ponds, implementation of O&M for the first 2 years	*ponds*	*43*	*1.500*	*64.500*
Đăk Nông province: setup shared pond user group, governance and O&M plan and planing for 73 ponds, implementation of O&M for the first 2 years	*ponds*	*73*	*1.500*	*109.500*
Contingency cost 10%				*27.750*

5.7 Operational and implementation modalities

The beneficiaries shall be selected based on their needs and ability to contribute to an agreed plan to set up ponds (with written commitments of population communities or beneficiaries), compile dossiers, provide detailed information (form guided by Department of Agriculture and Rural Development and project office) sent to Commune People's Committee.

The Commune People's Committee together with the technical assistant for assessment of rain harvesting shall synthesize the implementation plan in the whole commune and make detailed estimates of each project and submit it to the project management team and local DARD.

The implementation model can be as follows:

- Review the location for the pond,
- Make a preliminary agreement in the case of common ponds
- Preliminary design, based on norms (norms need to be pre-construction with the Technical Assistance Group - TAG)
- Communes and TAGs will check the field and confirm the size and location of the pond
- The commune supports the dossiers submitted to the PMU and DARD for appraisal and approval
- There are two forms of implementation:
- Pond is dug by water users group, with PMU monitoring
- Pond is constructed by a firm, with water users groups supervising

Construction implementation

- Constructing works: Assigning communities or beneficiaries directly to organize tasks themselves. In cases where communities or beneficiaries are incapable or unable to do so, they shall consider employing individuals or teams with full capacity for implementation but must be agreed to by the community.

- Conducting community supervision during construction: Commune People's Committee have established the Community Supervision Board with the participation of representatives from People's Council, Viet Nam Fatherland Front Committee, mass organizations, community representatives. Beneficiaries. Inter-ministerial Circular No. 26/20011 / TTLT-BNNPTNT-BKHDT-BTC of April 13, 2001 of the Ministry of Agriculture and Rural Development, the Ministry of Planning and Investment and the Ministry of Finance guiding one Decision No. 800 / QD-TTg dated 04/6/2010 of the Prime Minister and other relevant regulations.

- Checking and handing over works: The builder shall organize the pre-acceptance test of the completed project and put it into use (the composition of the pre-acceptance test is composed of the builder and the community supervision board, the commune irrigation traffic officer and the unit appraisal of dossiers of proposals).

- Payment and settlement of completed works: The builder shall compile the payment and final settlement dossier, including the decision approving the cost estimate of the work, the minutes on the takeover test of the completed work and putting it into use (with attachment of photos of ponds before and after completion), construction contracts (in case of employing individuals, teams, renting machinery and equipment, hiring consultants) and related invoices and vouchers (if any) sent to the Commune People's Committee for payment and settlement under the guidance of project management team and the Department of Finance.

6 DESIGN THE IRRIGATION SYSTEMS ON-FARM

6.1 Existing crop patterns and irrigation technology

There are several crops within and near WEIDAP project area; the table below lists the main crops that are dominant in each province. Each crop has different levels of water demand and irrigation techniques.

Table 29: Existing crop patterns in WEIDAP area of five target provinces

No	Crop	Type	WEIDAP region				
1	Coffee	perennial tree	Dak Lak	Dak Nong			
2	Pepper	perennial tree	Dak Lak	Dak Nong	Binh Thuan		
2	Dragon fruit	perennial tree			Binh Thuan		
3	Mango	perennial tree				Khanh Hoa	
4	Apple	perennial tree					Ninh Thuan
5	Grape	perennial tree					Ninh Thuan
7	Onion	2-3 moths/crop					Ninh Thuan
8	Garlic	1 crop/year					Ninh Thuan
9	Rice	2 crops/year	Dak Lak	Dak Nong	Binh Thuan	Khanh Hoa	Khanh Hoa
10	Vegetables, beans	2 crops/year	Dak Lak	Dak Nong	Binh Thuan	Khanh Hoa	Khanh Hoa

Advanced water-saving irrigation technology has been introduced and applied in the South Central and Central Highland provinces for a long time in various agricultural extension and scientific and technological models; however, over the past five years, it has only been more widely applied in the provinces with cash production of high-value upland crops such as vegetables in Da Lat city, Don Duong district (Lam Dong province); dragon fruit (Binh Thuan province); grapes and apples (Ninh Thuan province). A number of models have been tested on a few industrial crops and fruit trees in the Central Highland provinces such as coffee, pepper, avocado, and durian though on small areas and almost without application of water-saving irrigation. In particular, in the context of increasing climate change and rapid socio-economic development that has lead to water scarcity, government agencies, farmers, and scientific organizations are keener to develop water-saving irrigation. The situation of water-saving irrigation applications in the project provinces is discussed below.

In Dak Lak Province:

The province has significant experience with high economic value export crops such as coffee, pepper and cashew, which are irrigation-demanding and care-intensive crops. In recent years, water-saving irrigation technology has been promoted for coffee and pepper in Cu Kuin, Cu M'gar, Krong Pak districts and Buon Ma Thuot City at the individual household level on a pilot plots of about 1-2 ha; these irrigation systems were supported by the Provincial Agricultural Extension Center, scientific research centers and irrigation equipment providers in cooperation with local farmers. Coffee and pepper were the primary crops receiving water-saving irrigation. The most commonly used water-saving irrigation technology is drip irrigation with equipment to allow fertilizer application in water; this technology enjoys low operating costs, and is water and fertilizer saving, but has a high investment cost, high operating skills and requires quality water to prevent pipe blockage. Amounts of water, fertilizer, labor, fuel consumption, productivity and quality of crops are recorded during project implementation as the basis for expert analysis and performance evaluation of the water-saving irrigation system for potential replication. In addition, there are some locations where sprinkler irrigation is applied with simple and easy to install and operate techniques, and with an average investment rate, but this technology is not as efficient as drip irrigation and it is more difficult to apply fertilizers at the same time. In Dak Lak province, ethnic minority groups such as Ede, Bana, and others comprise a large proportion of the provincial population; they have a quite limited level of farming as well as limited knowledge and ability to adopt new technologies such as water-saving irrigation.

Water used for irrigation is from three main sources, i.e., groundwater through drilled and dug household wells, rivers and small streams directly pumped for irrigation, and more developed irrigation systems. None of the water sources is treated or quality tested regularly but may use only a simple filtration device attached to irrigation equipment, so there is high risk of deposition and blockage in pipes and taps.

Figure 41: Localized sprinkler irrigation for oranges at the Central Highland Agriculture Institute, Dak Lak province

Figure 42: Underground drip irrigation for coffee in Dat Ly, Buon Ma Thuot City, Dak Lak province

In Dak Nong province:

In Dak Nong province, farmers mostly use traditional irrigation techniques for pepper and coffee (using pumps to extract water from ponds, lakes, and canals to irrigate trees). This technique is very water-intensive with large water losses. To improve water efficiency in the province, the Provincial Agricultural Extension Center has installed experimental water-saving irrigation systems in eight districts/towns of Dak Nong province; each district tested two models, each model covering about 0.5 ha of pepper and coffee. The total experimental area of the province is eight ha; the water saving irrigation technology applied is sprinkler irrigation at the tree foot. There are also a number of programs and pilot projects developed by the Provincial Department of Science and Technology. In general, the programs are just at experimental level on small household areas. Exceptionally for coffee and pepper, which are currently supported with some water-saving experiments, there are almost no other crops with application of water saving irrigation in Dak Nong province.

In Binh Thuan province:

In the past years, given particular attention by the central government and Binh Thuan province, various water saving irrigation models and projects for high economic value upland crops were developed, promoted and supported by the Provincial Department of Science and Technology, Agricultural Extension Center and foreign organizations for investments, technical training, and awareness raising. Water saving irrigation solutions were applied on rather large areas of the key crops such as dragon fruit, pepper and other fruit trees in Ham Thuan Bac, Ham Thuan Nam, Bac Binh, and Duc Linh districts. This helped reduce the labor requirements for irrigation, save water resources for a water scarce province, and produce high economic efficiency. The main irrigation technologies applied are drip irrigation and sprinkler irrigation with irrigation equipment imported from Israel and Taiwan, which can help reduce irrigation water by up to 30-40%, compared with the traditional irrigation techniques, but also increase crop productivity. Drip irrigation systems are also used by farmers to combine with fertilizer application, which helps improve fertilizer efficiency by applying fertilizer at the right time and right place; the fertilizer is dissolved in water and absorbed completely by plants, therefore allowing savings on fertilizer and reduced labor requirements for fertilizer application. Findings from these experiences indicate that excessive watering does not increase crop yields but increases water requirements, increases disease risks, and increases labor and fuel cost for irrigation. Several experiments in Binh Thuan province are being conducted for dragon fruit with the application of drip irrigation using solar energy.

Besides dragon fruit, drip irrigation technology is also applied in some other places for cotton (Tuy Phong district) on 50 ha, sprinkler irrigation for root vegetables in Chi Cong - Tuy Phong, agricultural membrane and greenhouse (Ham Thuan Nam) for producing vegetables for export to Japan on 64 ha, that generate higher economic efficiency of 1.5 to 2 times.

In Ninh Thuan province:

Ninh Thuan Provincial People's Committee (PPC) issued Decision No.1209/QD-UBND dated June 1, 2011 approving the implementation of the "Irrigation model for South Central poor peoples living in Ninh Thuan Province" with a total investment cost of VND 22 billion, including VND 1.6 billion from International Development Enterprises (IDE) (phase I from 2011 to 2013), the rest from local people’s contribution. The project supports installation of water saving irrigation systems, which serve a total cultivated area of 380ha in 50 communes, wards and towns. In Phase II, the project is implemented in two districts, namely Bac Ai and Thuan Bac with a total budget of US$ 550 million supported by IDE for 700 households with a cultivated area of 192ha. The main crops selected are those of high economic value such as grape, apple, custard apple, fodder grass and other crops for domestic consumption.

Given the success of the pilot models, current water-saving irrigation technology is gradually being replicated in many other localities in the province, especially for high economic value crops such as grapes, fodder grass, etc. Since 2013, about 2,335 farmer households in Ninh Thuan province have invested in installation and use of water-saving irrigation systems serving a total area of over 500 ha. In particular, the typical models include:

Irrigation model for grape in the communes of Ninh Hai and Thuan Nam districts, in Xuan Hai Commune (about 7 of 85 ha of grape planted areas with water saving irrigation), and in Vinh Hai commune (approximately 100 ha);

Irrigation model for fodder grass to serve livestock husbandry in the communes of Ninh Phuoc district.

However, application of water-saving irrigation for high economic value crops requires large initial investments and a high level of farming, therefore the results are not as much as expected. Thus, it is necessary to provide economic and technical support for local people to promote widespread adoption.

Figure 43: Sprinkler irrigation for grape in Ninh Thuan province

Figure 44: Sprinkler irrigation for dragon fruit in Binh Thuan province

In Khanh Hoa province:

According to Decision No. 575/QD-TTg dated 04 May 2015 of the Prime Minister approving the Master Plan for high-tech agricultural areas and zones by 2020 and orientations to 2030, a high-tech agricultural zone with an area of 65.9 ha will be built in Khanh Hoa province. Accordingly, Khanh Hoa province has had a High-Tech Agricultural Center built in Suoi Cat commune and water sources are from Suoi Dau reservoir. The Centre is carrying out research on application of advanced farming and water saving irrigation models for some crops, such as sprinkler irrigation and drip irrigation models for mango (about 15 ha), for Mokara orchids (2.5 ha); a sprinkler irrigation model for the breeding of flowers and forest trees; and sprinkler irrigation for sugarcane and new varieties.

In addition, some households located within the irrigation districts have also invested in installation of water-saving irrigation systems such as drip irrigation and sprinkler irrigation for mango (Cam Lam), garlic (Ninh Hoa), and sugarcane (Dien Khanh). However, those systems are small-scale and household-scale only, because of insufficient water flow from drilled wells and high initial investment (wells and irrigation systems), which is not suitable for the majority of farmers.

Sprinkler irrigation model using water sources from drilled wells to irrigate for tangerine (7 ha), mango (30 ha) in Khanh Binh commune, Khanh Vinh district invested by the farmers themselves;

Drip irrigation and sprinkler irrigation model using water sources from drilled wells to irrigate for mango (1 ha) in Cam Thanh Bac commune, Cam Lam district;

Sprinkler irrigation model using water sources from drilled wells to irrigate for vegetables and garlic in Ninh Phuoc, Ninh Son, and Ninh Van communes, Ninh Hoa district;

Sprinkler irrigation model using water sources from drilled wells and Cai river to irrigate for vegetables (25 ha) in Vinh Thanh and Vinh Phuong communes, Nha Trang city;

Sprinkler irrigation model using water sources from drilled wells to irrigate for garlic (200 ha) in Van Ninh district.

Figure 45: Localized sprinkler irrigation for mango at EMU Company in Cam Lâm district

Figure 46: Low pressure sprinkler irrigation for garlic in Ninh Hoa town

Water used to irrigate mango is extracted from groundwater by drilling and digging wells; for mango growing areas situated along canals, water is pumped directly from the canals, and some households have even to buy water from water tankers for irrigation. However, according to assessments, those water sources are not stable or sufficient because the local groundwater reserves are not abundant and the canals are only fed when Cam Ranh reservoir releases for irrigation. The situation is more severe especially, in recent years when droughts are becoming more serious. The irrigation technique used by farmers is to enclose the foot to store water, and then flush water to the sinks for gradual absorption. This technique is labor-intensive and water-intensive but also less effective because it can facilitate the development of some diseases harmful to plants. In addition, farmers spontaneously cut the canals to bury their pump pipes or often block some canal sections to pump water for mango irrigation that damages some sections of the canals, as well as affecting the water flow in the canals.

Irrigation water shortage as well as the application of inefficient irrigation procedures and techniques results in a reduction in productivity, quality and value of products. Given that a number of household enterprises like the Australian Mango Export Enterprise (with an area of over 10 ha) in Cam Duc town and some other households in the district have invested in installing drip irrigation systems combined with fertilizer application. According to preliminary investigations, under conditions of agricultural labor shortage as at present, after application of drip irrigation technology, labor requirements were reduced by 90%, and approximately 30-50% of irrigation water was saved. The biggest advantage of drip irrigation is that the growers do not have to irrigate each tree manually as before, they do not have to enclose the foots to store water but can still maintain moisture for their orchards suitable for each growth cycle. This also helps to limit the spread of diseases and shedding of flowers and young fruits. Drip irrigation systems do not cause flow so they can avoid soil erosion, which in turn significantly reduces root rot in mango trees. In addition to labor force saving, irrigation water saving, and fewer pests, the installation of drip irrigation systems for new orchards can help shorten duration of the growth period (from 3 years to 2 years before producing fruits). In particular, thanks to regular irrigation and fertilizer input, the plants grow well with fewer diseases and higher yields of 20% ÷ 30%, and fruit quality is also better and their economic value increases.

Effectiveness and potential replication of the advanced water saving irrigation systems is huge. However, the biggest difficulties are water sources and funds to support the application of water saving irrigation methods in order to enhance the added value of agricultural production. For individual households who have adopted drip irrigation techniques, the main source of irrigation water is extracted from groundwater, but according to assessments by the relevant authorities, the local groundwater reserves are limited and distributed in deep aquifers, which are not easy to tap and are costly to extract for irrigation, making the possibility of replication very limited.

6.2 Key gaps

Different types of irrigation for crops were found in the project areas according to an intensive survey in 2015-2016 in the regions. Each irrigation method consumes different water volumes, electricity and labor.

Type 1: Conventional irrigation

This is the typical irrigation method for coffee, pepper and dragon fruit in the Central and Highlands region. It's require a suitable pump and rubber pipe. The water source is surface water with the maximum distance being 2km or shallow or deep water wells. It requires a lot of labor for irrigation, weeding and fertilizing.

And it is known as the most common irrigation method for regions where the water source is highly uncertain and the technical level of the local farmers is low.

Figure 47: Conventional irrigation method for mango, coffee and dragon fruit in project area

Type 2: Sprinkler irrigation

There are some areas that apply this method where the water source is close and relatively costant over a multi-year period. This method consumes more water than the other methods and requires more labor for weeding, however it require less labor for irrigation. This method is also costly in terms of energy consumption for irrigation.

Figure 48: Sprinkler irrigation system for dragon fruit and coffee (not HEI and not conventional irrigation)

Type 3: Spray irrigation

This is a smaller scale of sprinkler irrigation where the system focuses only on the lower bole section of a tree. This method is developed due to the disadvantage of the sprinkler method as mentioned above. This method is recommended for most of the crops in the region where is can integrate the auto fertilizing system. This method requires that water sources are stable in both quantity and quality, however, in some cases farmers have to revert to conventional irrigation because of unsecured water sources.

Figure 49: Sprinkler irrigation systems for dragon fruit and coffee (it's HEI)

Type 4: Drip irrigation

This This method is the most applicable in the project area, the most water-saving automated method in reports from local DARD and farmers. However, this method requires conditions as below:

- The farm owner must be willing and have the financial capacity to pay for the techniques. Many farmers are attracted to the technology but it's just too expensive to invest.
- A farm needs hired laborers (>1ha), or the owners of the farm have other sources of income. This means that farmers will not invest if investment takes them away from earning their other sources of income.
- The water source is ensured in term of quality and quantity over years

Normally, more than 50% of the farms are less than 1 hectare and most of them are using ground water for irrigation with very high seasonal variation. Investment may cost the equivalent of one year of farm production while at the same time the market may be uncertain. This results in a low rate of HEI adoption in the project areas.

Figure 50: Drip irrigation systems for dragon fruit and coffee, it's HEI

Figure 51: Burried pipes for HEI application in Central Highlands (Netafim Dak Lak)

Shortcomings and issues to be solved

Given the advantages of very favorable soil, climate and terrain conditions for the development of industrial crops like pepper, coffee and fruits (mango, grape, apple, dragon fruit, etc) of the five provinces in the project area, and in accordance with the agricultural restructuring orientations, the provinces all target the development of these crops in applying advanced science and technology in farming and irrigation for the ultimate purpose of higher-yield, good quality, and lower cost agro-products. As well, although the WEIDAP project will build, rehabilitate and upgrade irrigation structures to provide irrigation water for cultivated lands, there exist shortcomings and issues related to on-farm systems and physical management for higher irrigation efficiency, specifically:

Water saving irrigation development:

- Recently, water saving irrigation is more widely applied to better off households and enterprises who produce high economic value crops such as vegetables and flowers in Lam Dong province, and dragon fruit in Binh Thuan province, but not to other crops with unstable economic value, including coffee and pepper.

Most water saving irrigation applications in the provinces are of small-scale models invested by local farmers themselves or supported by research projects; they are tested on small areas from 0.5 to 2 ha, without centralized models with community participation. Therefore, it is not possible to reach full effectiveness in terms of water saving irrigation efficiency as well as replication to other local farmers of the awareness of water saving and economic benefits generated by water saving irrigation technology. The establishment of the centralized models with the participation of many households will help apply complete solutions of water resource management, resource mobilization, and facilitation in receiving support from government policies. It is important to set up new water users groups, agricultural cooperatives and agricultural production chain links to assist farmers to establish cash production areas with trademarks in applying a full set of technical measures, effective production organization, maximal use of labor and machinery to reduce costs and increase labor productivity.

Results of surveys, investigation and consultations showed that not only local people but also agricultural workers at district and commune levels in the project provinces have very little information on water-saving irrigation; some are not even convinced of the effectiveness of water-saving irrigation applications. Farmers are eager to apply water saving irrigation technology which is suitable for crops; they wish to be guided to apply the right technique to avoid damage, and have access to authentic equipment, however what they have is inconsistent information on mass media, low quality sprinkler irrigation equipment sold at markets, non-guaranteed, drip irrigation pipes, and lack of associated filtration and check equipment. There are few water-saving irrigation models developed in the provinces to observe and learn, and they are also difficult to access.

There are not many water-saving irrigation techniques for different crops that are suitable for the regional climate and soil conditions. Recently, MARD and the Directorate of Water Resources (DWR) issued a Handbook on water saving irrigation for some upland crops such as coffee, pepper, dragon fruit and other fruit trees. However, there are no guidelines available for some other crops such as mango, apple, grape, aloe vera, or asparagus, and then it is also difficult for farmers to access these materials. According to consultations, farmers mainly rely on their production experience and practices, and some simple but inaccurate guidelines provided by equipment providers' shops.

Institution and policy

It is difficult to control and collect water fees from those farmers who pump water directly from a reservoir but not from a canal system to irrigate directly. Hence, it is necessary to develop and adjust policies related to irrigation services to match regional characteristics.

According to the prevailing regulations, small and medium scale irrigation structures are handed over to the localities for management for them to assign farmers and cooperatives' responsibilities and obligations over the structures. However, the assigned managers are district and commune officials who work part time for irrigation management and lack specialized technical qualifications, therefore they cannot form a professional management organization. As a consequence, the management is very poor, and lacks stakeholder participation, leading to serious problems, with the structures to be transferred back to the IMCs.

In the project provinces, there are very few WUGs, some in the form of cooperatives, and some WUGs set up under foreign funded projects. Most irrigation management of small-scale structures is done by the CPCs and village leaders. Therefore, it is essential to analyze and promote the establishment of grassroots water users organizations.

Local authorities do not pay appropriate attention to the establishment of water users' organizations to manage irrigation structures in a professional manner, resulting in physical deterioration.

In the project area, there are a high number of ethnic minority people who have limited technical capacities, which makes the mobilization of farmer participation in irrigation investment management more difficult than in other regions such as the Red River Delta and the Mekong Delta.

Some WUGs were set up with support of various projects but stopped operation upon project completion due to lack of feasible mechanisms and policies to ensure viable long-term resources for implementation. The existing WUGs often are not capable or qualified to obtain loans from credit institutions for their operation. Therefore, their services are very poor, and the lack funds for rehabilitation/reparation of degraded structures.

6.3 Recommended interventions

Key interventions of this section is to support poor and near-poor households to develop water-saving irrigation on their farms, which will include:

Financial support in installation of HEI systems

Technical assistance for design HEI system suitable for each targeted household and management and operation of the HEI system.

6.3.1 Technical support for HEI development

To provide financial support for the development of modern water saving irrigation technology, the beneficiaries must meet the criteria set by the project. Decision support includes assistance in identifying sites, beneficiaries, technologies and financial support mechanisms for HEI development in the project area. Procedures and sample documents for support should also be developed.

To implement this effectively, it is necessary to have a support team to determine the suitability of the beneficiaries. The advisory group may be professionals, professional social organizations or competent financial institutions.

Objective of the work

Establishment of a basis to support the issuance of funding decisions for subjects applying modern water saving irrigation technology. The basis is based on criteria agreed by UNDP.

Develop a financial mechanism and disbursement appropriate to the type of irrigation technology, natural, economic and social characteristics of each area of the project.

Work content:

Determine the base framework to issue a decision approving HEI support in each household.

Establishment of a valid site data framework: Develop the framework that determines the eligibility of poor (1) poor and 'near poor' criteria according to the criteria of the Ministry of Labor, Invalids and Social Affairs.

Establishing a framework that decides the eligibility of criterion as having land use rights - as defined in the Land Law.

Establishment of the framework for determining the ineligibility of criterion on no-supported crops (rice).

Develop a framework for disbursement mechanisms for beneficiaries

- Level of support, progress of disbursement for each type of irrigation technology, each type of plant
- Level of support and progress of disbursement for the scale of land accumulation

Organize consultations with relevant agencies on decision support frameworks and disbursement mechanism framework.

Development of guidelines for the people to request funding support.

Prepare documents on the process of checking and acceptance for the beneficiaries

To set up the organizational framework, operation mechanism for the screening section, approve the dossier, organize the payment, supervise the implementation and make final settlement;

Provide documentation for training and communication activities.

Expected results from this activity:

The base framework document issued the decision approving the financial support for the participants in the HEI development.

Document on the mechanism of disbursement mechanism for beneficiaries

Guiding documents for application for funding support

Documentation on the process of acceptance inspection

Organizational structure of the apparatus, the mechanism of operation of the screening department, the approval of the dossier, organization of payment, supervision of implementation and acceptance of final settlement.

6.3.2 Design and installation of HEI

This proposed work is support for design and installing the water-saving irrigation system and related work items in the targeted communes in relation to last mile connection to WEIDAP and activities in rainfed areas. The work will provide suitable HEI solutions consistent with natural, technical and economic conditions, characteristics of crops and O&M capacity of beneficiary HHs approved by the competent agency.

The beneficiaries derive from the selection of beneficiaries within the scope of the last mile connection and support to rainfed areas.

Contents of the work

1. Consultant to do the detailed designs of the models in accordance with the criteria as the most economic investment norm, technology appropriate with crops, high durability, easy to use and ability to combine with fertilizer application mixed in water, etc. The contents to be implemented are:

   Surveying, investigating in details local conditions in areas where the models shall be established such as: water resources, hydro-meteorology, materials supply and prices, labor, power infrastructure, terrain, etc. for constructing the works;

   Undertaking topographic and geological survey for designing the area to be applied with the water-saving irrigation;

   Studying, selecting appropriate irrigation equipment and technologies that are suitable with the crops, cost, and field terrain conditions;

   Designing the network of water pipelines, irrigation taps, tanks, electric system, water gauge equipment and infrastructures related to the water-saving irrigation system;

   Estimating costs in details for work items in the design dossiers;

   Discuss with relevant stakeholders and users about the designs.

   Finalizing the design dossiers and submit them to the competent agency for approval.

2. Organization for HEI installation and maintenance: Based on the design dossiers that are approved by the Project owner, the water-saving irrigation system shall be constructed, installed with all work undertaken. The contents of tasks to be implemented are:

   Construction of the water-saving irrigation system and related infrastructures in accordance with the design dossiers;

   Operating the pilots, monitoring, evaluating and improving the irrigation system;

   Training HHs in operation, management, maintenance and routine repair of irrigation systems;

   Handing over the completed system to the users.

There are some typical design of drip irrigation system for coffee and dragon fruit, vegetable and flower in figures below.

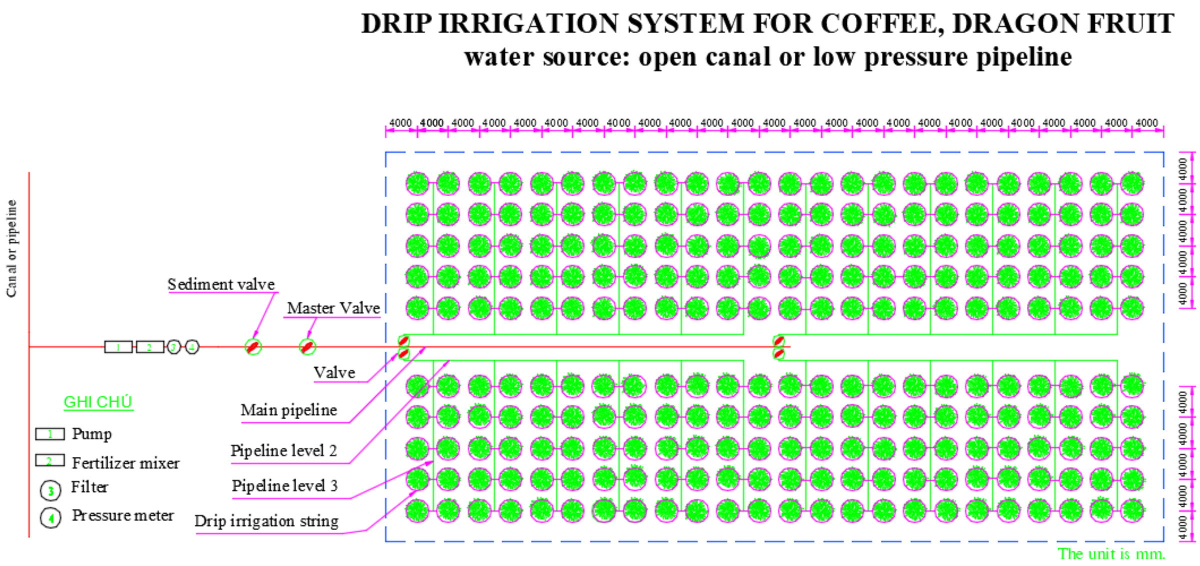


Figure 52: Typical design of drip irrigation system for coffee and dragon fruite

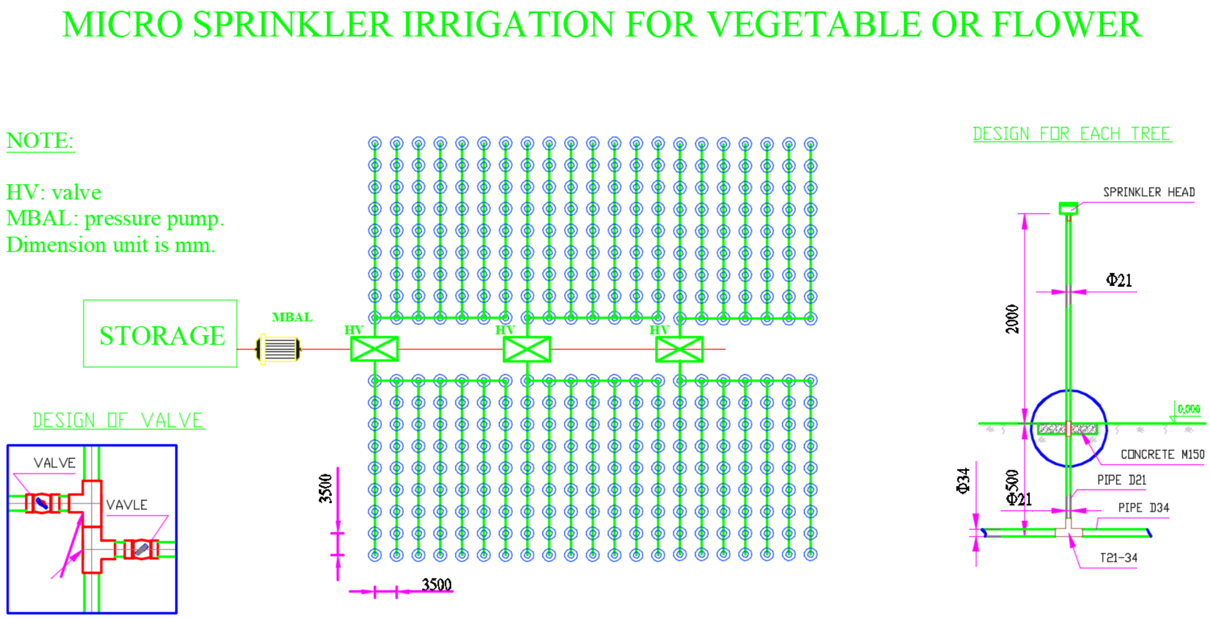


Figure 53: Typical design of drip irrigation system for vegetables and flowers

6.4 The beneficiary of interventions

Households who get support for last mile connection to WEIDAP and for supplementary irrigation in rainfed regions should be targetted for irrigation technology and technical assistance. Depending on the overall project budget, the project will select among the total of beneficiary households of 21,228 (sum of 4,765 households with last-mile connection and 16,463 households with suppplementary irrigation) those most vulnerable to be supported with water efficient technologies based on scoring exercise. The exact number will be defined and matched with activity 2.1 based on eligibility for vouchers for acquisition of inputs and technologies for CRA. Table 29 below shows the estimated number of beneficiary households by commune.

Table 30: Number of beneficiaryhouseholds for HEI support

No	Commune	Total household (2017)	Rate of benificaries HH in all communes	Shared area in rainfed (%)	Households to be selected as proportion of
	TOTAL	**139,416**	**30%**	**87%**	**21,228**
I	**Khánh Hòa province**	**22,153**	**6%**	**41%**	**1,774**
	Cam Lâm district	**22,153**	**6%**	**41%**	**1,774**
1	Cam Đức	4,195	6%	20%	224
2	Cam Tân	2,127	12%	30%	227
3	Cam Hoà	3,589	7%	40%	223
4	Cam Hải Tây	1,421	3%	50%	38
5	Cam Hiệp Bắc	800	7%	30%	50
6	Cam Hiệp Nam	1,375	6%	50%	74
7	Cam Thành Bắc	3,621	6%	50%	194
8	Suối Cát	2,489	21%	50%	458
9	Suối Tân	2,537	13%	50%	286
II	**Ninh Thuận province**	**30,980**	**42%**	**69%**	**7,073**
	Ninh Hải district	**12,909**	**17%**	**68%**	**1,106**
1	Phương Hải	1,783	16%	90%	218
2	Xuân Hải	4,245	8%	50%	274
3	Tri Hải	3,130	12%	80%	282
4	Nhơn Hải	3,751	12%	50%	332
	Ninh Sơn district	**6,534**	**32%**	**50%**	**1,158**
5	Mỹ Sơn	2,815	50%	70%	752
6	Nhơn Sơn	3,719	14%	30%	406
	Thuận Bắc district	**8,427**	**54%**	**76%**	**3,220**
7	Phước Chiến	1,155	82%	100%	723
8	Phước Kháng	614	88%	100%	412
9	Lợi Hải	2,974	44%	80%	999
10	Bắc Sơn	1,983	59%	50%	892

No	Commune	Total household (2017)	Rate of benificaries HH in all communes	Shared area in rainfed (%)	Households to be selected as proportion of
11	Bắc Phong	1,701	15%	50%	194
	Bác Ái district	**3,110**	**66%**	**83%**	**1,589**
12	Phước Tân	743	73%	100%	414
13	Phước Thắng	944	64%	100%	461
14	Phước Thành	853	77%	100%	501
15	Phước Trung	570	49%	30%	213
III	**Bình Thuận province**	**17,125**	**27%**	**81%**	**1,298**
	Hàm Thuận Nam district	**11,627**	**11%**	**85%**	**821**
1	TT Thuận Nam	3,329	5%	80%	139
2	Mỹ Thạnh	227	69%	100%	134
3	Hàm Cần	891	32%	100%	243
4	Tân Lập	2,187	6%	100%	112
5	Tân Thuận	3,593	4%	50%	122
6	Tân Thành	1,400	6%	80%	71
	Đức Linh district	**5,498**	**11%**	**77%**	**477**
7	Tân Hà	1,402	12%	80%	144
8	Đông Hà	2,029	9%	90%	156
9	Trà Tân	2,067	10%	60%	177
IV	**Đăk Lăk province**	**29,980**	**28%**	**83%**	**5,838**
	Ea Hleo district	**9,405**	**27%**	**93%**	**1,201**
1	TT. EaĐRăng	4,372	11%	90%	438
2	EaSol	2,838	19%	100%	480
3	Đliê Yang	2,195	14%	90%	283
	Cư M'Gar district	**1,601**	**16%**	**70%**	**182**
4	Quảng Tiến	1,601	12%	70%	182
	Ea Kar district	**4,280**	**35%**	**93%**	**1,548**
5	Ea Sô	889	61%	100%	493
6	Ea Sar	1,928	48%	100%	842
7	Xuân Phú	1,463	16%	80%	213
	Krông Păc district	**14,694**	**33%**	**75%**	**2,907**
8	Krông Buk	3,023	41%	70%	1,128
9	Ea Phê	5,152	14%	90%	653
10	Ea Yông	3,744	17%	50%	578
11	Ea Kênh	2,775	22%	90%	548
V	**Dak Nong province**	**39,177**	**19%**	**81%**	**5,245**
	Cư Jut district	**16,715**	**18%**	**73%**	**2,694**
1	Ea T'Ling	3,858	20%	80%	725
2	Nam Dong	4,026	15%	80%	549
3	Đăk DRông	3,316	15%	80%	468
4	Tâm Thắng	2,928	18%	80%	495
5	Cư Knia	1,835	20%	30%	344
6	Trúc Sơn	752	16%	90%	113
	Đăk Mil district	**15,925**	**10%**	**82%**	**968**
7	Đắk Lao	1,981	5%	90%	86
8	Đức Mạnh	3,653	4%	80%	137
9	Long Sơn	373	26%	80%	91
10	Đắk Sắk	3,559	10%	80%	335
11	Thuận An	2,629	3%	80%	74
12	Đức Minh	3,730	7%	80%	245
	Krông Nô district	**6,537**	**29%**	**87%**	**1,583**
13	Đăk Sôr	1,124	29%	100%	306
14	Nam Xuân	1,558	27%	60%	395
15	Đăk Drô	2,186	20%	100%	411
16	Nam Nung	1,669	30%	100%	471

6.5 Cost and budget estimates

The cost of installing water-saving irrigation systems varies from 30 million VND to 70 million VND depending on the installed equipment. If using devices and accessories manufactured in the country, the cost is about 30 million; if using equipment imported from developed countries with additional fertilizing systems, the cost can be up to 70 million VND per hectare. The smaller the size of the installation farm, the higher the relative cost. Note that for households that are the target of the project, the area is usually very low which will induce a higher cost in HEI installation, from 0.2 ha in the Central Highlands to 0.3 ha in the Central Highlands.

The unit price per hectare for installing a HEI system is calculated based on actual experience in localities where HEI are being developed in Ninh Thuan, Binh Thuan and Dak Lak. On everage, a unit price per hectare of 35 million VND is applied for calculation.

Estimated cost requirement for HEI system installation and technical support is approximately US $ 3.338 million.

Table 31: Cost and budget estimation for development of on-farm irrigation

Item	Unit	Amount	Price (USD)	Cost (USD)
Activity 1.4 Increase smallholder capacities to apply on-farm practices and technologies to maximize water efficiency to cope with rainfall variability and drought				***3.338.725***
1.4.1 Farmer Field School training on soil and biomass management to enhance moisture-holding capacity, recharge of groundwater, and water productivity conducted in the village/commune. (how many trainings, trainees, periodicity]				**1.210.000**
Training of lead farmerson soil and biomass management by trainers (60 communes x 30 persons/course x 1 courses/commune) in year 1, refresh training in year 3, 5, costs including meals for participants	course	5400	150	810.000
Training of farmer to farmer on soil and biomass management, 2 times/year (1 day/time) x 5 years x 3000 (FFS) including farmer field day, costs included meals for participants)	FFS	3000	100	300.000
Consultancy costs for training of lead farmer courses and continue to provide technical coaching for (F2F) by resource organization (NGO), 5 years	lumpsum			100.000
1.4.2 Training of trainers [government extensionists, FU, etc.] to support farmers' groups in co-design, costing and O&M of water efficient technologies [who, how many, etc.)				**189.000**
Training of trainers on co-design, costing and O&M of water efficient technologies (15 districts x 30 staff x one weeks/course, one course in each district in year 1 and refresh training in year 3, 5; costs including meals for participants, traveling of participants from province, commune to district (training location)				157.500
Consultancy costs for trainers in teaching the course on training of trainersand coaching the trained trainers in delivering the course on lead farmers, costs included consultancy fee/day, accommodation, travels and preparation of trainings handouts for participants, conduct by resource organization (NGO)				31.500
1.4.3 Installation of on-farm water efficiency systems of poor/near-poor smallholders linked to performance-based investment support [link to voucher system; #s, range of techs, prototypes, etc.] [O&M of these systems – in O&M plan which covers ponds, last mile, and techs – audit description relate to voucher] - cost linked to Activity 2.1.7; 40% of poor+near poor as beneficiaries		**8.621**		**1.939.725**
Package of water technology and installation of on-farm water efficiency systems for 0.15ha - Khanh Hoa	*household*	710	225	127.728
Package of water technology and installation of on-farm water efficiency systems for 0.15ha - Ninh Thuan	*household*	2829	225	509.256
Package of water technology and installation of on-farm water efficiency systems for 0.15ha - Binh Thuan	*household*	649	225	116.820
Package of water technology and installation of on-farm water efficiency systems for 0.15ha - Dak Lak	*household*	2335	225	420.336
Package of water technology and installation of on-farm water efficiency systems for 0.15ha - Dak Nong	*household*	2098	225	377.640
Household cofinancing for co-design and installation in Khanh Hoa (20%)	*household*	710	225	31.932
Household cofinancing for co-design and installation in Ninh Thuan (20%)	*household*	2829	225	127.314
Household cofinancing for co-design and installation in Binh Thuan (20%)	*household*	649	225	29.205
Household cofinancing for co-design and installation in Dak Lak (20%)	*household*	2335	225	105.084
Household cofinancing for co-design and installation in Dak Nong (20%)	*household*	2098	225	94.410

6.6 Operational and implementation modalities

Beneficiaries are supported after meeting the criteria specified in section 6.3.1 and are funded under the project support regulations.

Technical supporting team will

Screen and select applications for funding support according to the prescribed framework;

Disburse quickly and timely to beneficiaries for funding;

Monitor the implementation of the use of funds for the right purpose.

Implementation plan

Organize the recruitment of personnel, equipment for the selection of dossiers for support, payment of support funds, supervision of the installation of water-saving irrigation systems for selected farmers

Allocate, guide, receive, screen and approve requests for financial support;

Support and supervise the process of construction and installation;

Complete the finalization dossier and review and evaluate the contents already implemented.

7 APPENDIX 1: EXISTING RAIN HARVESTING SYSTEMS

7.1 Harvesting rain water – surface water: ponds

Figure 54: A typical pond to harvest rain water for mango irrigation in Cam Duc communes in Cam Lam Dictrict, Khanh Hoa

Figure 55: Existing pond combination for vegetable irrigation in Nhon Hai commune, Ninh Hai – Ninh Thuan

Figure 56: Existing water storages as potential shared ponds in Phuoc Trung communes, Bac Ai – Ninh Thuan.

Figure 57: Temporal pond beside a stream during dry-season, in Ninh Phuoc, Ninh Thuan

Figure 58: Existing pond for dragon fruit irrigation in Ham Thuan Nam, Binh Thuan

Figure 59: Existing pond for dragon fruit irrigation in Ham Thuan Nam, Binh Thuan

Figure 60: Existing pond for coffee and pepper irrigation in Ea Kar, Dak Lak

Figure 61: Existing shared pond for coffee irrigation in Cu Jut district, Dak Nong

Figure 62: A typical private pump in shared pond in Cu Jut and Dak Mil, Dak Nong

Figure 63: A checked dam for irrigation in Cu Jut district

7.2 Harvesting shallow ground water

Figure 64: A typical pond to collect and store shallow ground water for perennial crops in Cam Hiep Nam communes in Cam Lam Dictrict, Khanh Hoa

Figure 65: Existing well for vegetables in Ninh Hai – Ninh Thuan

Figure 66: Existing well for garlic and onion in Ninh Hai – Ninh Thuan

Figure 67: Building of underground weir for ground water exploration in Thuan Bac, Ninh Thuan

Figure 68: Potential ponds cause of clay earth mining in Phuoc Trung communes, Bac Ai – Ninh Thuan

7.3 Harvesting shallow ground water and surface water

Figure 69: Existing well – pond combination for vegetable irrigation in Nhon Hai commune, Ninh Hai – Ninh Thuan

Figure 70: A model of pumping well and storage pond for large scale farming (50ha) in Bac Binh, Binh Thuan

Figure 71: A model of well and storage pond for large scale farming (50ha) in Bac Binh, Binh Thuan

7.4 Existing bio-engineering solution

At present, bio-engineering solutions for erosion control, bank erosion and protection of highway slopes and irrigation works have been applied widely in the Northern mountainous provinces of Vietnam.

The main applications include:

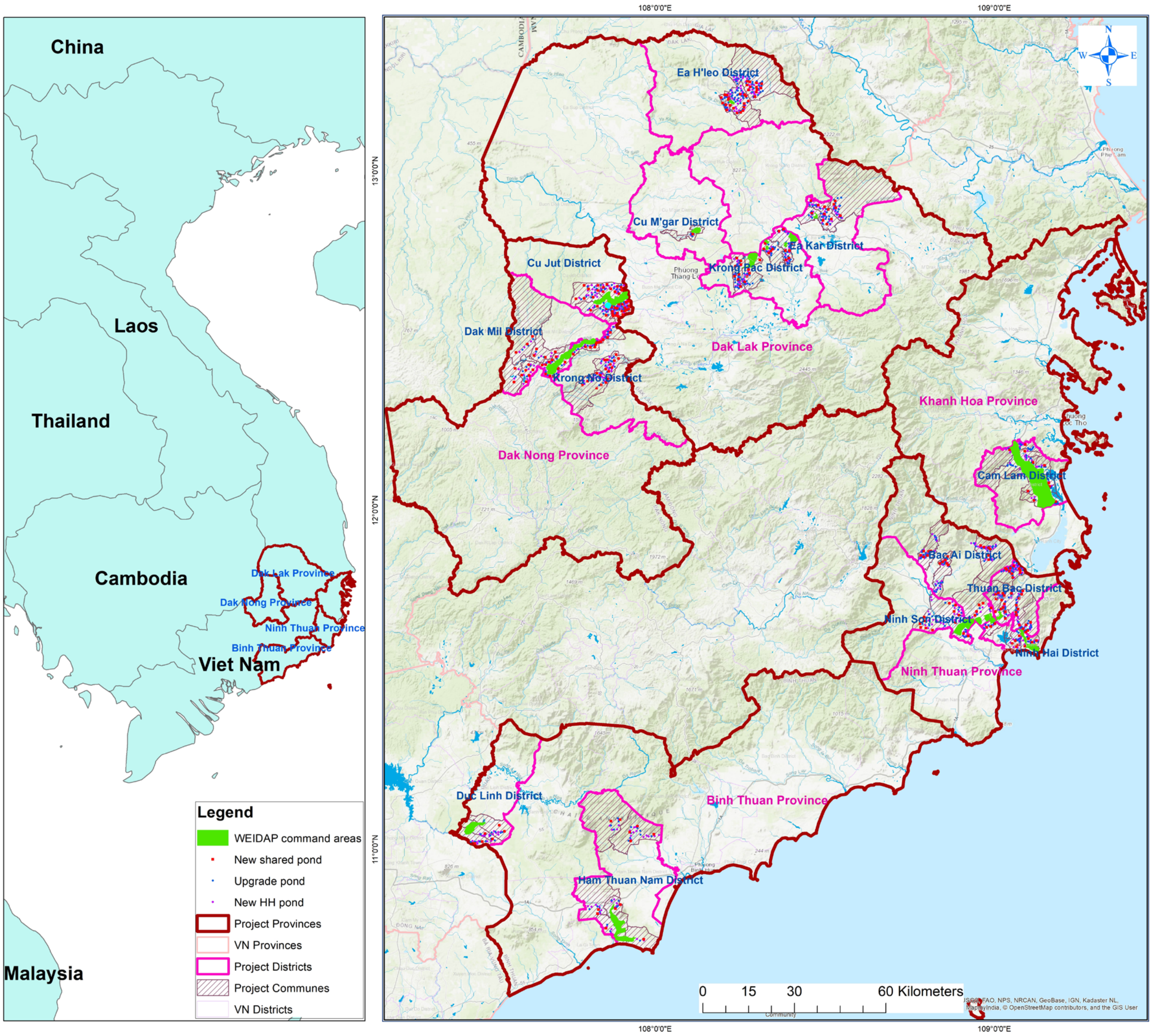
Bio-engineering solution for protection of slope and drainage system in Thai Nguyen (ICEM)

Bio-engineering solution for bank erosion protection in Bac Can province (ICEM)

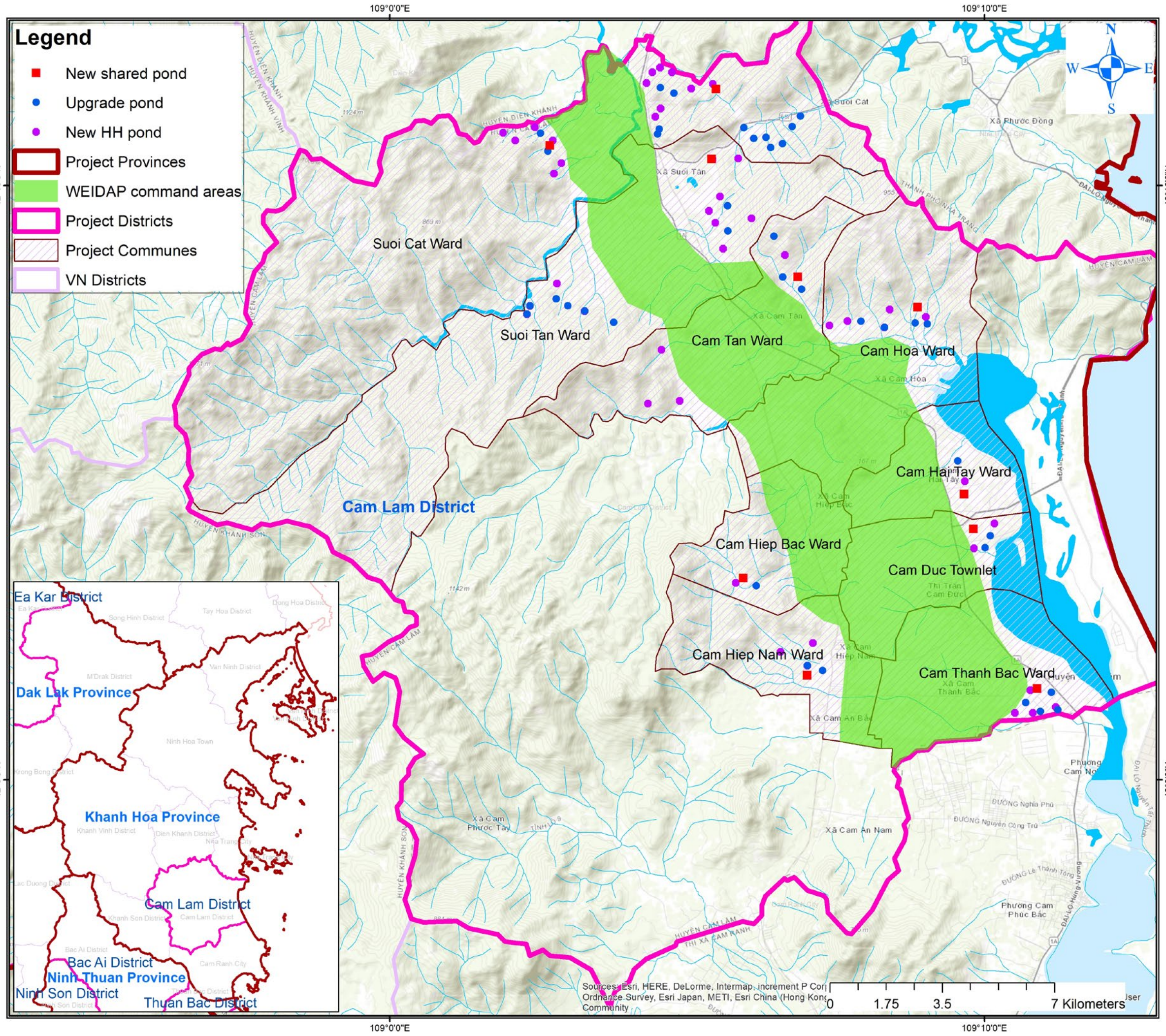
Bio-engineering solution for slope stabilization and water resource protection in orange farm, Hoa Binh province (IWRP)

8 APPENDIX 2: POND LOCATION MAPS IN TARGET AREA

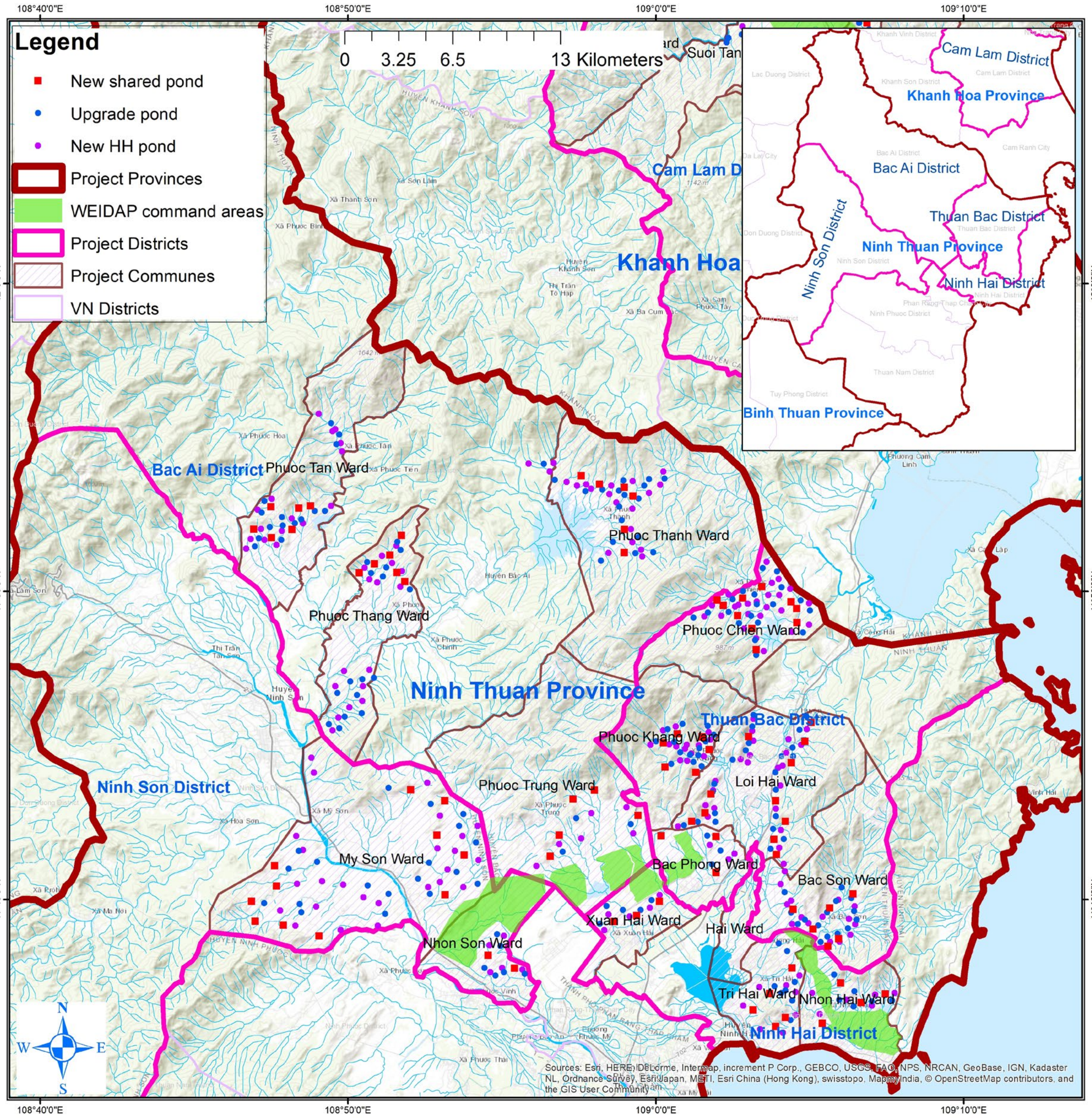
Map of beneficiary communes and districts in five target provinces



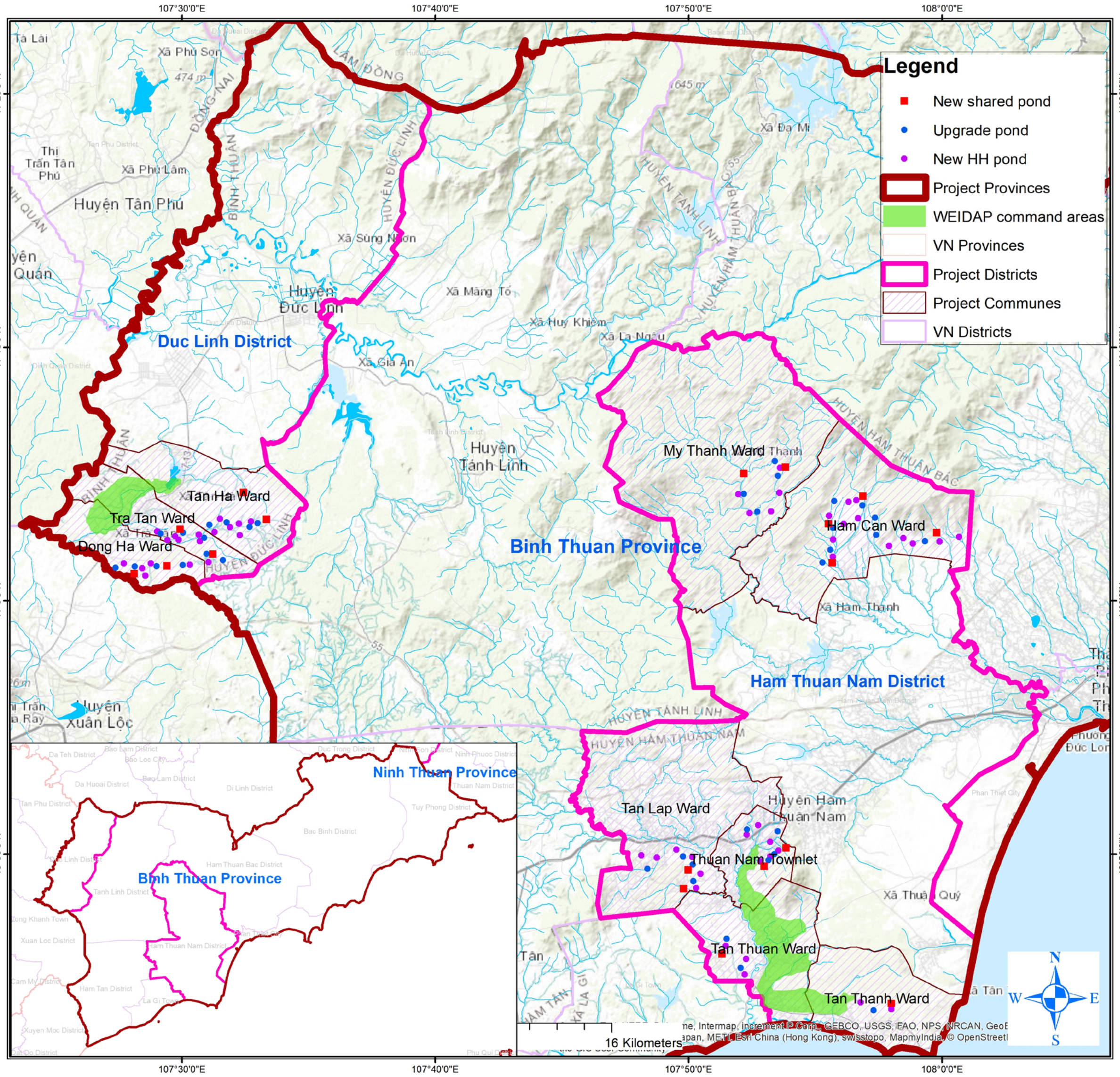
Map of beneficiary communes in Cam Lam district, Khanh Hoa province



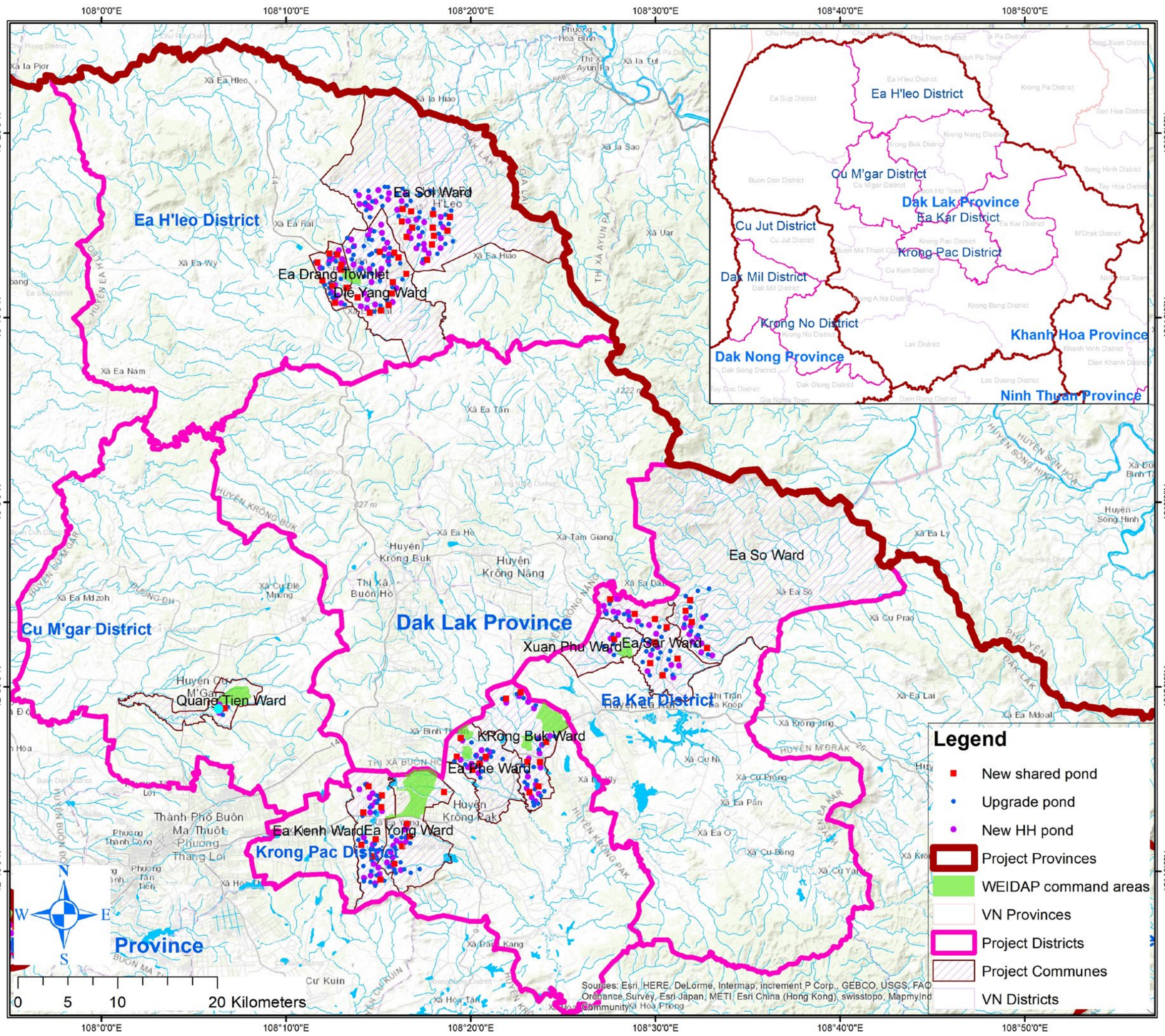
Map of beneficiary communes and districts in Ninh Thuan province



Map of beneficiary communes and districts in Binh Thuan province



Map of beneficiary communes and districts in Dak Lak province



Map of beneficiary communes and districts in Dak Nong province