Climate Adaptive Irrigation and Sustainable Agriculture for Resilience (CAISAR)

Annex 2: Feasibility study

Main Report

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CAISAR

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2 List of Abbreviations

ADB	Asian bank of Development
AFOLU	Agriculture, Forestry and Other Land Use (AFOLU)
AHNIP	Appropriate Hydrological Network Improvement Project
AIIB	Asian Infrastructure Investment Bank
AMK	AMK Cambodia
AP	Action Plan
ASEAN	Association of Southeast Asian Nations
AusAID	Australian Agency for International Development
AWD	Alternate Wetting-and-Drying
AWS	Automated weather stations
BKR	Boeng Konseng
BoQ	Bill of Quantity
CAISAR	Climate Adaptive Irrigation and Sustainable Agriculture for Resilience
CARDI	Cambodian Agricultural Research and Development Institute (
CBME	Community-based monitoring and evaluation system
CC	Climate Change
CEC	Cation exchange capacity
CIEWS	Climate Information and early warning systems
CIS	Climate Information Services
CISIS	Cambodia Information System on Irrigation Schemes
CoE	Centre of Excellence
Co2	Carbon Dioxide
CR	Climate Resilient
DAC	Damnak Ampil Canal
DAHW	Damnak Ampil Headworks
DEAFF	Department of Extension for Agriculture, Forestry and Fisheries ()
DED	Detailed Engineering Designs
DHRW	Department of Hydrology and River Works
DOM	Department of Meteorology
DPs	Development Partners
DR	Dry Season
DSD	Direct Seeding
DSR	Directly seeded rice
FWN	Farmer Water Net
EIRR	Economic Investment Rate of Return
ENPV	Expected Net Existing Value
ENSO	El Niño-Southern Oscillation
ETC	Et cetera
E&S	Environment and Social
ESIA	Environmental and Social Impacts Assessment
ESMP	Environmental and Social Management Plan
FOLU	Forestry and Other Land Uses
FS	Feasibility Study
FWUCs	Farmer Water User Communities
GAP	Gender Action Plan
GCF	Green Climate Fund
GCM	Global Climate Models
GDP	Gross Domestic Product
GEF-LDCF	Global Environmental Facility-Least Developed Countries Fund
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographical Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (
GRM	Grievance Redress Mechanism

GHGs	Greenhouse gas emissions
GoC	Government of Cambodia
Ha	Hectares
HH	Household
HSES	Health, Safety, Environmental and Social Policy
IDA	International Development Association
IFAD	International Fund for Agricultural Development
ILO	International Labor Organization
IMF	International Monetary Fund
IMT	Irrigation Management Transfer
ISF	Irrigation Service Fee
IPC	Interim Payment Certificates
IFC	International Finance Corporation
JICA	Japan International Cooperation Agency
KHC	Kbal Hong Canal
KHR	Khmer Riel
KOICA	Korea International Cooperation Agency
LDCs	Least Developed Countries
LLL	laser land leveling
LogFrame	Logical Framework
MC	Main Canal
MEF	Ministry of Economy and Finance
MSMEs	Micro-, small- and medium-sized enterprise
MoE	Ministry of Environment
MoWRAM	Ministry of Water Resources and Meteorology
M&E	Monitoring and evaluation
MOU	Memorandum of understanding
MRC	Mekong River Commission
MRD	Ministry of Rural Development
MTs	Master Trainers
NCDD	National Committee for Sub-national Democratic Development
NCDM	National Committee for Disaster Management
NDA	National Designated Authority
NGO	Non Governmental Organization
NSDP	National Strategic Development Plan
OHS	Occupational health and safety
OTP	Ou Ta Paong
O&M	Operations and maintenance
PCVA	Participatory climate vulnerability assessment
PDAFF	Provincial Department of Agriculture, Forest and Forestry
PDWRAM	Provincial Department of Water Resources and Meteorology
PEARL	Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood
PICSA	Participatory Integrated Climate Services for Agriculture
PIU	Project Implementation Unit
PIMD	Participative Irrigation Management Development
PMU	Project Management Unit
PO	Producers’ 0rganization
PPSF	Project Preparation Special Fund
RCM	Regional Climate Model
RCP	Representative Concentration Pathway
RDCYIS	Regional Drought and Crop Yield Information Service
RGC	Royal Government of Cambodia
RIMES	Regional Integrated Multi-hazard early Warning System for Africa and Asia
RoW	Right of Way
RPF	Resettlement Planning Framework
RSA	Responsibility Sharing Agreement
SD	Secondary Drain

SC	Secondary Canal
SCADA	Supervisory control and data acquisition
SCF	Standard Conversion Factor
SCMG	Sub-Committee on Meteorology and Geophysics
SDK	Svay Doun Kaev
SECAP	IFAD's Social, Environmental and Climate Assessment Procedures
SESAME	Specialized Expert System for Agro-Meteorological Early Warning
SEP	Stakeholder Engagement Plan
SFW	Special Fund Window
SMSs	Subject matter specialists
SOP	Standard Operating Procedures
SRI	System of Rice Intensification
STRV	Stress Tolerant Rice Variety
SWAT	Soil & Water Assessment Tool
TD	Tertiary Drain
ToRs	Terms of References
TOT	Training of Trainers
TSBRS	Biosphere Reserve Secretariat
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNICEF	United Nations International Children's Emergency Fund
USD	United Sate Dollar
WB	World Bank
WFP	World Food Programme
WMO	World Meteorological Organization
WRI	World Resource Institute
WS	Wet Season
4PF	Public – Private – Producer – Partnership Facility

3 Executive summary

3.1 Context

3.1.1 General

The Climate Adaptive Irrigation Supporting Agricultural Resilience (CAISAR) aims to support the GoC's efforts to sustain food security and improve climate resilience during and after the COVID-19 crisis through restoration and enhancement of smart and climate-resilient irrigation systems and associated ecosystems, flood control management and disaster resilience measures in 3 irrigation schemes situated in four provinces. The development objective of the CAISAR project is to restore rural adaptive capacity by increasing the resilience of the rural population in addressing climate change and variability, extreme events (flooding and drought), and disaster risks to achieve increased resilience and food security. The project will be implemented through the following 3 components: 1) Improving farm-level climate adaptation and resilience, 2) Upgrading and climate-proofing water infrastructure for increased resilience and 3) Institutional Strengthening.The estimated budget of the CAISAR project amounts to US 240 million with AIIB being the major lender but with grant co-financing from the GCF and IFAD.

The present report is the feasibility study report of the CAISAR Project and aims to assess the practicality and viability of a CAISAR project to determine if the project is worth pursuing by evaluating various factors such as economic, technical, institutional, operational, scheduling, and other aspects.

The study helps stakeholders understand the potential risks, costs, benefits, and challenges associated with the project before committing significant resources. Ultimately, its goal is to provide decision-makers (GoC, AIIB, IFAD, and GCF) with the information needed to make an informed choice about whether to proceed with the project or not.

3.1.2 Project Objectives

The project objective is to increase climate adaptation, mitigate the negative impact of extreme climate events, and improve the livelihoods of smallholder farmers and vulnerable rural communities in four provinces of Cambodia. This objective will be achieved by implementing three components that aim at addressing climate change vulnerabilities, increasing agriculture productivity, and developing institutional capacities. The components include Component 1: Improving farm-level climate adaptation, resilience, water use efficiency which focuses on climate resilient crop-water management practices, improve food security and income generation through strengthening and improving adaptive capacity and climate resilience focusing on rice, vegetable, poultry and aquaculture production, provide opportunities for greater market integration and agro-meteorological information and services. Component 2. Upgrading and climate-proofing of water infrastructure for increased resilience which will focus on modernization of irrigation schemes and ponds, flood-proofing and drainage improvements, establishment and training of FWUC and improve the water management of large-scale irrigation scheme with the establishment of a SCADA system, and Component 3. Institutional Strengthening which aims to strengthen Government institutions, mainly the MOWRAM, Ministry of Environment (MoE) and the National Committee for Sub-National Democratic Development (NCDD) and the FWUC. While the focus for MOWRAM will be on up-grading technical capacity in various aspects of irrigation design and management, key focus area for MoE will be on strengthening climate policies and strategies and in building capacities for monitoring climate actions at national level.

This CAISAR feasibility report is produced by MOWRAM with financing support from the PPSF grant from the AAIB, supported by a group of individual experts who were recruited to compile this feasibility report as basis for obtaining the GCF approval for funding. This overall CAISAR feasibility study reports builds upon 2 component reporting:

1) IFAD reporting on Components 1 and 3
2) WAPCOS FIRM reporting on Component 2.

The WAPCOS reporting was also prepared under the AIIB PPSF grant for MOWRAM but at the time of compilation of this overall CAISAR Feasibility report was the final WAPCOS reporting not available yet. The

MOWRAM team of experts were recruited to finalize and concretize the IFAD reporting and to finalize and concretize the WAPCOS FIRM reporting and compile this final CAISAR feasibility report.

3.1.3 CAISAR Project Description and impact

The project aims to bolster climate adaptation, mitigate extreme weather impacts, and enhance the livelihoods of smallholder farmers and rural communities across four provinces in Cambodia. Achieving this goal involves three key components:

- Component 1: Enhancing Farm-level Adaptation and Resilience. This component centers on implementing climate-resilient crop-water practices, fortifying food security, and boosting income through strengthened adaptive capabilities in rice, vegetable, poultry, and aquaculture production. Additionally, it aims to integrate markets and offer agro-meteorological information and services.
- Component 2: Upgrading and climate proofing water Infrastructure for Resilience. Focusing on the modernization of irrigation schemes and ponds, this component emphasizes flood-proofing, drainage enhancements, and the establishment and training of FWUC. It also seeks to improve the water management of large-scale irrigation schemes by implementing a SCADA system.
- Component 3: Strengthening Institutions. This component is geared towards fortifying government institutions, specifically MOWRAM, MoE, NCDD, Provincial Departments and the FWUCs. MOWRAM aims to enhance technical capacities in various facets of irrigation design and management, while MoE focuses on strengthening climate policies, strategies, and capacities for monitoring climate actions at the national level.

The Project is expected to generate the following results:

- Increased year-around water management by improved irrigation efficiency in the dry season and improved flood control and drainage in the wet season;
- Strengthened climate resiliency;
- Improved livelihoods of smallholder farmers and vulnerable rural communities.

The Project's broad reach spans across four provinces and various governmental agencies, promising substantial developmental benefits. It aims to decrease vulnerability to floods, enhance agricultural productivity through climate-resilient technologies, and positively impact over 2.3 million individuals. By ensuring a dependable irrigation supply, the initiative will enable smallholder farmers to intensify crop cultivation, diversify into high-value crops, and access improved farm roads for enhanced market connectivity, resulting in increased and more reliable farming incomes.

1.1 Climate Conditions, Climate Change Projections and Adaptation Measures

Cambodia has distinct dry and rainy seasons, influenced by tropical monsoons; the rainy season (under the influence of the Southwest monsoons) extends from May to October and accounts for 90% of the annual precipitation and the dry season extends from November to April. The average annual rainfall is 1,400 mm in the central plains and increases to 3,800 mm in the mountains and along the coast. In the four provinces the annual average rainfall varied between 1491 to 2458 mm for the period 1991-2020 with the highest rainfall in Pursat and the lowest in Kandal provinces. Annual average maximum temperatures for the four provinces ranged between 33.86°C – 34.92°C for the period 1991-2020, and the average annual minimum temperature ranged for the same period between 20.55°C – 22.32°C. The highest maximum and minimum temperatures were recorded in Kandal, whereas the lowest minimum temperature was recorded in Pursat. April is the hottest month, and January is the month with the lowest average minimum temperatures.

Annual mean temperature anomaly has increased at a rate of 0.23°C per decade since 1950, with a stronger signal of increase during the dry season. The rate of temperature change is notable in the dry season (December, January and February) followed by pre-monsoon (March, April and May) and, to a minor extent, by wet season months (June, July and August). The number of days in a year when the Heat Index exceeds 35°C has increased since 1960s/1970s, reaching around 63 days in 2020. Between 1991-2000 and 2011-2020, the number of days with Heat Index exceeding 35°C has particularly increased in the months of March, April, May, and June. Simultaneously, the number of nights with minimum temperature exceeding 20°C has increased in a major part of the dry season – November through February. No statistically significant changes were observed over the 20th century either in terms of annual rainfall or extreme events. An analysis of extreme indicators showed that the decline in annual rainfall is driven by the decrease in the number of rainy days over the rainy season. Despite this decline, the average rainfall on rainy days has increased suggesting heavier rainfall over shorter periods, which may lead to flooding or soil erosion. All four CAISAR provinces are prone to flash floods owing to repeated heavy rainfall in mountainous areas, which flows into the Mekong tributaries and streams. Such flash floods are swift and last only a few days but cause severe damage to crop and infrastructure, especially around the Tonle Sap Lake. With the increased intensity of wet-season rainfall, the duration and extent of flooding have increased in some areas. On average, annual damages and loss of wet season rice caused by floods and droughts is approximately 120,501 hectares in Cambodia, of which 70 percent of the damage and loss is due to floods and 30 percent is the result of droughts.

The climate projections indicate that precipitation and temperature have become increasingly unpredictable. The temperature anomalies by 2040-2059 against the reference period of 1986-2006 for Cambodia and CAISAR provinces show that the average monthly temperature is projected to increase by 1.83°C by 2040-59. By mid-century, climate change will result in more frequent heavy precipitation days: from 2.4 days to 4.9 days in the rainy season, and an increase in the number of consecutive dry days in the same season: from 0.8 days to 4.4 days. Future projections of climate change in the project area under the RCP4.5 scenario indicate a temperature increase of 1.4-1.6°C by mid-century (2040-2070) and up to 2.2°C by the end of the 21st century (2070-2100); the increase is much higher under RCP8.5 scenario (3.6°C, 2070-2100). With regards to the spatial variability, the inner Cambodia will experience a higher temperature change compared to the coastal areas. While the changes over time will be lower than 1ºC along the coastal areas, the inner parts of the country will experience a temperature rise of more than 2ºC in both RCPs.

The increase in temperature in the project area varies between 0.6-1.0ºC from present to the period from 2024-2050. Similarly, the precipitation shows an increase in the wet season.

Climate change is leading to the change in water balance components as well as total rainfall, water yield, actual evapotranspiration, and potential evapotranspiration in the four provinces. The change in average annual water balance components was simulated under three different climate change scenarios compared to a baseline period from 1995 to 2021 and the future period 2024-2050. All water balance components are expected to increase for climate change scenarios compared to the baseline period. Water yield is expected to increase higher than other water balance components dependent of the water basins. The RCP8.5 is likely to make the most significant change in water balance.

High flow generally occurs during the rainy season in September, October, and November, while the dry season flow in January, February, and March is low. Based on the projection results, the monthly flow change is projected to increase during the rainy and dry seasons for 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios. The highest monthly flow is predicted to increase in October by up to 22%-55% for the 4RCM-RCP4.5, and 4RCM-RCP8.5 compared to the baseline period. The lowest monthly flow will increase in February by 34%-44% for 4RCM-RCP4.5 and 4RCM-RCP8.5.

The project area is likely to experience changes in flood regimes due to the projected increases in temperature and changes in precipitation patterns. The predicted increase in the number of consecutive dry days during both the wet and dry seasons will intensify water scarcity issues, particularly during the dry season, putting increased pressure on water resources and altering catchment water balances. This is expected to largely affect those living in rain-fed regions around the Tonle Sap, as opposed to communities that have access to the mainstream of the Mekong River throughout the year or those with access to irrigation systems and reliable water supply. The intensification of storms and more frequent heavy rainfall events will worsen flood extremes at both the local and regional scale. During the wet season, it is predicted that more severe, frequent, and longer-duration flood events will occur, which will have significant implications for Cambodia. This is particularly concerning because Cambodia is already vulnerable to flooding due to its low-lying topography and the Tonle Sap's complex hydrology.

The changes in precipitation and temperature patterns induced by climate change in the project area could affect the climatic suitability of cereals, vegetables and starchy crops produced. On average, for most crops analysed for this project, the temperature suitability could progressively decrease with some crops falling outside their optimal temperature levels. Overall, this change in patterns could contribute to a reduction in crop yield for both irrigated and non-irrigated crops. For example, in the Kampong Chhang region, rice yield could decrease by anywhere from 9% to 12%, with and without irrigation, respectively, by 2050 (a period of 20 years centered around 2050) compared to 2020. These projections are for the RCP8.5 scenario and without CO2 fertilization. As smallholder farmers' incomes are largely dependent on their yield, it is anticipated that farmers' income could become more volatile with a decreasing trend over time. It is projected that vegetables will be increasingly exposed to heat-stress conditions during the pre-monsoon and early wet-season months (March-June). Over these months, heat-stress conditions (>36ºC) will be exceeded more than 50 days during the growing season, lasting approximately 90 days. The impact of climate on 13 different crops were analysed including rice, cassava, mango, and different vegetables. For most of these crops the suitability analysis showed that the conditions for growing will become worse with the projected climate change for these crops and for the climatic water balance in the project area.

Adaptation recommendations for crops have been suggested mainly dependent on the type of impact to be considered such as 1) Measures against unsuitable climatic conditions, 2) Measures against precipitation deficit, 3) Measures against precipitation excess, 4) Measures against adverse temperature conditions, and 5) Measures against adverse wind conditions.

As poultry production is considered as one of the value chains, also an assessment on how climate change will affect poultry was made. The results indicated that egg production will be less impacted by climate change than broiler production. However, in low humidity & high temperatures more than 300 days per year will be with severe stress exposure already from around 2025. In the situation with high humidity & low temperatures it is estimated that up to 2050 the number of stress exposure will be less than 200 days. Measures to alleviate stress could include careful selection of breed as per the locality that helps to adjust with temperature, poultry houses with proper air circulation, and adequate water supply.

Similarly, an analysis of how future projected climate change patterns in Cambodia would affect the aquatic food production system (both culture and capture fisheries) was made. Fish being cold-blooded animals, their metabolic rate is strongly affected by environmental conditions, especially the temperature. The changes in temperature can have significant influence on the growth and reproductive biology of fish. The influence may be positive or negative depending on the circumstances. Extreme weather events like floods and drought can have serious negative impacts like crop loss due to fish escape, mortality, etc. which will have adverse economic and social impacts on the dependent communities like fish farmers. To minimise the negative impacts, a range of actions can be taken / planned in the form of adaptation measures to climate change. An overview has been provided of the types of impacts there will be on aquaculture focusing on the impacts on fish, the production system and the stakeholders/owners of the system. This also included a list of potential adaptation measures focusing on the short-, medium- and long-term.

Several other studies have also shown that small-scale farmers will be more affected by climate change risks due to increased production costs in farm management and lack of support systems to recover from the effects compared to large-scale producers. Furthermore, it is important to note that climate change effects will not only affect aquaculture production systems, but also the entire value chain. Hence, climate change could be more viewed as an involuntary risk that creates vulnerability on the socio-economic development and raises stress especially on food demand and supply as well as the livelihood system of the farmers.

1.2 The project area

CAISAR project area is composed of the three sub-projects covering seven schemes in four provinces of Cambodia covering a total of 34,204 ha.

- Ou Ta Paong sub-project (Pursat Province)
- Lum Harch sub-project (Kampong Chhnang province)
- Krang Ponley sub-project (Kampong Speu, Kampong Chhnang and Kandal Province).

3.1.4 Ou Ta Paong scheme

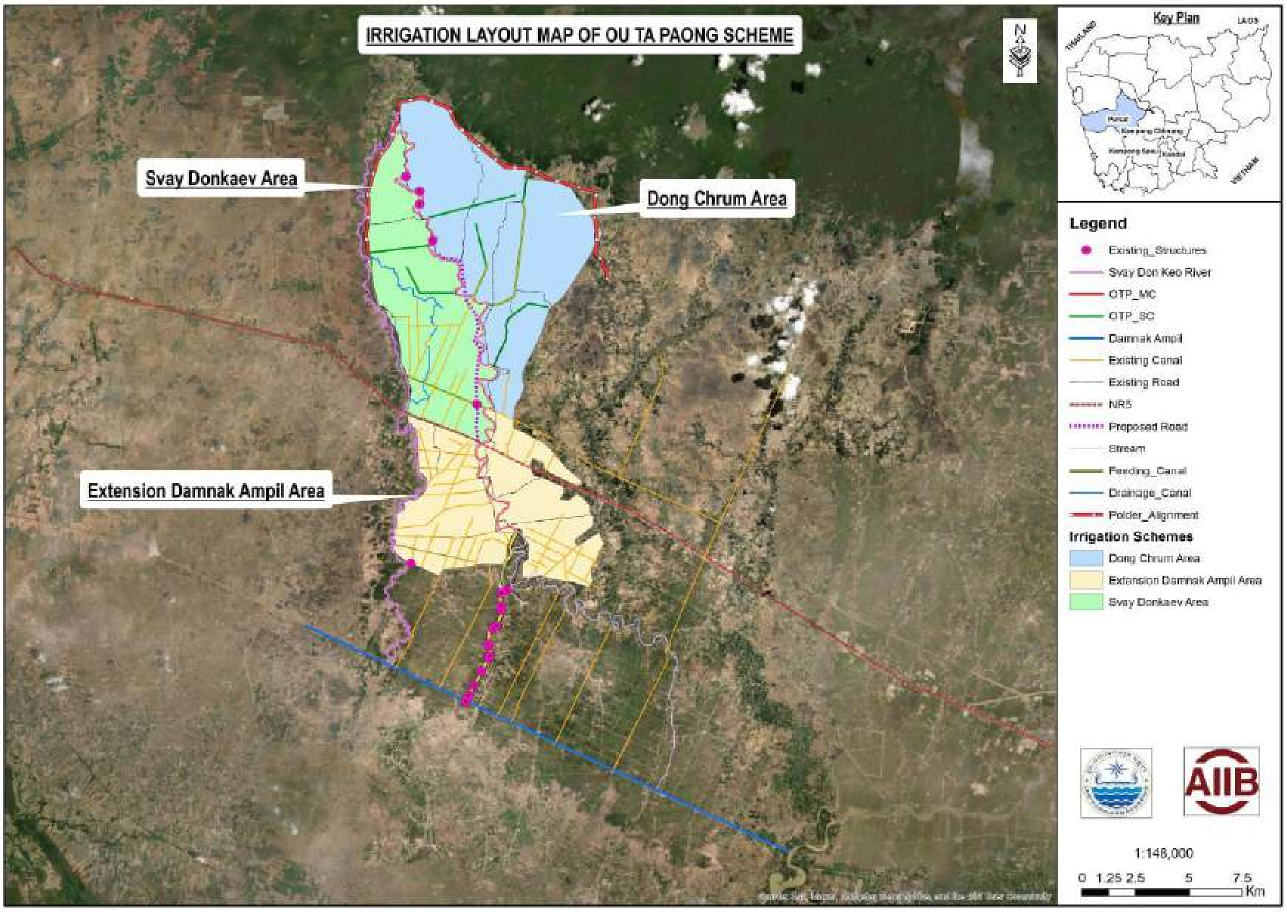
The Ou Ta Paong Irrigation scheme encompasses a command area situated alongside the Ou Ta Paong River, drawing its water supply from various sources. These sources comprise the Pursat River, Svay Donkeov River, and several other rivers that traverse the scheme, including the Ou Ta Paong River itself. This complex water supply system results in the creation of distinct hydraulic zones within the scheme, each characterized by specific water availability levels, which in turn have a direct impact on agricultural output.

The upper part of the scheme, located in south of national Road 5 is mainly supplied by Pursat River, via the Dam Ampil canal and associated irrigation network. The area presents a general slop direction from south to north. Normally, there is enough gradient in the command area to irrigate by gravity this block from Dam Ampil Canal. Therefore, due to the existing infrastructure design, this will be challenging. It will be necessary to develop distribution networks and regulating structures.

The eastern part of the scheme, located between Ou Ta Paong River on the West and XXX on the East, and the National Road 5 on the north. The area presents a general slop direction from south -north. Hence, the area is supplied by all southern infrastructures which include Dam Ampil hydraulic system, Kbal Hong hydraulic system, Wat Loung canal but also partially Svay Donkeov and Ou Tapong River. The gradient hydraulic is very low and due to the existing infrastructure design, the area cannot be irrigated by gravity and will require one stage pumping. It will be necessary to develop distribution networks and regulating structures.

The western part of the scheme, located between Svay Donkeov River on the west and Ou Ta Paing River on the East, and the National Road 5 on the north. The area presents a general slop direction from south -west to north-East. This explains that the area is mainly supplied by Svay Donkeov River. The gradient hydraulic is low and due to the existing infrastructure design, the area cannot be irrigated by gravity and will require one stage pumping. It will be necessary to develop distribution networks and regulating structures.

In all these blocks there are ample opportunities to develop two wet season rice crops by developing proper canal system. This blocks proper canal bed slope of the canal, tertiary canals, regulating structures and most importantly the canal management. As per study there is also an opportunity to develop dry season in 10% command area.



3.1.5 Lum Harch Scheme

The Lum Harch Irrigation scheme encompasses a command area situated downstream the old Lum Harch canal built during Polpot period (1075-1977), drawing its water supply from various streams crossing the canal. These sources comprise several other rivers that traverse the scheme and have very limited catchment area and flow. This water supply system results in the creation of distinct hydraulic zones within the scheme, each characterized by specific water availability levels, which in turn have a direct impact on agricultural output.

The area presents a general slop direction from south-west to north-East. This explains that the area is mainly supplied by the supper streams and make it challenging to divert water from other sources. The gradient hydraulic is low and due to the existing infrastructure design (Existing Lum Harch irrigation), the area cannot be irrigated by the existing infrastructure. Gravity irrigation will not possible and will require one stage pumping.

In all the scheme there is an opportunity to improve the river training and develop two wet season rice crops by developing proper irrigation system adapted to the local context: limited of water resource, soils conditions, lack of road access, low agricultural activities. Some upper land could also diversify crops all along the year.

3.1.6 Krang Ponley scheme

The Krang Ponley Sub-project encompasses four distinct schemes— Brambei Mom, Krapeu Troum, Yotasast, and Krang Bat—spread across Kampong Speu, Kampong Chhnang, and Kandal provinces. The r four schemes have existing irrigation infrastructure. Situated near Highway 5, this sub-project is the closest to Phnom Penh, catering to the significant agricultural demand in the area.

The initial FS study area encompassed part of the schemes, but recognizing the necessity for an inclusive river-basin-wide water resources management strategy to effectively regulate water utilization across all schemes and water-related activities along the river, the Yotasast scheme was incorporated into the CAISAR project in October 2023. Positioned on the left bank of the Krang Ponley, Yotasast's intake is downstream of Krapeu Troum and upstream of Krang Bat. Aligning Yotasast's standards with those of neighboring CAISAR schemes appears to be a logical step forward.

Sitting at an elevation of around 10 meters above sea level, the Krang Ponley floodplain possesses an unusually low permeability due to the accumulation of fine primary soil particles, rendering it highly susceptible to frequent flooding. River-based flooding remains restricted. Throughout the year, particularly during the wet season and the culmination of rainfall, the proposed sub-project zones within Krang Ponley experience extensive flooding. The tail end of the floodplain consistently receives floodwaters originating from the Bassac River and Mekong River, ultimately flowing into the Tonle Sap.

The main water source for these schemes is the river Krang Ponley. Only the Brambei Mom scheme, on the banks of river Ou Khley, has its own rather minor reservoir, but this can receive supplementary supply from an outlet on Anlong Chrey Reservoir.

3.1.7 Alignment with government policies

The CAISAR project is aligned with the Cambodian government's long-term development goals and policies in several ways.

Alignment with CLTSD 2030 and Cambodia Vision 2050

- Economic Diversification and Growth: CAISAR aims to increase the productivity and resilience of smallholder farmers, contributing to rural development and inclusive economic growth.
- Infrastructure Development: CAISAR focuses on rehabilitating and modernizing irrigation infrastructure, enhancing the efficiency and resilience of water management systems.
- Human Capital Development: CAISAR promotes climate-smart agriculture practices and provides training to farmers, enhancing their knowledge and skills.
- Social Protection and Poverty Reduction: CAISAR supports the livelihoods of vulnerable communities in rural areas, contributing to poverty reduction and social resilience.
- Environmental Sustainability: CAISAR promotes water conservation and sustainable agricultural practices, contributing to environmental protection and climate change adaptation.

Alignment with Specific Policy Initiatives

- National Agriculture Sector Policy 2019-2030: CAISAR supports the government's goal of promoting climate-resilient and sustainable agriculture.
- National Water Resource Management Policy 2016-2025: CAISAR contributes to the efficient and sustainable use of water resources for irrigation.
- National Climate Change Strategy 2019-2030: CAISAR helps enhance the resilience of agriculture to climate change impacts.

1.3 Details Component 1 - Farm Level Climate Adaptation and Resilience

The objective of this component is to build climate resilience of smallholder farmers through evidence-based planning and context-relevant climate resilient practices at the farm level. The component will support smallholder farmer groups in the project target irrigation command areas to implement climate-resilient crop and water management methods. It will strengthen institutional capacity to provide extension services on CR technologies, and ensure farmers have access to climate information and agro-meteorological advisory services for their agriculture planning. It will improve both digital and physical connectivity of the farmers for better production, transportation and improved market access.

The component will be implemented in the command areas of irrigation systems that will be improved in component 2. So, it will be working with the same group of farmers, FWUC and commune councils, and other stakeholders belonging to Ou Ta Paong, Lum Hach, Krang Ponley and other irrigation systems. However, sub-component 1.3 that focuses on agromet advisories and sub-component 1.4 that focus on climate proofing of rural roads will have wider beneficiary circles as these services will not be limited only to the farmers of the irrigation command areas. ~~In total, this component will directly benefit 105,000 families~~.

The component will be implemented following a participatory approach ensuring involvement of beneficiaries and relevant stakeholders including women and minority groups. An action plan to build Farmer's Resiliency shall be prepared blending the scientific knowledge and information together with the local adaptation practices, perceptions, criteria and preferences. The implementation of the AP will be facilitated by the project creating enabling conditions and capacity support. The outcome shall be continuously monitored, and lessons and experiences will be utilized to improve the implementation process. The overall implementation framework for this component is shown in Figure 1.1. With improved capacities and access to information on markets and climate, and continued extension support it is expected that the process of adaptation and change will continue even after the closure of the project.

The expected results of these components will be achieved through generation of the following five interrelated outputs and are described in the following paragraphs.

- **Sub-Component 1.1 Farm-level Climate Adaptation and Resilience**

Output 1.1. Increased farmer capacity in climate resilient agriculture

- **Sub-Component 1.2 Climate Adaptive Value Chains**

Output 1.2 Climate adaptive value chains developed by 4Ps and increased access to finance.

- **Sub-Component 1.3 Agro-meteorological information and services**

Output 1.3. Increased access to and use of climate information and advisory services for climate responsive water-use and crop planning

- **Sub-Component 1.4 Resilient Rural Roads**

Output: 1.4 Increased resilience of farm road infrastructure to climate changes

The four outputs are directly linked at farm level actions and will be implemented in an integrated manner. The component will be executed by the NCDD with assistance from provincial, district and commune agricultural departments, and other key stakeholders as required. The NCDD will require technical assistance in several areas in executing the activities, and these will be addressed through hiring of service providers or individual experts as required.

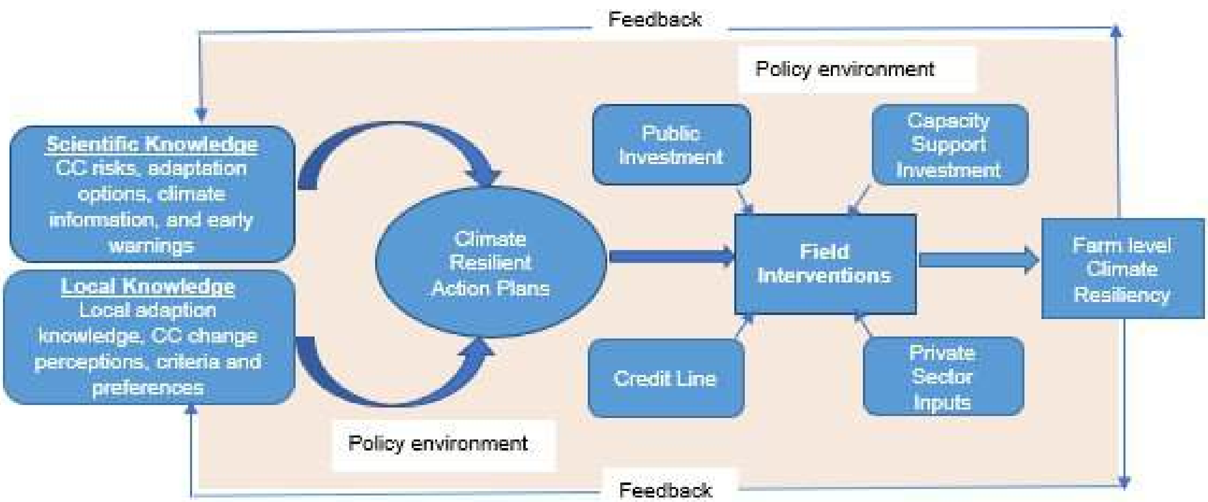


Figure 0-1. Implementation Framework for Farm Level Climate Resiliency

1.4 Details Component 2 - Upgrading and climate-proofing water infrastructure for increased resilience

Component 2 will focus on rehabilitating/creating and modernizing hydraulic infrastructure, including canals, ponds, flood-proof infrastructure (river, drain) and to provide high-efficiency climate-resilient irrigation systems for adapting to both increasing flood and drought conditions. It will include also support and capacity building to O&M operators at both, provincial (PDOWRAM) and scheme (FWUC) level, to ensure the sustainability of the scheme. The output it will secure and increase farmer's agricultural production by improving the irrigation supply and protection crops from water-related disasters.

These climate adaptation activities will ensure that the projected increase in extreme wet days and more frequent upstream flooding decrease the damage to the infrastructure, and more importantly to agricultural practices / rural economic activities, but also transform this risk into a green opportunity by storing more water in irrigation ponds, improved drainage facilities to drain the excess flood, create polder to specific schemes to adapt to climate change and increased access to water through solar pumping.

It will be implemented through four integrated sub-components.

Sub-Component 2.1. Modernization of irrigation schemes and ponds: Rehabilitating, upgrading and, where water and land resources are available and socially and environmentally possible, constructing new irrigation schemes and storage ponds have a positive climate adaptation and mitigation impact. Thus, this sub-component has two main benefits: (i) increasing water availability and restoring storage capacity for irrigation while decreasing the destructiveness of floods on downstream locations; and (ii) the possibility of implementing crop diversification and new activities to increase farming incomes such as fish farming or poultry production. It will also allow to creation of employment opportunities, especially for young people. This measure would be part of integrated and resilient water resources management and climate proofing to secure the sustainability of the overall irrigation system against negative climate impacts of droughts and dry spells as well as floods during the monsoon season.

The implementation will focus on maximizing ecosystem-based solution, reducing energy consumption, and consequently reducing GHG emissions. In addition, current diesel pumps lifting water to tertiary and secondary canals will be replaced by collective solar pumping systems when the pre-conditions are acceptable with low pressure water delivery at the plot level to increase the water efficiency, avoid land losses and improve the water service. The implementation will follow a participatory approach involving farmers right from survey, design, prioritization, and construction implementation. This subcomponent will be financed by AIIB, GCF and Government. Moreover, these technologies will allow to save time and labour, especially for women, and offer opportunities to engage rural youth.

Sub-Component 2.2. Flood-proofing and Drainage improvements: It focuses on improving disaster prevention and protection of farmlands and assets by establishment of early warning systems and improvement of the existing drainage and flood protection systems. Existing drainage and river training networks (especially of Ou Ta Paong and Lum Harch schemes) will be improved based on the results of the hydrological modelling and consultation with stakeholders living in the project areas. The applicability of nature-based solutions in flood management (e.g., revival of old river channels like Ou Ta Paong River, embankment improvement with vegetation strips, etc.) will be reviewed and subsequently used to inform the investment planning under this component. Farmers will also be supported to restore and construct farm level drainages as required while project will install sub surface drainages in needy areas. In addition, it will also support strengthening of river training and their embankments to make them resilient against intensifying flood threat under the changing climate context. These improved embankments will be linked to the flood risk assessments improved in Component 1 and the water-related data will feed into the national database to improve flood early warnings for target areas (delivered through sub-component 2.4). New flood protection embankments will be constructed in Ou Ta Pong and Stoeung Krang Bat irrigation schemes to avoid food from Tonle Sap on their command area.

Sub-Component 2.3. Establishment and training of Farmers Water User Communities (FWUC): FWUCs are critical for ensuring the sustainable and effective operation and maintenance of irrigation schemes, in particular at the distributary network system (secondary tertiary and quaternary levels. With the rehabilitation of the irrigation systems and the creation of a flood protection embankment system of the three subprojects, the project will support the establishment and capacity building of the FWUC from the participatory approach of FWUC creation in the design, development and sustainable use of the rehabilitated irrigation schemes to be rehabilitated by the Program as these organisations are crucial for O&M management. This will include investments in improving the capacities in 1) Institutional: dialogue with MoWRAM, legal recognition, responsibility sharing agreement, 2) Organisational: governance, internal operating rules for water and scheme management, agricultural development and marketing, 3) Technical: participation to the design of the irrigation networks, execution of maintenance and servicing tasks, farming practices; 4) Financial: preparation of budgets, fundraising, accounting management, Irrigation Contribution Service (ISC) planning and collection, access to financial institutions, 5) Gender focus with strong action for women's empowerment and their social participation.

Sub-Component 2.4. Water Information System: This sub-component will consist of establish a SCADA system for the West Pursat irrigation hydraulic system to improve the water availability of Ou Ta Paong Irrigation scheme. The SCADA model is crucial to tackle the significant challenges in the agricultural sector on the inefficiency of irrigation practices, characterised by both indiscriminate and irregular water distribution, leading to substantial water wastage. This approach offers real-time information on water levels and flow rates, enabling more accurate and timely responses to fluctuations in water demand. The SCADA presents a contemporary solution for the modernization of existing irrigation systems, prevent flooding and it does so with a fundamental, cost-effective approach. Implementing the Water Information System for the western hydraulic system of Pursat province allows for command and control functionalities while collecting valuable data on irrigation. This, in turn, will rationalise and streamline the irrigation process, significantly mitigating the wastage of water.

Sub-component 2.1 is dedicated to the enhancement, establishment, and modernization of hydraulic infrastructure to elevate irrigation practices within the framework of the three sub-projects. On the other hand, component 2.2 is geared towards enhancing infrastructure that guards against flooding, encompassing rivers, drainage systems, and embankments. Consequently, the project aims to deliver irrigation systems that are highly efficient and resilient to climate changes, catering to both increased flood risks and drought conditions. The outcomes of these two components are essentially the same – they aim to ensure and boost agricultural production by improving irrigation supply and safeguarding crops from water-related disasters.

1.5 Details Component 3 - Institutional Strengthening

This component aims to strengthen Government institutions, mainly the MOWRAM, the NCDD and the FWUCs. The focus for MOWRAM will be on upgrading technical capacity in various aspects of CR irrigation design and management. The key focus area under NCDD will be on climate resilient crop production. . This component will have two sub-components.

This MOWRAM sub-component supports, training and capacity development for the project management unit (PMU) and will enhance the institutional capacity of the Ministry of Water Resources and Meteorology (MOWRAM) and Provincial Departments of Water Resources and Meteorology (PDWRAM). This includes preparation of design manuals, capacity building and training in river basin management and water accounting, the operation of Supervisory Control and Data Acquisition (SCADA) systems, in the design and implementation of climate-smart green technology, low-carbon pathways, and climate-proof irrigation systems and gender mainstreaming and social inclusion. The development of standard designs and construction manuals will enhance the replicability and long-term sustainability of the project. In addition, it will build capacities to employ digital platforms and the best-available climate and water data to monitor and boost the operational performance of the irrigation systems and future maintenance plans. Key activities include: Strengthening Water Accounting Systems and River Basin Management, Communicating with stakeholders, Support to and guidance of Leaders of Commune, Village and FWUCs, Gender awareness and Preparation of climate resilient design manuals for irrigation and train staff.

The NCDDS Sub-Component will include:

Strengthening NCDDS' project management capacity: This includes training on project cycle management, financial management, monitoring and evaluation, human resources management and Climate Change aspect.

Policy formulation and implementation: Enhancing the capacity to develop and implement effective policies and programs at the sub-national level, especially the Sub decree 182 on the functions transferred to the district level. Disseminate and knowledge sharing the role and responsibility of district and municipality to support farmers.

Resource mobilization: Strengthening skills in resource mobilization, and planning at the sub-national level. GCF is another window where institutions can access to Climate Fund, so capacity building of NCDDS staff on project feasibility study and preparing full project proposal to GCF can help NCDDS to mobilize more resources.

Institutional strengthening and coordination: Promoting efficient institutional structures, coordination mechanisms, and inter-agency/ministry collaboration at the national level and sub-national level.

At the provincial level the Sub-component will focus on:

Conduct a detailed capacity development needs assessment - The full evaluation of the current capacity of PDAF, PDOC, PDWA to support extension service will be done by a consultant recruited for this purpose. Tools to be developed and administered to provincial staff and a report capturing the findings will be drafted. The purpose of a capacity development needs assessment is to identify the gaps between the current capacity of the Provincial Staff and the capacity required to achieve its objectives.

Training in technical concepts and cross-cutting subjects - Training and capacity building for Provincial staff in areas such as policy analysis, project management, market systems development and use of ICT tools. And also support on Adoption of ICT tools to improve the project efficiency, effectiveness, and transparency. To effectively carry out their duties, Provincial staff need to be well-versed in a wide range of technical concepts and cross-cutting subjects. In addition to the gaps, topics like - Sustainable agriculture, Climate change adaptation and Information and communication technology (ICT) to be included in training.

1.6 Implementation Arrangements

The institutional arrangements for the CAISAR project should be structured to ensure clear lines of authority, coordination among stakeholders, and efficient implementation of project activities. The project will have a Steering Committee chaired by a Minister of MOWRAM with memberships from MoWRAM, MEF, MOI (NCDD), and MOE, all at Secretary of State level and the 4 Governors of the participating provinces and meet at least once a year. The main tasks of the steering committee are to approve the annual project work plans and budgets, as well as monitoring project progress and ensuring compliance with project objectives and donor requirements.

The project will have MOWRAM as the main Executing Entity responsible for Component 2 and part of Component 3, while NCDDS will also be an Executing Entity responsible for component 1 and part of Component 3. In the implementation of Component 1 NCDDS will be using service providers for the agricultural parts of components 1&3. To properly implement the respective components, both MoWRAM and NCDDS will establish appropriate Project Management Unit (PMU) and Project Implementation Units (PIUs) working as Implementing Entities.

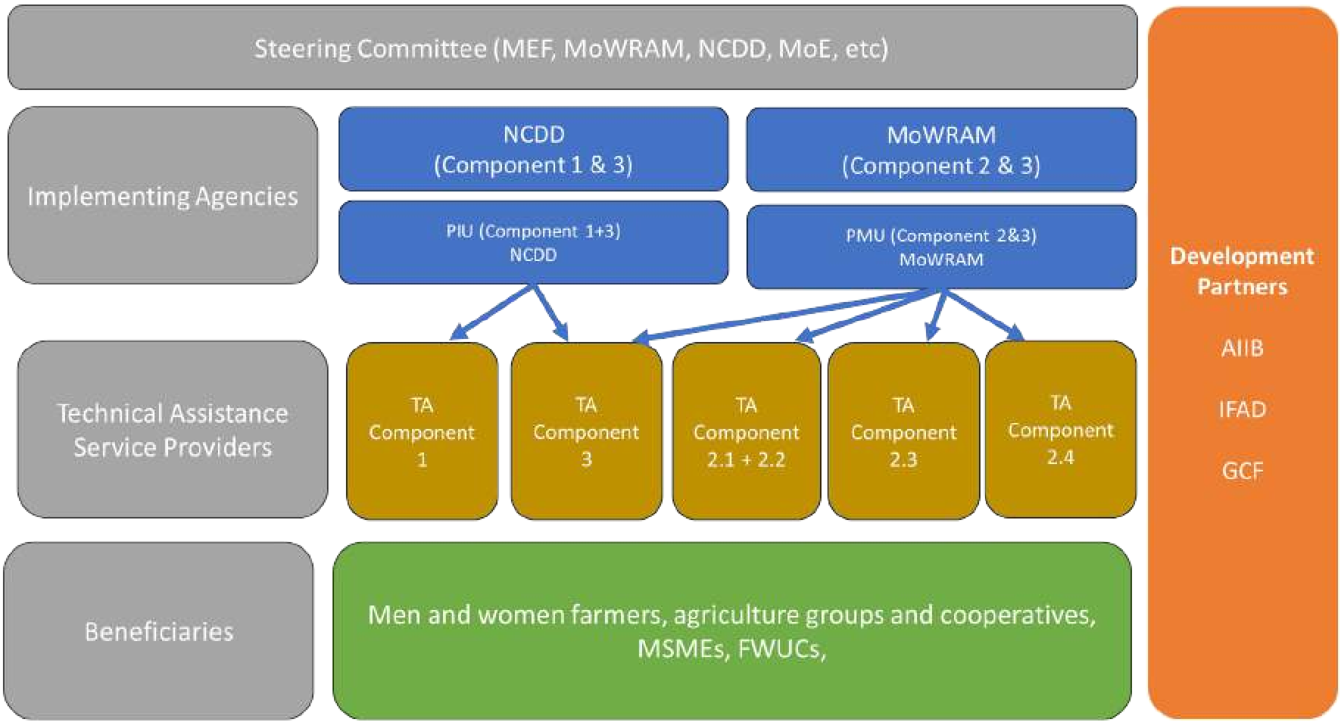


Figure 0-2 CAISAR Implementation Arrangements

1.7 Economic feasibility

The economic analysis of the CAISAR project, considering all costs, indicates promising economic returns over a 30-year evaluation period with a social discount rate of 9.47 percent. The estimated Economic Internal Rate of Return (EIRR) is 16.3 percent, and the Expected Net Present Value (ENPV) is projected at USD 143.6 million, with a benefit-cost ratio of 1.26 and a payback period of nearly 12 years. Sensitivity and scenario analyses underscore the robustness of these evaluations, suggesting that the project would remain profitable even with a 20-year evaluation period.

The implementation of activities under Components 1 and 2 is viable, considering a 30-year evaluation scenario and a social discount rate of 9.47%, with IRRs of 15.8% and 16.5%. Moreover, all schemes demonstrate an IRR higher than the social discount rate used in this analysis, indicating the economic viability of each scheme. This viability is primarily due to the significant reduction in damages caused by annual flooding, both on and off the farms, and significant contribution of the benefits related to the GHG emission reductions.

1.8 Timeline of the project

The project implementation period is planned for 7 years from 2025 to 2031.

4 Background and baseline conditions

4.1 Baseline Conditions

4.1.1 Agriculture in Cambodia

Cambodia is a lower middle–income country with a GDP per capita of 1,648 USD and a population of 16.3 million. The economy significantly expanded before the pandemic, growing at an average of 7.9 percent annually from 1999 to 2019. The manufacturing industry, particularly the textile industry, has been the main driver of economic growth. Manufacturing finally took over the service sector in 2021 as the biggest sector of the economy. The country has successfully initiated structural transformation, moving resources from an agriculture-intensive economy toward higher productivity sectors such as manufacturing and construction.

During the rapid economic expansion and structural change, the poverty rate in Cambodia halved from 33.8 percent in 2009 to 17.8 percent in 2019/20, meaning almost 2 million people were pulled out from poverty. The pandemic, however, reversed the progress back for around 460,000 people, raising the poverty rate by 2.8 percentage points. The government then introduced its first national cash transfer program in June 2020 to support 700,000 poor and vulnerable households during the pandemic. An impact assessment report by UNDP estimated a reduction of 2.7 percent in 2020 and 3.4 percent in 2021 of poverty rate thanks to the program. Moving forward, given the economy's stable recovery trajectory, Cambodia is estimated to pick up the progress on poverty alleviation.

According to labor data by the International Labor Organization (ILO), Cambodia maintained its level of unemployment to be the lowest among its ASEAN peers even during the pandemic. It went up from 0.14 percent in 2019 to 0.30 percent in 2020 and 2021 due to the recession. However, the Cambodia Labor Force Survey 2019 indicates that a large proportion of the employed population are in vulnerable employment, around 48.8 percent of the employment are working as unpaid family workers and own-account workers; and that 78.3 percent of the employed people are in informal employment. Apart from having the highest labor force participation rate in Southeast Asia since 2000, Cambodia also has a high proportion of youth in the labor force. In 2019, about 1.5 million youths aged 15-24 were in the labor force, representing 57.2 percent of the country's labor force. In addition to having low-paying jobs as blue-collar workers, participating in the labor market instead of continuing education and training will limit their future employment and career prospects.

Looking ahead, infrastructure development will continue to remain on the government's agenda. The Cambodian government recognizes the role of infrastructure as one of the enabling environments for economic diversification to maintain high economic growth in the medium- and long-term. The National Strategic Development Plan (NSDP) 2019-2023 listed the improvement of the logistic system and enhancement of transport, energy, and digital connectivity as one of the key priorities. Aligned with the NSDP, the government is currently preparing the Transport and Logistics Master Plan worth 50 billion USD for the next 10 years to improve and expand road infrastructure and connect the main highways among international border checkpoints. The Global Infrastructure Outlook estimated a total of 77 billion USD of investment needed for infrastructure in Cambodia from 2020 to 2040; 4 billion USD of which, approximately accounts for 5.2 percent of the total investment needs, comes from the water sector.

In addition to the promotion of high economic growth, the country also puts a lot of emphasis on inclusive and sustainable development by placing priority on boosting the resilience and productivity of the agriculture sector. The Agricultural Sector Master Plan 2030 was developed in alignment with the NSDP 2019-2023 to increase the competitiveness and sustainability of the sector by improving the irrigation system, land management, and connectivity to local and global markets.

4.1.2 Recent Economic Development

Cambodia is a lower-middle-income country with an income per capita of around USD1,600 and a population of 16.3 million. The country achieved high growth rates of above 7 percent since 1991, thanks to an increase in exports, strong internal demand, and an increase in FDI. Construction, garments and footwear, as well as tourism were the main drivers.

In 2020, the economy was significantly hit by COVID-19, mainly due to a decrease in external demand, leading to a contraction of 3.1 percent in real GDP. After reopening the economy at the end of 2021, GDP growth was estimated to recover to 3.0 percent in 2021 and 5.0 percent in 2022 due to the revival of the tourism sector and strong growth in exports.

Cambodia has been running persistent current account deficits, and the deficit is estimated to widen substantially in 2021. Imports of gold surged while tourism was subdued in mid- 2021, driving the current account deficit to widen significantly to over 47 percent of GDP. However, better trade performance in 2022, thanks to strong garment exports, helped to reduce the deficit to 30 percent. Despite high deficits, the exchange rate has been stable, while foreign reserves have been adequate, covering around eight months of imports.

Inflation rose to 5.8 percent in 2022 due to the rising global oil and food prices.

To counteract the negative impact of the pandemic, the government enacted countercyclical measures, which led to a budget deficit of 7.1 percent of GDP in 2021. Fiscal stimulus continued into 2022, but revenue improved with economic recovery, and the deficit narrowed to 4.1 percent in 2022. Public debt increased to around 36 percent of GDP in 2021 and 2022.

Table 1-1.Cambodian Macroeconomic Indicators

Selected Macroeconomic Indicators	2019	2020	2021*	2022*	2023*	2024*
Real GDP growth (%)	7.1	-3.1	3.0	5.0	5.4	6.1
Inflation (average, % change)	1.9	2.9	2.9	5.8	3.5	3.0
General government fiscal balance	3.0	-3.4	-7.1	-4.1	-5.0	-3.4
General government gross debt	28.2	34.4	35.9	36.3	37.2	38.2
Current account balance	-15.0	-8.5	-47.5	-30.0	-14.1	-9.9
External debt	28.2	34.4	35.9	36.1	36.3	36.6
Gross international reserves (months of imports)	9.8	9.6	9.4	9.1	9.5	9.9
Gross international reserves (USD billion)	18.8	21.3	20.9	20.7	..	..
Exchange rate (Riel/USD)	4,055	4,035	4,064	4,108	4,050	..

Source: IMF country report 22/371; in percent of GDP, unless indicated otherwise; FX rates from Refinitiv, end-of-period (for 2023: as of April 5); '*' denotes projections

4.1.3 Hydrological Conditions of Cambodia

Cambodia is heavily reliant on water inflows from upstream countries, with the Mekong River flowing through the country for approximately 500 kilometers before entering the Vietnamese Mekong Delta. The Tonle Sap River connects the Mekong River to the Tonle Sap Great Lake System, one of the world's most productive ecosystems, at the Phnom Penh-Chaktomuk junction. The Mekong River splits into two rivers downstream of Phnom Penh: the Lower Mekong River, which flows into the South China/East Sea after passing through the Vietnamese Mekong Delta, and the Bassac River, which flows directly to the East Sea with some spills and connections to the West Sea/Gulf of Thailand. Approximately 86% of Cambodian territory is within the Mekong River basin, including the catchments of the Bassac River, the Tonle Sap River, the Tonle Sap Great Lake, and its tributaries. The coastal area in the southwest and the Vaico basin in the southeast make up the remaining portions. In the wet season, the two Vaicos connect to the Mekong flood channels and are henceforth considered part of the Mekong delta. The four riparian countries, Laos, Thailand, Cambodia, and Vietnam signed the "Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin" (the 1995 Agreement) in April 1995. The Mekong River Commission (MRC) was established in 1995 based on the Agreement. There are significant discharge data gaps in Cambodian territory from the standpoint of data gaps. Due to the long-lasting political instability, no flow data have ever been available in Cambodia since the early 1970s. However, the upgrading process supported by AusAID's Appropriate Hydrological Network Improvement Project (AHNIP) had advanced as a trunk telemetry system of water level gauging stations along the mainstream. To avoid unfavorable overlapping with the AHNIP, the remaining hydrological stations located in and around the Phnom Penh areas were selected. These are

Kompong Cham, Chroy Changvar (Phnom Penh Mekong), Koh Norea, and Neak Luong on the Mekong mainstream, Phnom Penh Port on the Tonle Sap, Monivong Bridge (Chak Tomuk or Phnom Penh Bassac) on the Bassac River, as illustrated in Figure 1.1.

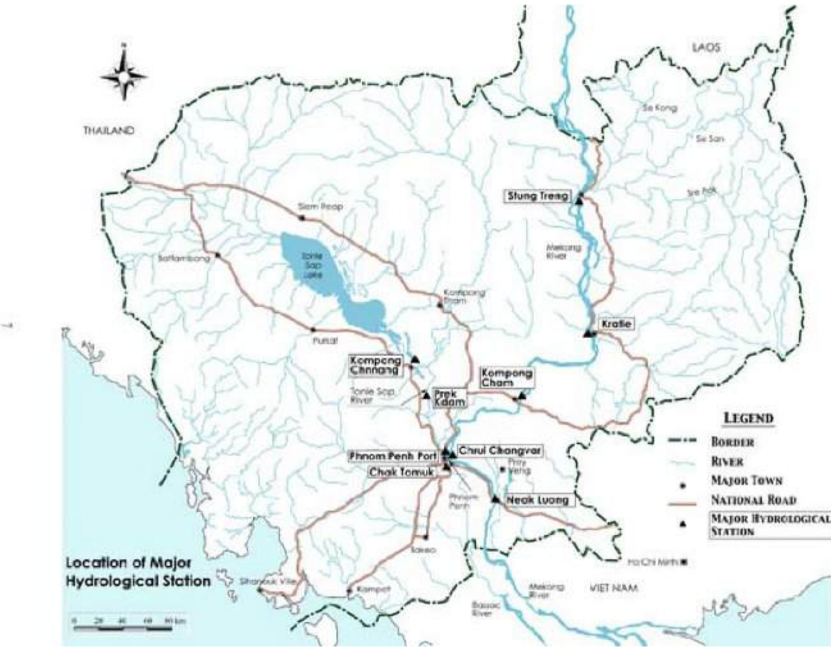


Figure 1-1. Major Hydrological Stations in Cambodia

The area downstream of Kompong Cham, particularly the capital city of Phnom Penh, is shielded from floods by the natural flood attenuation functions. These functions include reducing the flood peak by overbanking flooding in the floodplains and dispersing flood risk through flood water diversion into three channels. Additionally, flood flow conveyance to the Great Lake is a critical natural function for preserving the Great Lake's environment. During the same period, an almost equivalent volume of overbanking floodwater occurs compared with the Tonle Sap reverse flow. Therefore, these natural functions must be preserved to protect human lives and assets in cities and towns from floods, as well as to safeguard the Great Lake and floodplains' natural environment and resources from uncontrolled development. These functions are essential for Cambodia's sustainable development.

Upstream of Kratie, the river generally flows within a well-defined mainstream channel. In most years, this channel contains the full discharge with only local over-bank flow to natural storage. Downstream of Kratie, in its Delta, the Mekong flow is largely affected by backwater effects during the flood season and tidal effects during the dry season. Seasonal floodplain storage dominates the annual flow regime and there is significant movement of water between channels over flooded areas, the seasonal refilling of the Lake and the flow reversal in the Tonle Sap River.

MOWRAM distinguishes five River Basin Groups in Cambodia, based on their respective hydrology as show in Figure 1-2.

The Five River Basin Groups and main rivers in the Kingdom of Cambodia:

- The Coastal Catchments located in the south-western part of the country and confined by the Gulf of Thailand in the south-west and the Elephant and Cardamom mountainous chains in the north-east. It has a total area of 18,046 km². Eight river basins lie within this Basin Group.

- The 3S Rivers Basins: the Se Kong, Se San and Sre Pok Rivers draining to the Mekong River at Stung Treng. The 3S Basin Group catchment area is 78,645 km2, of which 25,965 km2 is located in Cambodia.

- The Upper Mekong, starting from the Laos-Cambodian border to some 20 km downstream of Kratie at the border between Prek Te and Prek Chhlong catchment boundary. The total area is 19,522 km2. The Mekong River here is characterized by a braided channel with sand islands.

- The Tonle Sap Great Lake, with a total area of 81,663 km2, which consists of the Great Lake, the Tonle Sap River and each of the tributary catchments. The Basin Group is bordered by the Elephant and Cardamom Mountains in the west and south-west shielding the basin from the Gulf of Thailand, and the Dangrek mountains in the north, which separates the basin from the Korat Plateau. Part of the catchment of the Mongkol Borei and the Sisophon fall within Thailand, also known as the 9T/9C catchment.

- The Mekong Delta from midway between Kratie and Kampong Cham to the border of Cambodia and Viet Nam, including the Vaico river system but excluding the drainage area of the Tonle Sap River and Lake. The total area is 35,839 km2. Most of the area is on the Mekong River floodplain, and most rivers in it are affected by the Mekong River flood waters. The grouping includes the Prek Chhlong and Prek Thnot and the Takeo River or Slaku.

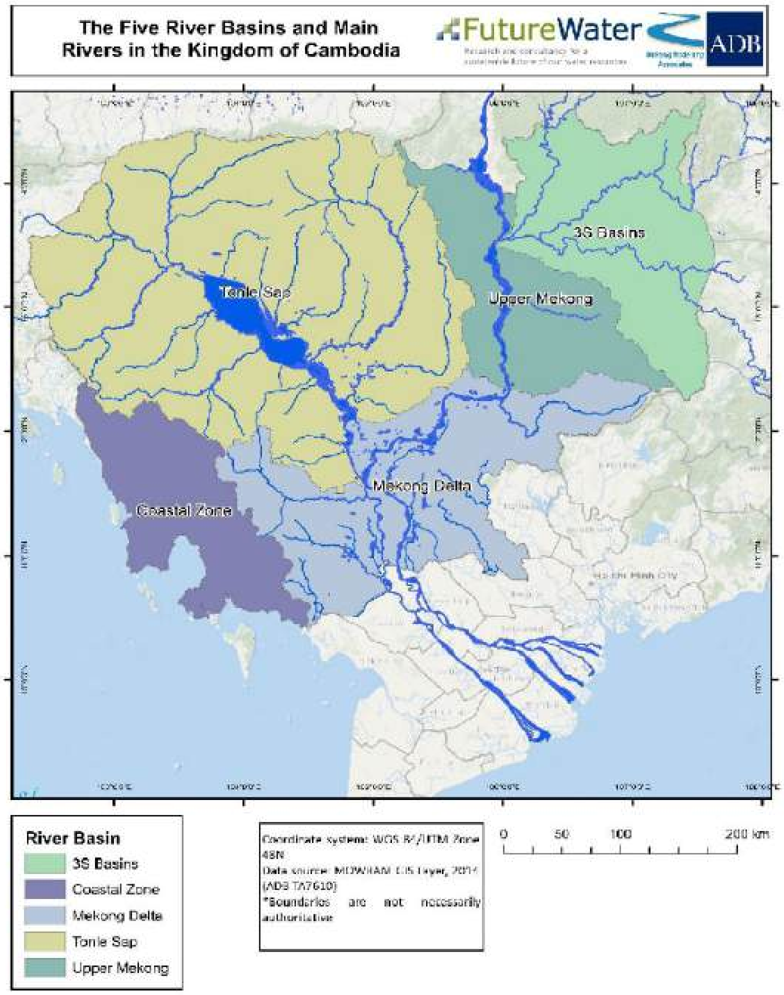


Figure 1-2. Five River Basin Groups and main rivers in the Kingdom of Cambodia.

1.9 The project area

CAISAR project area is composed of the three sub-projects covering six schemes in four provinces of Cambodia covering a total of 32,056 ha as shown in Tables 1-2 and 1-3 and Figure 1-3

- Ou Ta Pong sub-project (Pursat Province)
- Lum Harch sub-project (Kampong Chhnang province)
- Krang Ponley sub-project (Kampong Speu, Kampong Chhnang and Kandal Province).

The Table 1-2 presents the sub-project, schemes and provinces targeted by CAISAR project.

The Figure 1-3 shows the location of the 6 schemes under CAISAR.

Table 1-2. Summary of the CAISAR project targeted area

Sub-project	Schemes	Provinces
Ou Ta Paong sub-project	Ou Ta Paong	Pursat
Lum Hach	Lum Hach scheme	Kampong Chhnang
Krang Ponley	Krapeu Troum Yotasast Steung Krang Bat Brambei Mom	Kampong Speu, Kampong Chhnang and Kandal

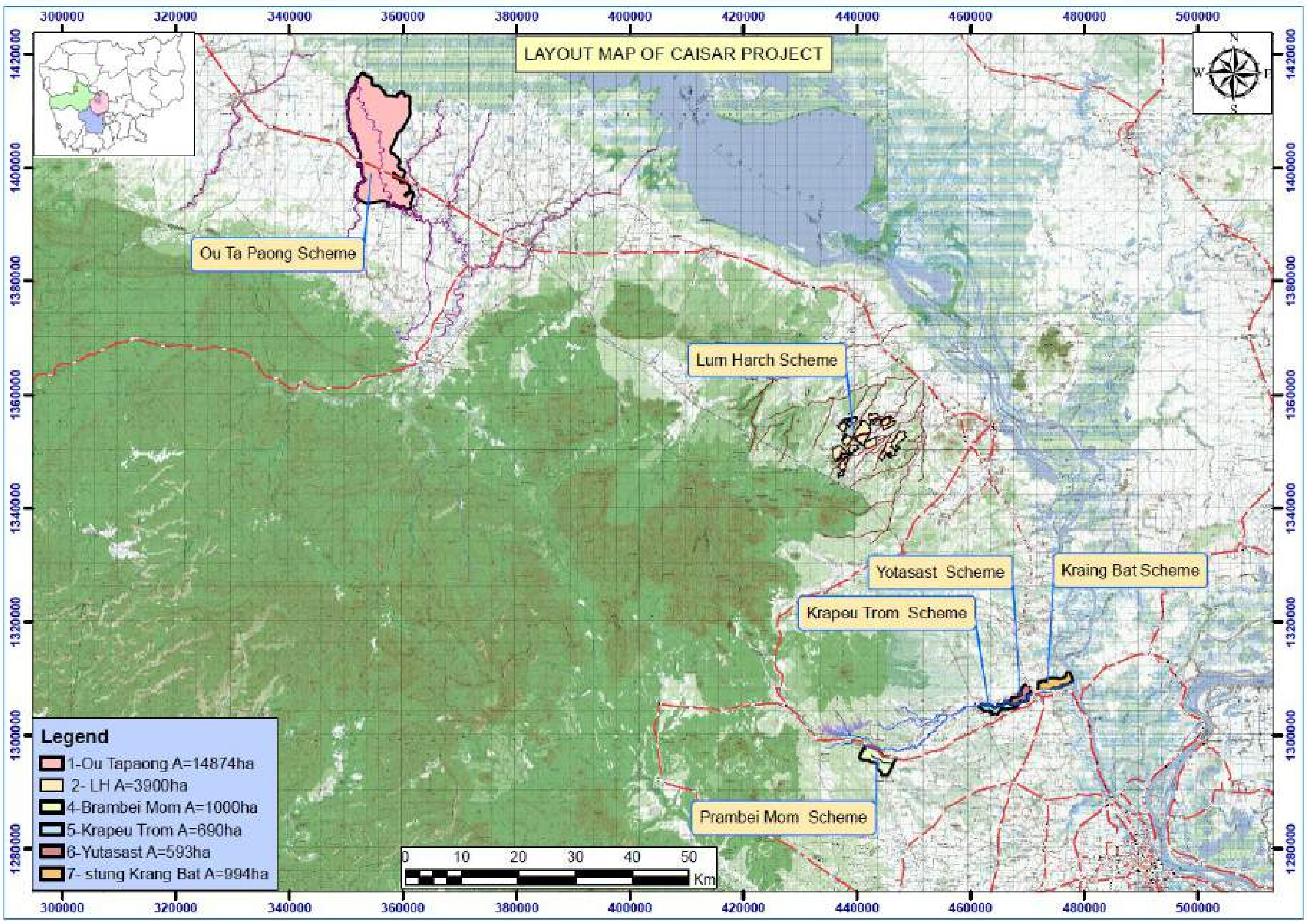


Figure 1-3 Location of the 6 CAISAR project schemes

The Table 1-4 detail the area covered by CAISAR project under each scheme.

Table 1-3. Summary of the targeted area for each scheme under CAISAR project

Irrigation scheme	Component 1 *Same as Comp 2.1+2.2		Component 2						Total	
			Component 2.1		Component 2.2 *Additional area of C2.1		Component 2.3 *Additional area of C2.1+ C2.2 ** Not included in the total area			
	Area(ha)	Ratio (%)	Area(ha)	Ratio (%)	Area(ha)	Ratio (%)	Area(ha)	Ratio (%)	Area(ha)	Ratio (%)
Ou Ta Paong	17,079	53%	14,874	67%	2,205	22%	80,000	100%	17,079	53%
Lum Harch	6,350	20%	3,900	18%	2,450	24%	-	-	6,350	20%
Kropeu Trom	1,140	4%	690	3%	450	5%	-	-	1,140	4%
Yotasast	2,693	8%	593	2%	2,100	21%	-	-	2,693	8%
Stoeung Krang Bat	1,394	4%	994	5%	400	4%	-	-	1,394	4%
Brambei Mom	3,400	11%	1,000	5%	2,400	24%	-	-	3,400	11%
Total	**32,056**	**100%**	**22,051**	**100%**	**10,005**	**100%**	**80,000**	**100%**	**32,056**	**100%**

C2.2* River training: length of river training work * 400 m (width of impact) converted in ha.
C2.2* Polder: length of polder (m) * 1000 m (width of impact) – converted in ha.
C2.3* Masterplan area potential impact (80.000 ha) – OTP scheme area (not included in total area)

Below is provided a short description of each of the target areas and a detailed baseline description is provided in Appendix 4.

4.1.4 Ou Ta Paong scheme

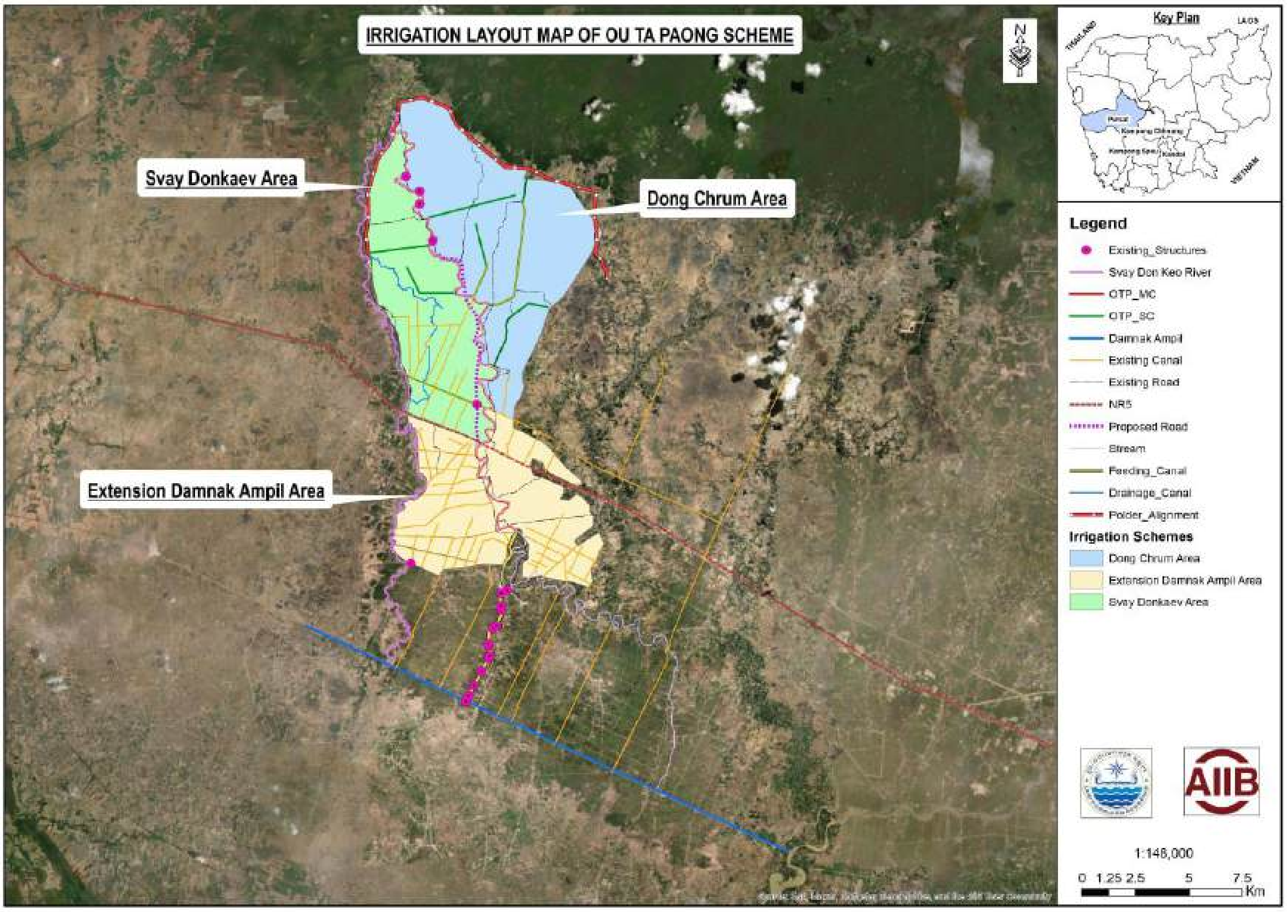
The Ou Ta Paong Irrigation scheme encompasses a command area situated alongside the Ou Ta Paong River, drawing its water supply from various sources. These sources comprise the Pursat River, Svay Donkeov River, and several other rivers that traverse the scheme, including the Ou Ta Paong River itself. This complex water supply system results in the creation of distinct hydraulic zones within the scheme, each characterized by specific water availability levels, which in turn have a direct impact on agricultural output.

The upper part of the scheme, located south of the national Road 5 is mainly supplied by Pursat River, via the Damnak Ampil canal and associated irrigation network. The area presents a general slope direction from south to north. Normally, there is enough gradient in the command area to irrigate by gravity this block from Damnak Ampil Canal. Therefore, due to the existing infrastructure design, this will be challenging. It will be necessary to develop distribution networks and regulating structures.

The eastern part of the scheme, located between Ou Ta Paong River in the West and Dong Chrum in the East, and the National Road 5 on the north. The area presents a general slope direction from south-north. Hence, the area is supplied by all southern infrastructures which include Damnak Ampil hydraulic system, Kbal Hong hydraulic system, Wat Loung canal but also partially Svay Donkeov and Ou Ta Paong River. The hydraulic gradient is very low and due to the existing infrastructure design, the area cannot be irrigated by gravity and will require one stage pumping. It will be necessary to develop distribution networks and regulating structures.

The western part of the scheme, located between Svay Donkeov River in the west and Ou Ta Paing River in the East, and the National Road 5 to the north. The area presents a general slope direction from south -west to north-East. This explains that the area is mainly supplied by Svay Donkeov River. The gradient hydraulic is low and due to the existing infrastructure design, the area cannot be irrigated by gravity and will require one stage pumping. It will be necessary to develop distribution networks and regulating structures.

In all these blocks there are ample opportunities to develop two wet season rice crops by developing proper canal system. This blocks proper canal bed slope of the canal, tertiary canals, regulating structures and most importantly the canal management. As per study there is also an opportunity to develop dry season crop in 20% of the command area.



4.1.5 Lum Harch Scheme

The Lum Harch Irrigation scheme encompasses a command area situated downstream the old Lum Harch canal built during the Pol Pot period (1975-1977), drawing its water supply from various streams crossing the canal. These sources comprise several other rivers that traverse the scheme and have very limited catchment area and flow. This water supply system results in the creation of distinct hydraulic zones within the scheme, each characterized by specific water availability levels, which in turn have a direct impact on agricultural output.

The area presents a general slope direction from south-west to north-East. This explains that the area is mainly supplied by the upper streams and make it challenging to divert water from other sources. The hydraulic gradient is low and due to the existing infrastructure design (Existing Lum Harch irrigation), the area cannot be irrigated by the existing infrastructure. Gravity irrigation will not possible and will require one stage pumping.

In all the scheme there is an opportunity to improve the river training and develop two wet season rice crops by developing proper irrigation systems adapted to the local context: limited water resources, soils conditions, lack of road access, low agricultural activities. Some upper land could also diversify crops all along the year.

4.1.6 Krang Ponley scheme

The Krang Ponley Sub-project encompasses four distinct schemes—Brambei Mom, Krapeu Troum, Yotasast, and Krang Bat—spread across Kampong Speu, Kampong Chhnang, and Kandal provinces. The four schemes have existing irrigation infrastructure. Situated near Highway 5, this sub-project is the closest to Phnom Penh, catering to the significant agricultural demand in the area.

The initial FS study area encompassed three schemes but recognizing the necessity for an inclusive river-basin-wide water resources management strategy to effectively regulate water utilization across all schemes and water-related activities along the river, the Yotasast scheme was incorporated into the CAISAR project in October 2023. Positioned on the left bank of the Krang Ponley, Yotasast's intake is downstream of Krapeu Troum and upstream of Krang Bat. Aligning Yotasast's standards with those of neighboring CAISAR schemes appears to be a logical step forward.

Sitting at an elevation of around 10 meters above sea level, the Krang Ponley floodplain possesses an unusually low permeability due to the accumulation of fine primary soil particles, rendering it highly susceptible to frequent flooding. River-based flooding remains restricted. Throughout the year, particularly during the wet season and the culmination of rainfall, the proposed sub-project zones within Krang Ponley experience extensive flooding. The tail end of the floodplain consistently receives floodwaters originating from the Bassac River and Mekong River, ultimately flowing into the Tonle Sap.

The main water source for these schemes is the river Krang Ponley. Only the Brambei Mom scheme, on the banks of river Ou Khley, has its own rather minor reservoir, but this can receive supplementary supply from an outlet on Anlong Chrey Reservoir.

5 Climate Conditions, Climate Change Projections, Adaptation Measures, and Climate Information

5.1 Climate Baseline

Cambodia is classified as a lower-middle income country (since 2015)[1], however between 1999 and 2019, the country experienced significant GDP (real) growth rate of 7.9%[2] – making it one of the fastest growing economies in the world, but with a high fluctuation from 6% to 13.3%. It remains one of the few Least Developed Countries (LDCs) in Asia and met the LDC graduation threshold[3] for the first time in 2021[4]. Cambodia is also highly vulnerable to climate change and disaster risks, and floods and droughts are recognized by the government as one of the main drivers of poverty. Cambodia is ranked at 148 out of 191 countries in the Human Development Index (HDI)[5]. It has a Multidimensional Poverty Index value of 0.07 (2021-22 survey) – only Lao PDR and Myanmar in the SE Asian region have a higher MPI value, and a poverty headcount of 16.6% (2.76 million people), with a further 20.5% (3.4 million) identified as vulnerable to multidimensional poverty[6].

Cambodia is ranked 149th out of 187 countries in the 2022 ND-GAIN Index. The World Risk Index value of 15.8 indicates a very high risk of disaster, with an exposure index of 27% and a vulnerability index of 59%[7]. Approximately 80% of the country is within the Mekong River and Tonle Sap basins, increasing exposure to floods, storms, and droughts. Over the last few decades, water resources in the Tonle Sap basin have been affected by rapid population growth, urbanization, deforestation, agricultural expansion, hydropower demand and changes in climatic conditions. The UNDRR estimates that Cambodia experiences over USD 250 million in average annual losses due to damage caused by floods (just over 1% of GDP)[8]. Climate impacts are likely to reduce GDP by 2.5% in 2030, 6.0% in 2040, and nearly 10% in 2050[9].

The CAISAR target provinces are Kampong Speu, Kampong Chhnang, Kandal, and Pursat (Figure 2-1). These provinces[10] have the highest population density, high total percentage of poor households (Figure 2.2), and a high percentage of women-headed households. The actual percentages of poor in the target communes are shown in Table 2-1 and ranges between 30.6% in Pursat to 6% in Kandal. In general, a decrease in poverty is seen from Pursat, Kampong Chhnang, Kampong Speu to Kandal. The livelihoods of the poorest and most vulnerable people in the region depend mainly on agricultural production and water availability through precipitation, river flow, and irrigation schemes.

[1] World Bank. https://data.worldbank.org/?locations=KH-XN

[2] IMF Datamapper. https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/OEMDC/ADVEC/WEOWORLD?year=2023. In 2009, real GDP growth rate dropped to 0.1%.

[3] Of the four countries that met graduation thresholds for the first time, only Cambodia met all three criteria (income, human assets, economic and environmental vulnerability).

[4] UNCTAD, 2021. The least developed countries in the post-covid world: Learning from 50 years of experience. https://unctad.org/system/files/official-document/ldc2021_en.pdf.

[5] A higher rank is indicative of lower human development. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI

[6] UNDP, 2023. 2023 Global Multidimensional Poverty Index (MPI): Unstacking global poverty: Data for high impact action. United Nations Development Programme: New York. https://hdr.undp.org/content/2023-global-multidimensional-poverty-index-mpi

[7] World Risk Report, 2022. https://weltrisikobericht.de/wp-content/uploads/2022/09/WorldRiskReport-2022_Online.pdf

[8] World Bank and GFDRR, 2019. Disaster Risk Finance Country Diagnostic Note: Cambodia. https://www.gfdrr.org/en/publication/disaster-risk-finance-country-diagnostic-note-cambodia

[9] Cambodia, First Biennial Update Report, August 2020 & NCSD, MOE

[10] The Asia Foundation, 2018. Cambodia Atlas on Gender and Environment (opendevelopmentmekong.net)

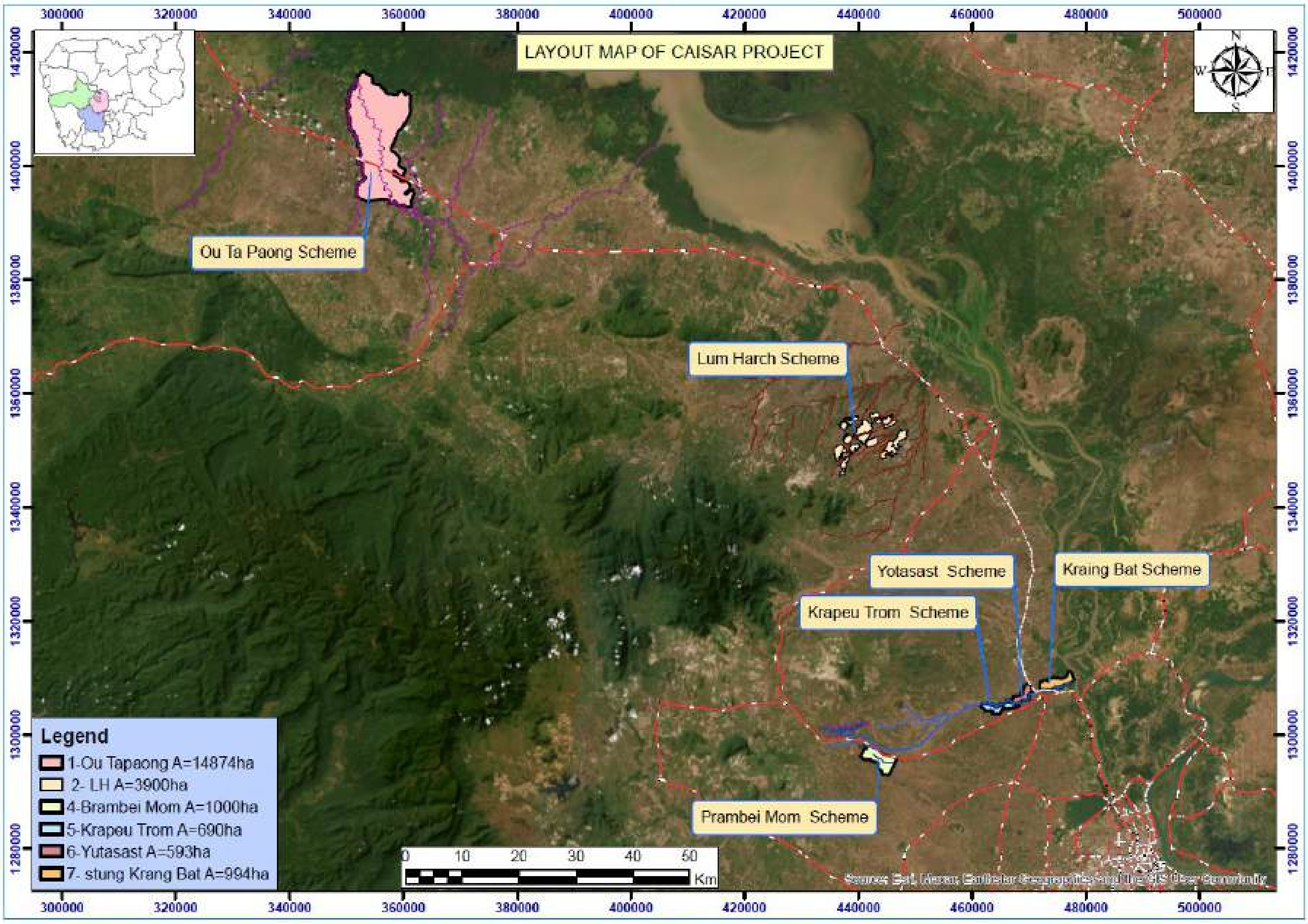


Figure 2-1. Map of the target area including the planned irrigation sub-projects

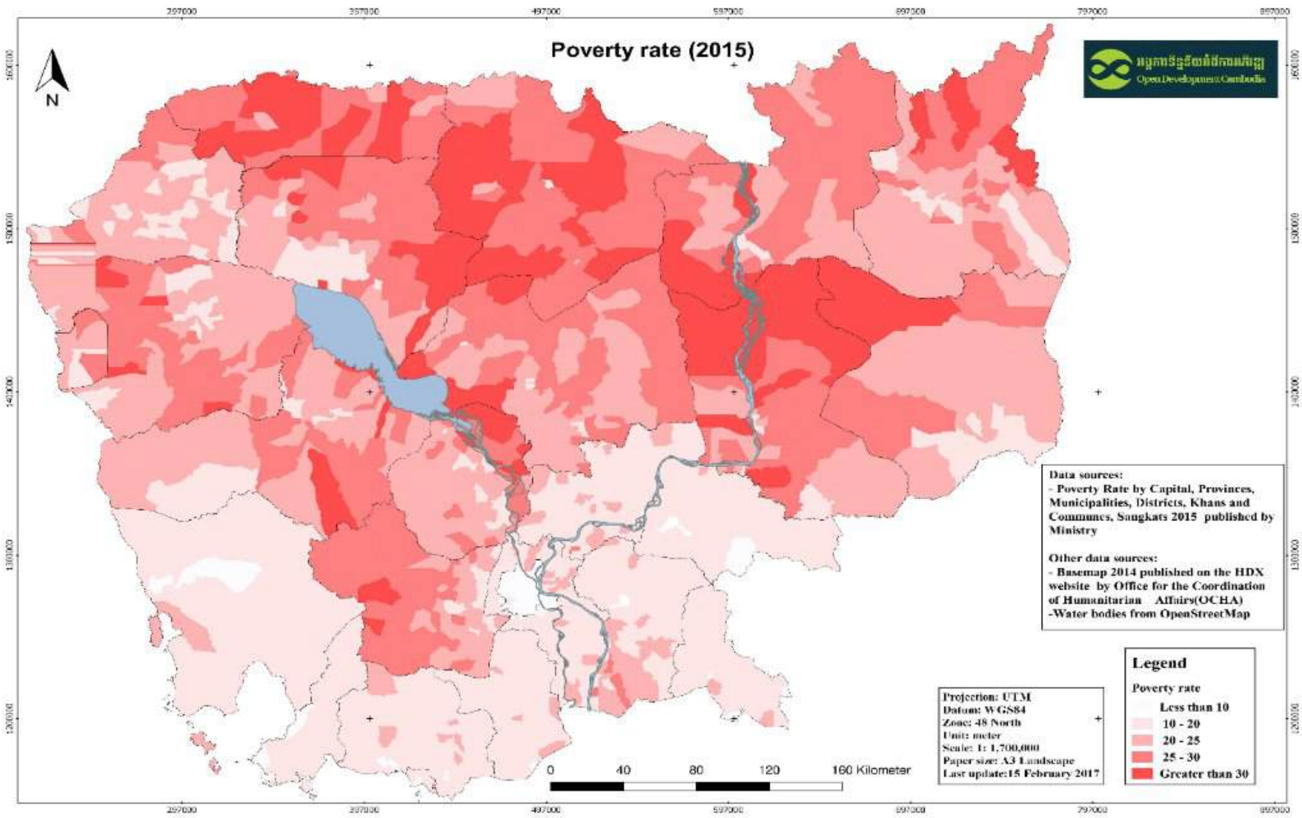


Figure 2-2. Poverty rate at commune level in Cambodia 2015

The project area was already under stress prior to the COVID-19 pandemic with small-scale farmers and larger food producers struggling to produce food and access markets. Food shortages face additional pressure from climate change with extended droughts[11] during the dry months and heavy monsoons, increased river discharge and flooding during the rainfall season. Rural communities highlight major water problems with competition in irrigation due to aging / damaged / lack of infrastructure and reduced water availability in rivers and ponds, which poor communities and households depend on.

Table 2-1.Total poor households, Poor 1 (%) and Poor 2 (%) from the target communes. Data missing from Oudong District. Based on IDPoor database

Province	Subproject	Commune	Total Households	Poverty rate (%)	Poor 1	Poor 1 of total (%)	Poor 2	Poor 2 of total (5)
Pursat	O Ta Paong Tanay Scheme (Pursat)	Ou Ta Paong	3763	30.8	614	16.3	543	14.4
		Rumlech	2322	26.4	233	10.0	380	16.4
Kampong Chhnang	Lum Hach Scheme (Kampong Chhnang)	Anhchanh Rung	1422	13.2	65	4.6	123	8.6
		Chrey Bak	3396	22.9	342	10.1	434	12.8
		Krang Leav	1698	22.6	169	10.0	214	12.6
		Krang Skear	1918	22.7	204	10.6	232	12.1
		Pongro	2296	14.4	123	5.4	205	8.9
		Prasnoeb	1747	17.6	121	6.9	187	10.7
		Prey Mul	1300	18.1	106	8.2	129	9.9
		Srae Thmei	3406	13.8	221	6.5	249	7.3
		Svay Chrum	2223	17.5	165	7.4	223	10.0
	Krang Ponley Kandal Scheme (Kampong Speu)	Longveaek	2362	13.3	108	4.6	207	8.8
Kampong Speu	Brambei Mom Scheme (Kampong Sp	Chan Saen	1756	na				
		Cheung Roas	1752	na				
		Mean Chey	1592	na				
		Monourom	1347	16.7	81	6.0	144	10.7
		Peang Lvea	1989	na				
		Phnom Touch	2775	na				
		Prambei Mum	2137	11.7	58	2.7	222	10.4
		Preah Srae	2431	na				
		Rung Roeang	2215	7.7	62	2.8	108	4.9
		Sambour	2417	9.8	106	4.4	131	5.4
		Trach Tong	1968	na				
		Yutth Sameakki	1924	na				
	Kra Peu Troum Scheme (Kampong Chhnang)	Veal Pong	3393	na				
	Krang Ponley Kandal Scheme (Kampong Speu)	Veang Chas	1543	na				
Kandal	Krang Ponley Kandal	Kampong Luong	2430	8.7	41	1.7	171	7.0

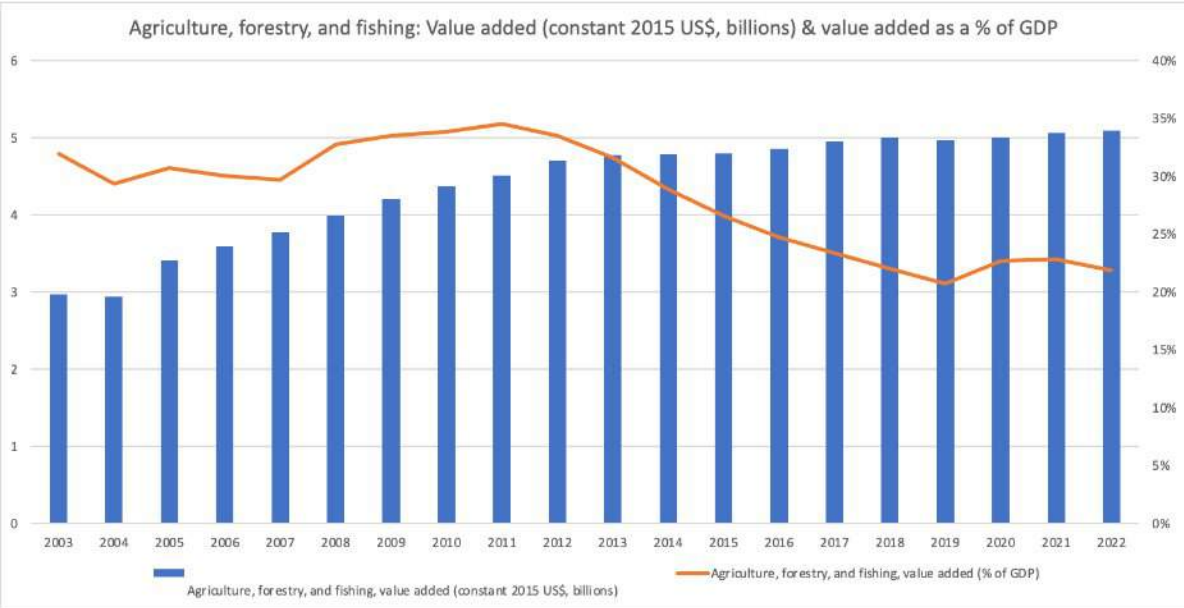
[11] Kampong Spoeu, one of the four target provinces, reported the highest number of droughts (one of the eight main natural hazards in Cambodia) between 1996 and 2013. https://www.unccd.int/sites/default/files/country_profile_documents/1%2520FINAL_NDP_Cambodia%255B1157%255D.pdf

Province	Subproject	Commune	Total Households	Poverty rate (%)	Poor 1	Poor 1 of total (%)	Poor 2	Poor 2 of total (5)
	Scheme	Vihear Luong	2238	6	28	1.3	106	4.7

The proposed underlying investment project will support the government's efforts to sustain food security and rural livelihood after the COVID-19 crisis through the restoration and enhancement of climate-smart and climate-resilient irrigation systems under the "Build Back Better" approach in the target provinces.

5.2 Socio-economic Context and Agricultural Sector Vulnerability

Cultivated land in Cambodia is approximately 4.5 million ha, 70% of which is rice production, followed by subsidiary and industrial crops (20%), rubber plantations (7%), and permanent crops (4%). Cambodia maintains a high reliance on the agriculture, forestry and fisheries sector, which accounted for 23.5% of the country's GDP in 2021[12]; the rural population in 2019 was 76.2% of the Cambodian population[13] and 37.1% of people in 2021 were employed in agriculture[14] . While the share of the agricultural sector in GDP fell from 32% in 2003 to 21.9% in 2022, the agricultural value-added increased (Figure 2.3); in fact, by around 4% per annum over 2010-2019[15] due to exports of rice and rubber. Cassava is one of the subsidiary crops that is largely exported (85% of production is exported) and whose share in exports is increasing. However, firstly, only about 10% of Cambodia's exports are processed in the country, including 17% of rice and 8% of cassava exports. For instance, while milled rice exports has increased six times from 105,000 tons in 2010 to 617,000 tons in 2021, over 3.52 million tons of unmilled rice was exported to Vietnam for processing and distribution[16]. Secondly, the expansion in agricultural production has come at the cost of environmental degradation and the associated loss of biodiversity and ecosystem services contributes to increased climate vulnerability of the sector. For example, an analysis of Northwestern Cambodian uplands bordering Thailand found that agricultural land expanded from 1% in 1997 to 61% in 2016, and that 65% of the associated forest cover loss occurred between 2006 and 2016[17].



[12] UNDESA, 2021. The Least Developed Country Category: 2021 Country Snapshots. https://www.un.org/development/desa/dpad/wp-content/uploads/sites/45/Snapshots2021.pdf

[13] MAFF, 2022a. National Agricultural Development Policy (NADP) 2022-2030. https://elibrary-maff-gov-kh.translate.goog/book/64828af2f3723

[14] ILOSTAT, Country Profiles. https://ilostat.ilo.org/data/country-profiles/

[15] MAFF (2022). Please note that estimates of GDP and rate of change in value-add vary by whether current or constant prices are used.

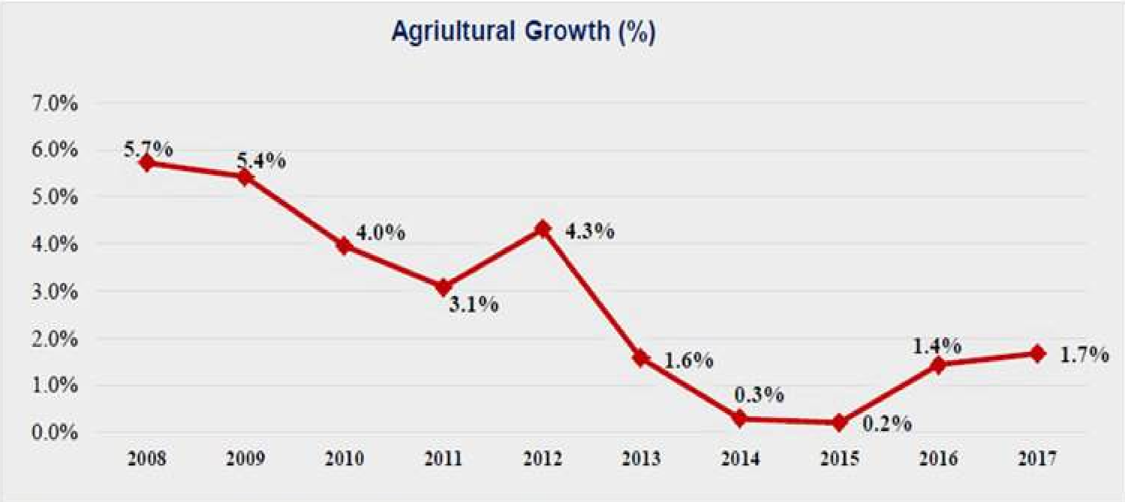
[16] MAFF, 2022a.

[17] Kong, R., Diepart, J.C.., Castella, J.C., Lestrelin, G., Tivet, F., Belmain, E., and Begue. A., 2019. Understanding the drivers of deforestation and agricultural transformations in the Northwestern uplands of Cambodia. *Applied Geography*, 102: 84-89. https://doi.org/10.1016/j.apgeog.2018.12.006

Figure 2-3. Agriculture's GDP share and its value add over 20 years, World Development Indicators, World Bank (2023)

Crops account for 58-59% of the total agricultural production; fisheries (22-24%), livestock (11%) and forestry (6.7-7%). Naturally, growth of the agricultural sector fluctuates and varies with rainfall, droughts, and floods: it was 1.7% in 2017 and dropped to 1.1% in 2018; post COVID-19, it was expected to be 1.4% in 2021[18].

Cambodia, relatively low yields, coupled with frequent natural disasters, contribute to temporary food shortages for vulnerable communities. Livelihoods rely heavily on rain-fed agriculture and non-poor households are vulnerable to falling back into poverty in the event of extreme or frequent climate shocks[19]. Floods in Cambodia are not strictly linked to high rainfall and are often driven by high water levels in the Mekong River and Tonle Sap Lake between early July and early October. Drought in Cambodia is strongly correlated with El Nino, for example, during the 2015/2016 El Nino event, one resulting in one of the worst droughts for Southeast Asia in decades, 2.4 million people across 18 provinces in Cambodia were impacted. According to the joint assessment of 2400 households by WFP, FAO and UNICEF in May 2016, 37% of the households reported water shortages; 18% of agricultural households experienced crop failures; household paddy and cassava production declined by 22%; animal morbidity and mortality rates were high especially for poultry; 62% of households reported income loss. Agricultural growth experienced a large dip during the period (Figure 2.4).



Source: Assessment by Ministry of Planning 2017

Figure 2-4. Agricultural growth in percentage over the period 2008-2017.

Women and children are among the most vulnerable groups to climate change. Based on food availability and access, a mapping of food security has been conducted for the country. Seven of Cambodia's 25 provinces (including Phnom Penh) are classified as acutely food insecure, and an additional seven are moderately insecure. Rice supplies 65-75% of people's energy needs and constitutes 21% of daily calorie intake and 13% of protein intake[20] – so, production shortfalls or price increase have immediate effects on food and nutrition security. In general, the prevalence of malnutrition stunting and wasting increases with food insecurity (Figure 2.5), and children from the lowest wealth quintiles having double the stunting prevalence as children from the highest quintiles[21].

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[18] MAFF (2022a).

[19] WFP, 2018. WFP Cambodia Country Brief. World Food Programme: Phnom Penh. https://docs.wfp.org/api/documents/WFP-0000147767/download/?_ga=2.188002408.1116277075.1681899242-636470978.1669479646

[20] ADB, 2019. Climate-smart Practices for Intensive Rice-based Systems in Bangladesh, Cambodia and Nepal. Asian Development Bank: Philippines. https://www.adb.org/sites/default/files/publication/533186/climate-smart-rice-systems-ban-cam-nep.pdf

[21] FAO, IFAD, UNICEF, WFP and WHO, 2020. *In Brief to The State of Food Security and Nutrition in the World 2020. Transforming food systems for affordable healthy diets*. FAO: Rome. https://doi.org/10.4060/ca9699en

There are several obstacles to women's economic empowerment in Cambodia, including (i) the amount of time and responsibility for unpaid domestic and care work – the highest in the region, a rate 10 times more than men[22], (ii) low levels of literacy and education, (iii) engagement in low skilled and low paid jobs in agriculture, with men taking over activities once they grow and become profitable, and (iv) a lack of access to resources necessary for economic empowerment. Women have higher participation in agriculture than men (women are 48% of the labour force, of which 30% women are employed in agriculture) but receive lower benefits and have lower access to land, extension services, financial services, markets, and technologies. One of the challenges in agricultural extension is that it dominated by men who cater to male farmers, and do not tailor services or advisories to women farmers; this has changed in recent years with increased number of female extension agents at commune and village level and MAFF tracking the number of women farmers provided training[23]. Rural youth face difficulties in accessing land, which also limits access to credit, as financial institutions generally require land as collateral and a high proportion migrate to urban areas for work, particularly in the garment sector. Poverty incidence among ethnic minorities is not significantly higher than among the majority, but they suffer disadvantages in access to health, education and other services.

Climate adaptation among rural populations and national institutions remains low as many households face rising debt caused by coping with natural disasters and the COVID-19 pandemic. Since 2020, the negative impacts of climate change and the pandemic have led to a 10% loss in GDP. In addition to negative climate impacts, stagnating global agricultural commodity prices, rising labor costs and the limited scope for cropland expansion in the country will challenge the agriculture sector (WB, 2015)[24].

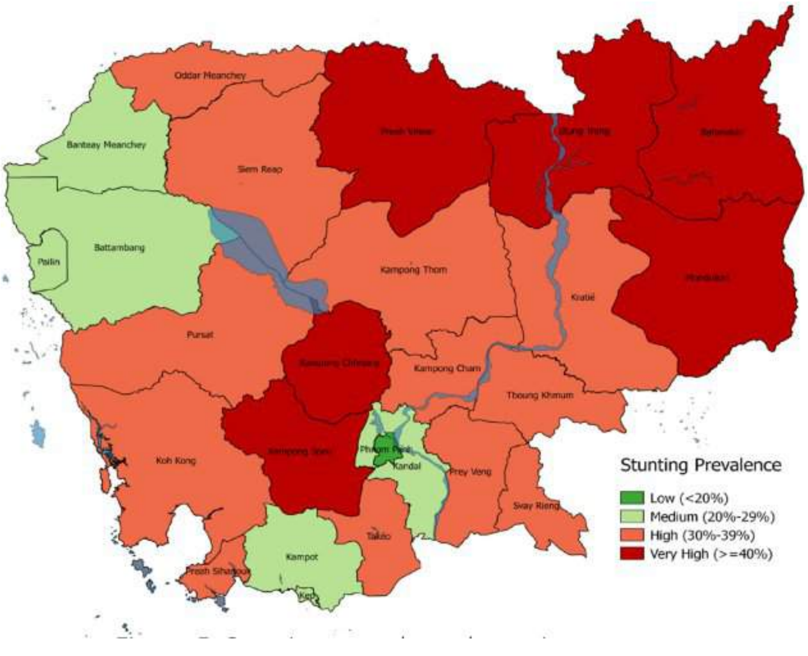

Figure 2-5. Stunting prevalence by region, National Institute of Statistics 2015[25]

Farming remains mostly subsistence-based and rain-fed, with low productivity. Only 7-8% of the total potential agricultural land area is under full irrigation in Cambodia. Further, only 15% of the cultivated rice area is irrigated (compared to 28% in Thailand and 33% in Viet Nam), and 85% of the rice cropping area is vulnerable to changing rainfall patterns[26]. Therefore, while rice accounts for 50% of agricultural GDP, yields

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22 MAFF, 2022b. Policy and Strategic Framework for Gender Mainstreaming in Agriculture, 2022-2026. https://elibrary.maff.gov.kh/book/64f9302c036dc

23 MAFF (2022b)

24 https://openknowledge.worldbank.org/entities/publication/78d3d276-3a5f-5bf2-915d-2d0381a13930

25 WFP, 2017. Fill the Nutrient Gap: Cambodia Survey Report. World Food Programme: Phnom Penh. https://docs.wfp.org/api/documents/WFP-0000070325/download/

26 Kono, A. and Chey, T., 2019. Rapid assessment of upland cashew, mango, organic rice, and vegetable production. Actions for Climate-resilient and Sustainable Agricultural Production in the Northern Tonle Sap Basin. FAO

are lower than in neighboring countries; for both Cambodia (3.93 t/ha DS rice and 2.44 t/ha WS rice, 2015) and in the project area with two rice crops, dry season paddy yield is higher than wet season. In the project's irrigation command area, the majority of rice production is rain-fed and occurs in the wet season (34,481 hectares out of 35,225 rice cultivation, 97.9%). While horticultural (vegetables, watermelon) and other crops are grown by farmers, agriculture is predominantly monoculture and there's no crop rotation on rice paddies. Horticulture crops in the command area draw water from canal / stream / river and well / pond (Table 2.2).

Table 2-2. Overview of agriculture activities by communes in the project's command area (District Bureau of Agriculture, Natural Resources and Environment, 2021

	Area (Commune)	Total Rice Cultivation Area[a] (Ha)	WS Rice Area[b] (Ha)	Average Yield (T/ha)	DS Rice Area[c] (Ha)	Average Yield (T/Ha)	Other Crop Area (Ha)	Horticulture Area (Ha)
OU TA PONG TANAI COMMAND AREA (OU TA PONG TANAI SCHEME)								
Bakan – Pursat	Beung Khnar	3966	630	3.9	3336	5.75	6.2	10
	Khnar Toteung	2824	0	0	2824	5.9	12.5	16
	Me Tuek	4332	51	3.85	4251	5.8	7	7
	Ou Ta Pong	6344	80	3.9	6264	5.75	7.3	15
	Rom Lech	4650	0	0	4650	5.8	10.5	14
	Svay Dounkeo	2557	0	0	2557	5.85	1	3
Total		24673	761	3.88	23882	5.81	44.5	65
BRAMBEI MOM COMMAND AREA (KRANG PONLEY SCHEME)								
Oudong – Kampong Speu	Preah Srae	1210	1210	3.21	0	0	6	2
	Trach Tong	1000	1000	3.2	0	0	12	4
	Ksem Ksant	900	900	3.01	0	0	8	2
	Mean Chey	1200	1200	3.18	0	0	14	4
	Yutt Samaki	1050	1050	3.14	0	0	6	4
	Cheung Roas	1000	1000	3.1	0	0	8	2
	Peng Lvea	1050	1050	3.17	0	0	6	4
	Phnum Touch	1050	1050	3.18	0	0	4	2
	Chant Sen	1200	1200	3.18	0	0	12	4
Tpong – Kampong Speu	Brambei Mom	1860	1860	2.9	0	0	N/A	N/A
	Monorom	1050	1050	2.93	0	0	N/A	N/A
	Rung Reung	1850	1850	2.91	0	0	N/A	N/A
Samroung Tong – Kampong Speu	Sambour	N/A	NA	N/A	N/A	N/A	N/A	N/A
Total		14420	14420	3.10	0	0	76	28
KRAPEU TROUM COMMAND AREA (KRANG PONLEY SCHEME)								
Oudong – Kampong Speu	Veal Pong	1340	1340	3.21	0	0	85	25
Total		1340	1340	3.21	0	0	85	25
LUM HACH COMMAND AREA (LUM HACH SCHEME)								
Boribour – Kampong Chhnang	Anhchanh Rung	4778	4312	3.24	466	2.98	67	35
Roleae B'ier – Kampong Chhnang	Svay Chrum	2605	2590	3.44	15	3.92	613	135
	Prasneb	5374	5374	3.71	0	0	0	62
	Banteay Preal	2712	2712	3.74	0	0	0	43
	Pongro	1462	1462	3.29	0	0	0	52
	Srae Thmei	1373	1373	3.59	0	0	0	58
	Krang Leav	3284	3284	3.49	0	0	0	50
	Chrey Bak	2833	2678	3.31	75	3.89	0	29
	Prey Mul	1755	1755	3.61	0	0	0	52
Tuek Phos – Kampong Chhnang	Krang Sker	5081	5076	3.37	0	0	N/A	N/A
	Tang Krasang	3968	3865	3.45	65	2.8	N/A	N/A
Total		35225	34481	3.48	621	3.40	680	516
STEUNG KRANG BAT COMMAND AREA (KRANG PONLEY SCHEME)								

	Area (Commune)	Total Rice Cultivation Area[a] (Ha)	WS Rice Area[b] (Ha)	Average Yield (T/ha)	DS Rice Area[c] (Ha)	Average Yield (T/Ha)	Other Crop Area (Ha)	Horticulture Area (Ha)
Ponhea Lueu – Kandal	Kampong Luong	120	0	0	120	4.5	0	0
	Vihear Luong	237	211	2.5	26	4.5	0	0
Notes: [a] Total Rice Cultivation Area is total rice cultivation area for the respective Commune [b,C] WS Rice Cultivation Area & DS Rice Cultivation Area are areas of harvested / implementing area in 2021								

The lack of water for irrigation is a crucial barrier for farmers to deal with climate change-induced water shortages, and to cultivate more than a single crop per year – limiting their resilience and adaptive capacity. Cambodia receives an abundant amount of rainfall in the wet season, but it experiences prolonged periods of dry days resulting in dry season droughts and extreme volumes of water in the wet season resulting in extensive flooding. Water scarcity (and conversely, flooding) is a result of poor water management – including drainage and flood protection, water storage options, and storage capacity rather than insufficient amount of water. For instance, in the few first months of the wet season, rainfall is erratic and early season droughts are common. In the case of rice, farmers engage in some autonomous adaptation actions, but these may come at the cost of low yields and economic returns. Because wet season rice depends on irrigation water, farmers cultivate medium maturity (120-150 days) or late maturity (more than 150 days) rice. Medium maturity rice allows farmers — typically those situated at higher elevated locations — to avoid potential damage from water shortages in late November, since rice is harvested in early November. Late maturing varieties, which have a better resistance to flood, are chosen by farmers in areas that normally experience longer / bigger floods and are predominantly used for household consumption (with the expectation that yield will be lower than dry season rice). Some farmers also cultivate what is termed recession rice i.e., after wet-season rice, cultivate another rice crop in October or November when floods recess taking advantage of precipitation. Recession rice does not require irrigation in early stages, but irrigation is essential in later development stages.

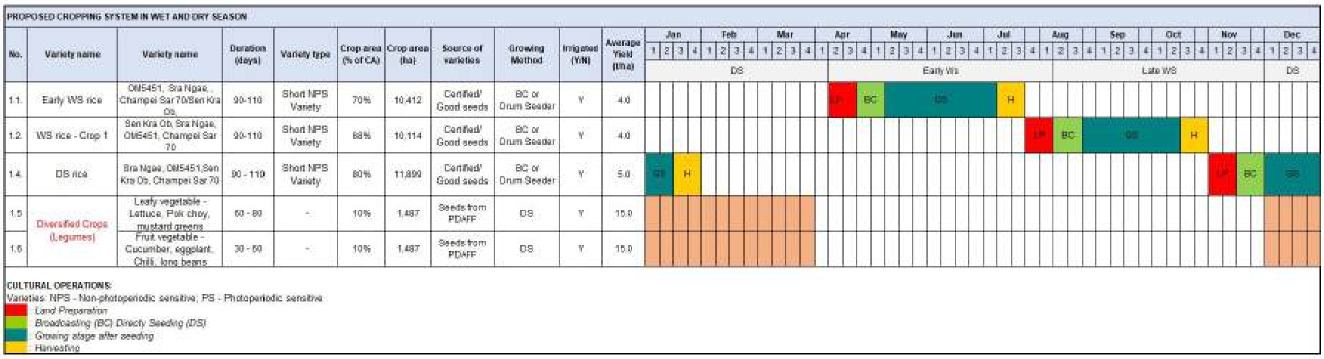

Figure 2-6. Potential cropping pattern within the proposed command area at Ou Ta Paong[27]

It is noteworthy that the use of dry season and early maturity rice also involves intensive use of mineral fertilizers (8-10 bags per hectare); use of fertilizers during the wet season rice is relatively lower (e.g., 3-4 bags per hectare). More importantly, the amount of fertilizer applied is not adjusted to soil fertility characteristics and excessive use of fertilizers — contributing to higher GHG emission intensity of rice — is driven by the need for better growth in a shorter growing period and to ensure return on other agri-input investments. The use of organic fertilizers (livestock manure) occurs to a limited extent for wet season rice, but not at all in dry season rice. Lack of awareness on integrated fertilizer management, lack of information on soil nutrient content, and lack of support (e.g., cement tanks for vermicomposting or microbial composting

[27] WAPCOS 2022. Agronomy ground survey. Annex 3 2022

using rice straw and manure, biochar production) are barriers to more efficient fertilizer input and increased use of organic inputs.

Cambodia has set a target of increasing irrigated rice crop (rainy and dry season) from 61.18% in 2019 to 70% by 2030, at the same time increasing water use efficiency in irrigated agriculture and enhancing water resource management[28]. Irrigation schemes in Cambodia provide three critical water services: irrigation, drainage, and flood mitigation / protection. Studies suggest that shifting to irrigated cultivation could result in annual overall production increases of up to 40%.

However, there are several challenges to the utility and sustainability of irrigation schemes, requiring climate-informed planning and management. During stakeholder consultations[29], it was evident that if farmers depend on rainfall or on pumping water from natural or poorly maintained canals, they do not see value in paying an ISF or having a FWUC. Cases where farmers are not engaged in design of the irrigation system are also ones where farmers do not take ownership of operations and maintenance. Farmers are also unlikely to pay ISF unless their income from agricultural production improves. On the other hand, FWUCs were found to view their primary role as limited to (1) operations of 'water gates' at the request of users or commune leaders and (2) monitoring the system, making repairs, and reporting larger repairs to PDWRAM. Finally, neither FWUCs, nor the commune administrations that they fall under, may understand water management – for instance, to negotiate with farmers on total cultivation area in a season and how to manage irrigation requirements

FWUCs will need to be supported and incentivized to (a) prepare annual plans, (b) undertake maintenance activities of canals, and (c) introduce irrigation service fees. While some capacity development activities can address these FWUC coordination and management challenges, there's also a critical role that information should play. That is, real-time information on actual water flow and demand could facilitate effective water resource management at both the basin and FWUC levels. Furthermore, farmers lack the knowledge and tools to adapt their farming practices / production techniques to climate change – including, timely information on droughts and floods (e.g., seasonal forecasts, the changing length). Stakeholder consultations[30] indicate that FWUCs and commune administrations do receive some information from the government and provide advice to farmers on how to improve climate resilience (e.g., limit paddy crop area to better manage water availability, enlarge pond capacity, crop diversification). While the same communication channel could be leveraged for climate information and early warning services, the timeliness, adequacy, and relevance of information flows (from PDWRAM via commune administration and FWUCs to farmers) needs significant improvement. Additionally, to facilitate data-informed water management, the observation network – particularly ungauged sub-basins and existing stations around the Tonle Sap Lake – needs upgrade and review[31].

Cambodia's agricultural census in 2019, a representative survey of farmers across 25 provinces, revealed that only 26% of farmers had received agricultural training[32]. Farmers are largely unaware of climate resilience practices (e.g., alternatives to flooded rice cultivation or application of AWD or SRI methods in rice), stress-tolerant seed varieties and improved planting materials, efficient input management, and the benefits of applying such practices. While Cambodia's Agricultural Research and Development Institute has introduced several stress-tolerant rice varieties-STRVs (e.g., CAR14, CAR15) that are short duration, require less water, suitable for broadcasting (direct seeding), and tolerant of heat / drought / flood / submergence, and have a yield advantage over traditional or other modern rice varieties, farmer surveys show that awareness and use of STRVs remains low[33,34].

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28 MAFF (2022a).

29 Field visits 17-20 May 2022: Learning about and from FWUCs. Annex 4, CAISAR – Feasibility Study and Project Preparation.

30 Field visits 17-20 May 2022: Learning about and from FWUCs. Annex 4, CAISAR – Feasibility Study and Project Preparation.

31 Cambodia, Third National Communication, September 2022.

32 Khun, C. and Lim, S. 2023. Productivity and market participation: Cambodian rice farmers. Journal of Asian Economics, 88: 101646. https://doi.org/10.1016/j.asieco.2023.101646

33 Vergara, G. V., Srey, S., Flor, R.J., et al. 2023. Enabling Adoption of Stress-Tolerant Rice Varieties and Associated Production Management Technologies by Smallholder Farmers in Cambodia. *Asian Journal of Agriculture and Development*, 20(1): 53-70. https://doi.org/10.37801/ajad2023.20.1.4

34 Mishra. A.K., Bairagi, S., Velasco, M.L., and Mohanty, S. 2018. Impact of access to capital and abiotic stress on production efficiency: Evidence from

The deployment of water-use efficiency technologies is also limited. Farmers currently leave their rice fields continuously flooded, particularly during the wet season, and do not drain water unless there are threats of floods. In case of dry season rice, since water shortage is the main issue, no alternate wetting and drying is practised. Continued puddling of rice has long term impacts on soil, particularly drainage. Use of other sustainable rice intensification practices is also limited; than 90% of farmers use direct seeding or broadcasting methods and there is very little transplantation or use of machinery (broadcasting, mechanized seed drill, drum seeder). Horticulture production that occurs on dedicated farmland does involve investments in and use of drip irrigation. When vegetables are cultivated during the dry season on rice paddies, irrigation is done through water hose or sprinkler. The significant investments associated with solar irrigation pumps are a barrier for farmers to shift away from the use of diesel pumps, the availability and cost for which are relatively lower. For expansion of drip irrigation or sprinkler irrigation of horticulture crops, similar barriers (access, investment costs) exist – particularly for the poorer farmers.

The labour shortage in rural areas has increased due to migration to urban areas, which in turn has led to a rise in agricultural wages. This is an important factor to consider since some climate-resilient practices such as SRI or organic fertilizer may increase the demand for labour, particularly that of women. Other significant barriers for small-scale farmers include access to credit on attractive and appropriate terms, and market intelligence.

The local private sector also fails to offer technologies that farmers need (e.g., stress tolerant seeds, bio-inputs, customized machinery and after-sales support) and engage in value addition (e.g., rice milling prior to exports) adequately and sufficiently. Production and distribution costs of agricultural products are high compared to the neighbouring countries, largely due to high energy and transport costs. Private sector investment in water saving micro technologies in irrigation and extension services remains low due to an unfavourable agri-business environment, such as access to appropriate finance, poor communication and cooperation between government and private sector, and the absence of a clear regulatory framework for the establishment, operation and pricing for the private management of water. Large agri-businesses face high costs and shortages of working capital. Many agri-business firms operate below capacity and potential new investors are reluctant to invest due to low profitability and a high risk of failure.

To summarize, rice production by subsistence or semi-subsistence farmers dominates Cambodian agriculture but is characterized by low or inefficient input use, low productivity, and high climate vulnerability. Cambodia is unlikely to achieve 5% of its annual agricultural growth target by 2030, without more investment in climate adaptation, sustainable irrigation, flood control and drainage schemes. Persistent poverty, limited access to finance, and insufficient institutional capacities have left the rural agrarian population vulnerable to the negative impacts of climate change, economic slowdown, and environmental degradation.

Rice is the principal main crop of farmers and the production accounts for 15% of agricultural value added, while paddy occupies 75% of the cultivated land. Rice production, processing, and marketing employ 3 million people, or more than 20% of the country's working-age population (IFC, 2015). Around 80% of rice production originates from local varieties cultivated during the rainy season. High- yielding varieties are mainly planted during the dry season, and account for the remaining 20% of the production. During the dry season, rice cultivation is concentrated in the areas with better water availability, in Lower Mekong River basins and around the Tonle Sap Lake (Figure 2.7). Rice productivity is highly dependent on weather conditions, and both flooding and droughts have resulted in significant decreases in yield production (e.g. 2004, 2015, 2018 and 2019). Based on data from the past 20 years, losses in rice production were mainly due to flooding (about 62%) and drought (about 36%).

Yields have gradually increased over the last decade but remain among the lowest in Asia. Around 50% of the paddy produced in Cambodia is exported to neighboring countries (primarily Vietnam and Thailand) for milling and further distribution, which represents a lost opportunity for Cambodian rice millers.

rice farming in Cambodia. *Land Use Policy*, 79: 215-222. https://doi.org/10.1016/j.landusepol.2018.08.016

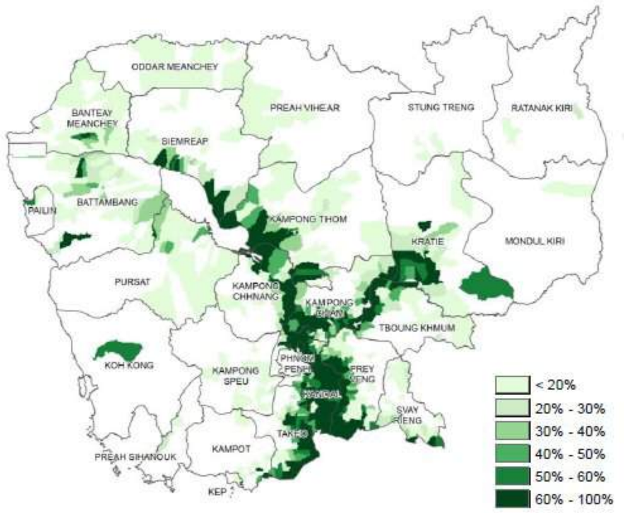


Figure 2-7. Percentage of dry-season rice cultivated areas (from UNDP, 2019, National Drought Study)

5.3 Climate Change Trends

Cambodia's topography broadly consists of the central plains surrounded by mountainous and highland regions, a coastline to the south, and 2,428 km land border with Thailand to the northwest, Lao PDR to the northeast, and Vietnam to the east and the south. The country has distinct dry and rainy seasons, influenced by tropical monsoons; the rainy season (under the influence of the Southwest monsoons) extends from May to October and accounts for 90% of the annual precipitation and the dry season extends from November to April. The average annual rainfall is 1,400 mm in the central plains and increases to 3,800 mm in the mountains and along the coast (Table 2.3, Figure 2.8). Annual maximum temperature for Cambodia ranged between 31.5°C – 36.1°C over 1985-2008, and annual minimum temperature range for the same period was 21.5 °C – 26.3 °C; April is one of the hottest months with an average maximum of 38°C and January's average minimum temperature is 17 °C[35]. Because of its topography, the country is not directly impacted by tropical cyclones and typhoons[36]. However, indirect impacts such as torrential rains and flash floods are common as cyclones and typhoons weaken / decay.

The Mekong River and its tributaries dominate the hydrology of Cambodia, and the country falls under the Lower Mekong Basin. The Tonle Sap Lake is an outlet of Mekong during the rainy season and borders the CAISAR provinces of Pursat and Kampong Chhnang; Tonle Sap is connected with the Mekong River through the 120 km Tonle Sap River with a confluence of both near the capital Phnom Penh. The total area of the catchment is 85,970 km^2, and the lake itself expands from an area of 2000-3000 km^2 during the dry season to 6,000-10,000 km^2 during the rainy season when the level of the Mekong River is high, and the flow of the Tonle Sap River is reversed[37]. The Tonle Sap Basin consists of the Tonle Sap Lake and 11 major tributaries; out of the 11 sub-basins, the following catchments are in the CAISAR project area: Ou Ta Paong Tanai scheme is located in the Svay Don Keo catchment but receives additional water from the Pursat river through the Damnak Ampil canal; the Lum Hach scheme is in the Boribor catchment, and the Krang Ponley scheme is in the Krang Ponley catchment. The annual flood pulse provides a critical ecosystem service (regulation): sediment replenishment is important for soil productivity, and floods sustain fisheries (since migration cycles are closely linked to the flooding extent)[38]. The downstream part of the Cambodian Mekong River basin

[35] Thoeun, H.C., 2015. Observed and projected changes in temperature and rainfall in Cambodia. Weather and Climate Extremes, 7: 61-71. http://dx.doi.org/10.1016/j.wace.2015.02.001

[36] Cambodia, First Biennial Update Report, August 2020

[37] Cambodia, First Biennial Update Report, August 2020

[38] Chua, S.D.X., Lu, X.X., Oeurng, C., Sok, T., and Grundy-Warr, C., 2022. Drastic decline of flood pulse in the Cambodian floodplains (Mekong River and Tonle Sap system), *Hydrol. Earth Syst. Sci.*, 26, 609–625, https://doi.org/10.5194/hess-26-609-2022.

(27,760 km^2), excluding the Tonle Sap Lake region, extends along the Mekong mainstream from Kratie Province to the Cambodian-Vietnamese border; it covers parts of 12 provinces in Cambodia including CAISAR provinces of Kampong Chhnang, Kampong Speu and Kandal.

Table 2-3.Cambodia and CAISAR provinces: Climatic baseline 1991-2020[39]

Province	Ecological Zone	Annual precipitation, average, Rainy season, mm	Annual precipitation, average, Dry season, mm	Total annual average precipitation mm	Mean Maximum Temperature, deg C	Mean Minimum Temperature, deg C
Kampong Speu	Plateau	1718	349	2067	33.86	21.44
Kampong Chhnang	Tonle Sap	1480	267	1747	34.83	21.49
Kandal	Plains	1193	298	1491	34.92	22.32
Pursat	Tonle Sap	2125	333	2458	33.95	20.55
National		-	-	1400-3800	34.6	20.4

[39] World Bank Climate Change Knowledge Portal. Last retrieved 30 September 2023.

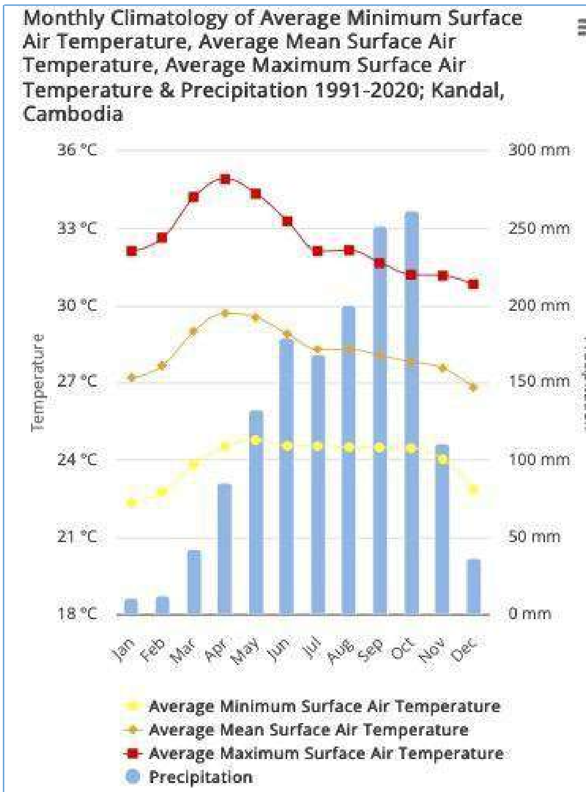


Figure a. Kandal climatology, 1991-2020

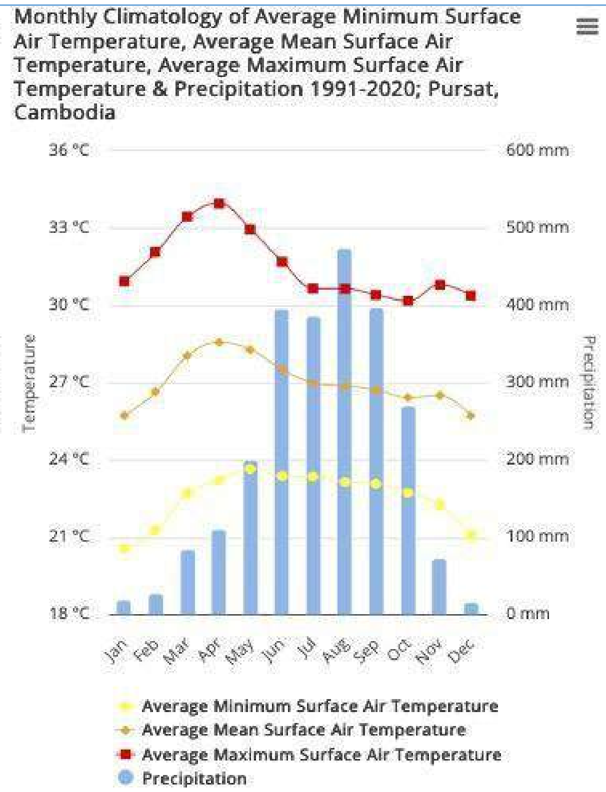


Figure b. Pursat climatology, 1991-2020

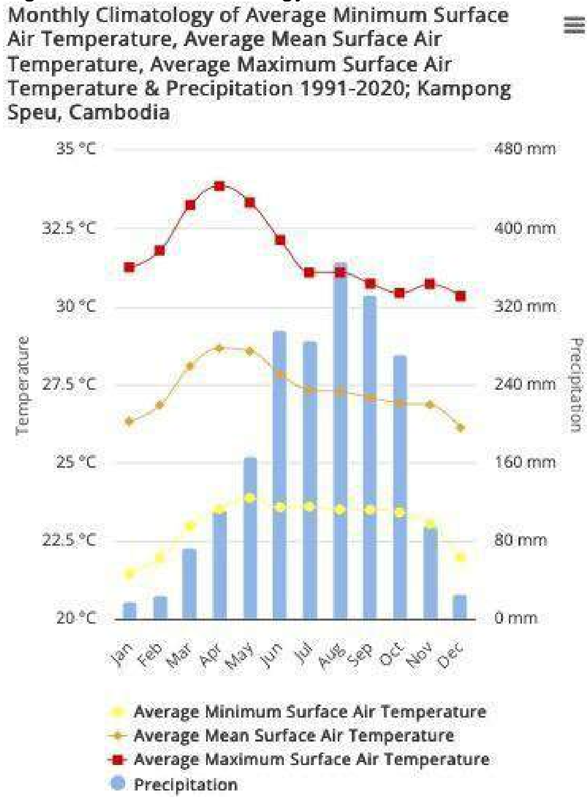


Figure c. Kampong Speu climatology, 1991-2020

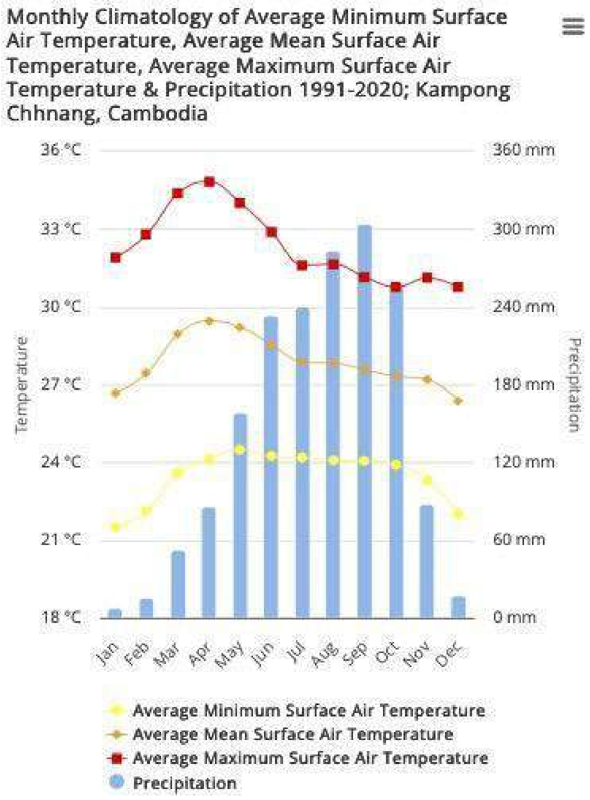


Figure d. Kampong Chhnang climatology, 1991-2020

Figure 2-8. Climatology of CAISAR provinces, 1991-2020[40]. Please notice different scale for precipitation

Agricultural droughts have four characteristics: (a) erratic variations in onset, amount, and duration of rainfall across Cambodia, (b) unpredictable delays in rainfall start in the early part of the wet season, (c) early withdrawal of monsoons / end to rains in the wet season, and (d) mini-drought occurrence of three weeks or

[40] World Bank Climate Change Knowledge Portal. Last retrieved 30 September 2023.

more during the dry season[41]. This means, for instance, that short droughts can occur prior to the wettest period at the end of August to the end of November. Such short droughts can last 15 days but occasionally they can be prolonged and last up to 60 days after the first monsoon rains, damaging rain-fed crops (ADB 2014).

Annual mean temperature anomaly has increased at a rate of 0.23°C per decade since 1950[42] (Figure 2.9a), with a stronger signal of increase during the dry season. The rate of temperature change is notable in the dry season (December, January and February) followed by pre-monsoon (March, April and May) and, to a minor extent, by wet season months (June, July and August). The number of days in a year when Heat Index exceeds 35°C has increased since 1960s/1970s, reaching around 63 days in 2020 (Figure 2.9b). Between 1991-2000 and 2011-2020, the number of days with Heat Index exceeding 35°C has particularly increased in the months of March, April, May, and June. Simultaneously, the number of nights with minimum temperature exceeding 20°C has increased in a major part of the dry season – November through February.

No statistically significant changes were observed over the 20th century either in terms of annual rainfall or extreme events. However, the variability in precipitation is linked to El Niño South Oscillation (ENSO) with years of strong El Niño correlated with moderate and severe droughts over the same period[43]. For instance, the 2015-2016 El Niño event, declared the worst natural disaster in 100 years, caused a severe drought in 18 out of 25 provinces. A rapid assessment survey of nine provinces[44] found that 50% of six Pursat districts and 63% of eight Kampong Chhang districts were drought-affected with wide-ranging impacts on distress migration, food and truck water prices, and food shortages (despite 2015 rice production being above five-year average). Another assessment found that 30,044 wells and 2,024 ponds dried out across 25 provinces, and one of the worst floods in Cambodia's history was in the year 2000, requiring 750,618 families to be evacuated; out of the 347 deaths reported, 80% were children[45]. A flood in similar intensity to 2000 also occurred in 2011 (once in 100 years flood, Table 2.4), and even with increased flood protection after the 2000 flood, the increase in population and economic growth meant that estimated economic damages in 2011 was 5 times higher than 2000[46].

[41] UNCCD, 2019. Drought Initiative - Cambodia. https://www.unccd.int/sites/default/files/country_profile_documents/1%2520FINAL_NDP_Cambodia%255B1157%255D.pdf

[42] Thoeun, 2015.

[43] World Bank and ADB, 2021. Cambodia Country Profile. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-08/15849-WB_Cambodia Country Profile-WEB.pdf

[44] Save the Children. https://resourcecentre.savethechildren.net/document/el-nino-induced-drought-cambodia-rapid-assessment-report/

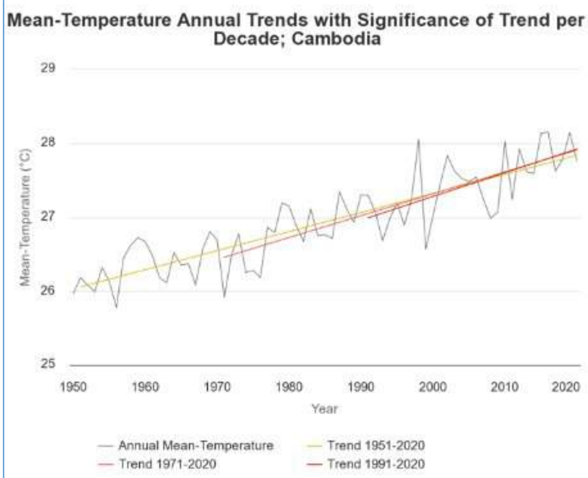
[45] FAO, UNICEF, WFP, 2020. Roadmap – Developing a risk-informed and shock-responsive social protection System, Cambodia. Bangkok: Food and Agriculture Organization of the United Nations and UNICEF and World Food Programme. https://www.fao.org/3/cb2195en/cb2195en.pdf

[46] Imhoff, R.O., 2016. Analyzing future flood risks in Cambodia. Deltares: Delft .http://spinlab.vu.nl/wp-content/uploads/2017/01/Analyzing-future-flood-risks-in-Cambodia_FinalVersion2.pdf

	Deaths	Houses destroyed	Houses damaged	Crops damaged (ha)	Rice fields damaged (ha)	Rural roads destroyed (km)	
2000	388	1,305	7,920	82,970	491,853	409	31,5
2011	458	963	1,838	26,815	277,379	667	144,4

Table 2-4. Loss and damage due to 100-year floods in 2000 and 2011[47]

In recent years, like other monsoon-dependent countries, climate change trends have manifested in longer dry seasons and more intense "El Niño" related droughts, delayed onset of the monsoon season, increased rain intensity and frequency, leading to floods and unexpected dry periods during the rainy season. The World Resource Institute (WRI) rates the upper and lower Tonle Sap watershed as extremely high for water risk (WRI, Aqueduct). The increase in mean annual temperature and decrease in dry season rainfall have manifested in droughts and water shortages significantly impacting rainfed agriculture due to a late start and early ending of the wet season[48].



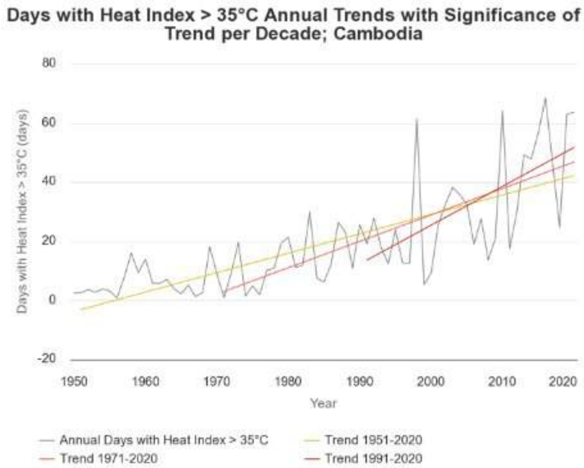
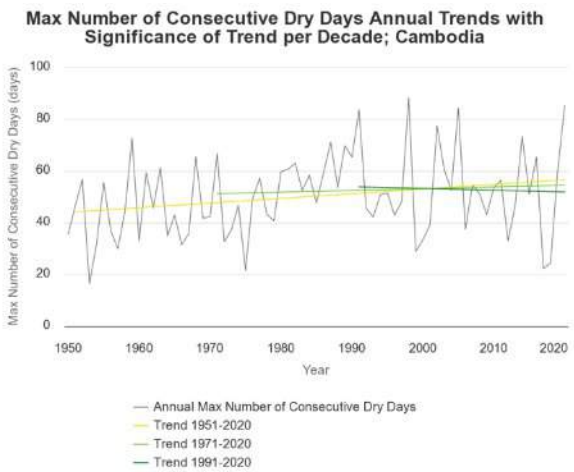


Figure a. Avg temp. change between 1950-2020 Figure b. Number of days/year with Heat Index >35°C



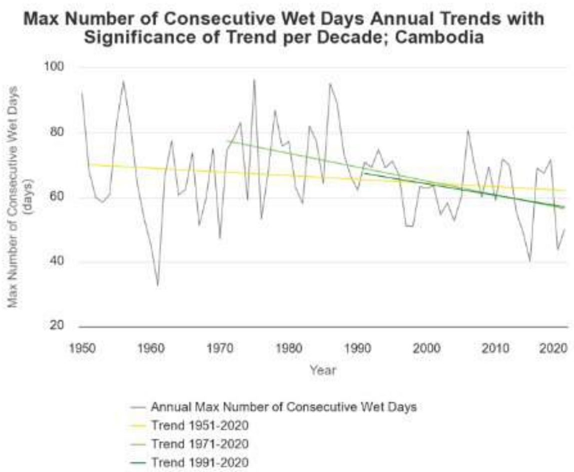


Figure c. Max number of consecutive dry days in a year Figure d. Max number of consecutive wet days in a year

Figure 2-9. Historical changes in temperature and precipitation variables, 1950-2020[49]

[47] NCDM & UNDP (2014) as cited in Imhoff, 2016.

[48] MAFF, 2017. MAFF Annual Report 2016-17.

[49] World Bank Climate Change Knowledge Portal. Last retrieved 30 September 2023.

5.4 Observed Trends in Extreme Weather Events

Analysis of extreme indicators shows that the decline in annual rainfall is driven by the decrease in the number of rainy days over the rainy season. Despite this decline, the average rainfall on rainy days has increased (Figure 2.10) suggesting heavier rainfall over shorter periods, which may lead to flooding or soil erosion. The evidence suggests the amount and duration of rain in the rainy season has decreased over the period 1980-2018 while the length of the dry season has increased.

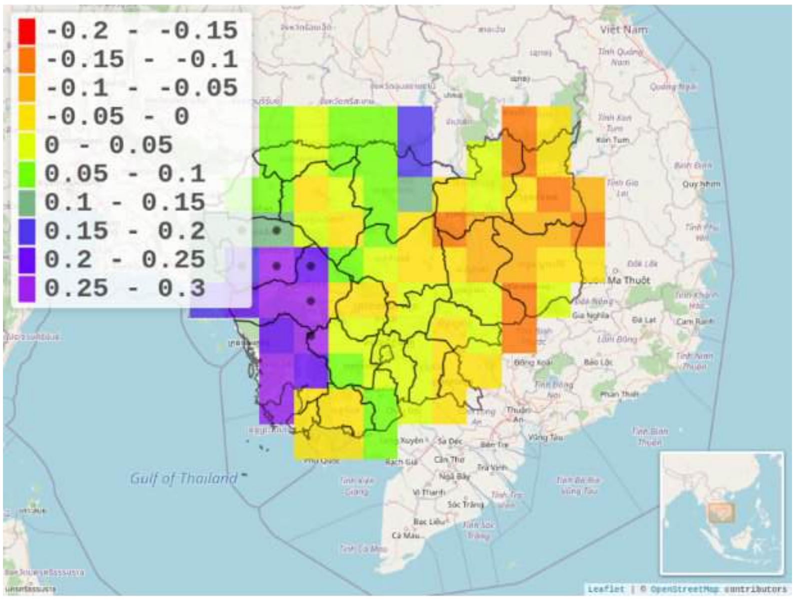


Figure 2-10. Trend in the number of days with precipitation >30mm during the rainy season May to October over the period 1980-2016 using the reanalysis dataset WE5E. Statistical significance of 0.05 indicated with a black dot (FAO CAVA tool).

<u>Droughts:</u> Drought has significant social and economic impacts in Cambodia, in particular in the project areas. One of the most severe drought events in 2002 affected 76 districts in ten provinces. Some 442,419 families (2,017,340 individuals) were affected. The total estimated damage was US$ 38 million[50]. Crop production, particularly maize and rice, was affected in all provinces and about half a million rural people faced food insecurity. Droughts events have become more frequent and are expected to intensify in future.

<u>Floods and flash floods:</u> Flooding occurs between July / August and October, and the two major flood types are floods due to overflow of the Mekong River and Tonle Sap Lake or flash floods owing to rains in the mountains. While local rainfall patterns are important for both irrigated and rainfed agricultural systems, the Mekong-Tonle Sap flood pulse dominates the flooding pattern[51] and hence plays an important role in the overall water management. Inter-annual variability in rainfall significantly influences river discharges and between one and four million hectares of Cambodia's floodplain, of which about 25% falls in the project areas, may be submerged during the wet season, reaching critical thresholds for irrigation and ecosystem stability. Studies have found declining flood pulse in Tonle Sap Lake[52]: that there have been significant declines in water level and inundation area from the late 1990s in the dry season, and for the whole year, over and above increased sub decadal variability.

[50] UNCCD. 2019 Drought-Initiative, Cambodia. https://www.unccd.int/sites/default/files/country_profile_documents/1%2520FINAL_NDP_Cambodia%255B1157%255D.pdf

[51] Majority of the water (53.5%) in the Tonle Sap basin originates from the Mekong mainstream, the Lake's tributaries contribute 25-30% of the annual flow and 12.5% is derived from precipitation. Oeurng et al., 2019.

[52] Chen, A., Liu, J., Kummu, M., Varis, O., Tang, Q., Mao, G., Wang, J., and Chen, D., 2021. Multidecadal variability of the Tonle Sap Lake flood pulse regime. Hydrological Processes, 35 (9): e14327. https://doi.org/10.1002/hyp.14327

Cambodia is vulnerable to ENSO related climate shocks; for example, between 1980 and 2015, there were eight El Niño events. A study from the Greater Mekong Sub-Region Flood and Drought Risk Management and Mitigation Project identified flood and drought prone areas in Cambodia (Figure 2.11). The major rice growing areas of the Mekong-Tonle Sap basin are exposed to flooding every year but in recent years have often been exposed to extreme flooding (NIS, 2002). In agricultural areas where temporary flooding occurs, floods result in severe challenges for germination of direct-seeded rice and most upland crops, including legumes. However, by contrast, during La Niña year the economy expands, and simulations indicate that national GDP gains during La Niña years offset the losses observed during El Niño events[53].

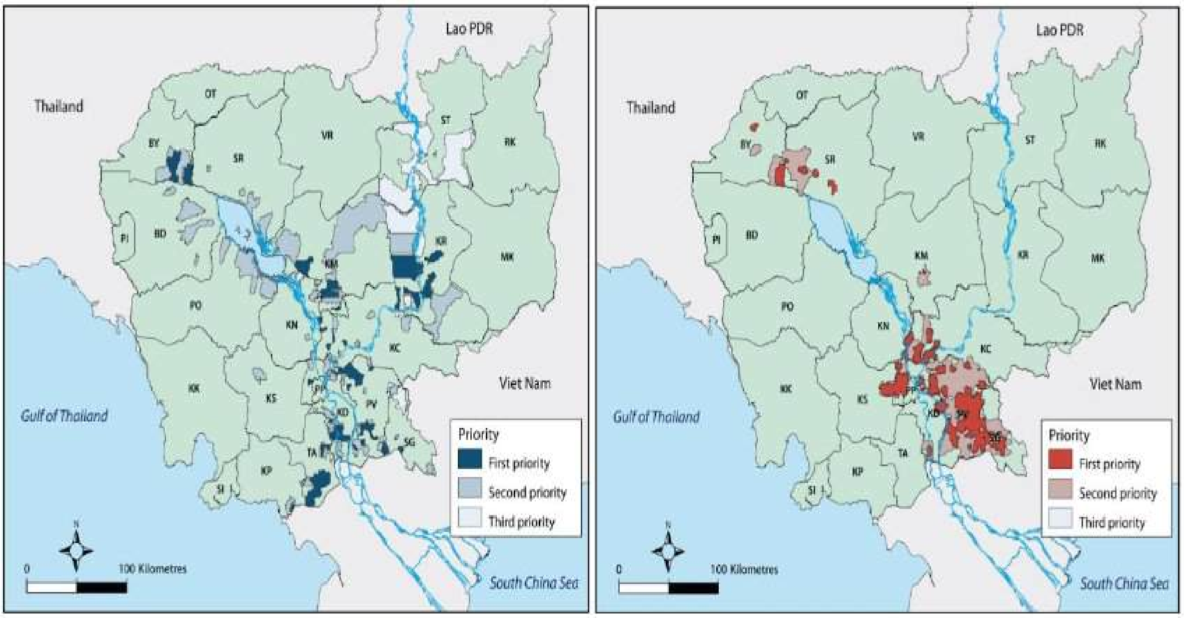


Figure 3-11. Flood and drought prone areas in the Greater Mekong Sub-region (food security atlas).

One study[54] that analyzed data from 1960-2019 found that, along the Tonle Sap River, the average annual reverse flow from the Mekong to the Tonle Sap Lake has decreased by 56.5%, from 48.7 km^3 in 1962-1972 to 31.7 km^3 in 2010-2018. This results in a shrinkage of lake area by 20.6% in the rainy season i.e., water levels dropped by 1.05m in 2010-2019 compared to 1996-2009. However, because the measured rainfall in Cambodian floodplains has remained fairly constant between 1960-2019, the local precipitation is not assessed as the factor that has driven discharge reduction. Instead, the study attributes reduction in discharge to local anthropogenic factors such as irrigation and channel incision (owing to sand mining and reduced sediment flux); upstream developments such as dams are assessed as having a limited role or an indirect role (through reducing sediment flux). However, climate change is expected to have a more significant impact on the Tonle Sap basin in the future as described in the section below.

All four CAISAR provinces are prone to flash floods[55] owing to repeated heavy rainfall in mountainous areas, which flows into the Mekong tributaries and streams. Such flash floods are swift and last only a few days but cause severe damage to crops and infrastructure, especially around the Tonle Sap Lake. With the increased intensity of wet-season rainfall, the duration and extent of flooding have increased in some areas.

5.5 Current Impacts of Climate Change

On average, annual damage and loss of wet season rice caused by floods and droughts is approximately 120,501 hectares, of which 70 percent of the damage and loss is due to floods and 30 percent is the result of droughts. Flooding occurs frequently and extensively in Cambodia. The source of these floods can be the

[53] Sutton et al. 2019. Striking a Balance Managing El Niño and La Niña in Cambodia’s Agriculture. World Bank
[54] Chua et al., 2022.
[55] FAO, UNICEF, WFP, 2020.

Mekong River including the Tonle Sap Great Lake, tributary flash floods, urban flooding, and failure of structures such as protection levees and storages.

The agricultural sector accounts for 94-98% of the water use in Cambodia, with 1-2% from industry and 4% from domestic sectors (FAO 2005)[56,57] Water use across sectors is 2-7% of available water that flows through the country annually, and water scarcity results primarily from limited access to irrigation and a lack of water storage capacity, particularly in the dry season[58]. Projections in 2003 suggested that industrial and domestic uses will increase to 15% and 11% by 2025 in Cambodia and other South-east Asian countries, and while this may no longer apply, it is plausible that there will be increased competition in the near-future due to climate impacts and economic changes upstream of the river basins (industrial use, deforestation, etc.) that are transboundary or national. Therefore, enhancing water use efficiency in agriculture and the agro-industrial sector are critical – including through tailoring advisories linked to agrometeorological information and climate forecasts.

Floods also damage roads, collapse ponds and cause canal breakages – impacting the irrigation infrastructure directly, and this then results in inadequate water supply for cultivation in subsequent years. Of the estimated[59] US$ 356.23 million loss and damage from 2013 floods, water and irrigation infrastructure accounted for US$ 52 million (14.5%) and national / rural roads for another US$ 79.61 million (22.3%). It is also the case that when irrigation infrastructure is designed without taking climate scenarios into account — as they are currently, it can affect water flow and drainage from fields. Stakeholder consultations[60] identified at least one instance when a drain that passes under the main canal was too small in diameter to handle large flows, resulting in rice fields upstream becoming flooded during the wet season, breakage of main canal embankment and drainage water entering the main canal, and another where the opening of the water gates was too narrow and under conditions of large discharge, the flow and velocity of turbulence causes soil erosion.

Climate change affects women, men, and vulnerable people differently, and their responses to its impacts also differ, including in relation to safeguarding food security and livelihoods and coping with hazards and risks. In the project area, women have significantly less access than men to financial instruments, land, natural resources, climate change resources and technologies, education, and other development services for successful adaptation to climate change. Women are also underrepresented in FWUCs, and typically perform administrative roles. A study of 10 selected irrigation schemes: three in Kompong Thom, three in Pursat and four in Kompong Chhnang showed that among 43 members of FWUCs in the study areas, only nine are female (21%)[61]. Most of the important positions in FWUCs, such as chair and first and second vice-chair, are dominated by men. While women mostly hold positions as treasurers and accountants in the committees. Cambodia's Women's Resilience Index found women less resilient in times of disaster than men due to women's unstable and insecure sources of income, limited access to shelters or safe places, inadequate climate information and early warning systems, poor housing, weak social safety nets and absence of emergency networks. Furthermore, women's responsibilities in household resources position them well to contribute to livelihood strategies adapted to changing environmental realities. However, lack of information, access to planning processes, and care obligations, limit their ability to contribute.

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[56] Cambodia National Mekong Committee (CNMC) Water Security, Food Security and Livelihoods in Cambodia and the Lower Mekong Basin. https://ppcrcambodia.files.wordpress.com/2012/11/watt-1106-w-food-security.pdf

[57] https://www.worldometers.info/water/cambodia-water/

[58] ADB Cambodia Agriculture, Natural Resources, and Rural Development, Sector Assessment, Strategy and Road Map. https://www.adb.org/sites/default/files/publication/718806/cambodia-agriculture-rural-development-road-map.pdf

[59] Note: WATSAN was a separate category from water and irrigation infrastructure. Roads included drainage structures such as pipe and box culverts and spillway locations. Government of Cambodia (2014). Post-flood early recovery need assessment report. https://www.undp.org/sites/g/files/zskgke326/files/migration/kh/Cambodia-post-flood-recovery-need-assessment-report.pdf

[60] Field visits 17-20 May 2022: Learning about and from FWUCs. Annex 4, CAISAR – Feasibility Study and Project Preparation.

[61] Gender and Water Governance: Women's Role in Irrigation Management and Development in the Context of Climate Change. CDRI Working Paper Series No. 89 -2014

5.6 Climate Change Projections

Precipitation and temperature have become increasingly unpredictable. The temperature anomalies by 2040-2059 against the reference period of 1986-2006 for Cambodia and CAISAR provinces are presented in Table 2.5. The average monthly temperature is projected to increase by 1.83°C by 2040-59. By mid-century, climate change will result in more frequent heavy precipitation days: from 2.4 days to 4.9 days in the rainy season, and an increase in the number of consecutive dry days in the same season: from 0.8 days to 4.4 days.

Future projections of climate change in the project area under the RCP4.5 scenario (Figure 2.12) indicate a temperature increase of 1.4- 1.6°C by mid-century (2040-2070) and up to 2.2°C by the end of the 21st century (2070-2100); the increase is much higher under RCP8.5 scenario (3.6°C, 2070-2100). With regards to the spatial variability, the inner Cambodia will experience a higher temperature change compared to coastal areas. While the changes over time will be lower than 1˚C along the coastal areas, the inner parts of the country will experience a temperature rise of more than 2˚C in both RCPs.

Table 2-5.Projected anomaly (changes °C) for average monthly temperatures, using median values of CCKP multi-model ensembles and showing 10-90th percentile in brackets

Region	Average Monthly temperature, 2040-2059	
	RCP 4.5	RCP 8.5
Kampong Speu	1.35 (0.22, 2.05)	1.75 (0.49, 2.54)
Kampong Chhnang	1.37 (0.13, 2.21)	1.81 (0.34, 2.83)
Kandal	1.34 (0.17, 2.1)	1.76 (0.49, 2.62)
Pursat	1.36 (0.10, 2.29)	1.72 (0.35, 2.89)
National	1.39 (0.04, 2.23)	1.83 (0.22, 2.78)

Nights exposed to high temperatures are projected to become more frequent during the 21^{st} century (+114 nights by mid-century and +151 nights by the 2080s). Population, crop and livestock systems will also experience heat extremes more frequently in comparison to the reference period (42 days by mid-century and reaching 62 days by the 2080s) and IFAD is expecting a drastic reduction in the productivity of crops and livestock.

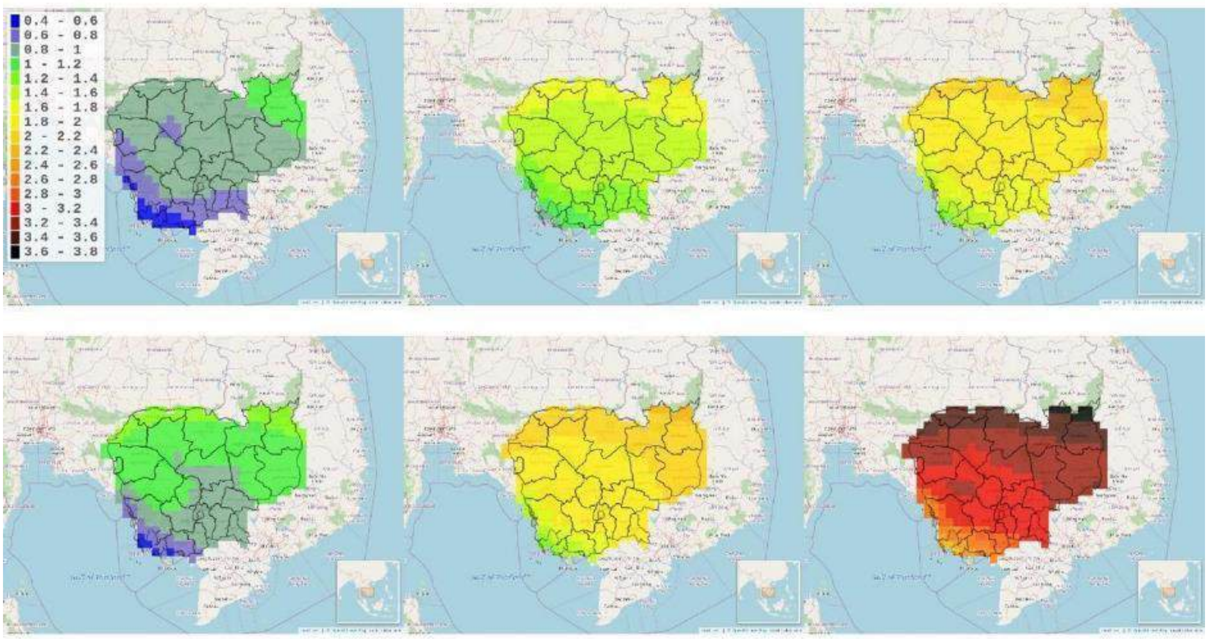


Figure 2-12. Temperature maximum deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected changes into the future in degree Celsius based on projections from bias corrected regional CORDEX data (FAO analysis, CAVA tool).

While annual rainfall is expected to increase, the number of days with rain is decreasing and daily rain intensity is increasing, resulting in extreme rainfall events and flooding risks[62].

Across Southeast Asia, a modest increase in precipitation is projected – from 1-8% by 2100 (IPCC AR5), but there are some uncertainties in the direction of changes in annual precipitation and river flows for the Mekong River Basin[63]. In general, it can be said that for the CAISAR observation points, models[64] show a reduction in rainfall during the dry season but an increase in rainfall during the wet season and an increase in frequency and intensity of heavy rainfall events which is described in more detail later.

For the Lower Mekong Basin, both an increase in drought days by 2100[65] and an increase in drought frequency[66] is predicted, and flooding is expected to increase in frequency, severity, and duration[67]. Studies find more severe flood inundation magnitude in the Lower Mekong Basin, in the future (2075-2099) compared to 1979-2003, under four RCP scenarios and sea surface temperature patterns[68].

Although there is significant variability in modelled future precipitation projections in Cambodia, most estimates of the mean annual rainfall indicate a decrease in rainfall into the near future (Figure 2.13) with potential more intense decreases in the medium to far future. There is an increasing trend in seasonal rainfall between June and August in the northwest, and a decreasing trend in the northeast of the country. Precipitation deviation from the historical average period (1980-2005), shows the largest increase in the near future, with subsequent decreases in annual precipitation in the medium and far future, with variation geographically (Figure 2.14).

[62] World Bank and ADB, 2021.

[63] Piman, T., Cochrane, T.A., Arias, M.E., Dat, N.D. and Vonnarart, O., 2014. Managing Hydropower under Climate Change in the Mekong Tributaries. Chapter 11 in S. Shrestha et al. (Ed.), Managing Water Resources under Climate Uncertainty: Examples from Asia, Europe, Latin America, and Australia, In Press, Springer. https://doi.org/10.1007/978-3-319-10467-6_11

[64] Global Climate Models and Regional Climate Models comparing data for 1995-2001 with 2026-2050 projections. WAPCOS and Phnom Penh International Consultants, 2023. CAISAR Feasibility Report D8, Version 1.2.

[65] Hirabayashi, Y., Kanae, S., Emori, S., Oki, T., and Kimoto, M., 2008. Global projections of changing risks of floods and droughts in a changing climate. Hydrological Sciences, 53 (4): 754-772. https://doi.org/10.1623/hysj.53.4.754

[66] MRC, 2010. State of the Basin Report 2010. Mekong River Commission: Vientiane.

[67] Thoeun, 2015.

[68] Try, S., Tanaka, S., Tanaka, K., Sayama, T., Lee, G., and Oeurng, C., 2020. Assessing the effects of climate change on flood inundation in the lower Mekong Basin using high-resolution AGCM outputs. Progress in Earth and Planetary Science, 2020 (7): 34. https://doi.org/10.1186/s40645-020-00353-z

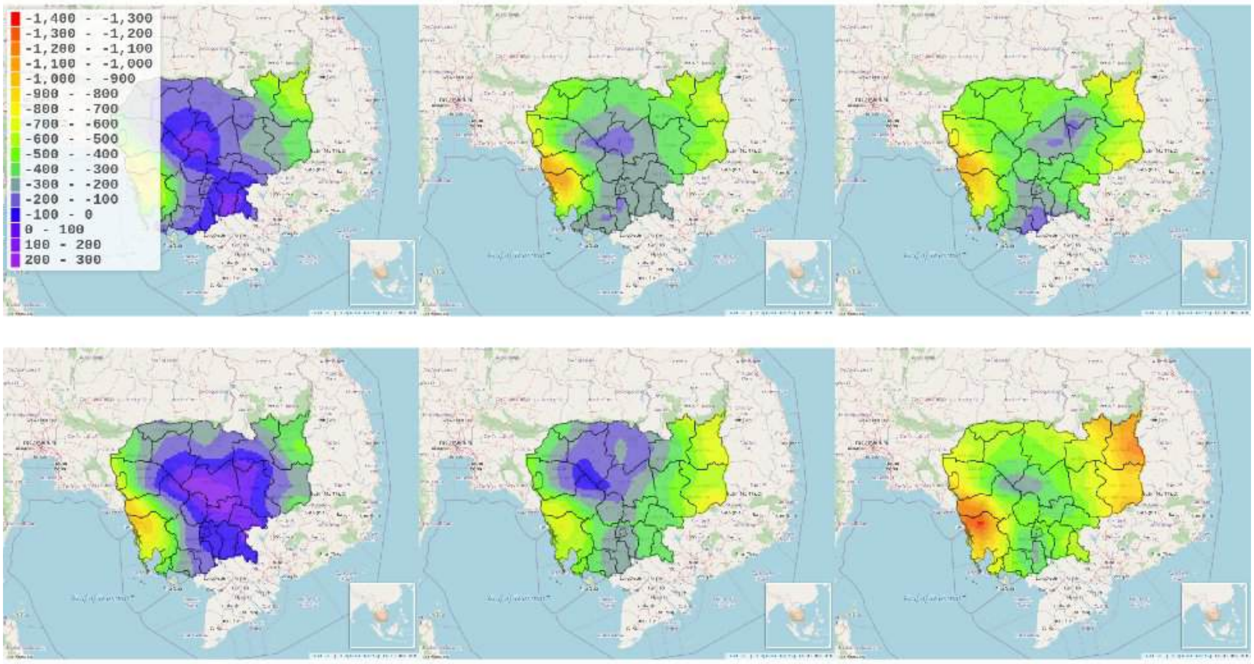


Figure 2-13. Cumulative precipitation per year deviation from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in millimeter/year based on projections from bias corrected regional CORDEX data (FAO analysis).

As many agricultural producers rely on rainfed production in the wet season, Figure 2.14 shows changes in cumulative precipitation in the wet season precipitation and deviation from the historical average in the wet season, respectively. This analysis suggests decreasing wet season precipitation into the future, to a higher degree under RCP8.5 and with changes up to -500 mm/year.

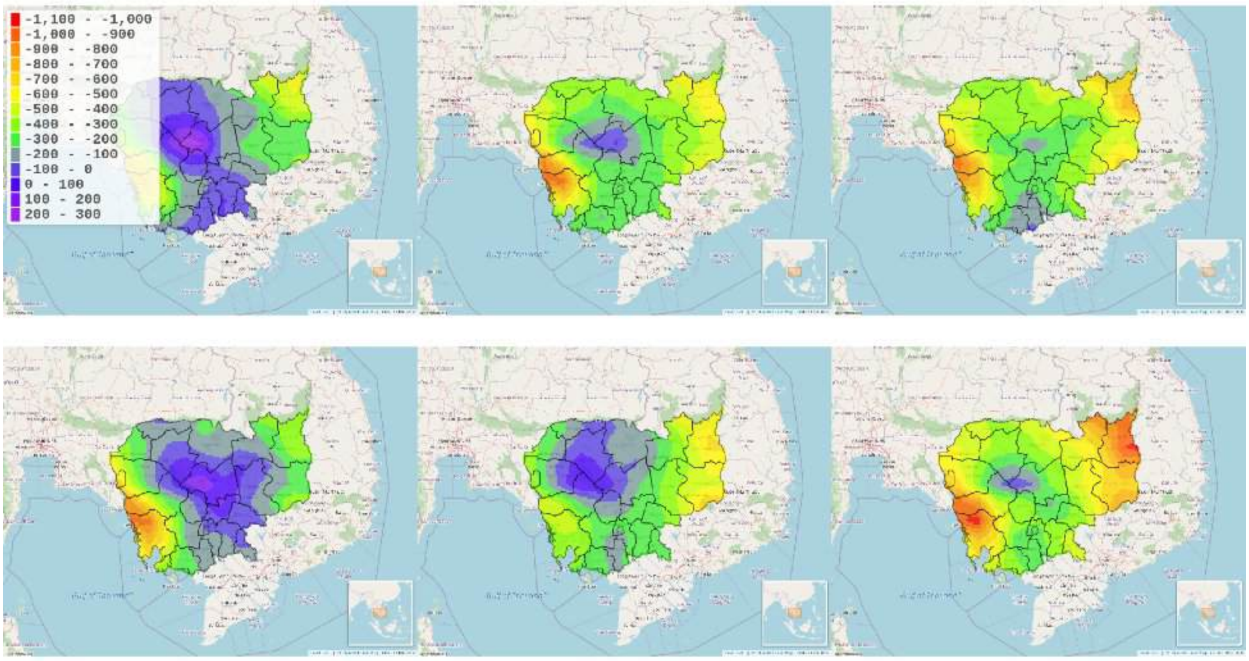


Figure 2-14. Deviation in cumulative precipitation in rainy season (May-October) from historical baseline period (1980-2005) under RCP 4.5 (top row) for the period 2011-2040 (left), 2040-2070 (middle) and 2070-2100 (right) and RCP8.5 (bottom row) for the same time periods. The deviation highlights the projected change into the future in millimeters based on projections from bias corrected regional CORDEX data (FAO analysis).

Other studies[69] find that climate change, in combination with land use change and other developments, could significantly reduce river flows within the Mekong River basin. That is, climate change will also likely induce a decrease in both wet and dry season river flows in all 11 sub-basins contributing to Tonle Sap Lake: mean annual projected flow reductions range from 9-29% for 2030s, 10-35% for 2060s, and 7-41% for 2090s. Additionally, future flood magnitudes are projected to reduce for all 11 sub-basins over a majority of time horizons and under at least one scenario; reductions are also projected for other scenarios used in the simulation for most sub-basins. Since a decrease in extreme river flows is also modeled, this would cause a decline in flood magnitudes and an increase in drought occurrences (in both wet and dry season) throughout the basin as well as an increase in extreme droughts in most sub-basins.

5.7 Climate change scenarios in the target provinces

It is noted that key changes in rainfall and temperature are observed when looking at results of Regional Climate Models (RCM) and Global Climate Models (GCM). For the CAISAR project the 4 RCMs as delivered by IFAD for RCP 4.5 and RCP 8.5 and as an alternative possible future situation also HighResMIP RCP 8.5 results were included. This section focuses on the hydrologic and hydraulic modelling of climate change parameters. For the hydrologic model the SWAT model was selected and that requires in particular as input the future average change in rainfall as a percentage by month and the average absolute increase of temperature by month, both expressed as change from the period of observations used in the study (P and T for 1995-2021) to a future period. For the future periods results are available for 2024-2050, 2051-2075 and 2076-2095, these represent respectively the project lifecycle (short term), the medium term and long-term future periods. In the next sections an overview of the results of the WAPCOS[70] hydrologic modelling is presented for the short-term.

5.7.1 RCP 4.5 climate change factors

Four bias-corrected Regional Climate Models (RCMs) from the CORDEX database were selected based on their ability to represent present-day climate (using ECMWF ERA-5). The four Global Circulation Models (GCMs) driving the RCMs are MIROC5, CSIRO-Mk3, EC-EARTH and HadGEM2. Based on the provided district areal averaged data of 4 RCMs the areal averages by command area and by river basin were calculated for application as climate change factors to the SWAT model, these are shown in tables 2.6 and 2.7. The increase in temperature varies between 0.6-1.0ºC. Similarly, the precipitation shows an increase in the wet season.

Table 2-6.RCP 4.5 Absolute average temperature increase by month from 1995-2021 to 2024-2050

RCP 4.5	River basins				Command areas		
	Increase in temperature in degrees from 1995-2021 to 2024-2050 (both periods 27 years)						
month	St. Baribour	St. Ponley Krang	St. Pursat	St. Svay Don Keo	Ou Ta Paong Tanai	Lum Hach	Krang Ponley
1	0.7	0.7	0.8	0.8	0.8	0.7	0.7
2	0.8	0.8	0.7	0.7	0.7	0.8	0.8
3	0.7	0.7	0.7	0.7	0.7	0.6	0.7
4	0.7	0.8	0.8	0.7	0.7	0.7	0.8
5	0.9	0.9	0.9	0.9	0.8	0.9	0.8
6	0.9	0.9	0.8	0.8	0.8	0.9	0.9
7	0.7	0.7	0.7	0.7	0.7	0.7	0.6
8	0.8	0.7	0.7	0.7	0.7	0.8	0.7

69 Oeurng, C., Cochrane, T.A., Chung, S., Kondolf, M.G., Piman, T., and Arias, M.E., 2019. Assessing Climate Change Impacts on River Flows in the Tonle Sap Lake Basin, Cambodia. Water, 11(3): 618. https://doi.org/10.3390/w11030618
70 WAPCOS 2022. Survey results and hydraulic modelling report

RCP 4.5	River basins				Command areas		
	Increase in temperature in degrees from 1995-2021 to 2024-2050 (both periods 27 years)						
month	St. Baribour	St. Krang Ponley	St. Pursat	St. Svay Don Keo	Ou Ta Paong Tanai	Lum Hach	Krang Ponley
9	0.8	0.8	0.8	0.8	0.8	0.9	0.8
10	0.8	0.7	0.8	0.8	0.8	0.8	0.7
11	0.9	0.9	0.9	0.9	0.9	0.9	0.9
12	1.0	1.0	1.1	1.0	1.0	1.0	1.0

Table 2-7.RCP 4.5 Relative average monthly rainfall change 1995-2021 to 2024-2050

RCP 4.5	River basins				Command areas		
	Increase in in rainfall (%) from 1995-2021 to 2024-2050 (both periods 27 years)						
month	St. Baribour	St. Krang Ponley	St. Pursat	St. Svay Don Keo	Ou Ta Paong Tanai	Lum Hach	Krang Ponley
1	22.3%	13.0%	14.6%	19.6%	27.1%	23.6%	11.1%
2	22.5%	21.0%	9.8%	8.7%	10.2%	25.9%	18.9%
3	15.8%	16.4%	10.9%	9.9%	9.2%	17.8%	15.8%
4	14.1%	12.6%	11.7%	11.9%	11.7%	15.0%	10.9%
5	13.5%	11.5%	8.7%	7.9%	7.0%	14.9%	10.8%
6	-6.9%	-5.6%	-0.3%	-2.5%	-6.3%	-6.7%	-6.1%
7	11.3%	9.5%	7.4%	7.6%	7.9%	11.9%	9.3%
8	5.1%	5.1%	1.1%	1.8%	2.5%	5.8%	5.7%
9	11.2%	11.0%	8.8%	10.9%	10.5%	12.2%	11.8%
10	12.5%	9.8%	9.8%	10.6%	12.3%	13.6%	7.1%
11	14.7%	9.9%	12.0%	10.5%	9.1%	15.8%	6.9%
12	41.8%	37.6%	25.6%	19.8%	17.2%	47.5%	30.3%

5.7.2 RCP 8.5 climate change factors

RCP8.5 is a "baseline" scenario that includes no policy-driven mitigation and is a high emission scenario that could be characterized as a "worst case" future situation. In terms of the level of GHG emissions, it is not considered the most likely. One can only get that high by a combination of several factors, such as high population / economic growth combined with a high coal use and high dependency on fossil fuels. The results are shown in tables 2.8 and 2.9. This indicates a potential increase in temperature of between 0.9 to 1.2 ^{o}C but also an increase in precipitation during the wet season.

Table 2-8.RCP 8.5 Absolute average temperature increase by month from 1995-2021 to 2024-2050

RCP 8.5	River basins				Command areas		
	Increase in temperature in degrees from 1995-2021 to 2024-2050 (both periods 27 years)						
month	St. Baribour	St. Krang Ponley	St. Pursat	St. Svay Don Keo	Ou Ta Paong Tanai	Lum Hach	Krang Ponley
1	1.2	1.2	1.2	1.2	1.3	1.2	1.1
2	1.1	1.1	1.1	1.1	1.1	1.1	1.1
3	1.1	1.1	1.1	1.1	1.1	1.1	1.2
4	1.2	1.2	1.2	1.2	1.2	1.2	1.3
5	1.2	1.2	1.2	1.2	1.2	1.2	1.2
6	1.2	1.2	1.2	1.2	1.2	1.3	1.2
7	1.0	0.9	0.9	0.9	0.9	1.0	0.9
8	1.0	1.0	0.9	0.9	0.9	1.0	0.9
9	1.1	1.0	1.0	1.0	1.0	1.1	1.0
10	1.1	1.1	1.1	1.1	1.1	1.1	1.0
11	1.1	1.1	1.1	1.1	1.1	1.1	1.1
12	1.1	1.1	1.1	1.1	1.2	1.1	1.1

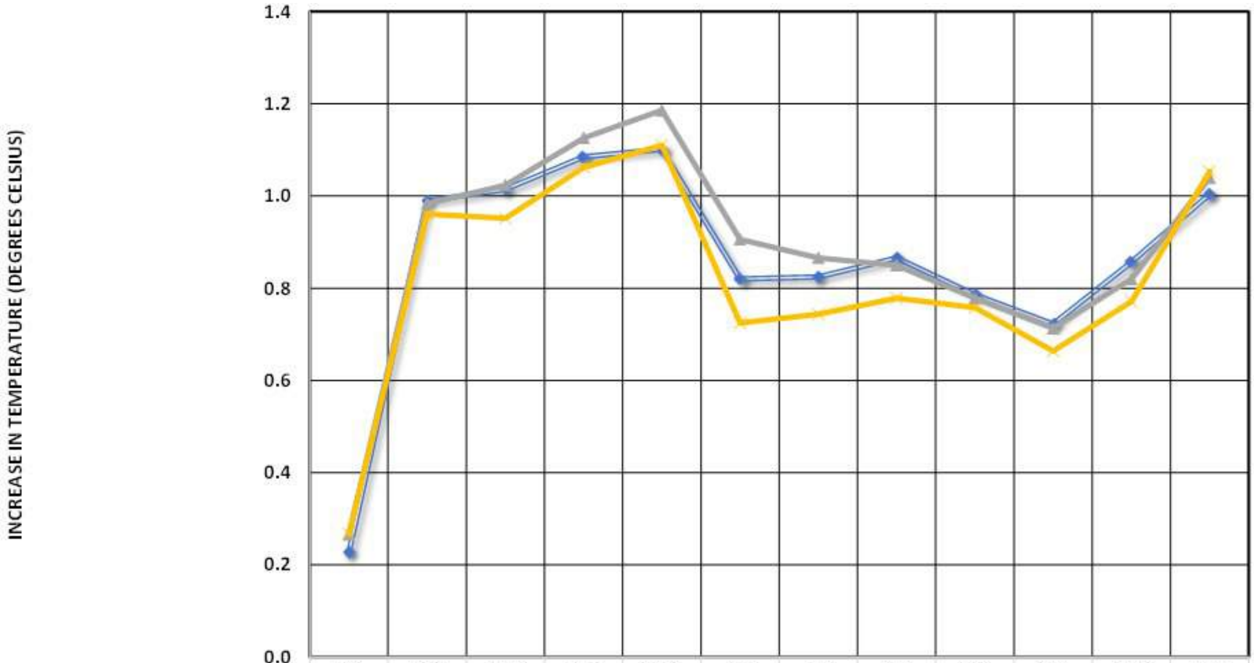
Table 2-9.RCP 8.5 Relative average monthly rainfall change 1995-2021 to 2024-2050

RCP 8.5 month	River basins				Command areas		
	Increase in in rainfall (%) from 1995-2021 to 2024-2050 (both periods 27 years)						
	St. Baribour	St. Krang Ponley	St. Pursat	St. Svay Don Keo	Ou Ta Paong Tanai	Lum Hach	Krang Ponley
1	27.8%	18.5%	20.6%	17.2%	15.5%	31.4%	15.1%
2	1.9%	1.2%	2.2%	3.0%	3.5%	1.5%	1.3%
3	-7.7%	-6.4%	-1.9%	-4.1%	-9.2%	-8.4%	-5.9%
4	-0.6%	-1.2%	1.6%	1.1%	-1.3%	-0.5%	-1.0%
5	14.2%	12.8%	12.3%	13.4%	14.0%	14.7%	13.2%
6	-6.3%	-5.1%	0.2%	-0.6%	-4.2%	-5.9%	-5.6%
7	21.0%	20.0%	14.1%	17.2%	19.1%	22.4%	21.3%
8	16.5%	17.5%	11.1%	11.6%	13.0%	17.3%	20.0%
9	9.4%	9.6%	7.9%	8.8%	6.7%	10.7%	11.4%
10	22.6%	18.4%	14.0%	11.2%	9.8%	25.5%	14.3%
11	19.8%	14.7%	13.8%	11.4%	9.1%	21.9%	11.4%
12	16.1%	12.1%	8.4%	0.3%	-4.5%	18.5%	8.8%

5.7.3 HighResMIP RCP 8.5 climate change factors

As described in the paper by Hariadi et al.[71] the RCMs based on the coupled model intercomparison project phase 5 (CIMP5) they analyzed did not perform well regarding the historical runs for the onset and cessation of the monsoon period. They compared this with an approach using high resolution GCMs from the high-resolution model intercomparison project (HighResMIP) and compared this against observational datasets for Southeast Asia. They acknowledge that a realistic representation of the monsoon rainfall is essential for agriculture in Southeast Asia and the analysis of crop patterns and crop intensities. Also, they analyzed the historical force atmosphere run (HighResSST) regarding the anomaly of the onset date and the total precipitation for different El Niño-southern oscillation conditions. They observed that changing the resolution of the GCMs used from 1.125º to 0.5º resulted in a dramatic improvement in rainfall over most of the Indonesian archipelago. The Southeast Asian domain that they analyzed covers the area between 12.5ºS–24.5ºN and 92.5ºE–142.5ºE and includes the northern part of Myanmar, Laos, Vietnam, Thailand, Cambodia, Malaysia and Indonesia. The results are shown in figures 2.15 to 2.18. These simulations indicated that temperatures would increase in general between 0.7 to 1.2 degrees in the command area from 1995-2021 to 2024-2050 and that the precipitation will be lower in the dry season from -20%-0% and in the wet season it would increase between 0%-25% in the command area.

[71] Hariadi et al., 2021: Evaluation of onset, cessation and seasonal precipitation of the Southeast Asia rainy season in CMIP5 regional climate models and HighResMIP global climate models

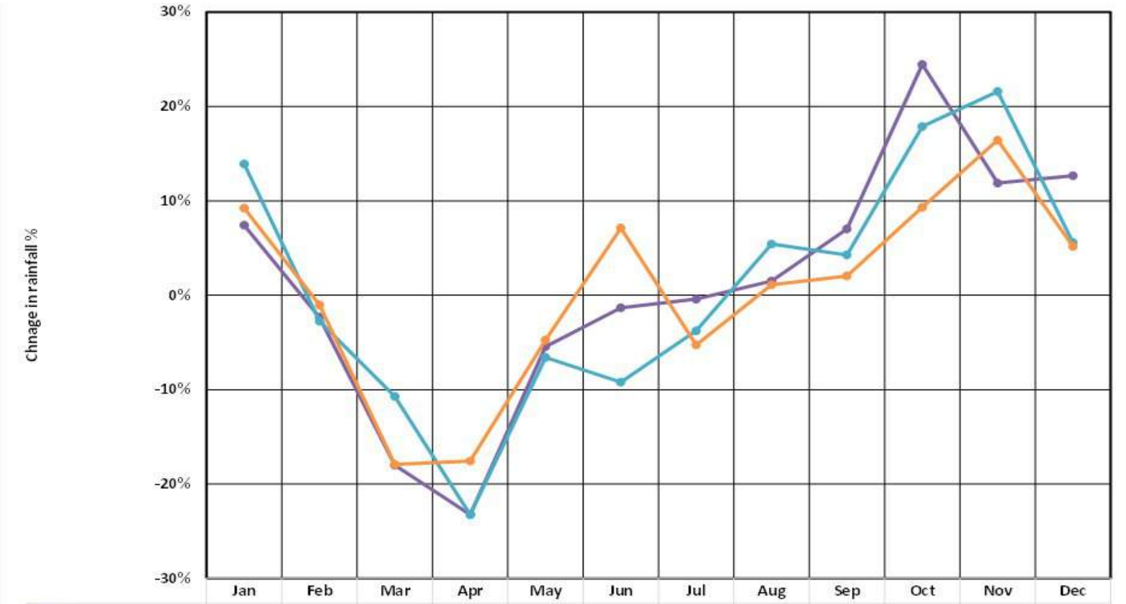


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
KrangPonley|HighResMIP-r1	0.2	1.0	1.0	1.1	1.1	0.8	0.8	0.9	0.8	0.7	0.9	1.0
LumHach|HighResMIP-r1	0.3	1.0	1.0	1.1	1.2	0.9	0.9	0.8	0.8	0.7	0.8	1.0
OuTapaong|HighResMIP-r1	0.3	1.0	1.0	1.1	1.1	0.7	0.7	0.8	0.8	0.7	0.8	1.1

Figure 2-15. HighResMIP RCP 8.5 Command area temperature change factors 1995-2021 to 2024-2050.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pursat	0.3	1.5	0.9	1.0	1.0	0.7	0.8	0.8	0.8	0.7	0.8	1.2	0.9
Svay Don Keo	0.3	1.6	1.0	1.1	1.1	0.7	0.8	0.8	0.8	0.7	0.8	1.2	0.9
Krang Ponley	0.2	1.6	1.0	1.1	1.1	0.8	0.8	0.9	0.8	0.7	0.9	1.2	0.9
Baribour	0.3	1.6	1.0	1.1	1.1	0.9	0.9	0.8	0.8	0.7	0.8	1.2	0.9

Figure 2-16. HighResMIP RCP 8.5 Catchment temperature change factors 1995-2021 to 2024-2050



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Krang Ponley	7%	-2%	-18%	-23%	-5%	-1%	0%	2%	7%	24%	12%	13%
LumHach	14%	-3%	-11%	-23%	-7%	-9%	-4%	5%	4%	18%	22%	6%
Ou Ta Paong Tanai	9%	-1%	-18%	-18%	-5%	7%	-5%	1%	2%	9%	16%	5%

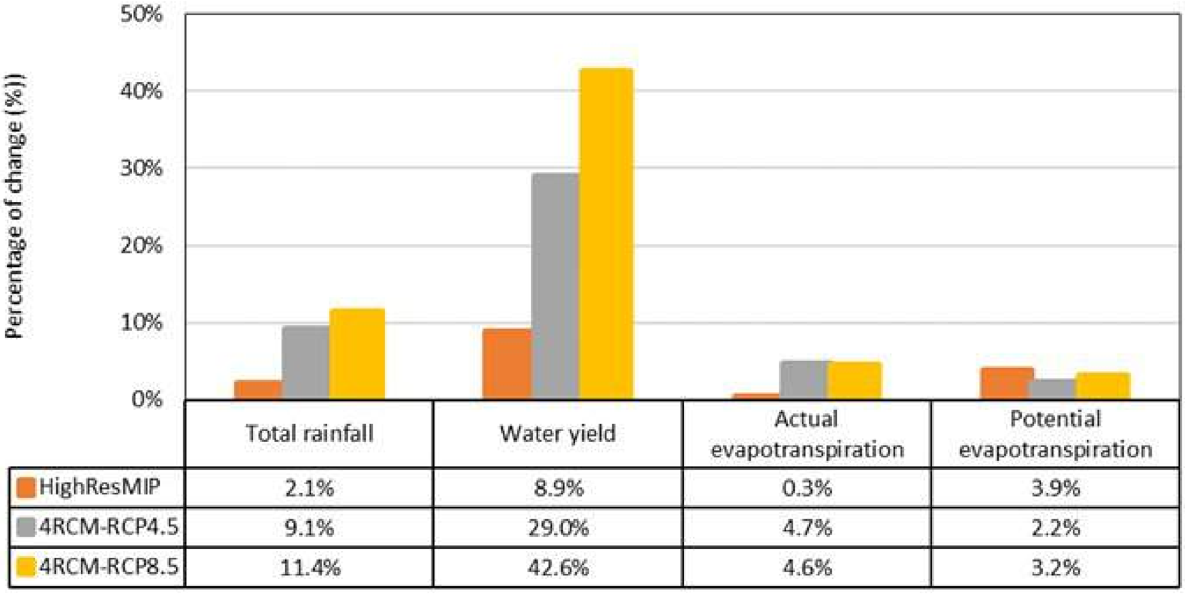
Figure 2-17. HighResMIP RCP 8.5 Command area rainfall change factors 1995-2021 to 2024-2050

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Pursat	-1%	-22%	-20%	-20%	-8%	-9%	-14%	-8%	-1%	2%	1%	-4%	-8%
Svay Don Keo	27%	4%	1%	-7%	-1%	7%	1%	9%	6%	9%	16%	11%	5%
Krang Ponley	8%	-18%	-13%	-21%	-4%	-3%	-3%	2%	7%	16%	6%	10%	0%
Baribour	10%	-15%	-11%	-18%	-4%	-6%	-4%	5%	5%	12%	11%	3%	0%

Figure 2-18. HighResMIP RCP 8.5 Catchment rainfall change factors 1995-2021 to 2024-2050

5.8 Climate change impact on water resources and catchment water balance

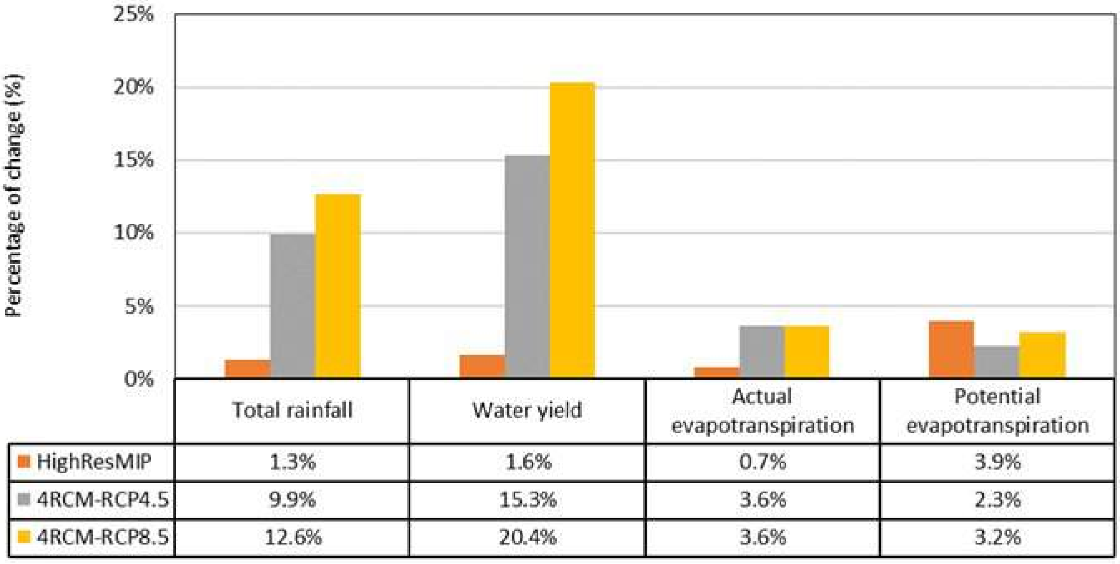
Climate change is leading to the change in water balance components as well as total rainfall, water yield, actual evapotranspiration, and potential evapotranspiration. The change in average annual water balance components was simulated under three different climate change scenarios compared to a baseline period from 1995 to 2021 in Krang Ponley watershed as shown in Figure 2.19. All water balance components are expected to increase for climate change scenarios compared to the baseline period. Water yield is expected to increase higher than other water balance components by 9%, 29%, and 43% for HighResMIP-RCP8.5, 4RCM-RCP4.5 and 4RCM-RCP8.5 compared to the observations from 1995-2021, respectively. RCP8.5 is likely to make the most significant change in water balance.



	Total rainfall	Water yield	Actual evapotranspiration	Potential evapotranspiration
HighResMIP	2.1%	8.9%	0.3%	3.9%
4RCM-RCP4.5	9.1%	29.0%	4.7%	2.2%
4RCM-RCP8.5	11.4%	42.6%	4.6%	3.2%

Figure 2-19. Average annual water balance simulated under climate change compared to the baseline period (1995-2021) in Krang Ponley scheme

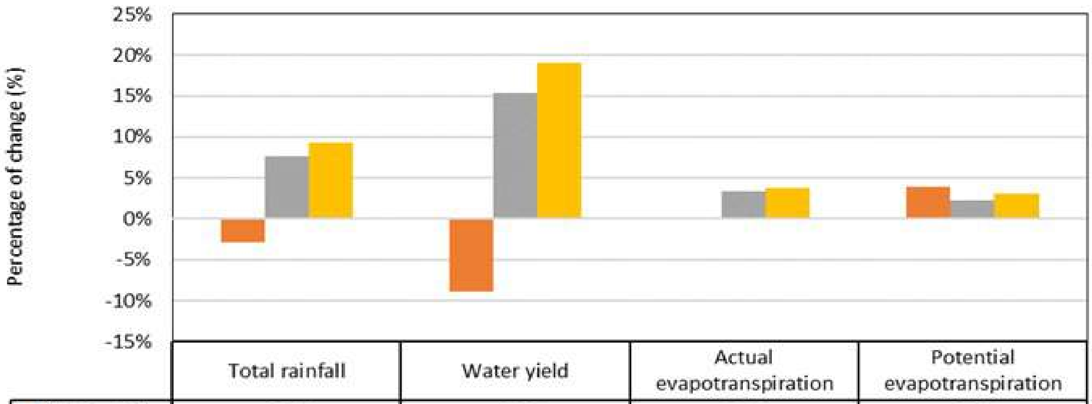
For the Lum Hach scheme the water yield is expected to increase by 15% for 4RCM-RCP4.5 and 20% for 4RCM-RCP8.5 compared to the 1995-2021 period of observations, which is higher than the other water balance components similar to the Krang Ponley watershed (Figure 2.20). The water yield increased by 20.4% on account of a 12.6% increase in 4RCM-RCP8.5 with a 2.7% increase over 4RCM-RCP4.5 in total rainfall.



	Total rainfall	Water yield	Actual evapotranspiration	Potential evapotranspiration
HighResMIP	1.3%	1.6%	0.7%	3.9%
4RCM-RCP4.5	9.9%	15.3%	3.6%	2.3%
4RCM-RCP8.5	12.6%	20.4%	3.6%	3.2%

Figure 2-20. Average annual water balance simulated under climate change compared to the baseline period (1995-2021) in Lum Hach scheme.

For Pursat and Svay Daunkeo river, water yield is expected to increase by 15% for 4RCM-RCP4.5 and 19% for 4RCM-RCP8.5 compared to a baseline period, which is higher than other water balance components, while potential evapotranspiration is projected to increase by 2% and 3% (see Figure 2.21). HighResMIP showed a negative change on water component except for potential evapotranspiration, while the other 2 climate scenarios predicted an increase compared to the baseline.

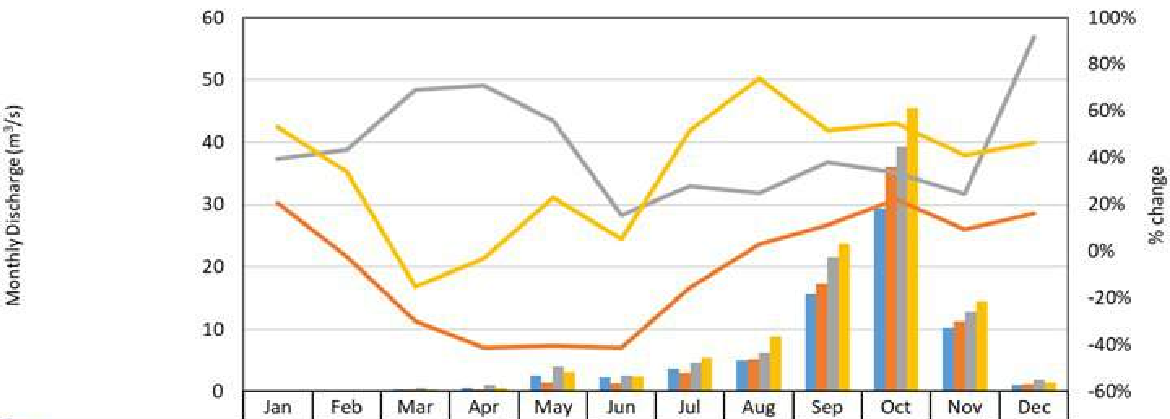


	Total rainfall	Water yield	Actual evapotranspiration	Potential evapotranspiration
HighResMIP	-2.9%	-8.9%	-0.1%	3.9%
4RCM-RCP4.5	7.7%	15.4%	3.4%	2.3%
4RCM-RCP8.5	9.3%	19.0%	3.8%	3.2%

Figure 2-21. Average annual water balance simulated under climate change compared to the baseline period (1995-2021) in Ot Ta Paong scheme

5.9 Climate change impacts on flow and flood

For Krang Ponley, the high flow generally occurs during the rainy season in September, October, and November, while the dry season flow in January, February, and March is low (Figure 2.22). Based on the results, the monthly flow change is projected to increase during the rainy and dry seasons for 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios, while HighResMIP is projected to increase during the rainy and decrease during the dry season compared to the baseline period. The highest monthly flow is predicted to increase in October by 22%, 34%, and 55% for HighResMIP, 4RCM-RCP4.5, and 4RCM-RCP8.5 compared to the baseline period, respectively. The lowest monthly flow will increase in February by 44% for 4RCM-RCP4.5 and 34% for 4RCM-RCP8.5, while HighResMIP is to decrease by 2%.

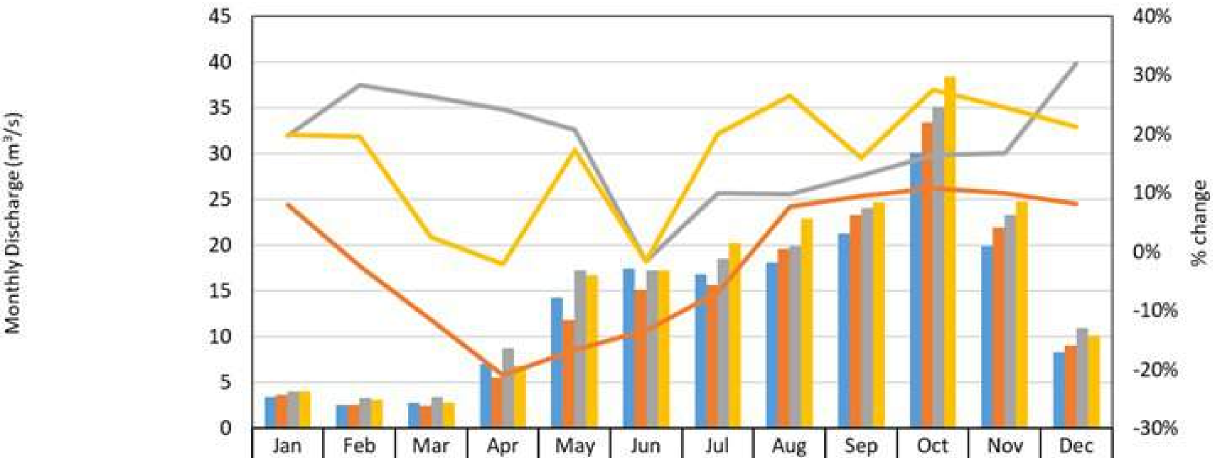


	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline (m3/s)	0.1	0.1	0.4	0.6	2.6	2.3	3.6	5.0	15.6	29.4	10.2	1.0
HighResMIP (m3/s)	0.1	0.1	0.3	0.4	1.5	1.3	3.0	5.2	17.4	36.0	11.2	1.1
4RCM-RCP4.5 (m3/s)	0.1	0.1	0.6	1.0	4.0	2.6	4.6	6.3	21.6	39.3	12.7	1.9
4RCM-RCP8.5 (m3/s)	0.1	0.1	0.3	0.6	3.1	2.4	5.4	8.8	23.7	45.5	14.4	1.4
% HighResMIP	21%	-2%	-30%	-41%	-40%	-41%	-15%	3%	11%	22%	9%	16%
% 4RCM-RCP4.5	40%	44%	69%	71%	56%	15%	28%	25%	38%	34%	24%	92%
% 4RCM-RCP8.5	53%	34%	-15%	-3%	23%	5%	52%	74%	52%	55%	41%	46%

Figure 2-22. Average monthly flow under climate change compared to the baseline period (1995-2021) in outlet 10 location of Krang Ponley scheme

In the Lum Hach watershed, the high flow generally occurs during the rainy season from May to November, while the low flow occurs during the dry season in January, February, and March. Generally, the highest monthly flow was considerably changed in October, increasing by 11%, 16%, and 27% for HighResMIP, 4RCM-RCP4.5, and 4RCM-RCP8.5 compared to the baseline period, respectively. However, the lowest monthly flow was changed in March, increasing by 26% for 4RCM-RCP4.5 and 3% for 4RCM-RCP8.5, while HighResMIP decreased by 12% (Figure 2.23).

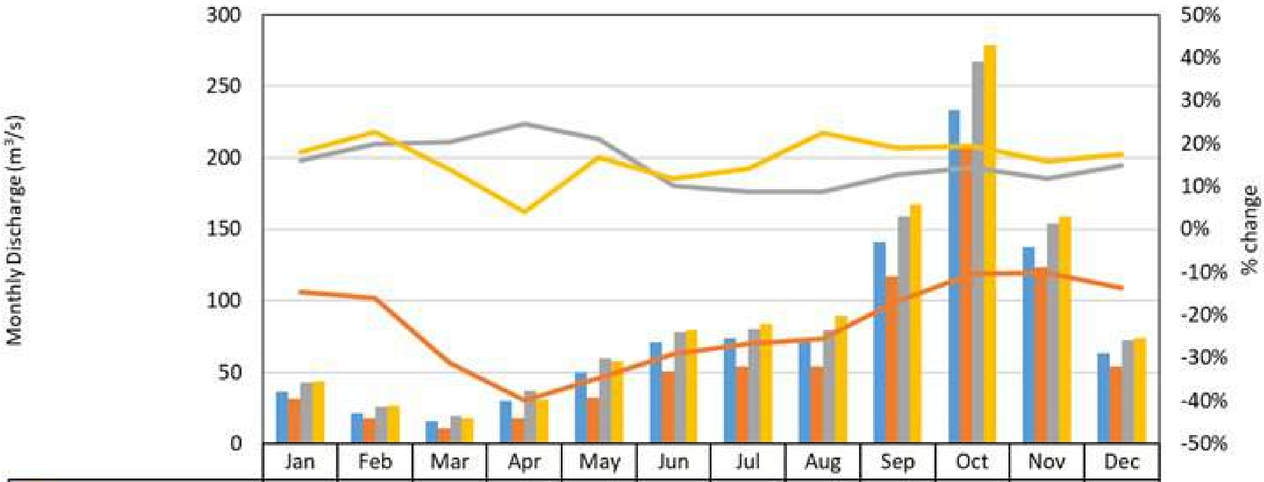
In the Ou Ta Paong the monthly flow change is projected to increase for 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios, while there is a decrease for HighResMIP both during the rainy and dry seasons compared to the baseline period (Figure 2.24). Overall, the highest monthly flow is expected to increase around 20% in October for 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios and decrease for HighResMIP compared to the baseline period. However, the lowest monthly flow is predicted to increase in February for 4RCM-RCP4.5 and 4RCM-RCP8.5 while decreasing for HighResMIP.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline (m3/s)	3	3	3	7	14	18	17	18	21	30	20	8
HighResMIP (m3/s)	4	3	2	6	12	15	16	20	23	33	22	9
4RCM-RCP4.5 (m3/s)	4	3	3	9	17	17	19	20	24	35	23	11
4RCM-RCP8.5 (m3/s)	4	3	3	7	17	17	20	23	25	38	25	10
% HighResMIP	8%	-2%	-12%	-21%	-17%	-13%	-7%	8%	9%	11%	10%	8%
% 4RCM-RCP4.5	20%	28%	26%	24%	21%	-2%	10%	10%	13%	16%	17%	32%
% 4RCM-RCP8.5	20%	20%	3%	-2%	17%	-2%	20%	26%	16%	27%	25%	21%

Figure 2-23. Average monthly flow under climate change compared to the baseline period (1995-2021) in outlet 10 location of the Lum Hach scheme

The project area is likely to experience changes in flood regimes due to the projected increases in temperature and changes in precipitation patterns. The predicted increase in the number of consecutive dry days during both the wet and dry seasons will intensify water scarcity issues, particularly during the dry season, putting increased pressure on water resources and altering catchment water balances. This is expected to largely affect those living in rain-fed regions around the Tonle Sap, as opposed to communities that have access to the mainstream of the Mekong River throughout the year or those with access to irrigation systems and reliable water supply. The intensification of storms and more frequent heavy rainfall events will worsen flood extremes at both the local and regional scale. During the wet season, it is predicted that more severe, frequent, and longer-duration flood events will occur, which will have significant implications for Cambodia. This is particularly concerning because Cambodia is already vulnerable to flooding due to its low-lying topography and the Tonle Sap's complex hydrology.



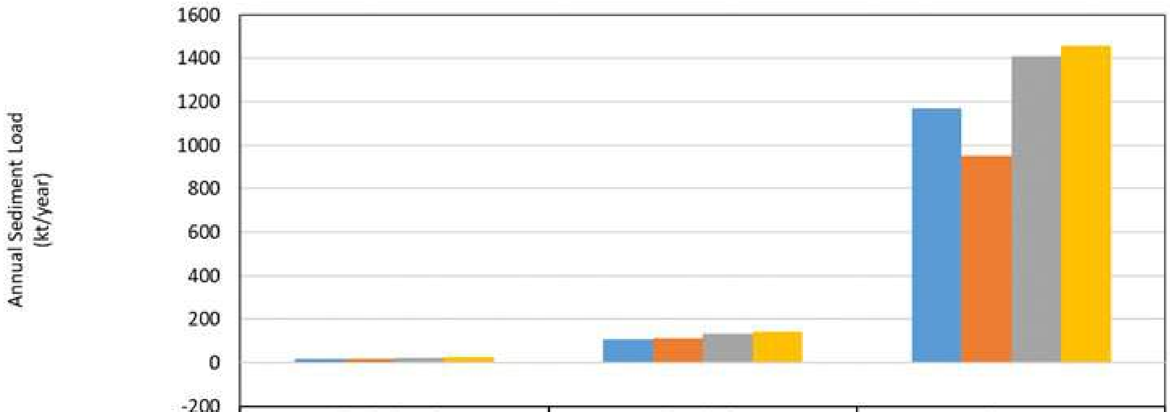
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline (m3/s)	37	22	16	30	50	71	74	73	141	233	137	63
HighResMIP (m3/s)	31	18	11	18	32	51	54	54	117	209	124	54
4RCM-RCP4.5 (m3/s)	43	26	19	37	60	78	80	79	159	267	154	72
4RCM-RCP8.5 (m3/s)	43	27	18	31	58	80	84	89	168	278	159	74
% HighResMIP	-15%	-16%	-31%	-40%	-35%	-29%	-27%	-26%	-17%	-10%	-10%	-14%
% 4RCM-RCP4.5	16%	20%	20%	25%	21%	10%	9%	9%	13%	14%	12%	15%
% 4RCM-RCP8.5	18%	23%	14%	4%	17%	12%	14%	22%	19%	19%	16%	18%

Figure 2-24. Average monthly flow under climate change compared to the baseline period (1995-2021) in outlet 35 location of the Ou Ta Paong scheme

5.9.1 Impacts on sediment

Due to the lack of sediment data, the study[72] used the similarity approach. The complete set of model parameters is transported from a donor catchment that is similar in physiographic attributes (in terms of land use, soils, geology, and rainfall patterns). In this case, the donor catchment is the ensemble of Prek Thnot River, Sen River, and Chinit basin. The study also included the possible option of using sediment parameters from adjacent watersheds. This common approach uses parameters from a donor using a regionalization-based approach. The study also included the overland sediment yield (literature or donor watershed) to validate the model and make sure that it is appropriately simulated. Unsurprisingly, the annual sediment load in the Pursat scheme is much more than the other schemes due to the size of the catchment area (Figure 2.25). Like flow, 4RCM-RCP8.5 causes the highest increase in annual sediment load.

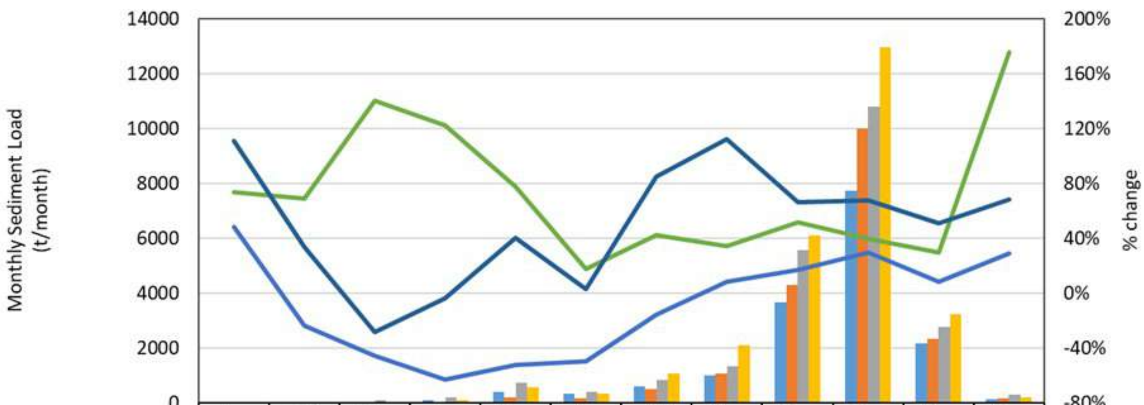
[72] WAPCOS 2022. Survey results and hydraulic modelling report



	Kraing Ponley	Lum Hach	Pursat
Baseline (kt/year)	16	110	1168
HighResMIP (kt/year)	19	113	952
4RCM-RCP4.5 (kt/year)	23	133	1411
4RCM-RCP8.5 (kt/year)	27	141	1456
% HighResMIP	16%	3%	-19%
% 4RCM-RCP4.5	43%	21%	21%
% 4RCM-RCP8.5	66%	29%	25%

Figure 2-25. Annual sediment load delivery under climate change compared to the baseline period (1995-2021) in three different schemes

The change in the average monthly sediment load of the Krang Ponley watershed due to climate change scenarios compared to the baseline period is shown in Figure 2.26. The high sediment load is generally transported during the rainy season from July to November, while the low sediment load during the dry season is in January, February, and March. The monthly sediment load change is projected to increase during the rainy and dry seasons for the 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios, while increase during the rainy and decrease during the dry season for the HighResMIP scenario compared to the baseline period.



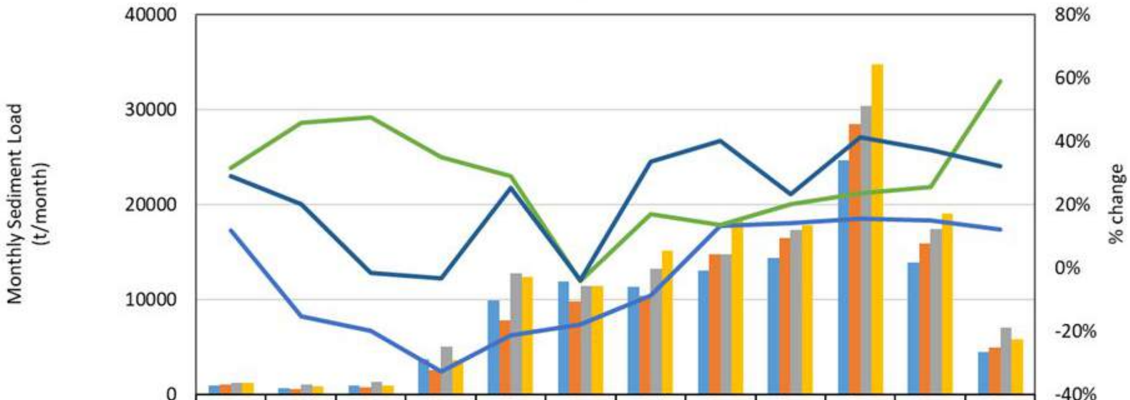
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	2	3	36	79	403	324	580	979	3668	7731	2147	112
HighResMIP	3	2	20	29	190	162	487	1061	4292	9991	2327	144
4RCM-RCP4.5	4	5	87	176	715	381	823	1314	5551	10784	2773	309
4RCM-RCP8.5	4	4	26	76	565	334	1071	2076	6094	12948	3241	189
% HighResMIP	48%	-24%	-46%	-63%	-53%	-50%	-16%	8%	17%	29%	8%	29%
% 4RCM-RCP4.5	74%	69%	140%	122%	77%	18%	42%	34%	51%	39%	29%	175%
% 4RCM-RCP8.5	111%	34%	-29%	-4%	40%	3%	85%	112%	66%	67%	51%	68%

Figure 2-26. Average monthly sediment load delivery under climate change compared to the baseline period (1995-2021) in outlet 10 location of the Krang Ponley scheme

In the Lum Hach watershed, the high sediment load is generally transported during the rainy season from May to November, while the low sediment load during the rainy season in January, February, and March.

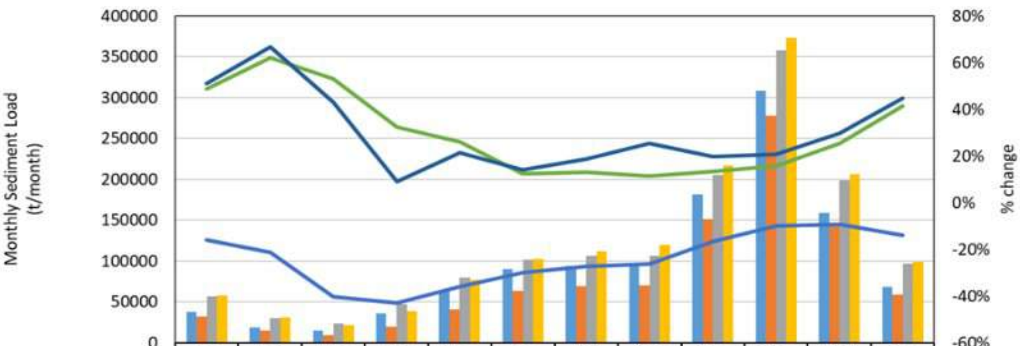
The monthly sediment load change is projected to increase both during the rainy and dry seasons for 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios, while the increase during the rainy and decrease during the dry season for the HighResMIP scenario compared to the baseline period. The highest monthly sediment load happened in October by increasing about 15%, 23%, and 41% for HighResMIP, 4RCM-RCP4.5, and 4RCM-RCP8.5 compared to the baseline period, respectively (see Figure 2.27).

For the Pursat and Svay Daunkeo watershed, the monthly sediment load change is projected to increase both during the rainy and dry seasons for the 4RCM-RCP4.5, and 4RCM-RCP8.5 scenarios, while the decrease for the HighResMIP scenario compared to the baseline period. The monthly sediment load was decreased for the HighResMIP scenario, while it increased during the rainy and dry seasons for the 4RCM-RCP4.5 and 4RCM-RCP8.5 scenarios (see Figure 2.28).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	934	683	908	3727	9862	11888	11329	13022	14394	24596	13851	4416
HighResMIP	1045	578	727	2502	7753	9766	10338	14749	16437	28407	15902	4949
4RCM-RCP4.5	1228	996	1339	5032	12714	11402	13247	14772	17276	30350	17364	7018
4RCM-RCP8.5	1205	819	893	3605	12340	11421	15128	18232	17749	34740	19014	5828
% HighResMIP	12%	-15%	-20%	-33%	-21%	-18%	-9%	13%	14%	15%	15%	12%
% 4RCM-RCP4.5	32%	46%	48%	35%	29%	-4%	17%	13%	20%	23%	25%	59%
% 4RCM-RCP8.5	29%	20%	-2%	-3%	25%	-4%	34%	40%	23%	41%	37%	32%

Figure 2-27. Average monthly sediment load delivery under climate change compared to the baseline period (1995-2021) in outlet 10 location of the Lum Hach scheme



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Baseline	38063	18456	15461	35540	63453	90339	94461	95259	181340	308548	158829	68479
HighResMIP	31983	14548	9225	20231	40767	63397	68847	70283	151360	278241	144164	58934
4RCM-RCP4.5	56583	29923	23646	47012	80042	101480	106902	106065	205895	357411	199026	96777
4RCM-RCP8.5	57456	30748	22146	38773	77067	103044	112183	119317	217238	372796	206327	99057
% HighResMIP	-16%	-21%	-40%	-43%	-36%	-30%	-27%	-26%	-17%	-10%	-9%	-14%
% 4RCM-RCP4.5	49%	62%	53%	32%	26%	12%	13%	11%	14%	16%	25%	41%
% 4RCM-RCP8.5	51%	67%	43%	9%	21%	14%	19%	25%	20%	21%	30%	45%

Figure 2-28. Average monthly sediment load delivery under climate change compared to the baseline period (1995-2021) in outlet 35 location of Ou Ta Paong scheme

5.10 Climate change impacts on agriculture

The changes in precipitation and temperature patterns induced by climate change in the project area could affect the climatic suitability of cereals, vegetables and starchy crops produced. On average, for most crops analysed for this project, the temperature suitability could progressively decrease with some crops falling outside their optimal temperature levels. Overall, this change in patterns could contribute to a reduction in crop yield for both irrigated and non-irrigated crops. For example, in the Kampong Chhang region, rice yield could decrease by anywhere from 9% to 12%, with and without irrigation, respectively, by 2050 (a period of 20 years centered around 2050) compared to 2020. These projections are for the RCP8.5 scenario and without CO_2 fertilization. A projected decline of up to 11% in the flooded area of Tonle Sap basin by 2050 may lead to a reduction in net sedimentation and aquatic net primary production of up to 59% and 38% respectively[73].

As smallholder farmers' incomes are largely dependent on their yield, it is anticipated that farmers' income could become more volatile with a decreasing trend over time. It is projected that vegetables will be increasingly exposed to heat-stress conditions during the pre-monsoon and early wet-season months (March-June). Over these months, heat-stress conditions (>36ºC) will be exceeded more than 50 days during the growing season, lasting approximately 90 days. The impact of climate on various crops in Cambodia is outlined in table 2.10 together with the impact of climate change and the impact on specific crops.

According to the International Rice Research Institute, rice grain yield will decline by 10% for each 1°C increase in growing-season minimum (night) temperature in the dry season. In Cambodia, drought has been negatively impacting rice production, and is widely recognized as one of the most serious climate risks for the agriculture sector.

In terms of the population affected, Cambodia is one of the world's most flood-exposed countries in the world. By 2050, the population exposed to floods is expected to reach 19% of the population. Projected climate change trend indicates more severe floods and droughts, which is expected to affect Cambodia's GDP by nearly 10% by 2050[74]. Changes in extreme flood events (25-year flood) under climate change are projected to increase agricultural damages by 18-28% over 2075-2099 compared to 1979-2003 under different flood scenarios; climate change impacts are also expected to be more influential in increasing the magnitude of extreme floods than reduction in flood risk and magnitude owing to dam reservoir in the Cambodian floodplains of the Mekong River Basin[75].

Table 2-10.Climate exposure to crops and potential impacts.

Crop	Climate Exposure	Impacts	Source
Rice	High temperature, rainfall variations	Low yields, loss of crop	IFAD CARD
Maize	High temperature, drought, rainfall variations	Reduced yields, water stress, loss of crop	IFAD CARD
Cassava	Drought, high temperature	Reduced yields, water stress	
Soybeans	High temperature, drought, rainfall variations	Reduced yields, water stress	
Sugarcane	High temperature, rainfall variations	Droughts, decreased yields, water stress	
Vegetables	Temperature extremes, water availability	Reduced yields, increased pest pressure, loss of crop	Climate Change Impacts on Irrigated crops in

[73] Arias et al, 2014 & Lamberts, 2008 as cited in Horton, A.J., Triet, N.V.K, Hoang, L.P., Heng, S., Hok, P., Chung, S., Koponen, J., and Kummu, M., 2022. The Cambodian Mekong floodplain under future development plans and climate change. Nat. Hazards Earth Syst. Sci., 22: 967–983, https://doi.org/10.5194/nhess-22-967-2022.

[74] Climate risk country profile, Cambodia. 2021. https://climateknowledgeportal.worldbank.org/sites/default/files/2021-08/15849-WB_Cambodia%20Country%20Profil

[75] Try, S., Sayama, T., Phy, S.R., Sok, T., Ly, S., and Oeurng, C., 2023. Assessing the impacts of climate change and dam development on potential flood hazard and damages in the Cambodian floodplain of the lower Mekong basin. Journal of Hydrology, Regional Studies, 49: 101508. https://doi.org/10.1016/j.ejrh.2023.101508

Crop	Climate Exposure	Impacts	Source
			Cambodia. 2022[76]
Fruits	Temperature extremes, water availability	Reduced yields, increased pest pressure, loss of crop, fruit fall	

Data from IFAD's Climate Adaptation in Rural Development – Assessment Tool (CARD) which explores the effects of climate change on the yield of major crops. It is intended to support the quantitative integration of climate-related risks in agricultural and rural development investments and strategies, including economic and financial analyses (EFA). CARD shows that the yields of all crops are expected to decrease (Figure 2.29).

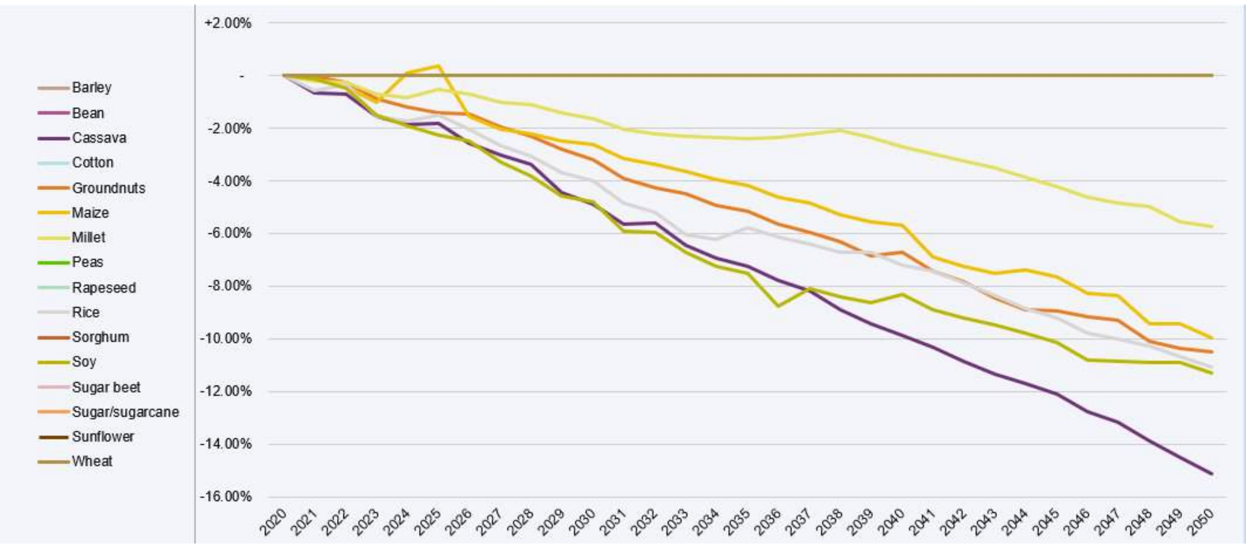


Figure 2-29. Projected Crop Yields without Irrigation in Cambodia.

5.11 Risk and adaptation for crop value chains

A suitability analysis was performed by FinRes[77] using the FAO EcoCrop method for the RCP4.5 and RCP8.5. In the following only the results for RCP8.5 are discussed. The method estimates the extent to which the levels of precipitation and temperature in a given area are suitable for a crop. The thresholds for optimal temperature and precipitation as well as maxima and minima are provided by FAO (EcoCrop database) and are provided in the introduction of every individual crop assessment. The assessment takes two medium lengths of growing seasons within the interval provided by EcoCrop. The results of the temperature and precipitation suitability analysis are used to prioritize categories of adaptive practices and technologies. As a result of this analysis, three main crop-climate indicators are derived for the current period and mid-century. These indicators are in relation with:

the current and mid-century level of precipitation suitability and the average daily deficit (or excess) in water supply from precipitation.

the level of temperature suitability and the number of days with maximal temperature exceeding the maximum temperature threshold of the crops;

the number of days with wind speed exceeding 15km/h as it is associated with an accelerated evaporation (up to 0.5kg/day depending on soil and temperature conditions).

For the project area the Climatic Water Balance of 150mm is the most likely and will be the one to be focused on.

[76] https://www.researchgate.net/publication/362455203_Climate_change_impacts_on_irrigated_crops_in_Cambodia
[77] Finres 2021. Climate change & Agriculture in Cambodia

The suitability analysis was made for the following crops:

- Bottle gourd
- Cabbage
- Cauliflower
- Cucumber
- Eggplant
- Hot pepper
- Lettuce
- Pak choi
- Tomato
- West Indian lemongrass
- Rice
- Longan
- Cassava
- Mango

For most of these crops the suitability analysis showed that the conditions for growing will become worse with the projected climate change for these crops and for the climatic water balance in the project area. More details for the mentioned crops are presented in Appendix 5.

5.12 Adaptation recommendations for agricultural crops

Finres[78] have been providing adaptation recommendations for crops for two Climatic Water Balances of 1190mm and 150mm. The three sub-project areas are mainly inside the 150mm cluster, which generally corresponds to the Köppen-Geiger Climate classification for Cambodia[79] and the adaptation measures suggested for the crops are presented in the following section for the 150mm. In the evaluation of adaptation measures the following actions were assessed:

Measures against unsuitable climatic conditions

Crop shifting is recommended for a crop within the same family, when either temperature or precipitation suitability falls below 0.2, which indicates the unsuitability of the current precipitation and / or precipitation patterns for this given crop. If all the crops of the same family fall below this threshold, recommendations are provided for the crops having the least unsuitable score for temperature and precipitation combined.

Measures against precipitation deficit

Soil covering and micro-water-harvesting are recommended when the precipitation deficit ranges between 0 and 2mm/day over the season. This range is determined as adaptive measures within these categories have the potential to harvest or conserve moisture within this range (e.g. mulching can increase yield per unit of water up to 60%[80] .

Improved irrigation for a water deficit exceeding 2mm/day over the growing season, improved irrigation is recommended. Improved irrigation relies on technologies that actually reduce evaporative losses such as drip irrigation or subsurface drip irrigation.

Measures against precipitation excess

[78] Finres 2021. Climate change & Agriculture in Cambodia
[79] Köppen_Geiger Climate Classification map for Cambodia (1980-2016) https://en.wikipedia.org/wiki/File:Koppen-Geiger_Map_KHM_present.svg
[80] Qin et al. 2015. Soil mulching significantly enhances yields and water and nitrogen use efficiencies of maize and wheat: a meta-analysis | Scientific Reports (nature.com)

Drainage is advised when the precipitation excess is on average above 2mm/day over the season. In flat areas, this would avoid excess precipitation to stagnate over the plot and lead to crops decaying.

Monitoring and evaluation in addition to **risk transfer**, the evolution of the weather patterns is to be carefully monitored and evaluated to ensure that measures are rapidly implemented in the face of new adverse evolutions in the local climate.

Measures against adverse temperature conditions

Agroforestry-based shading when the number of days with maximal temperature exceeding the maximum temperature threshold ranges between 0 and 10 days. Agroforestry systems have the potential to reduce daily temperature.

Artificial shading when the number of days with temperature exceeds the max. threshold surpasses 10 days, the recommendation focuses on artificial net-shading. Depending on the type, color, and height of the net, the temperature underneath can be reduced by up to 3-4°C.

Measures against adverse wind conditions

Agroforestry-based wind breaking wind accelerates soil and crop evaporation, by reducing its speed thanks to windbreaking technics, it is possible to preserve moisture for a longer period of time. For less than 10 days per growing season, agroforestry-based windbreaking is recommended due to its implementation and maintenance ease.

Artificial wind breaking when the threshold of days exceeds 10 days, artificial wind breaking is proposed.

Measures for high-suitability context

Risk transfer (crop insurance) for precipitation and temperature situations where crops are in the very and excellently suitable categories, risk transfer is recommended as it will protect farmers from effectively exceptional events.

Monitoring and evaluation in addition to **risk transfer**, the evolution of the weather patterns is to be carefully monitored and evaluated to ensure that measures are rapidly implemented in the face of new adverse evolutions in the local climate.

Table 2-11. Recommendations of categories of adaptive practices and technologies specific to crops in regions within the climatic water balance of 150mm

Crop	Climate	Urgent measures	Prospective measures
Cauliflower	Current period precipitation is very suitable with suitability of 0.63 (by mid-century: very suitable at 0.72) above minimum required precipitation with ~-0.2mm/day (~-0.9mm by 2050s) Current period temperature is marginal with suitability of 0.22 (by 2050s: not suitable at 0.11) the number of days with max. temperature above the crop max. threshold is ~89 days (~90 days by 2050s) Average windspeed is not expected to be exceeded more than 10 days per seasons (~7 days by 2050s)	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with more than 10 days of max. temperature exceeding the max. tolerance threshold of the crop (mean: 88.7 days) net shading is strongly recommended to avoid scorching. Windspeed: with between 0 and 10 days exposed to an average windspeed exceeding 15km/h (multi-model mean of 6.5 days) nature-based windbreaking is recommended to reduce preserve soil moisture.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: improved agroforestry technics
Cabbage	Current period precipitation is excellent with suitability of 0.91 (by mid-century: excellent at 0.88) above minimum required precipitation with ~-2.7mm/day (~-3.5mm by 2050s) Current period temperature is marginal with suitability of 0.33 (by 2050s: marginal at 0.22) the number of days with max. temperature above the crop max. threshold is ~105 days (~117 days by 2050s) The number of days with an average windspeed 15km/h -accelerated evaporation- is ~14 days (~15 days by 2050s)	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with more than 10 days of max. temperature exceeding the max. tolerance threshold of the crop (mean: 104.7 days) net shading is strongly recommended to avoid scorching. Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 13.6 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking
Cucumber	Current period precipitation is suitable with suitability of 0.44 (by mid-century: suitable at 0.54) precipitation in deficit of ~2.4mm/day (~1.7mm by 2050s) Current period temperature is excellent with suitability of 0.92 (by 2050s: excellent at 0.87) max. temperature is not expected to exceed the crop threshold more than 10 days per season (~12 days by 2050s)	Precipitation: with a daily precipitation deficit above 2mm (multi-model mean of 2.4mm/day) improved irrigation, e.g. drip combined, is recommended. To reduce the amount of irrigation required measures reducing evaporation are recommended: soil covering and shading Temperature: with between 0 and 10 days with temperature exceeding crop's threshold (mean 4.5 days) agroforestry-based shading are recommended to reduce plant heat stress.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking

Crop	Climate	Urgent measures	Prospective measures
	Average windspeed is not expected to be exceeded more than 10 days per seasons (~11 days by 2050s)	Windspeed: with between 0 and 10 days exposed to an average windspeed exceeding 15km/h (multi-model mean of 9.9 days) nature-based windbreaking is recommended to reduce preserve soil moisture.	
Tomato	Current period precipitation is excellent with suitability of 0.84 (by mid-century: excellent at 0.88) above minimum required precipitation with ~-1.2mm/day (~-1.9mm by 2050s) Current period temperature is very suitable with suitability of 0.62 (by 2050s: suitable at 0.5) the number of days with max. temperature above the crop max. threshold is ~33 days (~55 days by 2050s) Average windspeed is not expected to be exceeded more than 10 days per seasons (~11 days by 2050s)	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with more than 10 days of max. temperature exceeding the max. tolerance threshold of the crop (mean: 33.2 days) net shading is strongly recommended to avoid scorching. Windspeed: with between 0 and 10 days exposed to an average windspeed exceeding 15km/h (multi-model mean of 9.9 days) nature-based windbreaking is recommended to reduce preserve soil moisture.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking
West Indian lemongrass	Current period precipitation is excellent with suitability of 0.84 (by mid-century: excellent at 0.9) precipitation in deficit of ~0.1mm/day (~-0.5mm by 2050s) Current period temperature is excellent with suitability of 0.83 (by 2050s: very suitable at 0.74) the number of days with max. temperature above the crop max. threshold is ~72 days (~120 days by 2050s) The number of days with an average windspeed 15km/h -accelerated evaporation- is ~33 days (~35 days by 2050s)	Precipitation: with a daily precipitation deficit between 0 and 2mm (mean: 0.1mm/day) measures reducing evaporation are recommended: e.g. soil covering along with technics increasing soil moisture at root-level: e.g. water micro-harvesting. Temperature: with more than 10 days of max. temperature exceeding the max. tolerance threshold of the crop (mean: 71.8 days) net shading is strongly recommended to avoid scorching. Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 32.8 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking
Hot pepper	Current period precipitation is excellent with suitability of 0.92 (by mid-century: excellent at 0.9) above minimum required precipitation with ~-2.7mm/day (~-3.3mm by 2050s) Current period temperature is excellent with suitability of 0.9 (by 2050s: excellent at 0.85) max. temperature is	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with between 0 and 10 days with temperature exceeding crop's threshold (mean 0.6 days) agroforestry-based shading are recommended to reduce plant heat stress.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: improved agroforestry-based shading Windspeed: net-

Crop	Climate	Urgent measures	Prospective measures
	not expected to exceed the crop threshold more than 10 days per season (~3 days by 2050s) The number of days with an average windspeed 15km/h -accelerated evaporation- is ~17 days (~18 days by 2050s)	Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 16.6 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	based windbreaking
Lettuce		Unsuitable level of precipitation and temperature advocates for shifting towards less vulnerable crops: e.g. cauliflower, cabbage, cucumber, tomato, west indian lemongrass and hot pepper.	not applicable: shifting during current period
Pak choi, Bottle gourd, Eggplant		Unsuitable level of precipitation advocates for shifting towards less vulnerable crops: e.g. cauliflower, cabbage, cucumber, tomato, west indian lemongrass and hot pepper.	not applicable: shifting during current period

Table 2-12. Recommendations of categories of adaptive practices and technologies specific to Rice crops in regions within the climatic water balance of 150mm cluster

Crop	Climate	Urgent measures	Prospective measures
Rice	Current period precipitation is marginal with suitability of 0.28 (by mid-century: marginal at 0.39) precipitation in deficit of ~2mm/day (~1.3mm by 2050s) Current period temperature is excellent with suitability of 0.97 (by 2050s: excellent at 0.95) max. temperature is not expected to exceed the crop threshold more than 10 days per season (~12 days by 2050s) The number of days with an average windspeed 15km/h -accelerated evaporation- is ~11 days (~12 days by 2050s)	Precipitation: with a daily precipitation deficit above 2mm (multi-model mean of 2mm/day) improved irrigation, e.g. drip combined, is recommended. To reduce the amount of irrigation required measures reducing evaporation are recommended: soil covering and shading Temperature: with between 0 and 10 days with temperature exceeding crop's threshold (mean 4.6 days) agroforestry-based shading are recommended to reduce plant heat stress. Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 10.8 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking

Table 2-13. Recommendations of categories of adaptive practices and technologies specific to Longan in regions within the climatic water balance of 150mm cluster

Crop	Climate	Urgent measures	Prospective measures
Longan	Current period precipitation is excellent with suitability of 0.85 (by mid-century: excellent at 0.86) above minimum required precipitation with ~-0.8mm/day (~-1.3mm by 2050s) Current period temperature is excellent with suitability of 0.89 (by 2050s: excellent at 0.82) the number of days with max. temperature above the crop max. threshold is ~21 days (~46 days by 2050s) The number of days with an average windspeed 15km/h - accelerated evaporation- is ~49 days (~53 days by 2050s)	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with more than 10 days of max. temperature exceeding the max. tolerance threshold of the crop (mean: 20.9 days) net shading is strongly recommended to avoid scorching. Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 49.4 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking

Table 2-14. Recommendations of categories of adaptive practices and technologies specific to cassava crops in regions within the climatic water balance of 150mm cluster

Crop	Climate	Urgent measures	Prospective measures
Cassava	Current period precipitation is excellent with suitability of 0.99 (by mid-century: at 1) above minimum required precipitation with ~-1.9mm/day (~-2.4mm by 2050s) Current period temperature is excellent with suitability of 0.83 (by 2050s: very suitable at 0.74) the number of days with max. temperature above the crop max. threshold is ~40 days (~78 days by 2050s) The number of days with an average windspeed 15km/h - accelerated evaporation- is ~44 days (~47 days by 2050s)	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with more than 10 days of max. temperature exceeding the max. tolerance threshold of the crop (mean: 39.6 days) net shading is strongly recommended to avoid scorching. Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 44.1 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: net shading Windspeed: net-based windbreaking

Table 2-15. Recommendations of categories of adaptive practices and technologies specific to Mango in regions within the climatic water balance of 150mm cluster

Crop	Climate	Urgent measures	Prospective measures
Man go	Current period precipitation is excellent with suitability of 0.85 (by mid-century: very suitable at 0.78) above minimum required precipitation with ~-3.5mm/day (~-4mm by 2050s) Current period temperature is excellent with suitability of 0.95 (by 2050s: excellent at 0.93) max. temperature is not expected to exceed the crop threshold more than 10 days per season (~0 days by 2050s) The number of days with an average windspeed 15km/h -accelerated evaporation- is ~38 days (~41 days by 2050s)	Precipitation: no imminent adaptation needs, constant monitoring and evaluation required to respond to changes in precipitation patterns. Crop insurance could also be considered for exceptional events. Temperature: with between 0 and 10 days with temperature exceeding crop's threshold (mean 0 days) agroforestry-based shading are recommended to reduce plant heat stress. Windspeed: with more than 10 days with an average windspeed exceeding 15km/h (multi-model mean of 38.3 days) artificial windbreaking is strongly recommended to limit excessive soil and crop evaporation.	Precipitation: evaporation reduction and water micro-harvesting measures Temperature: improved agroforestry-based shading Windspeed: net-based windbreaking

5.13 Risk and adaptation to Value Chains

5.13.1 Livestock

Warming temperature and changing precipitation patterns will also affect livestock capacity to grow and resist illness and diseases. In this section, the extent to which climate change is projected to modify the duration of period during which livestock faces temperature and humidity stress are assessed. The analysis focuses on severe stress. In the current period (2006-2035), the least affected regions are the ones characterized as high humidity & low temperature. Within these areas, goats present the least vulnerable profile, with an estimated 20 days of severe stress per year, in comparison to sheep that could face the highest stress with 340 days. Still during this period, the regions that could experience the highest level of stress are the ones categorized as low humidity & high temperature. In these regions, the predicted level of stress is higher by 100 days for goats and is higher than the number observed in the regions with high humidity & low temperature for sheep. In the 2066-2095 period, the least affected regions are the ones characterized as high humidity & low temperature. Within these, goats are the most resilient animals, with about 210 days of severe stress annually, compared to sheep that could experience the most stress with 360 days. In this period, areas that could encounter the worst stress are the ones defined as low humidity & high temperature. In these regions, the projected stress level is higher by 90 days for goats and is equal to the number measured in the areas with high humidity & low temperature for sheep.

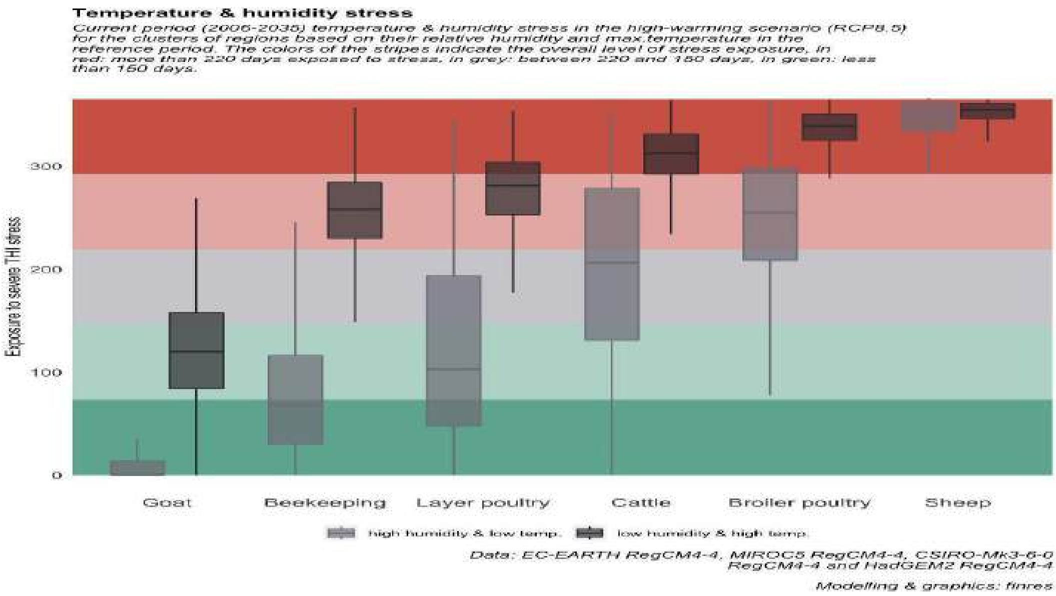


Figure 2-30. Temperature and humidity stress

As poultry production is considered as a potential activity to increase resilience in the communities more details have been provided for both broiler production and egg production. The figures below indicate days with stress because of temperature and humidity.

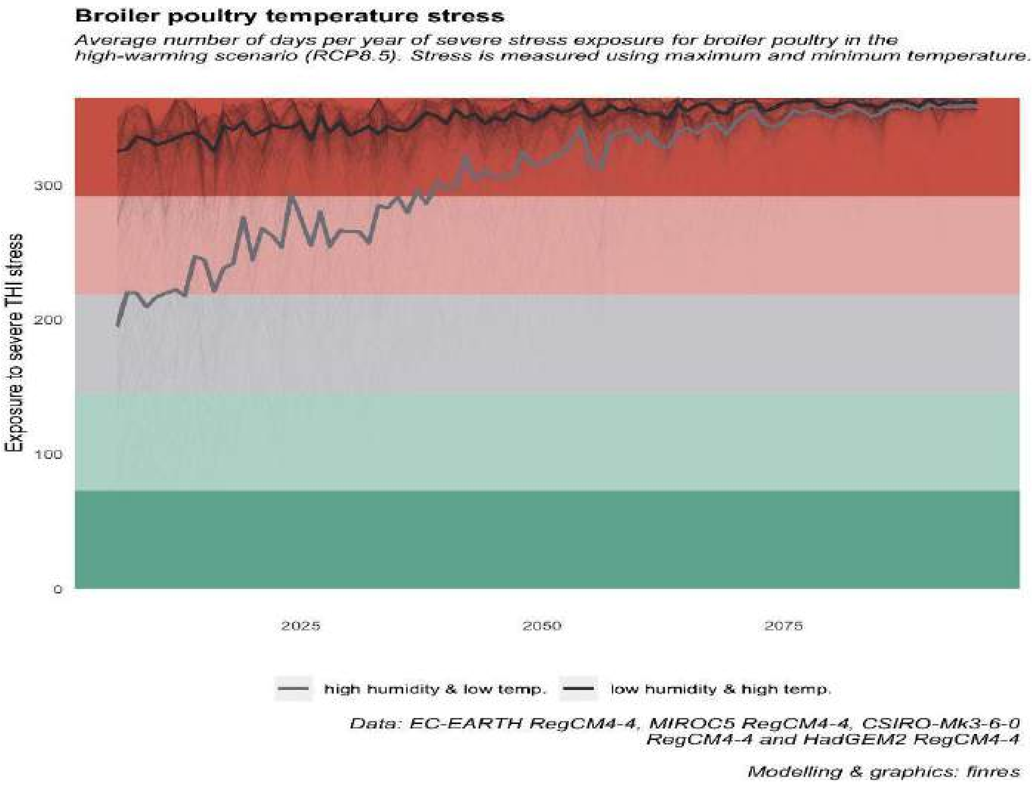


Figure 2-31. Broiler poultry temperature and humidity stress.

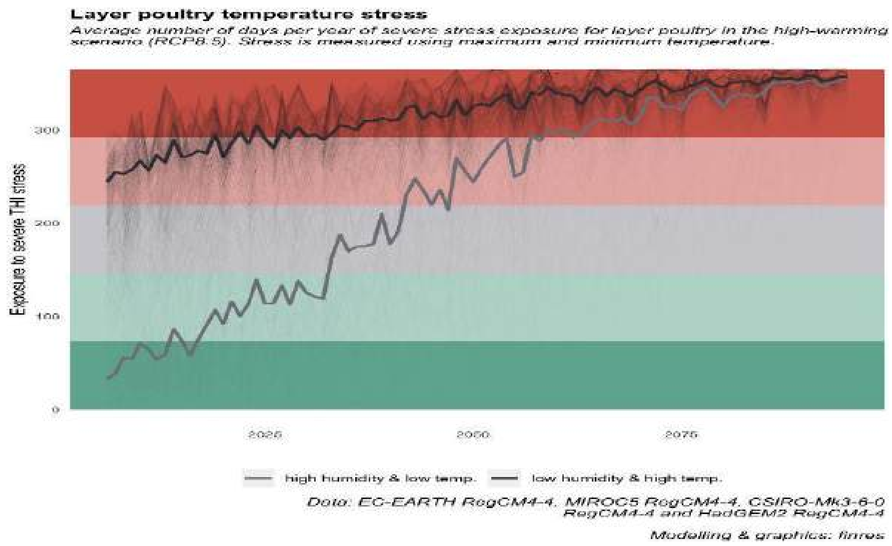


Figure 2-32. Layer poultry temperature and humidity stress

These figures indicate that egg production will be less impacted by climate change than broiler production. However, in low humidity & high temperatures more than 300 days per year will be with severe stress exposure already from around 2025. In the situation with high humidity & low temperatures it is estimated that up to 2050 the number of stress exposure will be less than 200 days. Measures to alleviate stress could include careful selection of breed as per the locality that helps to adjust with temperature, poultry houses with proper air circulation, and adequate water supply.

In addition to the measures evaluated above some additional adaptation measures could be applied in relation to crops and poultry production as listed below.

	Climate risk to supply chain	Risk significance	Solution measures
Cassava, Cashew Nuts, Fruits, Vegetable	i) Change or unpredictable rain pattern and intense rainfall decrease in production and quality, ii) Drought; water stress and impact on productivity due to increased heat iii) Land damage and impact on production by flood, iv) Crops damage due to storm, there were relatively low damage reported from farmers for cassava, cashew nuts and mango; however, impact could be large for the vegetable and banana v) increase number and intensity/impact of disease and pest, vi) unpredictable rainfall during harvesting time increase damage and decrease price vii) Obstruction on road and transportation due to heavy rainfall and soil erosion	Medium to High	i) and ii) prepare participatory seasonal crop calendar analysing recent shift in rainfall pattern, work to provide early information on the climate, proper plantation techniques to best utilise rainfall water, selection of drought tolerant species. iii) Promote good agriculture practices and climate smart technologies, plant grass and trees with good root network in potential flood risk areas, intercropping, iv) Hedge row plantation and maintain trees in the wind side of farmland, for banana: proper moulding, provision of supports v) Intercropping, crop rotation, capacitate on integrated pest management, good agricultural practices, onsite support to identify and suggest for the control measures, regulate seeds, promote quality organic seeds, vi and vii) Early climate information, proper storage and drying facility,
Poultry production	i) Increase in mortality and production decline due to heat stress, ii) increase impacts and number of diseases, iii) obstruction in transportation to market.	Low	i) proper selection of breed as per the locality that helps to adjust with temperature, poultry house with proper air circulation, adequate water supply, ii) good management practice, maintain hygiene, regulations and easy access of medicine, provision of proper monitoring, iii) Provision of meat storage and processing

Table 2-16. Climate risk and potential adaptation measures for crops and chicken production [81]

[81] IFAD 2022. ASPIRE AT Climate Risk Analysis

5.13.2 Aquaculture

In the analysis of future projected climate change patterns in Cambodia, the climatic phenomena like rise in temperature, change in precipitation, flood, drought, etc. become prominent and these are affecting the aquatic food production system (both culture and capture fisheries) the most. Fish being cold-blooded animals, their metabolic rate is strongly affected by environmental conditions, especially the temperature. The changes in temperature can have significant influence on the growth and reproductive biology of fish. The influence may be positive or negative depending on the circumstances. Extreme weather events like floods and droughts can have serious negative impacts like crop loss due to fish escape, mortality, etc. which will have adverse economic and social impacts on the dependent communities like fish farmers. In order to minimise the negative impacts, a range of actions can be taken / planned in the form of adaptation measures to climate change. Adaptation is the process of adjusting to change (both experienced and expected).

The following Table 2.17 provides an overview of the types of impacts there will be on aquaculture focusing on the impacts on fish, the production system and the stakeholders/owners of the system. Following this is listed potential adaptation measures focusing on the short-, medium- and long-term. Some of the impacts can be beneficial such as warming of water, but others will have negative impacts. This is indicated by the color codes in the table.

Although aquaculture activities, such as power input, transport, and feed production are considered the main pathways of the sector's contribution to GHGs[82], the sector's contribution is relatively small despite being significant when compared to other food production sectors. For example, the contribution of aquaculture to global GHGs particularly CO^2, emission in 2010 was estimated at 385 million tons, ~7% of the agricultural sector's contribution that year[83]. Recent estimates by IPCC[84] show that agriculture, forestry, and other land uses contributed about 13% CO^2, 44% CH4, and 82% N2O emissions from anthropogenic activities for the period 2007–2016, accounting for 23% of net anthropogenic emissions of GHGs. On the other hand, aquaculture's main GHGs emission is CO^2 through the normal respiration of aquatic animals[85]. However, there is still a gap in existing knowledge regarding the pathways and contribution of aquaculture production to global GHGs emission.

Recently, aquaculture has recorded significant technological advances that enable the sector to expand its current production toward meeting the rising demand for aquatic products[86]. However, climate change is increasingly becoming one of the major issues confronting the sustainability of food production systems and aquaculture is no exception. According to IPCC[87], sustainable development which balances environmental protection, economic prosperity, and social well-being is closely linked to climate change effects and responses. This suggests that it is impossible to achieve sustainability in aquaculture production without addressing climate change effects.

Numerous reports have emerged showing that climate change effects on aquaculture may vary depending on geographical areas, economy, climatic zones, production systems, and cultured species. For example, Barange[88] predicted higher effects on producers in developing nations and poorer economies compared with

[82] Adhikari, S., Keshav, C. A., Barlaya, G., Rathod, R., Mandal, R. N, Ikmail, S., et al. (2018). Adaptation and mitigation strategies of climate change impact in freshwater aquaculture in some states of India. J. Fish. 12, 016–021.
[83] Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, A. L., Funge-Smith,S., and Paulain, F. (2018). Impacts of Climate Change on Fisheries and Aquaculture, Synthesis of Current Knowledge, Adaptation and Mitigation Options. Rome: FAO.
[84] IPPC (2019). Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems, Summary for Policymakers Approved Draft. Geneva: IPCC.
[85] De Silva, S. S., and Soto, D. (2009). "Climate change and aquaculture: potential impacts, adaptation and mitigation," in Climate Change Implications for Fisheries and Aquaculture: Overview of Current Scientific Knowledge. FAO Fisheries and Aquaculture Technical Paper. No. 530, eds K. Cochrane, C. De Young, D. Soto, and T. Bahri (Rome: FAO), 151–212.
[86] FAO (2020). The State of World Fisheries and Aquaculture 2020. Sustainability in Action. Rome: FAO.
[87] IPCC (2018). Global Warming of 1.5∘C. An IPCC Special Report on the Impacts of Global Warming of 1.5∘C Above Pre-industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty, eds V. Masson-Delmotte et al.
[88] See 85

those in developed ones. Handisyde[89] reported that climate change effects on aquaculture producers are expected to differ depending on the culture environments (freshwater, brackish, and marine).

Several other studies have also shown that small-scale farmers will be more affected by climate change risks due to increased production costs in farm management and lack of support systems to recover from the effects compared to large-scale producers[90]. Furthermore, it is important to note that climate change effects will not only affect aquaculture production systems, but also the entire value chain[91]. Hence, climate change could be more viewed as an involuntary risk that creates vulnerability on the socio-economic development and raises stress especially on food demand and supply as well as the livelihood system of the farmers.

The elements shown in table 3.17 will not affect aquaculture production equally, since, like any other farming practice, the sector is defined in time, space, and size, and therefore, have a fair degree of maneuverability while affecting fish populations at different life cycles as well. Moreover, the current scientific knowledge regarding the effect of individual consequences varies and is often limited to the combined effects which make adaptation planning within the aquaculture sector practically difficult[92].

Table 2-17.Overall impacts of climate change on aquaculture production system and adaptation options[93]

Drivers	Potential Impacts			Adaptation Options		
	Fish	**Production System**	**Stakeholder**	**Short-term**	**Medium-term**	**Long-term**
Warming (Warming of water)	▪ Increased metabolism ▪ Increased growth rate ▪ Advancement in the onset of the breeding and longer breeding period for carps.	▪ Increased fish production ▪ Improved feed conversion efficiency for species with higher thermal tolerance ▪ Shift to shorter production cycle ▪ Intensified production	▪ Shorter production cycles leading to more income and higher profit	▪ Adjustment in farming Calendar ▪ Change/modification of farming practices ▪ Use of hide-outs in ponds to provide shade to fishes ▪ Weed refuge-based fishery in wetlands	▪ Creating Climate-smart facilities (*e.g.*, deeper ponds for aquaculture, deep pool-based fishery for wetlands, etc.)	▪ Farming of species /strains with higher thermal tolerance ▪ Risk-based Spatial planning for aquaculture ▪ Selective breeding to develop strain with wide thermal tolerance ▪ Culture of climate resilient fish species
	▪ Increased plankton respiration and proliferation ▪ Changes in reproduction ▪ Increased/ decreased transmission of some diseases	▪ Lower feed conversion efficiency for species subjected to increased stress ▪ Increased harmful algal blooms ▪ More risk on account of disease	▪ More feed required			
	▪ Decreased performance for species with narrow thermal range ▪ Increased sensitivity to other drivers like					

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[89] Handisyde, N., Telfer, T. C., and Ross, L. G. (2017). Vulnerability of aquaculture related livelihoods to changing climate at the global scale. Fish Fish. 18, 466–488. doi: 10.1111/faf.12186

[90] King, A. D., and Harrington, L. J. (2018). The inequality of climate change from 1.5 to 2◦C of global warming. Geophys. Res. Lett. 45, 5030–5033. doi: 10.1029/2018GL078430

[91] See 85

[92] Seggel, A., De Young, C., and Soto, D. (2016). Climate Change Implications for Fisheries and Aquaculture: Summary of the Findings of the Intergovernmental Panel on Climate Change Fifth Assessment Report. FAO Fisheries and Aquaculture Circular No. 1122. Rome: FAO

[93] Chand BK, Rajendran S and Mohan CV (2022). Climate Resilient Technologies/Practices to Support Pond Aquaculture and Beel Fisheries under APART, Assam, India. Penang, Malaysia: WorldFish

Drivers	Potential Impacts			Adaptation Options		
	Fish	**Production System**	**Stakeholder**	**Short-term**	**Medium-term**	**Long-term**
	low pH, pathogens					
Lowering of Dissolved Oxygen (Hypoxia)	▪ Increased mortality ▪ Reduced growth ▪ Higher sensitivity to some pathogens	▪ Lower carrying capacity of pond ▪ Increased aeration costs ▪ Reduction in the number of annual crops where hypoxia is seasonal	▪ Increased aeration costs ▪ Farmers culturing hardy species like tilapia, pangasius, etc. not affected	▪ Reduction in biomass / stocking density ▪ Pumping of aerated water into pond	▪ Making provision for aeration ▪ Increased monitoring of water quality	▪ Shifting to more tolerant (hardy) farmed species or strains
Changes in other Hydro-graphic variables	▪ Increased mortality ▪ Reduced growth	▪ Poor water quality ▪ Accumulation of wastes	▪ Changes in production levels	▪ Liming at regular interval in ponds	▪ Bottom drying and desilting for ponds ▪ Provision for bore well in farm	▪ Spatial planning for favourable areas to do aquaculture ▪ Restoring riverine connectivity in wetlands
Flood	▪ Escape of fish stock from pond ▪ Entry of unwanted fishes ▪ Growth retardation of fishes ▪ Increased mortality	▪ Breach of pond dyke ▪ Ingression of flood water into pond ▪ Increased risk of fish escapes as a result of flooding, overspills ▪ Deterioration of water quality	▪ Loss in production ▪ Facility destruction ▪ Economic loss	▪ Net fencing along the pond dyke ▪ Effective dyke management and intercropping in dyke ▪ Sack cultivation of vegetable on pond dyke ▪ Mechanisms for Flood Early Warning System to farmers and fishers	▪ Short duration fish farming ▪ Introduction of scheme for fish crop insurance ▪ Preparation of flood contingency plan by Fishery Dept., GoA	▪ Investing in stronger flood protection facilities ▪ Relocating farms in less prone areas
Drought / water stress situation	▪ Mortality ▪ Reduced growth ▪ High physiological stress	▪ Less water ▪ Early drying of pond and wetlands in summer ▪ Poor water quality ▪ Eutrophication of pond and wetlands ▪ Reduced production efficiency	▪ Loss or disruption of Livelihoods ▪ Increased competition for water ▪ Economic loss	▪ Shift to shorter production cycles ▪ Promoting Hotel size fish production ▪ weed refuge-based fishery in wetlands	▪ More deep ponds ▪ Deep pool-based fishery in wetlands	▪ Shift to indoor facilities like Recirculating Aquaculture Systems (RAS), Biofloc, etc. ▪ Invest in water efficient technologies
Depletion of ground water leading to water stress condition	▪ High physiological stress ▪ Reduced growth ▪ Mortality	▪ More risk for ground water dependent production system ▪ Reduced production efficiency ▪ Poor water quality	▪ Higher costs of maintaining pond water levels ▪ Poor production ▪ Economic loss	▪ Arranging alternative water source to reduce dependency on ground water	▪ Focusing on efficient surface-water irrigation infrastructure	▪ Demand-side management by restricting excessive withdrawal of groundwater ▪ Supply-side management by adopting recharge enhancement measures
High intensity weather event (heavy rain, storm, etc.)	▪ Increased mortality ▪ Escape of fish stock & entry of unwanted species	▪ Disruption in supply of inputs such as Seed, feed etc. ▪ Pollution by heavy runoff	▪ Increased work hazards ▪ Economic loss	▪ Taking emergency measures to prevent escape of stock ▪ Relief for affected stakeholders	▪ Preparation of contingency plan for natural calamities by Fishery Dept., GoA	▪ Relocating farms in less prone areas
Less predictable rainy/dry season	▪ Impacting fish mating and spawning behaviour	▪ Affecting the hatchery operations ▪ Loss in breeding opportunity	▪ Decreased ability to plan the work ▪ Economic loss	▪ Increased monitoring of weather variables	▪ Agro-meteorology advisories	▪ Developing weather-controlled facilities
Climatic hazards	▪ May get contaminated	▪ Overflowing of untreated sewage during flood	▪ Health hazards ▪ Economic loss	▪ Emergency preparedness	▪ Adoption of best practices in	▪ Enhancing bio-security practices

causing food safety issues	with heavy metals and pesticides, infected with food borne parasites and pathogens	▪ Increasing run-off of fertilizers, topsoil, as well as pollutants, such as pesticides, herbicides, trace metals and persistent organic pollutants		▪ Early warning ▪ Risk mitigation strategy	production and post-harvest operations	▪ Implementing hazard-specific food safety measures
Knowledge Gaps in resilient practices	▪ The impact may differ depending upon the spectrum of tolerances of cultured species	▪ Farm facilities are not in sync with adaptation requirements	▪ Farmers make ill-informed aquaculture choices ▪ Higher cost of adaptation if maladaptation options are chosen first	▪ Strengthening Early warning systems and better monitoring ▪ Emphasis on diversified production system ▪ Selecting species with wide spectrum of tolerance	▪ Modified insurance schemes ▪ Social protection strategies	▪ Focus on research to fill the gaps and reduce uncertainties ▪ Selective breeding to develop strains with high thermal tolerance

Colour Legends	Overall Favourable Impact (light Green)		Both Positive and Negative Impact (light Blue)		Overall Unfavourable Impact (light Red)		No Foreseen Impact (light Grey)	

5.14 Effects of different adaptation measures

The figures 2.33 below present results from a CAISAR-commissioned analysis[94] of the effects of selected technologies and practices i.e., solar pump irrigation, SRI and LLL (laser land leveling) on rain-fed rice in Cambodia. In this analysis, the projected rain-fed rice yield is estimated to decrease by an average of 2.2% between 2021 and 2030, with a further decrease of 9.5% by mid-century compared to the current baseline yield (2.1 t/ha). Even as yield declines are inevitable under RCP8.5, solar pump irrigation can help increase the average yield by 4.5%-6.5% compared to a rain-fed system; SRI up to 30% compared to traditional practice; and LLL up to 24% compared to uneven land.

[94] Finres 2023. Climate change impacts & adaptation on crops and adaptation for Cambodia

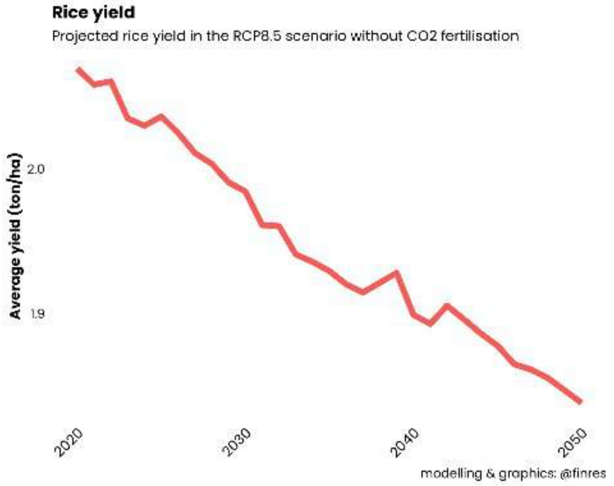


Figure a. Impact of climate change on rice yield

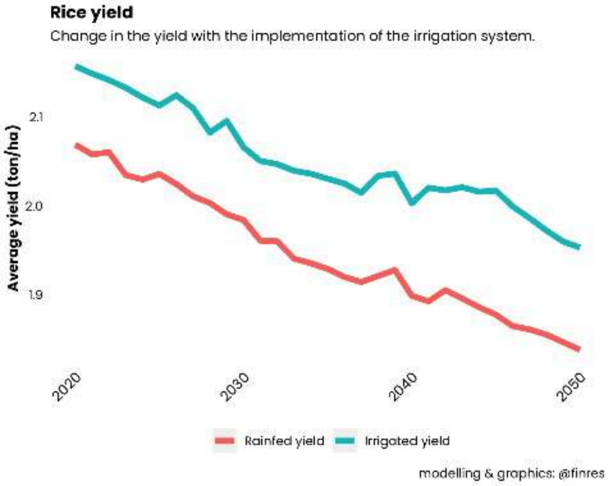


Figure b. Effect of solar pump irrigation on rice yield

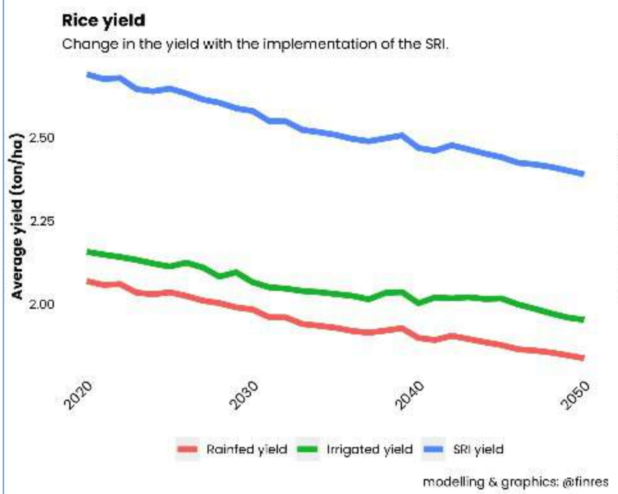


Figure c. Effect of SRI on rice yield

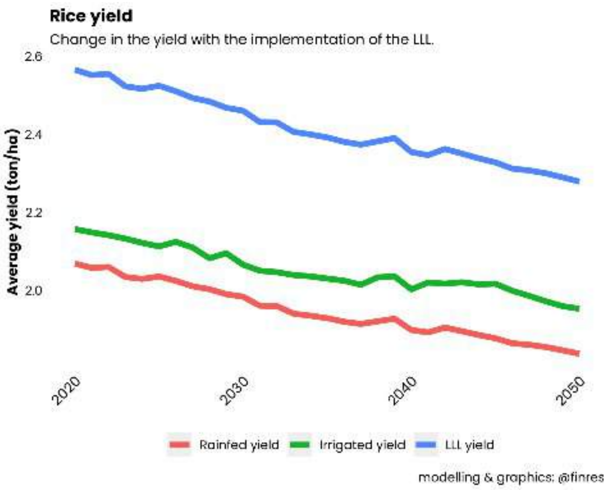


Figure d. Effect of LLL on rice yield

Figure 2-33. Effect of climate resilient technologies and practices on rice yields

About 25% to 32% of the total wet rice and dry rice (respectively) production costs is for purchase of fertilizer and labour associated with fertilizer application, and another 40% of total dry rice production costs is for purchase of diesel and 16-18% is for seed purchase[95]. Hence, improving water use efficiency through technologies (e.g., drip irrigation) or improved management (e.g., AWD, SRI), expanding the use of integrated fertilizer management (including, organic inputs), enabling sustained adoption of high-yielding and stress-tolerant rice varieties, and/or shifting to solar pumps for irrigation all have potential to increase productivity and resilience of rice cultivation.

Different measures as shown in Figure 2.34 can be introduced to increase the productivity of egg production such as improving the feed and providing additional shade and air circulation. Such measures could partly alleviate the impacts of temperature on poultry productivity.

95 Field visits 17-20 May 2022: Learning about and from FWUCs. Annex 4, CAISAR – Feasibility Study and Project Preparation

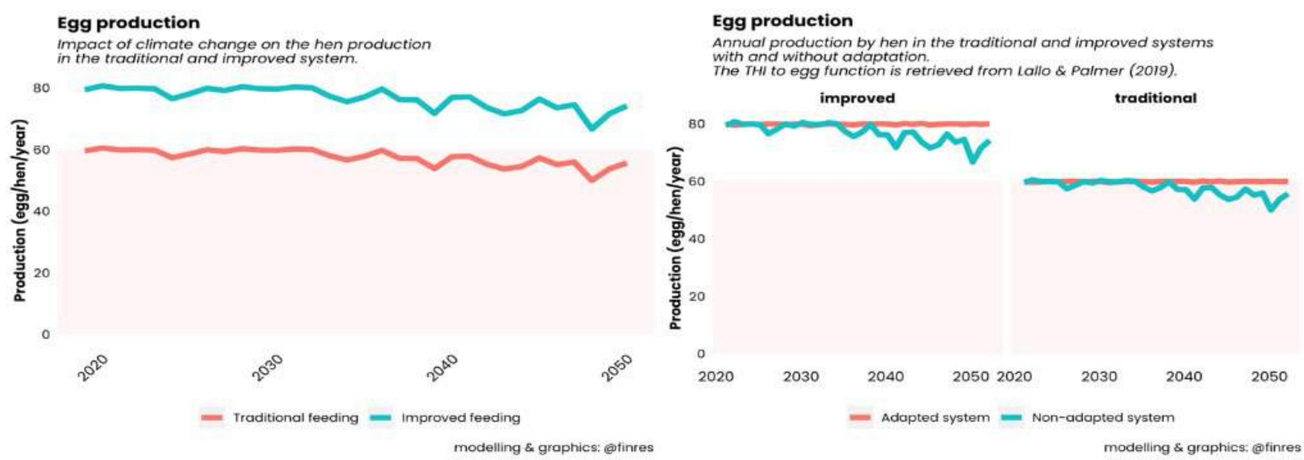


Figure 2-34. Egg production with traditional feeding and improved feeding (left) and egg production with improved feeding and provision of shade and air circulation (right)

5.15 Greenhouse Gas Emissions and Agriculture Sector in NDCs

In Cambodia, GHG emissions (2016) are dominated by the Forestry and Other Land Uses (FOLU) sector (60.9%)– the main driver for which is deforestation – and agriculture (16.9%), followed by energy (12.0%), IPPU (7.9%) and waste (2.1%) sectors. Forest cover of Cambodia was 73% in 1960 and had declined to 57% in 2010 and 54% in 2014[96]. GHG emissions without the FOLU sector are dominated by the agriculture sector (43.3%), followed by energy (30.9%), waste (5.5%), and IPPU (20.3%). Agricultural emissions increased by ~3% each year between 1994 and 2016 – the main driver being rice cultivation. Under a business-as-usual (BAU) scenario, Cambodia forecasts an increase in emissions from 125.2 MtCO2eq in 2016 (Table 2.18, Col A) to 155.0 MtCO2eq in 2030 (Table 2.18, Col C).

The NDC emissions reduction scenario by 2030 (Table 4 Col D) largely targets FOLU and energy but also IPPU sectors with 40-50% reduction. Agriculture emissions will only reduce by 23% in the same period – the sector contributing about 9.6% of the overall 64.5MtCO2eq reduced (difference between Table 4 Col C and Col D); but owing to the links between FOLU (land-use and forest conversion) and agriculture, actions to increase productivity of agricultural lands and interventions such as land management and organic input agriculture are likely to have an indirect effect on FOLU targets. Improving water use efficiency of rice cultivation using techniques such as AWD or SRI, introducing stress-tolerant and improved seed varieties, and deploying drip irrigation for certain crops can directly reduce methane emissions from rice and indirectly reduce intensity of agricultural emissions (CO2eq per ton of production) through better yield stability or increased yields. Finally, gravity irrigation is not feasible in all parts of the command area, and farmers resort to pumping water from rivers and canals using diesel engines to irrigate their rice fields. In fact, even farmers who primarily rely on gravity irrigation may resort to pumping groundwater or surface water from ponds during the dry season or dry days in the rainy season. Shifting to solar irrigation would help reduce costs in the long run and reduce energy emissions associated with agriculture (see Annex 22 for EX-ACT calculations on CAISAR's emissions reduction potential).

Table 2-18.GHG emissions and scenarios (BAU, NDC)

Sector	A. BAU 2016[97], MtCO2eq (% of total)	B. 2016 GHG inventory[98], MtCO2eq (% of	C. BAU scenario 2030[99], MtCO2eq (% of total)	D. NDC scenario 2030[100], MtCO2eq (% of	E. BAU scenario 2050[101], MtCO2eq (% of

[96] Cambodia, Third National Communication, September 2022.

[97] Cambodia, First NDC (Updated submission), Dec 2020

[98] Cambodia, First Biennial Update Report, August 2020 & NCSD, MOE

[99] Cambodia, First NDC (Updated submission), Dec 2020

[100] Cambodia, First NDC (Updated submission), Dec 2020. FOLU has 3 NDC scenarios, and the numbers presented here correspond to scenario 2: reduction of 50% of historical emissions by 2030 (REDD+ programme).

[101] Cambodia, National Inventory Report (NIR), November 2020.

		total)		total)	total)
FOLU	76.3 (60.94%)	131.01 (80.08%)	76.3 (49.2%)	38.2 (42.21%)	21.2 (13.59%)
Agriculture	21.1 (16.93%)	18.39 (11.25%)	27.1 (17.5%)	20.9 (23.09%)	34.9 (22.37%)
Energy	15.1 (12.06%)	9.60 (5.87%)	34.4 (22.19%)	20.7 (22.87%)	82.7 (53.0%)
Waste	2.7 (2.16%)	2.76 (1.69%)	3.3 (2.13%)	2.7 (2.98%)	6.5 (4.17%)
IPPU	9.9 (7.91%)	1.82 (1.11%)	13.9 (8.97%)	8.0 (8.84%)	10.7 (6.86%)
Total	125.2	163.59	155.0	90.5	156.0

5.16 Baseline on Climate Information Services and Early Warning Systems

Introduction: Effective and tailored climate information services (CIS), also referred to as climate information and early warning systems (CIEWS), for the agriculture sector includes the production (collating, analysis), translation, transfer, and use of climate knowledge and weather information (including, early warnings) for climate-informed decision-making from the farm to the policy level and at timescales ranging from daily and weekly to seasonal and long-term trends and projections. Key attributes of climate information services that meet the needs of agricultural users include timeliness, accessibility, dependability, usability, appropriateness (or context-specificity), and equity. In addition, climate information should be co-produced with intermediate users (e.g., extension officials) and end-users (e.g., farmers) using approaches such as PICSA (Participatory Integrated Climate Services for Agriculture) and allow for adaptive change based on robust feedback mechanisms (Figure 2-35). Some of the main barriers to the effective and equitable communication of CIS in low-income and middle-income countries are the lack of national capacity for communication, lack of client-driven tailoring of services, insufficient translation of relevant services into actionable products, limited engagement with other actors involved in agricultural value chains (private and public, MSMEs), and the lack of capacity to integrate CIS with other complementary interventions.

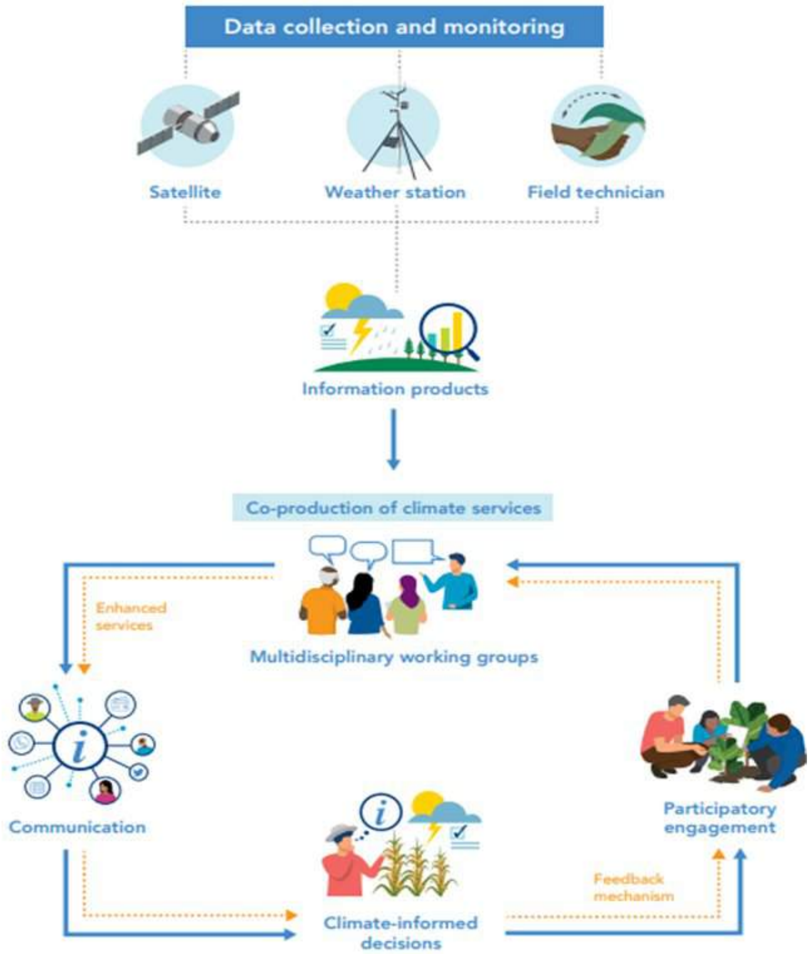


Figure 2-35. Value chain for an effective provision of climate services

The current Cambodia context: Cambodia has undertaken various initiatives to support the development of agrometeorological services through investment projects over the last decade. These efforts include developing the meteorology, hydrology and agrometeorology infrastructure and improving agromet forecasting skills in collaboration with development partners[1]. Table 2-19 highlights ongoing initiatives in Cambodia and their focus along the climate information services value chain. Section 2.16.1-2.16.3 is an assessment of the capacities along the “CIS value chain” as shown in Figure 2-35 (actions ranging from data collection and analysis to tailoring and communication; actors involved from meteorology and hydrometeorology departments to extension officials and farmers), and section 2.16.4 presents recommendations based on the assessment of major challenges.

Current efforts and investments are focused on the first stages of the climate services framework, monitoring and production of information products, but far fewer investments are focused on the later stages of the framework, or the “last mile”, which involves tailoring, dissemination and uptake of climate services by farmers. For flood and drought (hydrological / meteorological) monitoring, there is also a need to invest in and strengthen the number of sensors and improve the maintenance of the current system as well as refresher training for staff. The flood forecasting lead time and coverage could also be improved, since it is limited to five-day lead time but with un-certainties for day 4 and 5 for five stations along the Mekong mainstream (Mekong, Tonle Sap, Bassac) to cover vulnerable areas along major tributaries (World Bank, UNISDR, NHMS, WMO 2013, Garsdal, personal communication).

There was established a flood forecasting system for Pursat river, as reported by the Department of Hydrology and River Works, through a pilot flood forecasting and early warning system funded by ADB. The Pursat river forecasting system established in 2018 is not operational, owing to lack of funds for O&M, and in need of upgrading. There are no similar systems covering the Anlong Chrey, Brambei Mom, Kra Peu Truom, Lum Hach and Krang Ponley schemes.

The summary in Sections 2.16.1-2.16.4 outlines the current capacities in Cambodia for climate services and areas which require enhanced investments, through projects like CAISAR, to ensure that the target beneficiaries of organizations like MOWRAM, MAFF and IFAD have access to and capacity to use CIEWS for effective decision-making.

Strategic fit of CIS in CAISAR: One of the priorities of the CAISAR project is to enhance the availability and usability of water availability and water use-related CIS tailored to the needs of project beneficiaries for improved use of water resources linked to the project’s investments in irrigation improvement and flood management as well as agriculture. This recognizes that the agricultural system is highly sensitive to climate change. For instance, rice production is characterized by low yields (even with access to irrigation in the dry season), and rice varieties that farmers grow are not particularly tolerant of floods or droughts – with a maturity period that increases their susceptibility to climate risks[2]. In other words, in the project context, observed climate impacts are most felt through water and soil moisture effects. Analysis of future climate impacts on crops analysed for CAISAR indicate reduced yields, water stress and crop loss due to higher temperatures, rainfall variations, and droughts.

Variability under climate change, in combination with other human activities (e.g., hydropower dams), is expected to significantly alter the river flow conditions, the quality of water, river morphology, groundwater levels, etc., with the Tonle Sap catchment projected to suffer high stress during the dry season even by 2030 (Eastham et al. 2008).

The CAISAR project will aim to enhance existing CIS and early warnings systems in place in Cambodia and use the investment to ensure access to services for the last mile, with a focus on water management and use. The investments, both hard and soft, will also target activities aimed at tailoring existing services to the local context and to the needs of the project beneficiaries, with emphasis on outreach to women and youth farmers. A major challenge for the uptake of CIS in the target communities of CAISAR is the effective tailoring, communication and engagement of users in the production of services. To become a service, a climate product needs to be deemed useful by the user. This requires appropriate testing and validating the services to ensure that they enhance decision-making. Addressing the wide variety of user needs is beyond the capacity of any single organization. It calls for major collaboration between the public and private sector, research institutions and agricultural communities.

Table 2-19.Existing investments and ongoing initiatives on CIS and EWS in Cambodia

	Data and service production			Last mile: delivery and uptake by farmers			
EXISTING INITIATIVES FOCUSED ON ENHANCED CIS	Monitoring, data collection and equipment	Capacities of national institutions	Forecasting	Tailored services to agricultural sectors	Dissemination and extension	Participatory engagement of farmers & end-users	Farmer training and demo
DOM[1] Monitoring and forecasts							
UNDP-GEF[2] Early warnings for development							
WMO-CIAT[3] Forecasting and insurance				Coffee, rice, sugar, dairy, rubber, cassava			
FAO-University Southern Queensland[4]				Pest and disease alerts			
WFP-FAO-UNICEF				Social protection			
Technical Working Group-CARDI-MAFF Agromet bulletin production							
UNDP-RIMES-SESAME Forecasts and crop advisories							
WB Monitoring and planning							
ADB National Flood Forecasting Center							
ADB National Water Resources Data Center							

5.16.1 Meteorological and hydrometeorological capacities

Institutions, their roles and functions.

First, the DOM (Department of Meteorology), under the MoWRAM, is the main provider of weather and climate information services for Cambodia. DOM is responsible for meteorological infrastructure maintenance and management, meteorological data analysis and management (including archiving), and issuance of weather forecasts, extreme event warnings and seasonal climate forecasts. The structure of DoM is presented in Figure 2-36 below, and as of 2021, the institution reported 47 staff members at headquarters in Phnom Penh and 50 meteorological staff in provincial centers. Since the meteorological stations are located in different provinces, the provincial authorities are responsible for allocating land and for staffing the stations through the PDOWRAM (DHI 2021).

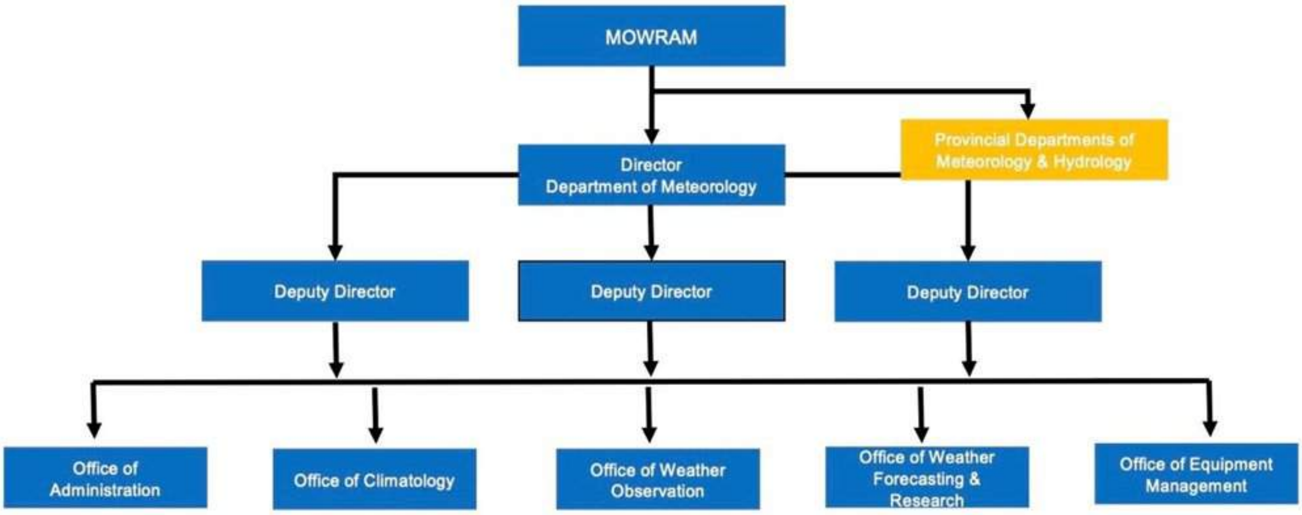


Figure 2-36. Structure of DoM and main offices

Second, Department of Hydrology and River Works (DHRW) is responsible for the installation, monitoring, operations and maintenance of the hydrological stations (surface and groundwater) to monitor water levels, discharges and quality, and to provide flood forecasting and early warning as well as general advisories on water quality, use and availability. The structure of DHRW is presented in Figure 2-37, and the institution reported 60 staff members at headquarters but no details or hydrological staff in provincial departments. While the PDOWRAM's hydromet offices are supposed to be engaged in data collection, in practice, DHRW staff in Phnom Penh conduct all hydrological data collection (including discharge measurements and water quality sampling). DHRW staff also provide limited maintenance of the stations within a small budget.

Finally, the National Committee for Disaster Management (NCDM) coordinates all disaster management activities together with ministries, institutions, armed forces, civil society, and other actors. NDCM also coordinates with the National Committee of Sustainable Development. The Climate Change Department in the Ministry of Environment provides climate change projections and information.

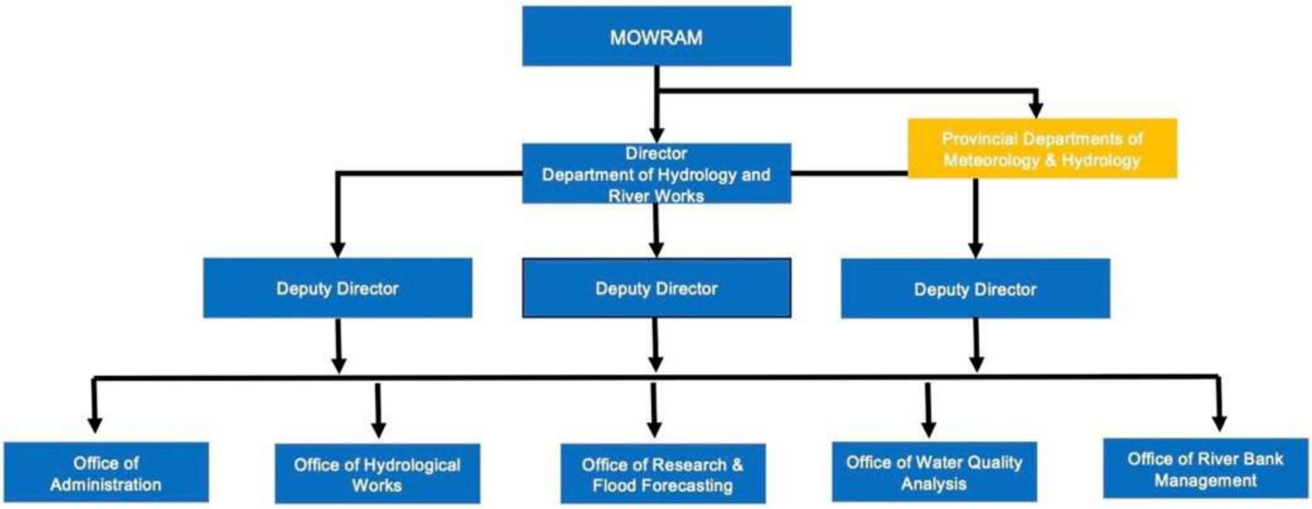


Figure 2-37.Structure of DHRW and main offices

To summarize, DOM is responsible for extreme event warnings such as storms, thunderstorms, extreme heat, extreme rainfall and dry spells whereas DHRW is responsible for flood (riverine and flash flood) warnings and drought monitoring. DOM and DHRW are members of NCDM. However, DOM and DHRW databases are maintained separately, and integration could enhance access, data storage capabilities, and analysis of information on weather-, water-, and climate-related hazards (CREWS 2021). The new National

Data Centre at MOWRAM under establishment will house data from the network of meteorological and hydrometeorological as well as Cambodia Information System on Irrigation Schemes (CISIS), which can be accessed by PWDRAMs, DOM and DHRW and will also be important for providing data to agro-meteorological services.

H*ydro-met and agro-met data collection and analysis.*

Through its website (http://www.cambodiameteo.com/), DOM provides six-hourly weather forecasts of maximum and minimum air temperature, rainfall probability, relative humidity, wind speed, and cloud cover over the next three days with an update frequency of once a day. The six-hourly weather forecasts are produced from the Synergy System of Meteo-France, JMA, RIMES and WMO Regional Association II climate centres. In addition, daily weather forecasts include forecasts of maximum/minimum air temperature, rainfall probability, and cloud cover over the next seven days. Both six-hourly and daily weather forecasts have a spatial resolution of province level. Probabilistic seasonal forecasts for the next three months are issued based on the SASCOF consensus on regional seasonal forecasts. DOM issues seasonal forecasts for temperature and rainfall variables once a month at the provincial level, but they have not been translated into agriculturally relevant information for the end-users (FAO, 2021).

Similarly, DHRW through its website (https://dhrw-cam.org/) issues flood- and drought-related bulletins and warnings. It is also possible to view a hydrograph of the water level for 7 locations across Cambodia (along the Mekong-Tonle Sap-Bassac rivers), and the rainfall station network within the Pursat basin. The National Flood Forecasting Center (http://www.nffc.dhrw-cam.org) under DHRW, the capacity of which was the target of the ADB project (Greater Mekong Sub-Region Flood and Drought Risk Management and Mitigation Project GMS-FDRMMP) also presents data related to rainfall, floods, and droughts. The drought condition and drought prediction maps have not been updated since 2020/2021[3] and require investment in more regular updating to ensure the best available information is used for decision making.

DOM has 25 manual weather stations (MWS), and 86 automated weather stations (AWS) also covering the 25 manual stations. DHRW has 101 automated hydrological stations and some also equipped with rainfall sensors. However, the functionality of these stations is in question: as a 2020 terminal evaluation of a GEF-LDCF (Global Environmental Facility-Least Developed Countries Fund) project noted, only few of the hydrological stations were fully functional at the start of the project in 2018 and the project installed an additional stations[4]. Key gaps are the capacity and lack of funds for national and provincial departments to provide maintenance and quality assurance for stations and gauges. There is the potential to a) improve the capacity and budgeting for this essential step or b) engage others to support in the maintenance of equipment. DOM has a doppler radar at their head office in Phnom Penh. The radar is equipped with 3 ranges: 80 km, 240 km and 450 km, which cover the whole study area how many.

The weather stations most relevant for the project are shown in the following figure.

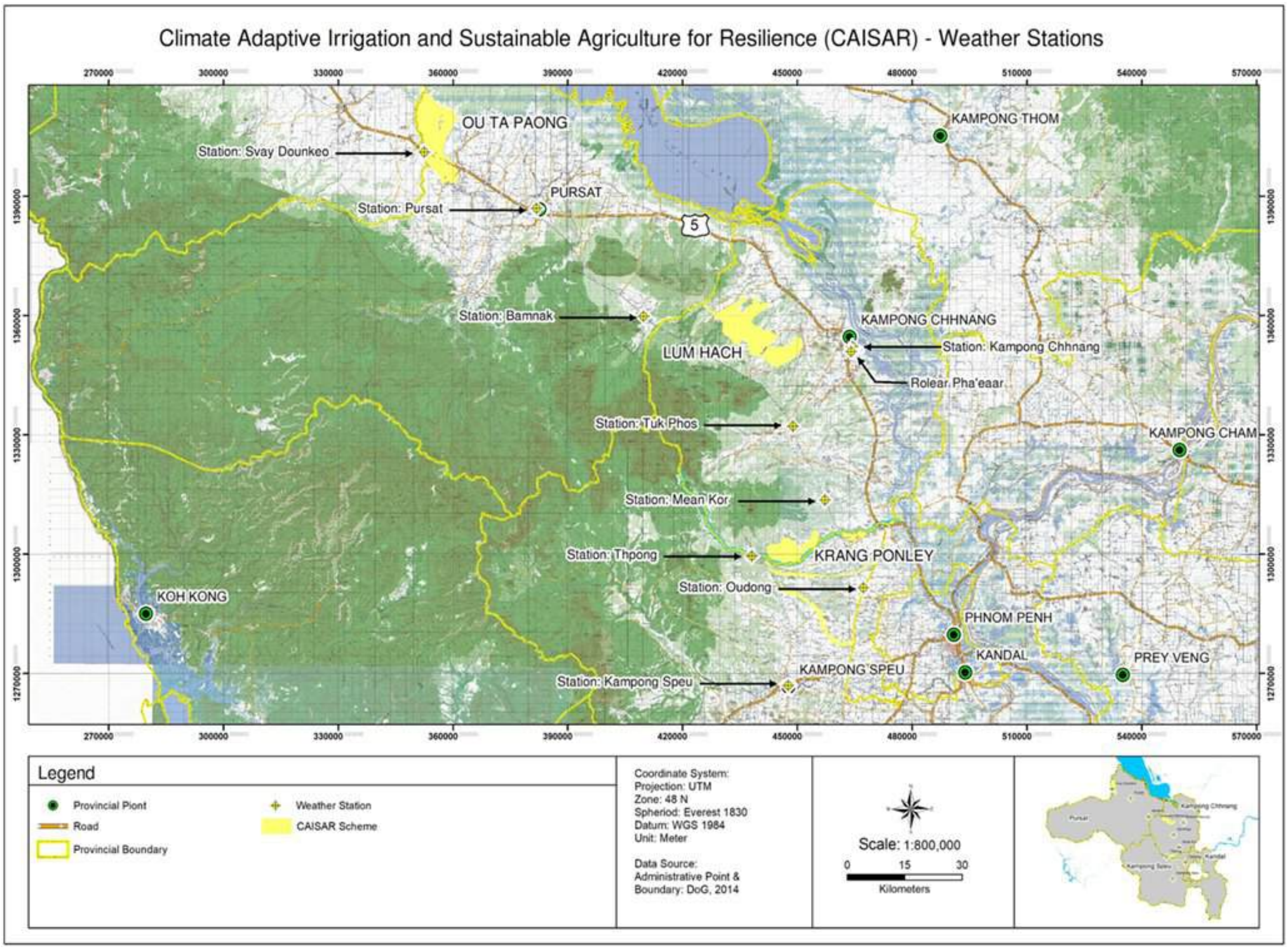


Figure 2-38. Location of existing weather stations and irrigation schemes

DHRW does not have digitized maps of river systems and continues to rely on topographic maps developed in 2012 (CREWS 2021). The following table illustrates the gradual increase and current status of weather stations and hydrometeorological stations in Cambodia, most of these stations are automatic. However there has been no increase in staffing and subsequent trainings in this period (DHI/CNMC 2021).

Table 2-20. Number of hydrological and weather stations in 2012 and number of stations added in the period 2015 to 2021 (DHI/CNMC 2021)

Station type	2012	2015	2016	2018	2021	Total stations 2021
Hydrology	12	15	17	41	16	101
Weather	14*	20	15	24	39	112

Private sector actors providing CIS in Cambodia.

Besides the public infrastructure managed by DoM and DHRW, there are private actors that have collaborated with MOWRAM to set up AWS/AHS and weather advisories. In particular, there have been efforts of the private sector to link forecasts to insurance schemes for agricultural beneficiaries as well as some targeted efforts to create CIS for specific high value crops. There is some potential for CAISAR to engage the private sector in these areas.

Communication channels for CIS.

Consultations with MoWRAM highlighted that most of the users of their data access information through social media or mobile applications (Facebook, Telegram, Viber, Line) or their website. NCDM has also established a EWS 1294 line, under a UNDP project, that sends warnings to registered users (who select province, district and commune) on flooding risks. There is a need to ensure that these initiatives are aligned and also products are made available to smallholder farmers and CAISAR beneficiaries. Figure 4.78 shows the structure for the flow of information to the public and external users from MOWRAM.

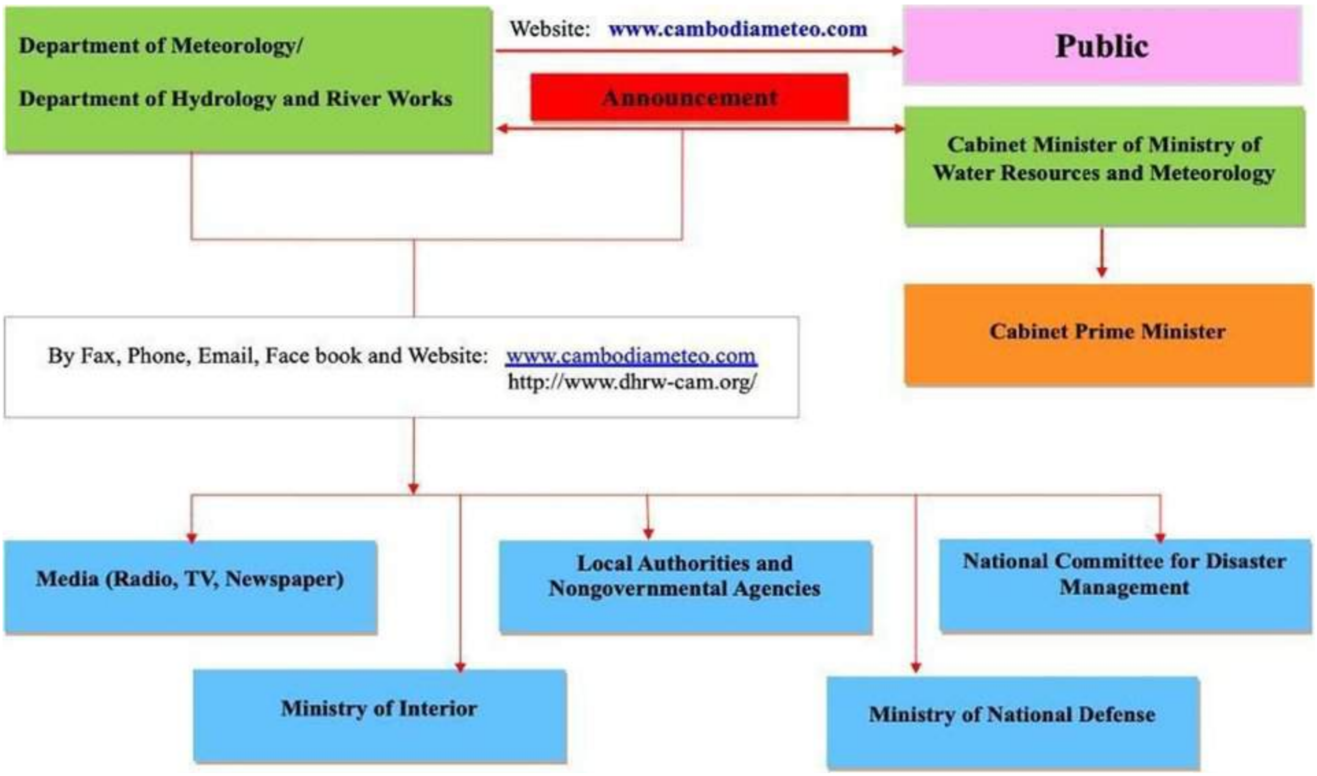


Figure 2-39.Flow of meteorological products to public, ministries, media and others (MOWRAM presentation)

Figure 2-40.Survey results from Cambodia's MOWRAM on delivery mechanisms and agromet advisory products prepared by the institution. Source: FAO, 2021

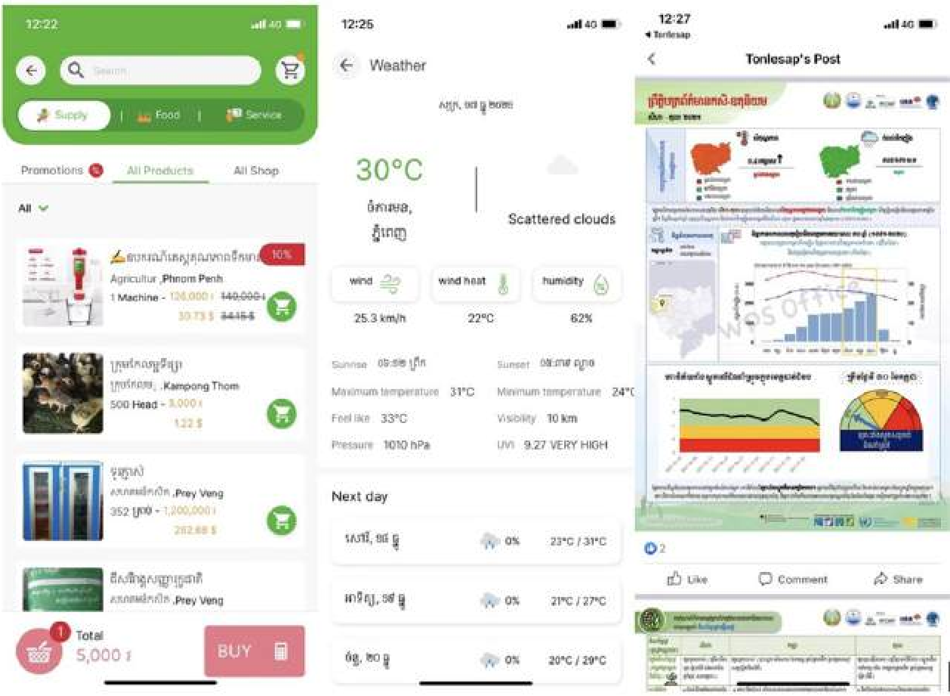


Figure 2-41. Tonle Sap app functionalities, including market information, buying and selling of agricultural products, weather information from MoWRAM website and forecasts for farmers.

Through visits to agricultural cooperatives and consultations with national NGOs, the use of digital applications, including the TonleSap app and EcoKsekar, that provide agricultural users with various types of information (including weather information) was confirmed. It is recommended that CAISAR links investments in communication channels and dissemination of information to these digital apps (Figure 2-41). All the sensor devices are integrated with a smart web application platform (Central System). The Central application platform receives information from environment sensors which display the information on real-time basis. The platform includes an intelligent analytical engine that makes information meaningful using graphs and colour codes and makes it available to the authorized body for ease in decision making. Appropriate alerts and notifications also are generated for target users in case of emergency. The GUI can be accessed using a commonly available browser and can be converted into a convenient mobile application.

5.16.2 Agricultural crop calendar and climate data capacities

The Department of Planning and Statistics of the MAFF maintains provincial level crop production and harvested area data of multiple crops. No official crop calendars are available, but previous projects collected crop calendars at selected sites for baseline analysis. Cambodian Agricultural Research and Development Institute (CARDI) maintains experimental plots for crop monitoring as a national agriculture research institute. CARDI collects agricultural data upon request from collaborating projects; it has actively been involved in multiple international projects for agromet data, research, or services development. Although it is scattered among different departments, CARDI is equipped with necessary capacities required for agromet services.

The Department of Extension for Agriculture, Forestry and Fisheries (DEAFF) is responsible for managing Cambodia's extension and advisory services, with a vertical extension service structure from DEAFF to provincial departments of agriculture, forestry, and fisheries (PDAFF), District Agriculture Office, and Commune Agriculture Center. PDAFF in the target provinces of the CAISAR has extensive connections to the agricultural cooperatives and supports coordination and outreach among them. The Royal University of Agriculture is the potential institution for the technical and scientific support of agromet services. No other regular crop monitoring is taking place. There is no information found for the national level soil profiles digitized in a GIS format (FAO, 2021).

AGRICULTURAL FACTORS		CAPACITIES
Crop production/ harvested area	Spatial resolution of the data	Province
	Data collection frequency and available period	Annual, but no available period information
	Crops for which the crop production/ harvested area data are available	Multiple crops
Crop calendar	Crops for which a crop calendar is available	[From projects] Major crops
	Spatial resolution of the crop calendar data	[From projects] Livelihood zones
Technical or research institutes/ university	National agriculture research institutes that can technically support agromet services	CARDI
	Local universities that can support agromet research and development	Royal University of Agriculture
Extension services	Extension service system from national to local	DEAFF-PDAFF-DAO
Crop and pest & disease monitoring	Crop monitoring system	[From projects] Irregular monitoring
	Spatial resolution for crop monitoring	[From projects] Pilot sites only
	Pest and disease monitoring and reporting system	Irregular monitoring and hardcopy records of historical reporting

Table 2-21.Crop and pest/disease monitoring capacities of key agricultural institutions. Source: FAO, 2021

At a regional level, various programmes and investments also provide relevant information available online or through specialized databases or platforms. Key regional sources of relevant information for Cambodia include the Regional Drought and Crop Yield Information Service (RDCYIS). This service provides comprehensive drought monitoring and forecasting models, plus crop yield information, to assist local governments and agricultural sector with seasonal drought forecasting and in implementing short- and long-term mitigation measures during and in advance of droughts. As part of the Regional Integrated Multi-hazard early Warning System for Africa and Asia (RIMES), there is the Specialized Expert System for Agro-Meteorological Early Warning (SESAME) https://www.adaptation-undp.org/sites/default/files/resources/5._annex_4._sesame_guide_for_ cambodia.pdf

Mekong Drought and Crop Watch is an integrated web-based information system that is intended to (i) improve the operational, technological, and institutional capabilities to prepare for and respond to droughts in the Lower Mekong region; (ii) support local decision-makers in drought monitoring, analysis, and forecasting (iii) provide policymakers and farmers with current and forecast drought indices to facilitate decision-making within the current growing season; (iv) provide ecological and financial forecasting information to inform seasonal cropping seasons. https://mdcw-servir.adpc.net/home/. CAISAR project will explore the use of this platform as a basis for scaling up different CIS for target beneficiaries.

5.16.3 Capacities to produce and disseminate agromet bulletins

Recently, the SESAME system that is capable of agro-advisory generation was developed in Cambodia by RIMES. However, no agromet bulletin has been produced yet from the SESAME. DeRisk SE Asia (https://deriskseasia.org/) project is also attempting the development of agromet bulletins targeting the upcoming wet season of 2021 in the Battambang and Kampong Speu provinces. The FAO Agromet Programme developed a monthly agromet bulletin for select provinces (FAO, 2021). The monthly agromet bulletin contains the following contents:

1. Past/present meteorological information: Daily maximum/minimum air temperature and rainfall estimates over the last month are extracted from satellite remotely sensed data and weather models and are presented on the graph. Monthly rainfall and maximum/minimum average temperatures are compared with historical climatology for 1997-2019.
2. Past/present agricultural information: Monitoring summary from crop fields provide crop, pests and diseases assessments with current crop phenological stages and any pests and diseases occurrences with general advisories for control measures. Selected pests and diseases are monitored, and the incidence or infestation levels are reported on the bulletin.
3. Future meteorological information: Descriptive three-day weather forecasts for maximum/minimum air temperatures are provided and compared with the climatological temperature range to estimate possible anomaly conditions over the next three days.
4. Future agricultural information: Considering the three-day weather forecasts, management advisories for reported or forecasted pest and disease epidemics are provided.

To date, work on the production and dissemination of agromet bulletins remains mainly with support from investment projects and there is little national sustainability and ownership of the process (Table 2-22).

AGRICULTURAL FACTORS		CAPACITIES
Agromet services (bulletins)	Temporal and spatial resolution of the existing agromet services	[From projects] Monthly for 3 pilot sites
	Spatial resolution of the agro-advisories on the agromet services	[From projects] Site-specific advisory
	Existence of four basic components of agromet bulletin	[From projects] 4 components
	Dissemination method	[From projects] paper/email
Agromet service production	Agromet service working group	[From projects] Technical Working Group (CARDI, MAFF)
	Meeting frequency of the working group for agromet service production	[From projects] Monthly meeting
	Financial support for agromet service production	[From projects] Project-financed
Self-sustainability	Self-sustainability of agromet services after the FAO Regional Agromet Programme	None

Table 2-22.Agrometeorological bulletin services and sustainability in Cambodia. Source: FAO, 2021
Major challenges and recommendations to overcome last mile barrier to climate services in Cambodia

The table below provides the major identified challenges and recommendations to overcome these challenges (Table 2.23). In chapter 4.3 measures to be implemented in CAISAR for improving the access and use of CIEWS data for agromet advisory services are described.

Table 2-23.Major challenges and recommendations to overcome last mile barrier to climate services in Cambodia. Building on FAO, 2021 analysis.

Climate services stage	Major challenges	Recommendations for investment in relation to CAISAR scope)
Data collection, monitoring and forecasting	o Insufficient observational network (automated and manual) with essential meteorological and agromet variables required for developing agromet services o Insufficient budget for maintenance of hydrological and meteorological stations, resulting in stations malfunctioning at the end of warranty period and loss of	o Review and update the suitability of existing river basin modelling tools under current and future conditions and whether it provides a robust basis to understand the impact of land use change (particularly water demand from changed crops, crop varieties and management practices), flow regulations, water abstractions etc. o DHRW and DOM to put in place O&M systems to regularly check the status

	investment o No coordinated database or mechanism for data sharing between institutions o Differential capacities and tools in DOM and DHRW resulting in overall weak technical capacity for data storage and analysis: DHRW has comprehensive database tools (three hydromet databases are HYMOS, HYMET and CamOHMDB) for further analysis and DOM does not use time series database for further post-processing and analysis (DOM relies on MS Excel). There is a need for centralized database for data access o Lack of use of agricultural datasets combined with meteorological data to contextualize services for farmers o Lack of focus on water management and use – including data on water availability (groundwater/surface) in sub-basins of relevance to provinces – and the need to expand drought/flood forecasting capacities o Inadequate number of staff – not commensurate with the increase in number of stations and the associated maintenance / operational demands or the type of equipment in use (e.g., Doppler rainfall radar). o Lack of monitoring capacity (infrastructure, staff) on other key variables of interest. For example, there is a lack of focus on silt entering rivers and canals which chokes the waterbodies. These may also harm the crops when they find a way to the fields.	(working condition) and maintenance of the hardware network o Support a harmonized and integrated data management and analysis system between DHRW and DOM, holding spatial and temporal data and other information relevant to flood/drought forecasting o Rehabilitate (replace/upgrade/repair) existing DOM and DHRW stations and procure additional stations in sparsely covered project regions to increase coverage and network density. Focus on additional instruments that are supportive of agrometeorology Support technical capacity for the continued operation and maintenance of weather stations and data collection without disruptions through trainings. These programs should be designed to encourage officers to contribute to expanding their own knowledge base and introduce current ideas in forecasting and the Internet of Things. o Upgrade the forecasting capabilities by improving the access and use of global and regional datasets, products and tools according to latest technologies that are available o Develop dynamic cropping calendars that integrate forecasted precipitation patterns with sufficient time for farmers to adjust their planting dates and irrigation planning o Support agricultural institutions with tools and technical capacity for monitoring and digitalization of agriculture data. Selected officers may be invited to refresher courses to enhance capacity and foster interest o To the extent feasible, estimate and showcase the business case for continued government investments (for e.g., loss averted in each season of the CAISAR project for each USD of investment)
Data sharing and coordination of relevant agencies	o Lack of coordinated and digitalized collection of agriculture and pest/disease data through agricultural ministries (e.g. MAFF, CARDI and Royal University of Agriculture) and research institutions o Limited technical, financial, and human resources available to support national staff to collaborate and regularly meet as task force (technical working group led by MAFF and MoWRM) o Lack of incentive for collaboration and data sharing o Insufficient access to necessary technologies for digital and online data collection and sharing o Data sharing on a payment basis o Lack of high-res hazard and vulnerability maps	o Invest in further establishment of existing agromet technical working group and support national institutions to join regular meetings. o Strengthen governance arrangements and formalized agreements, including coordination and communication mechanisms within MoWRAM and stakeholders across sectors o Invest in data collection technologies that facilitate digitalization (tablets, handheld devices) and development and maintenance of national databases / web interface where information can be shared easily between relevant institutions and stakeholders. o Invest in programs at least twice a year to facilitate interaction and exchange of ideas between relevant agencies

Co-production of tailored agromet advisories	o Lack of mechanisms for exchange of information among key stakeholders (including private sector, FWUGs, ACs etc.) o Lack of standard operating procedures for the coordination and co-production of agromet services by multiple stakeholders. Lack of data sharing between DoM and DWRM o Weak collaboration or communication between MAFF, MoWRAM and other key institutions	o Prepare concrete national road maps towards strengthening and operationalizing agromet services o Develop a standardized national framework for data collection, sharing, analysis, translation into actionable services, and last-mile communication processes is systematically documented o Support sensitization workshops and training sessions to encourage dialog and bring together key actors, including farmers and end users
Communication of services to the last mile	o Challenges related to translating climate and agronomic information o Inadequate means for communicating the information o Lack of understanding of how farmers in the region are accessing information or ICT used o Lack of coordination with various digital application under development through NGOs or private sector	o Invest in surveys and information collection from farmers and target users to better understand how they prefer to receive information (communication means, format etc.) o Invest in development of products and ICT means based on the needs assessment of farmers o Ensure coordination of existing applications used by farmers in the region to link services to trusted means of communication o Establish an effective two-way communication and timely data collection and sharing between information providers and users.
Participatory engagement of last mile	o Lack of awareness of climate and agronomic information generated by NMHSs and MoAs (DoM, DWRM, MAFF and other national institutions) o Lack of effective two-way communication between agromet services providers and users	o Promote participatory approaches such as farmer field schools or training events with lead farmers in the region o Focused trainings or FFS on Integrated Pest Management (IPM) o Support participatory scenario planning processes consisting of different interactive and iterative learning processes o Invest in pilot programmes or community outreach initiatives to engage farmers with agromet services o Financially support the engagement of farmers and users in national tasks forces for service production
Climate-informed actions	o Insufficient resources to apply climate informed recommendations even if information is available (e.g., irrigation or land preparation capacity) o Lack of access by farming communities to forecasting information that is translated into actionable climate-resilient advice tailored to the type of production (rice, maize, cassava, soybeans, sugarcane, vegetables, fruits, etc.) o Lack of timely climate information to the last mile, as it usually reaches households too late to make decisions (e.g., planting and harvesting dates), and lack of information appropriate to the timescales (e.g., seasonal outlook, site-specific 1–5 day forecasts, data on agriculture-specific variables such as soil moisture or	o Invest in the translation of agromet data into services specific to target crops and relevant for climate sensitive periods of crop production for CAISAR target crops. o Support farmer associations, farmer water user groups (FWUGs), ACs and extension services to support farmers with understanding of how climate is affecting their production and how to implement climate informed actions. For instance, ensure exchange of ideas and observations related to climate in (say) bimonthly meetings between farmers / FWUG, and dedicated sessions on climate in Farmer Field Schools. This approach will also help the government to understand how climate-nformed actions may be more focussed towards the results from each meeting. o Through support to FWUGs/ACs, increase farmers resources and access to necessary equipment, information and financial services to implement recommended actions

	evapotranspiration). o Lack of extension or advisory support on how to implement climate information actions	o Ensure access to market information through ACs and digital applications

[1] CIEWS partners include the World Bank, UNDP, ADB, the United Nations Office for Disaster Risk Reduction (UNDRR), the World Meteorological Organization (WMO) with financial support from the Global Facility for Disaster Reduction and Recovery (GFDRR), the ASEAN, Sub-Committee on Meteorology and Geophysics (SCMG), Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) Germany, Regional Integrated Multi-hazard Early Warning System (RIMES) for Africa and Asia, JICA and JMA Japan.

[2] Chhinh and Millington 2015 describe how the most popular rice varieties are the traditional, long maturing rice that utilize soil moisture throughout the wet season. They estimate that long-, medium- and short-duration rice by area planted to be 22, 40, and 33 per cent, but that even short season rice – the least susceptible to drought – can still be affected by delayed onset of monsoon and failure of late wet season rains because all three varieties are harvested in November. Other authors (Poulton et al. 2016) note that long-duration (late maturing varieties) in the rainfed season account for 33 percent of national production.

[3] The drought condition map is available for 12 months (Jan-Dec 2020) and the drought prediction map is available for five months (Jan-May 2021). One minor, but relatively easily fixable issue with these websites is that security certifications are not up to date – this may currently leave them vulnerable to hacking.

[4]UNDP 2020.

6 Rationale for Intervention and barriers

6.1 Objective

The CAISAR project originated from the RGC's National Water Resources Management and Sustainable Irrigation Road Map and Investment Program (2019 -2023), which provides a Strategic Framework for the Irrigation Sector. It is designed to assist the Ministry of Water Resources and Meteorology (MOWRAM) with its strategic plans to modernize the irrigation sector. The overall goal of the project is to make the agriculture sector in Cambodia climate resilient and sustainable. The specific objective of the project is to modernize the irrigation sector by installing smart irrigation systems and enable farmers to adapt to and mitigate climate risks through use of energy and water efficient technologies, timely weather information and improved market integration. CAISAR's approach is premised on the experience that addressing the complex impacts of climate change on rain-fed and irrigated agriculture requires action at three levels; farm level; irrigation scheme level and at the national level for creating a strong institutional base and an enabling environment.

The project objective is to increase climate adaptation, mitigate the negative impact of extreme climate events, and improve the livelihoods of smallholder farmers and vulnerable rural communities in four provinces of Cambodia. This objective will be achieved by implementing three components that aim at addressing climate change vulnerabilities, increasing agriculture productivity, and developing institutional capacities. The components include Component 1: Improving farm-level climate adaptation, resilience, water use efficiency which focuses on climate resilient crop-water management practices, improved food security and income generation through strengthening and improving adaptive capacity and climate resilience focusing on rice, vegetable, poultry and aquaculture production, provide opportunities for greater market integration and agro-meteorological information and services. Component 2. Upgrading and climate-proofing of water infrastructure for increased resilience which will focus on modernization of irrigation schemes and ponds, flood-proofing and drainage improvements and establishment and training of FWUC and Component 3. Institutional Strengthening which aims to strengthen Government institutions, mainly the MOWRAM, MoE, NCDD and the FWUC. While the focus for MOWRAM will be on up-grading technical capacity in various aspects of CR irrigation design and management, key focus area for MoE will be on strengthening climate policies and strategies and in building capacities for monitoring climate actions at national level.

6.2 Key Barriers

In the project area, the analysis have highlighted three main risks for farmers: (1) a decline in the rainy season days, despite increasing precipitation the project area is likely to experience more extreme dry periods; (2) rapidly increasing temperatures causing deteriorating suitability conditions for many crops,, and further drying in the wet season (through evapotranspiration); (3) increasing risk of heavy precipitation potentially leading to flooding, erosion and destruction of crops, livestock, and infrastructures; and (4) unpredictability of rainy season onset and the timing of rainfall within season. The project design is taking these risks into consideration through climate change adaptation measures that focus on balancing the watershed's ecosystem services and the climate-proofing of existing combined irrigation and flood control infrastructures. Where possible, the project employs smart irrigation systems that collect and distribute key aggregated data to maximize irrigation and flood control, key weather data for water resource managers and farmers, and outreach to last-mile smallholder farmer groups on adaptive water and crop management methods. Thus, the project promotes viable business models for the private sector to offer affordable smart water solutions and adapted farming technologies respecting agro-ecological context and climate-sustainable principles. The project has been informed by hydrologic and hydraulic modelling to assess water sources, water availability, existing and new canal networks, and optimize the irrigation and drainage/flood control system in the project area.

A major barrier to sustainable and climate-resilient development of irrigation and water infrastructure in the project area is insufficient investment in planning and long-term maintenance of infrastructure in a systematic way. In addition, the technical capacities of relevant national institutions and Farmer Water Use Communities (FWUCs) are rarely assessed in detail at the design stage. In most irrigation schemes, there is largely no systematic cost-recovery practice leading to a lack of incentive for the FWUCs members board to manage the infrastructure properly, making sure the voices of vulnerable groups are heard. The design process of the proposed project included a capacity and needs assessment of both MOWRAM, including PDWRAMs and relevant FWUCs and other relevant provincial and district offices in the project area to ensure targeted interventions and suitable training programs are included in the project to build the skills needed to undertake O&M responsibilities, but also to become more inclusive. The approach considers our understanding of the mid-to long-term impacts of climate change on water resources and irrigation infrastructure as well as agricultural development needs including (i) a secure water supply to support dry-season cropping, (ii) climate-proofing and quality of design and construction of irrigation schemes, and (iii) sustainability through investment in farmer water use communities.

Another important barrier in the project area is the lack of extension services at the provincial and commune level. Agricultural extension lacks personnel, capacity and network to access remote communities. In addition, current extension personnel possess an inadequate understanding of climate change and climate-smart / climate-resilient practices and technologies that are suitable for local contexts. Farmers have limited knowledge of technologies and techniques that are more sustainable and climate resilient. The technologies offered or available are not always appropriate and farmers are generally resistant to adopting them when the technology is not climatically fit, or it is labour intensive, costly or not suitable to smallholder farmers. Agricultural expansion has been possible through unsustainable practices, including mono-cropping, excessive application of chemical fertilizers and pesticides, and poor soil nutrient management. Farmers, agricultural cooperatives and SMEs have limited access to finance, which can facilitate the adoption of appropriate technologies and techniques. Access to finance remains the major barrier as small holder farmers and agribusinesses often cannot meet the high collateral requirements of financial institutions, and their higher interest rates and short tenors reflect both the risks inherent in agriculture activities as well as a less nuanced approach to managing those risks. Further lack of farmer credit histories and their low financial literacy contributes to poor financial access. The project will address the specific challenges that women, youth and people from other vulnerable groups face in accessing extension services and dedicated credit lines.

The local private sector also fails to offer technologies that farmers need (e.g., stress tolerant seeds, bio-inputs) and engage in value addition (e.g., rice milling prior to exports) adequately and sufficiently. Production and distribution costs of agricultural products are high compared to the neighbouring countries, largely due to high energy and transport costs. Private sector investment in water saving micro technologies in irrigation and extension services remains low due to an unfavourable agri-business environment, such as access to appropriate SME finance, poor communication and cooperation between government and private sector, and the absence of a clear regulatory framework for the establishment, operation and pricing for the private management of water. Large agri-businesses face high costs and shortages of working capital. Many agri-business firms operate below capacity and potential new investors are reluctant to invest due to low profitability and high risk of failure.

There are several obstacles to women’s economic empowerment in Cambodia, including (i) the amount of time and responsibility for unpaid domestic and care work, (ii) low levels of literacy and education, and (iii) a lack of access to resources necessary for economic empowerment. Women have higher participation in agriculture than men but receive lower benefits and have lower access to land, extension services, financial services, markets, and technologies. Rural youth face difficulties in accessing land, which also limits access to credit, as financial institutions generally require land as collateral and a high proportion migrate to urban areas in search of work. Poverty incidence among ethnic minorities is not significantly higher than among the majority, but they suffer disadvantages in access to health, education and other services.

6.3 Alignment with government policies

The CAISAR project is aligned with the Cambodian government's long-term development goals and policies in several ways.

Alignment with CLTSD 2030 and Cambodia Vision 2050

Economic Diversification and Growth: CAISAR aims to increase the productivity and climate resilience of smallholder farmers, contributing to rural development and inclusive economic growth.

Infrastructure Development: CAISAR focuses on rehabilitating and modernizing irrigation infrastructure, enhancing the efficiency and resilience of water management systems.

Human Capital Development: CAISAR promotes climate-smart agriculture practices and provides training to farmers, enhancing their knowledge and skills.

Social Protection and Poverty Reduction: CAISAR supports the livelihoods of vulnerable communities in rural areas, contributing to poverty reduction and social resilience.

Environmental Sustainability: CAISAR promotes water conservation and sustainable agricultural practices, contributing to environmental protection and climate change adaptation.

Alignment with Specific Policy Initiatives

National Agriculture Sector Policy 2019-2030: CAISAR supports the government's goal of promoting climate-resilient and sustainable agriculture.

National Water Resource Management Policy 2016-2025: CAISAR contributes to the efficient and sustainable use of water resources for irrigation.

National Climate Change Strategy 2019-2030: CAISAR helps enhance the resilience of agriculture to climate change impacts.

In summary, the CAISAR project is well-aligned with the Cambodian government's development priorities and policies, contributing to the country's long-term goals of economic growth, poverty reduction, environmental sustainability, and climate change resilience.

7 Component 1 - Farm Level Climate Adaptation and Resilience

The objective of this component is to build climate resilience of smallholder farmers through evidence-based planning and context-relevant climate resilient practices at the farm level. The component will support smallholder farmer groups in the project target irrigation command areas to implement climate-resilient crop and water management methods. It will strengthen institutional capacity to provide extension services on CR technologies, and ensure farmers have access to climate information and agro-meteorological advisory services for their agriculture planning. It will improve both digital and physical connectivity of the farmers for better production, transportation and improved market access.

The component will be implemented in the command areas of irrigation systems that will be improved in component 2. So, it will be working with the same group of farmers, FWUC and commune councils, and other stakeholders belonging to Ou Ta Paong, Lum Hach, Krang Ponley and other irrigation systems described in Appendix 4. However, sub-component 1.3 that focuses on agromet advisories and sub-component 1.4 that focus on climate proofing of rural roads will have wider beneficiary circles as these services will not be limited only to the farmers of the irrigation command areas. ~~In total, this component will directly benefit 105,000 families.¶~~

The component will be implemented following a participatory approach ensuring involvement of beneficiaries and relevant stakeholders including women and minority groups. An Action Plan to build Farmer's Resiliency shall be prepared blending the scientific knowledge and information together with the local adaptation practices, perceptions, criteria and preferences. The implementation of the AP will be facilitated by the project creating enabling conditions and capacity support. The outcome shall be continuously monitored, and lessons and experiences will be utilized to improve the implementation process. The overall implementation framework for this component is shown in Figure 4.1. Improved household and institutional capacities developed value chains and continued extension support are expected to sustain the process of climate adaptation post-project.

The expected results of these sub-components will be achieved through generation of the following five interrelated outputs and are described in the following paragraphs.

- **Sub-Component 1.1 Farm-level Climate Adaptation and Resilience**

Output 1.1 Increased farmer capacity in climate resilient agriculture

- **Sub-Component 1.2 Climate Adaptive Value Chains**

Output 1.2 Climate adaptive value chains developed by 4Ps and increased access to finance.

- **Sub-Component 1.3 Agro-meteorological information and services**

Output 1.3. Increased access to climate information and advisory services for climate responsive water-use and crop planning

- **Sub-Component 1.4 Resilient Farm Roads**

Output: 1.4 Increased resilience of farm road infrastructure to climate changes

The four outputs are directly linked at farm level actions and will be implemented in an integrated manner. The component will be executed by the NCDD in close coordination with provincial, district and commune agricultural offices. The NCDD will require technical assistance in several areas in executing the activities, and these will be addressed through hiring of service providers or individual experts as required.

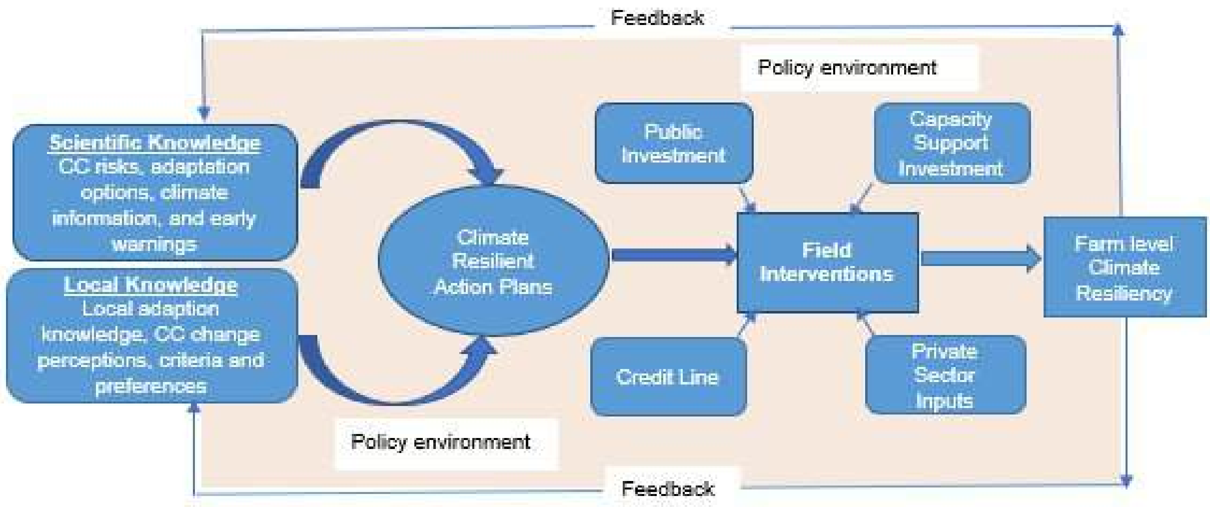


Figure 4-1. Implementation Framework for Farm Level Climate Resiliency

7.1 Sub-Component 1.1 - Farm-level Climate Adaptation and Resilience

Output 1.1 Increased farmer capacity in climate resilient agriculture

The project will introduce already proven technologies and practices in CR rice cultivation (Table 4.1) such as CR rice varieties (e.g. Fragrant rice, Champei Sar 70) alternative wet and drying (AWD), mechanized Direct-Seeded Rice (mDSR), land laser levelling (LLL), Integrated Pest Management (IPM) and straw management in rice cultivation. At the same time, the project will demonstrate and facilitate the adoption of vegetable production techniques across schemes. Many vegetables require lower amount of water compared to rice and there is a strong demand for locally produced vegetables in the target provinces. Producers with diversified cropping portfolio is shown to be 13-80% more profitable compared to those growing only rice. This intervention is expected to help farmers to diversify from rice to non-rice crops in the long run and in tandem with the evolving market conditions.

Table 4-1. Climate-resilient technologies and practices for rice cultivation, poultry and aquaculture

Technologies/ Practices	Description	Documented benefits
CR rice varieties	Fragrant rice, Champei Sar 70 released by CARDI in 2022, in addition several other flood and drought tolerant rice varieties have also been released by CARDI)	Flood/ drought tolerance, can be grown two to three times a year, yield up to 4.5 ton/ha
Mechanized Direct Seeded Rice (mDSR)	Traditionally, rice is established by transplanting young seedlings in puddled field. The practice requires numerous laborers working in tandem. In direct seeded rice, pre-germinated rice seeds are drilled or sown directly into the wet or dry soil. Direct seeding can be done as manual broadcast or with the help of seeding machineries. Cambodian farmers have already shifted	Globally • Reduce seeding rate >50% compared with the broadcast seeding practice • Reduce fertilizer use by 20-30% • Reduce risk of pest/ diseases and lodging • Reduce GHG emissions by 10-

	from transplanting to manual seed broadcasting mainly due to lack of labor. However, the shift has introduced a different set of challenges including the use of high seed rates, losses from weeds and pests, and lodging. All these have led to lower yields and profits. A further shift to mechanized direct-seeded rice (mDSR) provides a solution as the method reduces the seed and fertilizer rate which leads to improvement in weed management and plant growth and typically results in higher profitability.	25% ● No yield penalty. Cambodia 0.4 to 0.9 tons/ha higher year across four provinces over three years (2021 to 2023). ● Reduced seed rates by 50-65% compared to manual broadcasting. ● 22-40% higher gross income compared to farmers' practice, depending on the season.
Laser land leveling (LLL)	Smallholding farms are not typically well-leveled which leads to inefficient water management. With laser land leveling, guided by laser transmitters to ensure an even surface, soil is redistributed across the field to create a precisely-leveled field. The technology helps water conservation, supports uniform plant growth and improves input use efficiency.	Globally ● increased yield by 5%, ● reduce agronomic inputs by 10% ● reduce GHG emission by 10% Cambodia and SE Asia ● A net benefit of USD 52-84 per rice season ● A decreased emission by 1151-1486 Kg Co2 eq ● Cambodia ● A likely average increase in yield of approximately 20% on dry season rice yields
Alternate Wetting and Drying (AWD)	Alternate Wetting and Drying is a water-saving technology that reduces irrigation water consumption in rice fields without decreasing yield. This is achieved by flooding the rice fields intermittently. The interval between two flooded soils varies from 1 to more than 10 days depending on factors such as soil type, climatic factors, and crop growth stage. There are many ways to inform farmers on the timing and length of drainage in AWD which include sensor-based monitoring systems. Another approach is to optimize a calendar-based drainage timing that can be applied at tertiary or secondary canal levels.	Global ● If implemented correctly, AWD has reduced irrigation water input by up to 38% with no yield penalty. ● Reduction in water pumping expenses and fuel consumption decrease contributed to an increase in farmers' income by 17-38%. ● AWD in rice fields led to reduction of CH4 emissions by 73% in the dry season and by 21% in the wet season.
App-based efficient Fertilizer management	Based on site-specific nutrient management (SSNM) principles, the Rice Crop Manager (RCM) is an app-based tool to identify the best nutrient management practices for specific rice fields. Consideration of the timing, quantities, and types of fertilizers are some of the key components of these findings. RCM recommendations are provided to farmers	Use of RCM recommendations provided an average yield increase of 0.4 tons (400 kg) per crop per hectare equivalent to about USD100/ha/cropping season added net benefit in the Philippines and an average of 0.5 tons (500kg) per crop per hectare equivalent to about USD150/ha/cropping season in India.

	through a one-page print-out and a short messaging service (SMS) to improve and guide crop management	
Rice straw management	Rice straw is an important factor in controlling the GHGs from low land rice cultivation, as CH4 emission from rice are mostly due to anaerobic decomposition of straw and crop residue under continuously flood conditions. Currently, only about 30% of the rice straw is collected and used for various purpose in Cambodia, 30% is burnt and the remaining is left in the field to decompose. Straw is collected both manually and using bailing machine, the latter is now available as a service provided by nascent service providers in Cambodia. Collected rice straw can then be utilized in a circular economic activities, such as mushroom production, cattle feed, mechanized composting/ organic fertilizers, biochar and production of bioplastics or other bioproducts.	New rice variety selection, non-continuous flooding and straw removal strategies reduce GHG emissions by 24%, 44% and 46% on average, respectively Partial and complete removal of rice straw reduces GHGE by 30% and 40% compared to complete straw retention, respectively.
Homestead gardening with vegetables	This option will target women and smallholder famers with no or very small parcel of land. The aim is to help these group of farmers to be more climate resilient with increased possibility of income. In vegetable production, priority will be given to introducing climate smart measures like shading, netting, wind breakers, mulching, low-cost Alternative Drip Irrigation Technologies (ADIT) and conservation practices for vegetables together with relevant IPM methods. Vegetables which grow off seasons with high market value and require less water will be given high priority as they can address both quick and slow onset climate change impacts. These measures together with smart water application technologies will help reduce ET and water consumption while also improving the health of soils and are effective for dry season vegetable cultivations while conserving water for other purposes.	Vegetable gardening supports household food security and can act as resiliency measures for small holder farmers. Low-cost ADIT serves as climate adaptation measures as it improves water use efficiency. IPM and other measures described will provide adaptation options for increasing climatic vulnerability and ways to conserve biodiversity in agroecosystems.
Poultry production	The production of broilers or eggs has been providing clear evidence of providing income to smallholder farmers. It is normally an activity which attract women and together with the activities in sub-component 1.2 to ensure value chains for such kind of production this could make an example for implementation in other areas of Cambodia.	The semi-intensive poultry production model applied in Cambodia has shown net income increases of 2,600$ for broiler production and 4,360$ for chick-hatching production Application of solar incubators reduce greenhouse gas emissions resulting from chicken production by reducing diesel consumption in power generation
Aquacult	Another option for improving livelihood for	

ure	the poor is production of fish in traditional ponds or aboveground systems. An important aspect in relation to this is to develop a system and value chain to make it profitable to produce to a wider market based on activities conducted in sub-component 1.2.	

International Rice Research Institute (IRRI) has been continuously active in Cambodia since 1986. The organization has supported the government agencies in various aspects of rice sector development, including varietal development, seed systems, IPM, improved agronomic practices, mechanization and water management. The project plans to engage a service provider through a TA contract on several aspects of this sub-component, including activities 1.1.1 - 1.1.5 below. The project will also engage a service provider to deliver activities 1.1.2-1.1.4 on vegetables, poultry and aquaculture. Finally, the project also plans to engage a service provider to deliver online extension information, including climate-informed agricultural advisories, and to link farmers to service providers for climate resilient technologies.

7.1.1 Activity 1.1.1 Preparation of community-based action plans (AP) to transform agriculture with CR practices and technologies.

Relevant awareness materials on climate change and its general impacts will be prepared by using a Climate Smart (CS) Mapping approach. The CS Mapping for the first year will be assisted by the service provider and to build capacity among relevant agencies to conduct CS Mapping. CS Mapping will be conducted through workshops at the district level, gathering participatory assessment data of the key climate risks. In the first year the participatory data will be merged with GIS and crop modelling data to provide risk maps. Through scenario analyses in the crop models, adaptation options can be identified. The resulting output include CS Maps showing the districts and communes with the risk areas for each climate stress (drought, flood, etc) and recommended adaptation options delineated, and gender disaggregated where required to ensure that the needs of women are reflected.

Apart from CS Maps, the project will facilitate formulation of Value Chain Action Plan (VCAP) at the provincial level (Activity 1.2.1) and the VCAP will be used to inform the development of annual commune-level Action Plan (AP).

The annual commune Action Plan (AP) will be prepared through a participatory sessions involving both men and women farmers, Producer Organizations (PO), FWUC, service providers, value chain actors and NGOs engaged in agriculture and water management activities. Commune facilitators will collaborate with the leaders of commune councils at each target commune to prepare the commune AP. The commune council will ensure representation of men, women and minority groups at the AP preparation. Equipped with the CS Maps and VCAP, the annual AP will delineate community’s preference on rice varieties to grow (including new CR rice varieties), choices of vegetables, other adaptation measures such as poultry production or aquaculture, as well as the capacity support needed for the selected value chain. The AP will also set the schedule and targets for implementation and indicate monitoring arrangement. The AP will be revised annually, including the targets and crop choices and other adaptation technologies based on the new information and knowledge available from implementation of the plan each year. A community-based monitoring and evaluation system will be established to monitor the outcome of the AP implementation and are described in 1.1.5. The findings and recommendations of the Community-Based Monitoring and Evaluation (CBME) as well as information from climate information and early warning systems (component 1.3.) will be integrated in revising the AP annually. At least one representative from each target commune that’s heavily involved in the preparation of the AP will be identified to join the meetings of the district-level multi-stakeholder platforms (DMSPs) aimed to improve value-chain coordination (Activity 1.2.2). These commune representatives will serve as liaisons, bringing information and voice of the commune-level AP into the deliberation of DMSPs and vice versa. Special efforts will be made to ensure the inclusion of at least 30% women and 20% youth in these forums. MSMEs will also be a key part of these forums given their vital role in agriculture development in Cambodia. CAISAR will include elements of the APs into commune plans and build local capacity to enable them to develop them on their own. Representatives from other communes will be invited to learn from the experience for further dissemination. Provincial level staff will also be trained in the development of these VCAP to enable them to develop them on their own. MSMES will be engaged in the exercise to enable the private sector to work with local farmer groups and cooperatives and develop them independently. Representatives from other provinces and communes will be invited to learn from the experience and ensure that the MSMEs and private sector service providers are able to expand the idea to other areas due to the value they add in helping them increase their revenue and increase farmer incomes. Lead farmers are expected to be an important resource to demonstrate the impact on agriculture productivity.

7.1.2 Activity 1.1.2 Preparation of training materials to support implementation of the AP

This activity will develop training curricula and compile, revise, and update available materials to be used to support farmer learning and adoption of CR technologies and practices as outlined in the action plans. Priority will be given to short visual learning materials combined with charts, leaflets and short notes that a user-friendly learning material are available to accommodate men and women farmers who usually have lower literacy rate. The training materials will be reviewed regularly and modified and updated based on field experiences with farmers, new practices, new varieties, and new information available. Once climate information and agrometeorology services are available from Output 1.3 and 2.4, these will be also included in the training materials. The training materials will be mainstreamed in among the provincial, district and commune agricultural offices to scale up application of CR technologies and practices in the target provinces.

The project will hire qualified subject matter specialists (SMSs) to prepare the training materials who will continuously provide guidance and supervision to the implementation of the training programs. The training materials will be developed in a way so that they can be used for Training of Trainers (ToTs) and as farmer field and business school (FFBS) training materials. The ToT materials and curriculum shall include FFBS facilitation techniques as well as the technical aspects of crop, livestock and agribusiness management. The FFBS training materials shall include a complete curriculum and a set of hands-on learning activities on both production (e.g. crop and water management/ livestock management across season) and agribusiness side of target crop and livestock (e.g. business planning, post-harvest processing, sales and marketing). The training materials will be used deploy the technologies and practices as described in activities 1.1.3 and 1.1.4. The following sets of training material will be considered, both for ToTs and for FFBS, based on the feedback from the participants:

1. Improving best management practices for irrigated and rain fed lowland rice (including water saving techniques such as AWD for rice); a supplemental rice seed production module will be developed to be used in training of a subset of FFBS
2. Improving vegetable production including drip irrigation and soil mulching.
3. Fish farming and aquaculture
4. Improving household chicken production.

For rice crops, several learning materials produced by GDA, CARDI and IRRI can be further adapted to take into account the specific contexts (e.g. soil type, preferred rice varieties, water availability) of the target provinces. New material will be developed as required and utilizing the lessons learned and feedback from already available materials. The materials shall be developed in close coordination and collaboration with the above agencies/ institution making use of their knowledge, experiences and involvement. Inputs from service providers, traders, mechanics and manufacturers shall be utilized. Interactive consultative meetings can be organized as required inviting all relevant partners so that the training materials are context specific and addresses the need of the farmers.

7.1.3 Activity 1.1.3 Conduct training of trainers (ToTs) to create a pool of expertise to demonstrate and propagate the CR technologies and practices.

The trainings of trainers (ToTs), aimed at creating a pool of Master Trainers (MTs) to propagate the CR technologies in line with the AP in each province and to support implementation of Activity 1.1.4, will start in the second year of the project. There is currently a huge gap in Cambodia extension services to support the CR practices in both rice and non-rice crops. Once the training materials are prepared as above, TOTs will be organized to create a pool of expertise to propagate the CR technologies and practices. The project will engage a service provider to conduct the ToTs on rice production. The project will also engage other expert-based organizations to assist with the ToTs on vegetable, chicken and fish production. The district and commune agriculture officers are the main audience for the ToTs, supplemented with interested NGOs, universities or any external institutions and private entities. Altogether 200 MTs will be trained to implement FFBS planned under 1.1.4. The service providers will continue to provide the support to the MTs in testing and adapting to new technologies and practices.

A total of eight TOTs will be organized (two in each province) to train on various aspects of the CR technologies and practices. The training material developed will be continuously improved based on the lessons and feedback out of the training of the MTs and that of the farming community described in the next activity. The eight ToT sites will be retained until the third year of the project (a total of two years) and become demonstration hubs to strengthen the knowledge base of the MTs and key farmers who will help in facilitating the rest of the FFBS; to test, modify and collect evidence base for new technologies and practices as required based on the changing context. The service provider will manage the rice ToT sites and the project may enter into agreement with international/ national expert-based organizations to manage the ToT sites on vegetable, chicken and fish production. Technologies tested at the ToT sites may include soil moisture sensors at the field level to inform water management in AWD, mDSR and drought tolerant rice varieties, solar pump and drip irrigation for vegetable production, etc. Measurement and analyses of greenhouse gas emission may also be conducted at the ToT sites in comparison with relevant control fields. The medium and small-scale enterprises receiving Public-Private-Producer Partnership Facilities (Activity 1.2.3) shall provide support in demonstrating various techniques and technologies at the ToT sites. The pool of expertise developed here will help address the extension gaps in the CR in technologies applications and will be able to support and expand the evolving CR practices even after the closing of the project.

7.1.4 Activity 1.1.4 Training and advisory on CR technologies and practices

Two major training and advisory approaches will be adopted to facilitate adoption of CR technologies and practices among target farmers. Farmer field and business school (FFBS) forms the first approach, while use of videos and advisory hotline through a mobile application, forms a complementary second approach. Altogether, 40,000 farmers will be trained through an organization of 1600 FFBS. The FFBS will cover one or two major growing cycles for one of the four target crops/ livestock activities (rice, vegetables, chicken, fish). After participation in the FFBS, farmers will have access to the how-to videos available in mobile application video library as a tool for practical day to day refresher. Additionally, the mobile application will provide an advisory text-based hotline through which farmers can consult experts to trouble shoot their production problems. Further details on these two approaches are described below:

Farmer field and business school

After at least one season of training, the 200 MTs trained above will start training farmers using the training materials developed earlier. The farmers will be selected from irrigation schemes being rehabilitated in component 2 as well as the small-scale existing irrigation schemes that are adjoining to the main irrigation schemes. Given the need to cover such huge numbers of farmers in a short time, a cascade approach will be followed. It will begin with 200 FFBS in the first half of the third year implemented by the MTs, and will be expanded utilizing newly trained farmers, who are young and innovative, but under the supervision of the MTs. The program will continue until the 7th of year of the project. The project may enter into agreement with the NGOs and other private entities who have been trained earlier (MT trainings above) to implement the FFBS programs. FFBS implementation targets are presented in the table 4.2 below.

Table 4-2. FFBS implementation plan

Year	Target groups	FFBS target	Beneficiary target	Objective	Remarks
1	Master trainers only (NGOs, PDAFF, research institutes, young agricultural graduates etc.)	8	200	Develop master trainers (MTs) to conduct training to farmers	Trained by subject matter specialists (SMS) at IRRI and a service provider in collaboration with commune facilitators. These MTs will be responsible for training to farmers from year 2.
2	Farmers	160	4000	Build farmers 'capacity on CR technologies	Trained by MTs, supported/supervised by SMS
3	Farmers	320	8000	Build farmers 'capacity on CR technologies	Trained by key farmers and MTs, overall supervision by SMS
4	Farmers	320	8000	Build farmers 'capacity on CR technologies	Trained by key farmers and MTs, overall oversight by SMS
5	Farmers	320	8000	Build farmers 'capacity on CR technologies	Trained by key farmers and MTs, overall oversight by SMS
6	Farmers	320	8000	Build farmers 'capacity on CR technologies	Trained by key farmers and MTs, overall oversight by SMS
7	Farmers	160	4000	Build farmers 'capacity on CR technologies	Trained by key farmers and MTs, overall oversight by SMS
	Total	1,600	40,000		
About 40% of FFS will be focused on women groups only (vegetable production, mushrooms, chicken production, aquaculture etc), FFS will have at least 40% women participation and at least 15 % youth participation (age group till 30 years).					

As the FFBS will also cover post-harvest management, sales and marketing, these portions of the training will build their capacities to participate in the value chain development as covered under the Output 1.2. During the FFBS, participating farmers will be exposed to demonstrations of CR technologies and practices and critically assess their ease of use and profitability as compared to conventional farming practices. Farmers graduating from the FFBS will be supported to apply the technologies and practices in the next cropping season in their own fields. Such support will include technical advisory through a mobile application (see below), access to service providers (activity 1.1.5) as well as market linkage as outlined in the sub-component 1.2

About 35% of the FFBS will be implemented in the Ou Ta Pong Irrigation schemes given its size (roughly 15,000 ha) and potential to transform agriculture. This scheme has relatively better water availability as compared to other schemes. The rest will be implemented in Lum Hach, Krang Ponley and other irrigation schemes that are going to be rehabilitated in component 2. Four types of FFBS are envisioned covering the four target crops and livestock (rice – both wet and dry season, vegetables, chicken, fish). The AP for each commune will determine the number of FFBS in each type to be conducted in a given year. The project will ensure that all the target farming families will be able to participate in at least one of the FFBS. Farmers wishing to switch to vegetable production or other livestock activities will be prioritized for relevant FFBS.

Each FFBS is planned as a season-long activity. It will involve introducing CR technologies and practices at each stage of the crop growth integrating crop and water management practices at the farm level. Each FFBS will be supported to host a demonstration plot where the participants can conduct hands-on learning and experimentation. For example, rice has three main stages: Vegetative phase, reproductive phase and ripening phase and each have different stage. Farmers will be trained on crop water practices at each phase and stages, organizing structured trainings and field days. A typical FFBS for rice will therefore run for about 105 days with many of the activities conducted in the demonstration plot. An FFBS on vegetable production may include several different vegetable crops, incorporating materials on crop rotation, diversification, and water management such as drip irrigation with the use of solar pump. The medium and small-scale enterprises receiving Public-Private-Producer Partnership Facilities (Activity 1.2.3) may be engaged to provide support in demonstrating various techniques and technologies at the demonstration plots as needed.

Some of the FFBS will specialize in seed production to ensure local seed availability of drought/ flood tolerant rice varieties. The relevant FFBS training material for seed production (Activity 1.1.2) will be used for these training. The farmers receiving this training will receive further support from the project to receive quality declared seed (QDS) certification and are expected to incorporate seed production in their future operations. The number of FFBS covering seed production in a particular commune or district will be decided in the AP.

The targets (Table 4.2) and the generic guidelines for FFBS implementation described above will be discussed and updated as needed during the AP formulation process described in the previous sections to ensure full ownership of the process by the farming community. Thus, the targets will be reviewed annually.

Practical video library and advisory hotline through mobile application

A mobile application will be used that IFAD has applied in other projects in Cambodia to develop and disseminate practical information in the form of videos on various aspects of chicken production in other Cambodian provinces. The mobile application also contain similar video libraries on rice, vegetable and fish production. The project will engage as service provider to amend the mobile application's video library by adapting the FFBS training materials into video forms. Furthermore, the mobile application also facilitate delivery of advisory services by allowing registered users to ask practical question through the application. Agents and experts are on standby to answer these questions. The project will include such advisory hotline solution through the mobile application for FFBS participants, thus ensuring continuing support for farmers after the conduct of the training. Finally, awareness raising among FFBS participants on the availability of these resources will be provided.

The mobile application will also serve as a marketplace platform for agricultural input, services and commodities. The project shall also leverage the service marketplace platform portion of the mobile application to scale up the use of mechanized DSR, LLL and straw collection as delineated in activity 1.1.5 below.

Technologies and practices for non-rice adaptation measures.

The focus here are vegetable crops, chicken production and aquaculture. Priority will be given to introducing climate smart measures like shading, netting, wind breakers, mulching and conservation practices. These measures together with smart water application technologies described in the following sections will help reduce ET and water consumption while also improving the health of soils and are effective for dry season vegetable cultivations, and water for other purposes.

Diversification strategies are adopted for more reasons than climate change as small holders or poor do not have land for applying the above-mentioned techniques so to allow them to be more climate resilient other approaches are needed considering availability of land and their possibility to make an income. This approach builds on association with market, livelihood strategies, and agro-ecological context. In recent times, diversification has been considered as a successful strategy to improve the resilience of communities in the changing climate context. Priority will be given to high value crops. Potential of crop diversification will be discussed with farmers, traders and the plan for crop diversification will be developed as outlined in 1.1.1.

Diversification however requires a flexible water supply to respond to changing needs of the crops, new capacity on cultivation skills and market linkages. The project will ensure that all these basic conditions are met to encourage farmers towards crop diversification. Flexibility in water delivery services will be ensured through irrigation modernization described in component 2 while capacities to grow diversified crops with CSA approaches are covered in previous activity. Support in value addition and market linkages will be developed out of implementation of sub-component 1.2.

Three livelihood and climate resilient options are considered for women and poor.

Homestead gardening

As part of the diversification, the project will also encourage farmers to establish homestead or larger scale gardening or greenhouse production. This will be focused on women and smallholders with relatively small land holdings. Vegetables which grow off seasons with high market value and require less water will be given high priority as they can address both quick and slow onset climate change impacts. Where needed they will be equipped with simple cheaper Alternative Drip Irrigation Systems.

Chicken production

For improving income of small hold farmers the production of broilers or eggs has been providing clear evidence of providing income. It is normally an activity which attracts women and together with the activities in sub-component 1.2 to ensure value chains for such kind of production this could make an example for implementation in other areas of Cambodia. The options for small holder farmers with limited land holdings are limited but it is important to consider their options in relation to climate change impacts. Adaptation measures and production of poultry are described in more detail in Chapter 2. A semi-intensive poultry production model will be applied, which is described in more detail in Appendix 6. The planned training and support are described below:

- Technical training of interested small-holders that covers chicken production techniques and improved technologies, as well as the use of incubators regulated by solar energy or electricity. The project will organize regular follow-ups, coaching and mentoring sessions, and a monitoring and reporting system is created to document chick production improvements.

- Farmers will receive theoretical training on the technical aspects of poultry housing and equipment construction, breeding, feeds and feeding techniques, and poultry health care (such as adoption of biosecurity measures, disease prevention and deworming).

- Farmers will have visits to the "demonstration farms" of peer farmers so that they can gain from their knowledge and experience while identifying practices and methods they could replicate or adapt on their own farms. On demonstration farms, farmers will receive practical training in chicken pen construction, chicken feed mixing, sanitation, vaccination, disease prevention and economic analysis.

- Provision of a set-up package (including vaccination, feed and a net) and a solar egg incubator with 2 or 10 blocks for chicken breeding farmers and for poultry fattening farmers a set-up package including a chicken pen model will be provided

- Farmers are trained in market-oriented broiler production and facilitation by connecting poultry producers to collectors and buyers; supporting farmers in accessing markets or collection points; and assists in the negotiation of product price are provided. See more details in Sub-Component 1.2.

Aquaculture production

Another option for improving livelihood for the poor is production of fish in traditional ponds or aboveground systems. An important aspect in relation to this is to develop a system and value chain to make it profitable to produce to a wider market based on activities conducted in sub-component 1.2. Adaptation measures of aquaculture are described in more detail in Chapter 2. Additional information regarding aquaculture considerations is provided in Appendix 7. The planned training and support are described below:

1. Strengthening Value Chains:

Input Market Development:

- Facilitate the establishment of collective purchasing groups for fingerlings, feed, and other essential aquaculture inputs.
- Encourage the development of local hatcheries and feed production facilities to improve access and affordability.
- Partner with research institutions to develop and disseminate information on cost-effective and locally-sourced feed alternatives.

Output Market Development:

- Organize training programs on post-harvest handling and processing techniques to minimize spoilage and add value to fish products.
- Improve market access by linking farmers to local retailers, restaurants, and consumers through cooperatives or farmer associations.

2. Knowledge Sharing and Training Programs:

Develop training modules:

- Create training modules that cover essential topics like pond management, water quality control, disease prevention, best aquaculture practices, and financial management specific to small-scale aquaculture.

Training Delivery Methods:

- Organize farmer field schools where experienced farmers can share their knowledge and best practices with others.
- Utilize participatory approaches during training sessions to encourage active learning and problem-solving among farmers.
- Explore the use of extension services, demonstration plots, and farmer-to-farmer exchange programs for knowledge dissemination.

3. Context-Specific Aquaculture Models:

Promote Integrated Aquaculture-Agriculture (IAA) Systems:

- Encourage the adoption of integrated rice-fish farming systems, where fish are raised in paddies alongside rice cultivation. This leverages existing infrastructure and provides additional income for farmers.
- Explore other IAA models suitable for local contexts, such as integrating fish farming with vegetable production using water from aquaculture ponds for irrigation.

Species Selection:

- Promote the diversification of cultured fish species to reduce reliance on a single species and mitigate market risks.

4. Addressing Water Quality Management:

Training and Capacity Building:

- Integrate water quality management principles into training programs for farmers.
- Provide training on affordable and practical methods for water quality testing and monitoring.

Technology Adoption:

- Promote the adoption of simple and affordable technologies for water aeration and treatment, where appropriate.

By implementing these activities, farmers can significantly improve their livelihoods. A combination of improved access to inputs and markets, enhanced knowledge and skills, context-specific farming practices, and market-driven production strategies will contribute to a more sustainable and productive aquaculture sector in Cambodia

7.1.5 Activity 1.1.5 Strengthening and fostering tailored mechanization service providers for improved mechanization service delivery.

This activity focuses on improving the provision of high-quality mechanization services to farmers, especially to support them to shift towards the mechanized direct seeded rice (mDSR). In addition, increased application of LLL and mechanized collection of rice straw will be enhanced. It will provide capacity support to service providers and assist them in bundling the services of new machinery in their existing business models. The mechanization service providers are relatively common in some of the target provinces, mainly focusing on combine harvesting of rice yield.

There is already strong desire among farmers and willingness to pay to shift from existing manual broad-casting method to mDSR. Additionally, from service provider's point of view, there is a business opportunity to add straw harvesting and balling to their service offers. Harvested straw can be sold or utilized as animal feed either by the service providers or by the farmers. Lack of access and knowledge are the key limiting factor for more farmers to adopt mDSR and straw collection services. In order to facilitate rapid transformation towards mDSR and straw collection, the project will contribute part of the cost to mDSR and straw collection services, either as cash co-pay or e-voucher utilizing service booking platforms such as mobile applications, covering 3600 ha across the project cycle. This will also help the service providers to integrate mDSR and straw collection into their existing business model.

For LLL, there is a growing interest among farmers, but the technique is still seen as expensive. In addition, farmers have seen benefit of LLL mostly in dry season rice or in dry direct seeded rice practices. The project shares the cost of procurement of some LLL machineries a part of 4PFs delineated in activity 1.2.3. The machines will be integrated with existing service providers to increase access for interested farmers. This approach has already worked well to establish successful private industry laser levelling providers in Cambodia as demonstrated by the ACIAR project in Northern Cambodia.

The district and commune agricultural officers will be capacitated to promote mechanization especially in rice cultivation. The project will engage as service provider to develop training curriculum, materials and technology notes to be used in training district and commune officers on agricultural mechanization in rice cultivation. The training materials will cover the specificities of the technologies as well as successful business models of mechanized DSR, LLL and straw collection. The service provider and relevant project SMS will conduct a training event for all district and commune agricultural officers on these technologies. These government extension workers are then expected to provide two different types of coordination support. First, they will provide coordination of the machinery value chain actors (manufactures of machine, equipment or spare parts, traders and suppliers, maintenance mechanics) as the service providers are heavily reliant on value chain actors for both equipment and skills. Second, they will link service providers with the farmers to co-ordinate the required machinery services. The SMS will monitor and provide trouble shooting support for district and commune agricultural officers.

Through these interventions, the project will create a favourable environment for the machinery service providers to include additional machinery (e.g. mDSR, LLL and rice straw collection) to their existing services (primarily combine harvesting). The service providers will be further linked with the 4PF activities described in activity 1.2.3 to enhance their business opportunities and deliver services to farmers in line with their requirement. The service providers receiving 4PF support are expected to contribute in demonstrating the benefits of these techniques at the demonstration hubs / the ToT sites (Activity 1.1.3) while project's partial contribution to farmers for increased machinery uses will increase their business opportunities.

7.1.6 Activity 1.1.6 Community-based monitoring and evaluation (CBME)of the implementation

Local farming communities are at the heart of implementing the climate resilient measures. Their participation in monitoring the results is essential for continued adoption of the measures. The CBME strengthens ownership of the farming community on the whole process right from initial planning to the final evaluation. A set of community-based performance indicators will be identified in consultation with men and women farmers and other relevant stakeholders to monitor and evaluate the outcomes of the interventions listed in the AP. Such indicators could be of farmers trained in applying specific technologies, numbers of female farmers engaged in vegetable production, poultry production, aquaculture, new varieties introduced etc. These indicators will be scientifically validated so that the data and information can be used in the project's M&E framework as well as in Climate Action Monitoring systems at national level. Results and lessons from the CBME will be integrated to the Web-based monitoring systems of the National level Centre of Excellence (CoE) to be established under activity 1.1.3. The flow of information and feedback will be established in reverse direction too: from national portal to the community-based systems so that lessons learned and feedback from other similar projects could be also adapted to the implementation of this project. The information flow at various level of monitoring system is shown in Figure 4.2. By sixth year of project implementation, a discussion will be held at the sub-national level to discuss the possibility of adopting the community action planning and CBME process as a routine process post-project. The M&E system will report also on the project performance in the inclusion of women and youth in the training programmes. Commune level officers and MAFF and NCDDs staff will be included in understanding the monitoring system so that they can then use it for their own purposes and potential upscaling to other areas.

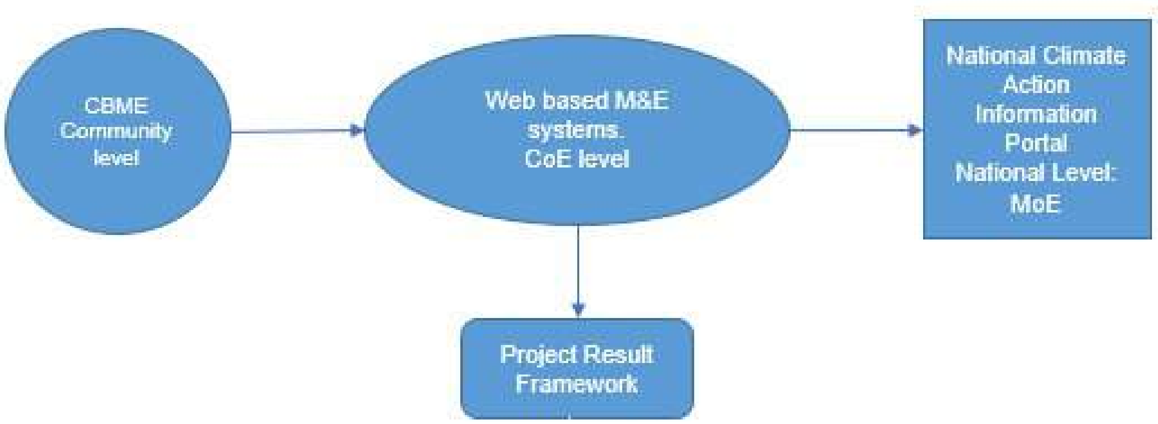


Figure 4-2. Information Flow among various monitoring levels

7.1.7 Implementation strategy and arrangement for sub-component 1.1.

NCDD will be responsible for implementation of this sub-component. The sub-national agricultural officers (e.g. district and commune agricultural officers) will be fully involved in the project, organizing APs, serving as Master Trainers and facilitating the strengthening if mechanization service providers.

It is foreseen that the project will engage three service providers:

SP1 to provide technical level input in areas of application of mDSR and in best agronomic practices for climate resilient rice cultivation. The SP1 will provide in developing training and knowledge products (e.g. CS Maps), training Master Trainers, maintaining demonstration plots and conducting GHG measurements at the plots and especially support in demonstrating and training and in developing knowledge products.

SP2 to provide e-vouchers to support farmers trying new mechanization services such as mDSR, LLL and straw collection. The mobile application will also make practical video library on climate mitigation and adaptation techniques in rice cultivation available, together with videos in vegetable, chicken and fish production. Additionally, the mobile application will make online consultation service available for farmers in the target province. Finally, climate-informed agricultural advisories will be made available through the mobile application.

SP3 to develop training materials and conduct ToTs in vegetable, poultry and fish production. The technical support provider will also provide commune-level facilitators to support the organization of the AP multistakeholder annual workshops (activity 1.1.1) as well as to support communities in CBME process (1.1.5). These facilitators will act as interface between the farming community, sub-national agricultural officers and the project management. The facilitators will engage in coordination with the district and commune agricultural officers, as well as commune councils, for AP and CBME process.

The three service providers could form a consortium with one lead organization. NCDD could then engage the consortium through a single contract with the lead organization.

7.2 Sub-component 1.2 - Climate adaptive value chains

Output 1.2 Climate adaptive value chains developed by 4Ps and increased access to finance.

This sub-component aims to address the financial barrier to invest and improve sales of smallholder farmers, farmer groups, agricultural cooperatives and related MSMEs by helping them to leverage capital for adaption and value chain investment. The scaling up of climate smart practices, services, and technologies demonstrated under sub-component 1.1 will be supported under this sub-component. This sub-component consists of three key and synergistic activities: (i) Value chain (VC) study that aims to identify the gaps and improve VC governance; (ii) Establish and facilitate multi-stakeholder platforms to improve VC coordination and stimulate investment from the financial sector to invest in climate change adaptation through VC development; (iii) Public – Private – Producer – Partnership Facility (4PF) that crowd in, de risk, and co-finance investment with MSMEs and farmers in support of climate-sensitive commodity development and rural employment generation. The development of these value chains activities will be undertaken from a gender perspective to capture the engagement of women in the different agriculture commodities and their specific role in each value chain and how they can benefit from the activities of the project.

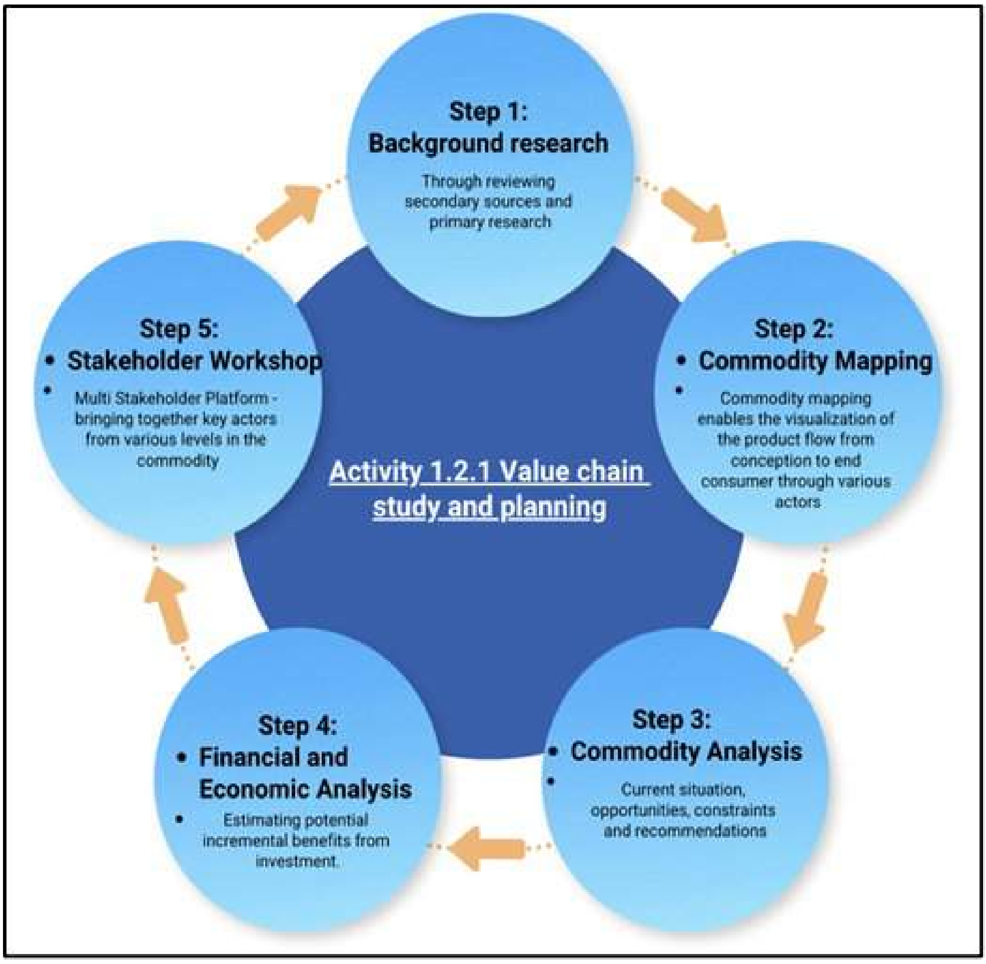
7.2.1 Activity 1.2.1 Value chain study and planning

Based the Cambodian Agricultural Development Plan and IFAD’s guidelines on pro-poor value chain and building on the project feasibility study, the project will work on the following value chains: rice, vegetable, native chicken, and fish. Additional commodities can be added at a later stage during implementation if deemed necessary.

In the first six months of the Project, the Agri-Enterprise Development (AED) team, supported by international technical assistance, will, through a mix of theoretical and case-based training and resource allocation, capacitate provincial and district partners to prepare concise value chain action plans (VCAP) including mapping of commodity actors, processes, the added value at each link, and an initial identification of challenges and opportunities. The VCAP will identify value chain interventions that offer higher income potential, are inclusive of the poor, women and youth, are resilient and adapted to changing climate and that are linked to private sector technical support and/or off-takers. During the first year of the project, the focus of this activity is on developing, verifying and implementing the framework to identify and rank potential interventions, support the development of demonstrations farms at the ToT sites (Activity 1.1.3), identification of lead farmers, identification of applicants for the Public – Private – Producer – Partnership Facility (4PF) (Activity 1.2.3).

At least four approved value chain action plans (VCAP) for rice, vegetable, chicken, and fish will be developed in each target province (total 16 VCAP in 4 provinces). Empowered provincial and district agencies with AED support, will subsequently: (i) support the integration of commodity development in the provincial development programmes; (ii) provide technical support to commodity development across the Project area; (iii) provide mentoring to value chain actors and co-ordinate their capacity development; (iv) coordinate with specialists in specific commodities and in "climate proofing" agriculture production; (v) mentor contract negotiations between farmers and other value chain entities; and, (vi) facilitate business registration, conflict resolution and mediation when required.

The VC action planning process will involve 5 steps as shown below:



- background research on the chosen commodity/crop by reviewing secondary sources of information concerning the commodities provincial and national importance, environmental requirements, role in household economies, end-markets, etc. This will be followed by primary research in the provinces through interviews, focus groups, surveys and observation involving value chain actors (farm households, processors, input suppliers, advisors etc.);
- using the aforementioned information, map the commodity/crop sectors in four provinces. Commodity mapping enables the visualization of the product flow from conception to end consumer through various actors, as well as the supporting markets and enabling environment affecting the commodity;
- prepare a table listing the structural and dynamic factors in the commodity, and briefly describe the current situation, opportunities, constraints and recommendations for addressing those constraints including tangible How, Who and Financing status;
- prepare a financial and economic analysis of each commodity detailing the estimating potential incremental benefits from investment in their development, including, *inter alia,* rates of return on investment, increased household income, number and type of household benefiting; job creation; increased export; import substitution, etc.;
- conduct a workshop (as part of the Multi Stakeholder Platform – Activity 1.2.2) bringing together key actors from various levels in the commodity to vet the findings of the analysis and discuss if the chosen strategy for increasing commodity competitiveness is valid.

The VCAP, with periodically updated, will be used as the framework for calling agribusiness entrepreneurs to express their interest for investing in four provinces. The validated VCAPs will be used to inform the community-based adaptation planning (AP) occurring at the commune level (Activity 1.1.1).

7.2.2 Activity 1.2.2 – Establish Multi-Stakeholder Platforms (MSPs)

MSPs are forums where all actors in the value chains could come together and meet face to face. The project will facilitate these ongoing MSP, business to business (B2B), business to service (B2S) and Contract Farming processes and then provide technical and financial support to address the particular priority bottlenecks and actions identified by the value chain actors that they cannot directly address without additional external technical or financial support.

Two types of MSP will be established and facilitated in this activity:

(i) District commodity-based MSPs and

(ii) Provincial Agro-Financing Workshops.

District commodity-based Multi-Stakeholder Platforms (DMSPs) aim to improve value chain governance by enhancing coordination and strengthening relationships between actors within selected value chains. A DMSP consist of relevant stakeholders within a value chain, including farmer representatives, farmers' and private sector organisations (including identified business partners), government representatives, traders, processing enterprises, input suppliers, consumer representatives and financial institutions. Expected results of the platforms include improved networking and coordination for tangible results like higher producer prices, improved market transparency, trade contracts or product branding. In some districts, the local governments and projects including the IFAD funded ASPIRE-AT, SAAMBAT, AIMS, already organises similar events; in these cases, the existing initiatives should be taken up and further developed, rather than establishing parallel structures[102].

[102] For detailed background on organization and facilitation of MSPs, see Brouwer, H. and Woodhill, J.

Value Chain development through DMSPs is a process-oriented approach. The main measured output is the number of events organised in the framework of multi-stakeholder platforms – including DMSP meetings, promotional events, sub-group meetings, bilateral and multilateral meetings between VC actors; informal visits to VC actors with the purpose of coaching or information collection are not to be counted. The target value is at least 1,000 events over the lifetime of the project, averaging to 9 organised events per district and year. Included in these events are stakeholder groups supplying, testing and potentially adopting the introduced technologies in Activity 1.1.3 to engage potential incentive mechanisms for adoption at scale. MSP events are expected to lead to improved market linkages – the target is to increase the number of formal farmer groups – market linkages established as outcome of multi-stakeholder platforms.

Impact will be assessed when updating the Value Chain Action Plan at the end of the project intervention, by estimating changes in added value within the chain, and by attributing this to internal or external actors. Due to the high flexibility of the MSP process, and the difficulty to attribute changes unambiguously to single factors, no target value is set.

The process of stakeholder engagement and coordination includes identification of opportunities and challenges, development of mutual understanding, definition of roles for coordinated and joint actions. DMSPs also act as brokers for innovative technologies, especially when specific market demands require specific production technologies (e.g. mDSR, LLL, mechanized straw collection, drip irrigation, solar pump – See Output 1.1). Partners of FMSP activities are linked to the Public – Private – Producer Partnership Facility (Activity 1.2.3), where relevant.

For each DMSP meeting, the composition and agenda of the DMSP can change over time according to participants' perception of problems and relevance of the platform. Stakeholders might include farmer representatives, farmers' and private sector organisations, government representatives, traders, processing enterprises, input suppliers, consumer representatives and financial institutions are invited. The following points are possibly on the agenda:

- Introduce and explain the DMSP concept, including the project related activities; discuss scope and expectations;
- Present and verify the Value Chain Action Plan, using discussion to add further details and viewpoints;
- Discuss participants' viewpoints on challenges and opportunities for positive intervention; add information from VC Analysis and context, where necessary; prepare and rank lists of challenges, fields for improvement and potential interventions;
- Pick possible interventions with good potential and feasibility, and identify related key stakeholders; and
- Plan for follow-up action involving key stakeholders: formation of sub-groups, contact with actors interested in further support.

Outcomes of DMSPs are difficult to predict, as they depend on the initial context, commitment of participants, skills, coordination and commitment of facilitation and the scope of feasible improvement options that can be identified. Possible outcomes are:

- Improved market transparency and market information e.g. by providing transparent information on price and traded volumes;
- Improved linkages between VC actors in terms of number and quality – new partnerships may evolve, and existing ones may be strengthened;
- Joint and coordinated action, e.g. group and cooperative formation, involving business associations;

et.al. 2015. The MSP Guide – How to design and facilitate Multi-Stakeholder Partnerships. Centre for Development Innovation, Wageningen University and Research, Netherlands.

- Promotion and lobbyism towards the government and its role in providing enabling framework conditions for trade and commerce;
- Mutual understanding between VC actors and conflict resolution resulting in a broader feeling of ownership of developed activities.

Apart from DMSP meetings, follow-up action is organised flexibly, including break-off sub-committees and bilateral communication with key stakeholders. The AED team's ability to understand the context, to proactively interact with relevant actors and to organise and facilitate meetings and events is decisive for the success of the DMSP.

When promising interventions have been identified, and stakeholder commitment has been ensured, collaborative action is planned for. Bilaterally or in subgroups, detailed action plans are developed, resources, support and stakeholder contributions are secured. It is important to find a good balance applying timely and consequent follow-up and close involvement of stakeholders, but without overstretching their capacity.

Most DMSP interventions will in the given context fall under the following categories:

- Facilitating market linkages between farmer groups and buyers/processors of primary products, where farmers and/or farmer groups develop production capacity in regard to quantity and quality, and pool their sales towards a single buyer under contract conditions;
- Goal-oriented capacity development of VC actors with support from the Public Private Producer Partnership Facility (4PF);

Provincial Agro-Finance Workshops will be organized twice a year in each target province, will bring key local and regional financiers, agro-enterprises, donors, and producers' representatives together to share opportunities and information on various types of financing options for value chain participants in the provinces. The organization of the bi-annual Provincial Agro-financing Workshops in each province is the responsibility of the AED and related provincial agencies. They will actively cooperate with local and regional financial institutions and agri-business companies to create and implement workshop programme that is relevant for the participants. Importantly, they should cooperate with IFAD (Cambodia), and AIMS, SAAMBAT, APIRE-AT to secure the participation of institutions such as the World Bank, Asian Development Bank, as well as the Head Offices of ARDB, SME Banks, AMK, and other MFIs. IFAD can also assist in strengthening the workshop programme by creating contacts to include in the workshop programmes international presentations on innovative schemes such equity funds that are likely to emerge on a wider scale in the agro-market of Cambodia. It is expected that some sustainable relationships will be built after the organization of the large number of events throughout the project lifecycle which will foster partnerships and can be continued on their own. In case some of these partnerships are successful they are expected to be scaled up beyond the project area due to mutual benefit. While the bi-annual workshops at the provincial level may not continue after the end of the project it is expected that some of the introductions made during the process will lead to better access to financial institutions and some of the access to financing options are expected to continue beyond the project period.

7.2.3 Activity 1.2.3. Public Private Producer Partnership Facility (4PF) and leveraging of capital

Cambodia's agricultural sector has enjoyed almost two decades of strong growth, contributing to significant poverty reduction, national food security, social stability, and increased regional and international economic integration. There are, however, concerns about both the quality and sustainability of the country's agricultural growth and its impact on the welfare of producers and consumers. Cambodia's agriculture growth is frequently characterised by mixed or uncertain product quality and food safety, low value addition and limited technological and institutional innovation. Agriculture growth has, in some cases, also incurred a high environmental cost.

Cambodia's strategy for agricultural and rural development is evolving to adopt and apply the concept of 'sustainable development', organizing key objectives under the 'Triple Bottom Line' of economic development, social development and environmental protection. In applying this strategy, the GoKC sees the opportunity and need to pursue various forms of public-private collaboration in order to realize these objectives.

The complexity of a modernizing agriculture extends beyond what the State can readily provide—in terms of investment, expertise, and clear direction in the face of many uncertain variables. As elsewhere, the role of the State in the sector must evolve to focus on ensuring the provision of core public goods and regulatory services, while acting to facilitate farmer and private sector investment and initiative. In some areas, the State may be able to delegate or contract others to provide certain services; in other areas, systems of 'co-management' or 'co-regulation' may be possible as observed from local and international experience. In essence, RGC seeks to pursue various forms of public-private partnership/collaboration in order to more quickly or effectively realize key sectoral (economic, social, and environmental) goals. Specifically, RGC expects 4PF initiatives to contribute to:

- increasing the volume of rural and agricultural investment, even in the face of fiscal constraints;
- increasing the quality of sectoral investments and the quality of technical services;
- fostering innovation, both of a technical and institutional nature;
- improving management—of natural resources, supply chains, and of various production and commercial risks; and
- contributing to more rapid structural change at the primary production level and within supply chains, to bring about improved efficiencies.

The Public Private Partnership Facility (4PF) has the purpose to strengthen commercial actors – micro, small and medium agri-enterprises as well as commercial farms with strategic position in the value chain – so they can perform their role for their own benefit as well as for the benefit of related smallholder households. The 4PF will be managed, likely by a third-party contractor, to ensure a private sector approach, including due diligence and standards of service. The facility has a special focus on promoting a new generation of young rural entrepreneurs, and women entrepreneurs. Grant beneficiaries receive technical and financial support to strengthen their business skills, and to carry out investments with good potential for profitability and positive side-effects to target farmers. Subsidies are used to reduce small enterprises' business risk and to promote fair business practices with producers. Small enterprises with small investment requirements can apply for full grant finance, while for larger investments; enterprises are required to contribute a progressive share either from own capital or from formal credit. It is a particular objective of the facility to link participating enterprises to Business Development Services including formal financial institutions (Activity 1.2.4) to cover their growing demand. A *Manual for 4PF* will be prepared during project start-up in line with IFAD guidelines in designing matching grants. 4PF operates under the following main principles:

- All items in the investment plan that need to be purchased are eligible for grant financing, including machinery, office material, IT and vehicles. Existing enterprise resources, own labour and local material available at no financial cost are considered as enterprise contributions.

- The share and size of the grant depends on the size of the financial investment, with the rationale that small enterprises, planning for small investments, have larger constraints to access funds than larger enterprises with more capital-intensive investments. For larger investments, it is expected that a larger share of investment costs is covered by either own equity or by formal credit. Linking rural enterprises to banks and relevant microfinance institutions is integral part in this project (see Activity 1.2.4). Investments up to USD 2,500 (Category I) are 100% grant financed; investments up to USD 15.000 (Category II) attract 100% grant for the first USD 2,500 and 50% grant for the expenditures from USD 2,501 and up to 15,000; investments over USD 15,000 (Category III) attract 100% grant for the first USD 2,500, 50% grant for the expenditures from USD 2,501 and up to 15,000 and 25% for expenditures from USD 15,001 and up to 50,000.

Investment Category	Grant for up to USD 2,500	Grant for USD 2,501 - 15,000	Grant for USD 15,001 - 50,000
Category I (up to USD 2,500)	100%	-	-
Category II (up to USD 15,000)	100%	50%	-
Category III (over USD 15,000)	100%	50%	25%

Stage of Grant Application

Stage		Activity	Description
Applicant Screening and Selection	Pre-screening	Applicant Assessment	AED Team evaluates applications based on profile, investment potential, impact, and alignment with program goals.
	Capacity Development	Grant Provision	Successful applicants receive funds for training and advisory services.
	Application Finalization	Coaching and Support	AED Team assists applicants in developing 4PF applications.
	Committee Review	Evaluation and Approval	4PF Committee assesses applications and makes final decisions.
Grant Disbursement and Monitoring	Grant Agreement	Contractual Obligations	Approved applicants sign agreements outlining terms and conditions.
	Fund Transfer	Financial Disbursement	Grant funds are transferred directly to the grantee's account.
	Monitoring and Supervision	Progress Tracking	AED Team and consultants monitor investment progress and compliance.
	Financial Verification	Expenditure Verification	Financial Division verifies purchases and asset ownership.
Evaluation and Impact	Post-Investment Evaluation	Impact Assessment	AED Team conducts evaluation one year after investment completion.

Assessment	Data Collection	Information Gathering	Evaluation includes progress reports, benefit calculations, and feedback.
	Performance Measurement	Target Achievement	Program aims for an 80% increase in net turnover and average RoR over 10%.

- The AED Team is responsible to ensure the smooth operation of the facility. Identification of candidates is made during the numerous networking activities carried out by the team in cooperation with partners and partner organisations. Information about the facility is disseminated widely, with focus on young rural entrepreneurs (e.g., amongst members of the Chamber of Commerce, at agricultural colleges, Youth Organisation). Potential candidates for the 4PF are also identified or confirmed during Multi-Stakeholder Platform events (Activity 1.2.2), where strategic actors within the relevant value chains are convened.
- The project will work closely with the Provincial SME Support Centres (SSC) under the Cambodia Chamber of Commerce, offering Business Development Support services, and specifically, preparatory business planning, financial management training and coaching during investment implementation. Trainings can be tailor-made to the requirements of AIF applicants and focus particularly on the development of the grant application and its auxiliary documents. The participation of applicants at these courses will be obligatory for all enterprises legally required to have a business license.
- Application for support by 4PF is open to all individuals and businesses with relevance to the value chains promoted under the MSP including, but not restricted to, wholesale traders, processing entities, input and service providers, licensed farmers' organisations and farm equipment repair and maintenance shops. Female and young applicants have a preferential status and scoring weight will be adjusted accordingly.
- The investments made in 4PF will be focused around the following IFAD's common climate change investments taxonomy. Applications will need to delineate the adaptation potentials of the proposed activities.

Hazards	CCA Investment Types		
	Small-Scale Crop Producer	**Small-Scale Livestock and Aquaculture Producer**	**Agribusiness Enterprise**

Water Deficit & Temperature Stress	- Drought and heat-tolerant seeds and seedlings - micro water harvesting and storage - Small-scale sustainable irrigation solutions - Shade house, shading, and cover cropping - Soil management and mulching - Sustainable fertilizer solutions - Product diversification and intercropping - On-farm post-harvest facilities	- Rainwater harvesting systems, dams, and reservoirs - Climate-resilient aquaculture solutions - Integrated farm systems with aquaculture - Climate-resilient shelters, logistics, construction - Natural and artificial shading facilities - Heat stress reduction systems (e.g., ventilations, showers) - Species selection	(Relevant for all climate risk categories) **Input material and equipment services** - Climate-resilient inputs delivery - Irrigation systems delivery and services - Mechanization services and/or distribution - Sustainable energy solutions (e.g. solar irrigation pump) - Technical assistance **Digital platforms and CCA intelligence** - Digital value chain services - Digital financial services - Digital climate adaptation services - Advisory services - Data management and decision support tools - Climate risk and impact assessment

Water Excess, Floods	- Adapted seeds and seedlings - Pest and disease-tolerant variety selection - Integrated pest management - Integrated soil fertility management - Product diversification and intercropping - Farm-based post-harvest infrastructure	- Water flow management infrastructure and drainage systems - Rainwater harvesting systems, dams, and reservoirs - Sustainable pesticide solutions - Climate-resilient aquaculture systems - Climate-resilient shelters and logistics - On-farm processing of livestock and fish products - Veterinary prophylaxis and vaccination facilities	**Climate risk transfer** - CCA insurance services - Bundled product development - Index-based service solutions **Supply chain lead companies** - Contract farming arrangements - Primary production TA and quality assurance - Logistics and storage services - In-kind finance of farm inputs and services

Heavy Wind	- Physical and biophysical flood protection - Storm and flood-proofed infrastructure - Upstream water management infrastructure - On-farm post-harvest facilities - Drainage systems	- Physical and biophysical flood protection - Storm and flood proofed infrastructure - Wind breakers and covers - Product diversification - Climate-resilient shelters and logistics	
Soil Depletion	- Integrated soil fertility management - Soil management and mulching - Drainage systems	- Water flow infrastructure - Drainage systems	

The AED Team pre-screens interested candidates with investment plans on the background of the following eligibility criteria:

- Assessment of personal characteristics of the applicant reflecting on the investment perspective: reliability, commitment, educational background and professional experience;
- Profitability and economic viability of the planned investment;
- Potential for positive impact towards the target group including expanded outreach;
- Scoring of proposals will be weighted in the areas of nutrition, gender, vulnerable groups, environment, and climate impact.

The criteria above will be further developed by NCDDS and detailed in the 4PF manual.

Selected candidates are eligible for an initial capacity development grant up to USD 1150 per applicant to be used for participation at relevant trainings and other learning opportunities, and for advisory services in regard to the development of the 4PF application. The applicants are coached through the application process by the AED Team and linked to relevant service providers, market links and sources of knowledge.

The 4PF aims at supporting a total of at least 100 MSME with a goal of achieving an 80% increase in net turnover among recipients and an internal rate of return exceeding 10%. At least 40% of these enterprises will be those which are led by women or youth or have a majority of women shareholders or employees. Separate windows will be established to ensure the inclusion of women and youth in the grant application call. This targeted promotion for pipeline development along with weighted scoring, will ensure this client segment is reached. Sub grant disbursement of $2500 US or less will ensure that these target groups are not precluded from participating due to lack of access to finance. Where it makes sense when some parts of the investment remain unfunded, we will help link to partner banks and ensure that the proposals are “bank ready” in the event co financing is needed.

This output is closely interlinked with other outputs: MSME investment supported by the facility must have a beneficial effect on project farmers and/or farmer groups (40000 farmers) supported by the project (see Output 1.1), either by farming contract, fair trade linkages, or by providing crucial services to target farmers. The input and service providers receiving the 4PF grants are expected to support the development of the ToT sites (Activity 1.1.3) where the benefits of the input/ services can be demonstrated to the MTs and FFBS participants. The MSPs (Activity 1.2.2) facilitate new or improved market linkages between farmers and/or farmer groups and agri-enterprises.

Once the applications and its auxiliary documents prepared are collected by the AED Team, they are to be checked and rated, following an objective set of criteria. The checked and rated applications are then submitted to the 4PF Committee, consisting representatives of NCDD, AED, Chamber of Commerce, Financial institutions, and relevant provincial agencies. During sessions convened quarterly or upon demand, the Committee reviews all applications for final approval. Investment Grant Agreements for approved applications are signed by the applicant and the assigned leader of NCDD.

Upon processing and clearing for payment, the grant is transferred directly into the grantee’s personal or business bank account. The AED Team coaches and supervises the investment process, with the support from external consultants, where necessary. The Project Financial Division verifies that purchases are made following the Grant Agreement. All items purchased with grant money remain property of the project until an investment completion report including documentation for purchases is submitted and approved by the Project Financial Division.

One year after investment completion, the AED Team organizes an evaluative appraisal of the supported investments involving the grant recipient, including a concise progress report since the completion of the investment, a simple benefit calculation resulting in an annual Rate of Return to the investment, comments regarding challenges encountered and recommendations given to the enterprise.
The project co-finance will be used to reduce the business risk for climate adaptive investments; to promote fair business practices with producers; and to stimulate external finance from domestic banks and MFIs. Small enterprises with small investment requirements can apply for a higher grant finance, while for larger investment, enterprises will be required to contribute a progressive share either from own capital or from formal credit sources. It is a particular objective of the facility to link participating enterprises to Business Development Services including formal financial institutions to cover their growing demand for finance.

Reflecting the overall development trends in Cambodia, the financial sector has gone through a period of major transformation during the past 20 years. The fast expansion in banking activities and in the volumes of their financing operations is considered one of the key factors behind the fast economic growth in the country. While in the past few years the financial sector has been affected by the overall slowdown of the economy, it is expected that the sector will return to its earlier rapid growth path during the implementation period of the planned CAISAR.

Despite the overall financial sector progress, however, the commercial banks still tend to prefer lending to large and known borrowers at the expense of low-income rural clients and micro, small and medium enterprises (MSMEs). In this situation, accelerated private investment in higher value agriculture can only happen on a large scale with significantly increased financing from mainstream banks and MFIs to farmers, cooperatives, MSMEs, agribusinesses and service enterprises.

Since the beginning of IFAD's operations in Cambodia, interventions in rural finance have been an integral part of the supported program-based multi-component projects, including the on-going Accelerating Inclusive Market for Smallholders (AIMS), the Sustainable Assets for Agriculture Markets, Business and Trade (SAAMBAT), and the Agriculture Services Programme for an Inclusive Rural Economy and Agricultural Trade (ASPIRE-AT). These projects have partnered with the mainstream MFIs including the Agriculture Rural Development Bank, the SME bank, the AMK who have substantial existing portfolios in agriculture as well as taken specific steps to strengthen their internal capacity to lend to agriculture. The partnerships based on genuine common interest and included:

- Participation of MFIs in the multi stakeholder platform (MSPs) (Activity 1.2.2) to better understand the financing opportunities and demand of actors in the supported VCs and to meet farmers and businesses wanting to make complimentary investments,
- In-depth information sharing from projects' supported investments by farmers, business and other on the actual cash flow and financial performance of these investments in order to increase the MFIs' understanding of the financial risks and returns and the suitability of similar copycat investments for mainstream for loan financing.

Building on the success of IFAD's experience, Activity 1.2.4 will stimulate the financial sector to invest in climate change adaptation and value chain development activities in the project area. To substantially impact the rural economy and poverty alleviation, climate change adaptation and rural value chain operations will require significant investment capital. Potential financial sources are listed below.

Financial Institution	**Role**	**Potential Contribution**
SME Bank	Development finance	Long-term loans for agricultural MSMEs
Agriculture and Rural Development Bank	Specialized lending	Credit for agricultural activities and rural development
AMK	Microfinance	Financial services for small-scale farmers and entrepreneurs
Commercial Banks	Mainstream lending	Potential for larger-scale agricultural financing with appropriate risk mitigation

The MFIs are liquid, and report that they have sufficient financing for medium and long-term investments but lack the risk management tools and incentive structure to invest in climate adaptation activities. Importantly, various MFIs have access to the large national agricultural credit lines subsidized interest rates for the rural lending operations. In this situation, one key objective of CAISAR and its management will be to work in a pro-active manner to attract financing from various types of financial institutions to the value chain and CC adaptation processes of the Project to ensure an appropriate level of scaling up. Experience from elsewhere clearly shows that bank and financial institution investments in rural projects is proportionate to their level of information of rural activities. The organization of semi-annual Provincial Agro-Finance Workshops (Activity 1.2.2) should facilitate the flow of information between value chain actors and financial institutions at the provincial level.

Leveraging funding for agricultural value chains can have a major impact on agricultural investments and incomes in the four provinces if these activities are conducted successfully and in a pro-active manner. With the liquid banking sector and donor-financed credit lines available for well-informed applicants, the potential for raising substantial financial resources for agro-investments through improved financial sector linkages to agro-enterprise is obvious.

7.3 Sub-Component 1.3 - Agro-meteorological information and services

Output 1.3. Increased access to climate information and advisory services for climate responsive water-use and crop planning

In Cambodia, the availability and capacity to use the weather and climate data and translate them into advisory services for agriculture application is limited. The PEARL project by GCF has made a detailed assessment on existing gaps to produce the agromet services focusing on two key activity areas: data and service production and delivery and uptake by farmers. The result shows that while there is now considerable investment on data generation and production, value added services and last mile delivery and uptake of the services by the farmers are almost missing.

Few NGOs have been engaged in providing climate informed advisories but are project specific, usually lacking long-term approach. In addition, platforms, guidelines and regional scale information systems have been developed[103], but they have been prepared for specific purposes that do not coincide with farm level advisory services. As an example, working with the Government of Cambodia’s National Committee for Disaster Management, the World Food Programme (WFP) launched the Platforms for Real-time Information Systems (PRISM) initiative in 2015. It however focuses on social protection against extreme climate events. In a case of tropical storm, for example, PRISM can rapidly estimate the size of populations potentially affected by the storm, facilitating rapid response.

Weather and hydrometeorological information systems form the basis for agrometeorological services. The hydrometeorological information and services falls under the remit of Department of Hydrology and Meteorology (DHRW) meteorology information under Department of Meteorology (DOM) under the MoWRAM. There are several ongoing initiatives within the MoWRAM to strengthen the national weather and water information and warning systems, producing a functional systematic framework on general weather forecasting and early warning services. The existing background context of hydromet sector have been covered in Chapter 2. There is a need to continue building the capacity of DOM and DHRW for data collection and modeling to improve

[103] See for example, SESAME - supported by UNDP with Cambodia; https://www.rimes.int/node/1067) or EWS1294 (https://ews1294.com/en/); WFP's Prism (https://prism.wfp.or.id/) now managed by National Committee for Disaster Management, and JAXA's Jasmin (https://asia-rice.org/tools/).

the forecasts and early warning. Furthermore there's a need to translate the weather forecasts and early warnings into agricultural advisory.

Component 2.4 below will cover the activities to strengthen national institutions capacity of DOM to acquire and operate hardware and software for data collection, management and analyses to improve water and weather information system and making forecasts and early warnings (flood/drought) readily available.

Leveraging expected improvement in hydrometeorological and weather information, this sub-component (1.3) will develop and disseminate better agrometeorological information and early-warning systems for use in the agriculture sector combining the crop-based information at local level. The sub-component aims to ensure that agrometeorological services are accessible and useful to farmers to manage climate risks and vulnerabilities in their farms. The information needs of women and the most appropriate channels of communication for them will be examined to ensure they access the information they need given their key role in crop and livestock management. It will therefore directly contribute to the Action Plan preparation process as well as implementation of sub-component 1.1 ultimately supporting farmers in practicing climate informed agriculture cultivation practices.

The overall framework for implementing the agrometeorological services to farmers is shown in figure 4.3. It involves four stages: information gathering, production of climate-informed agricultural advisories, delivery and dissemination, and the feedback from the end users. It is therefore designed as a learning process with lessons and feedback from end users are continuously incorporated in the process. The project will closely work with other ongoing projects engaged in hydroclimate and agrometeorology services[104] so as to avoid duplication. Specifically, Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin (PEARL) is an ongoing GCF funded project in Cambodia, implemented by FAO, MAFF and MOE. One of the activities in PEARL is to "Develop the standard operating procedures (SOPs) for the production and dissemination of agrometeorological advisory services and data sharing needs and architecture, targeting cashew, mango, rice, and vegetables" at the national level. The project will engage an international expert-based organization to support this sub-component. CAISAR will support PEARL in developing the SOPs for the production and dissemination of agrometeorological advisory services at the national level and at the same create awareness and capacities at the provincial, district and commune level to contextualize the national level advisories into provincial/ district level advisories and to disseminate the advisories to the farmer level.

A diversity of dissemination channels and mechanisms has been proposed to take unique circumstances into account. In general, information will be accessible through mobile apps but also disseminated through traditional communication channels where appropriate and feasible (extension system, local radio, village commune leaders). Within the mobile apps, the project will explore alternatives to text-based content – using visual and verbal options. In addition, reinforcement on availability of information and its utility will occur through FFS (in which 40% of target participants are women) and FWUCs, with FFS sessions dedicated to discussing forecasts and advisories at critical junctures in the cropping season or when specific risks are triggered. A coordination platform will be established at provincial level bringing all the relevant stakeholders together in the platform which will be responsible for preparation of the provincial and district-level agro-met advisory services utilizing the national-level advisories as the starting point. In addition to providing the agro-met advisory services, the platform will also provide additional agricultural information to the farmers that help them both in production and marketing. The services from this output will benefit 750,324 farmers directly and indirectly (50% women).

[104] Some of these projects include: : Public-Social-Private Partnerships for Ecologically-Sound Agriculture and Resilient Livelihood in Northern Tonle Sap Basin (PEARL), FAO GEF LDC project, forthcoming Cambodia Water Security Improvement Project (CWIMP)

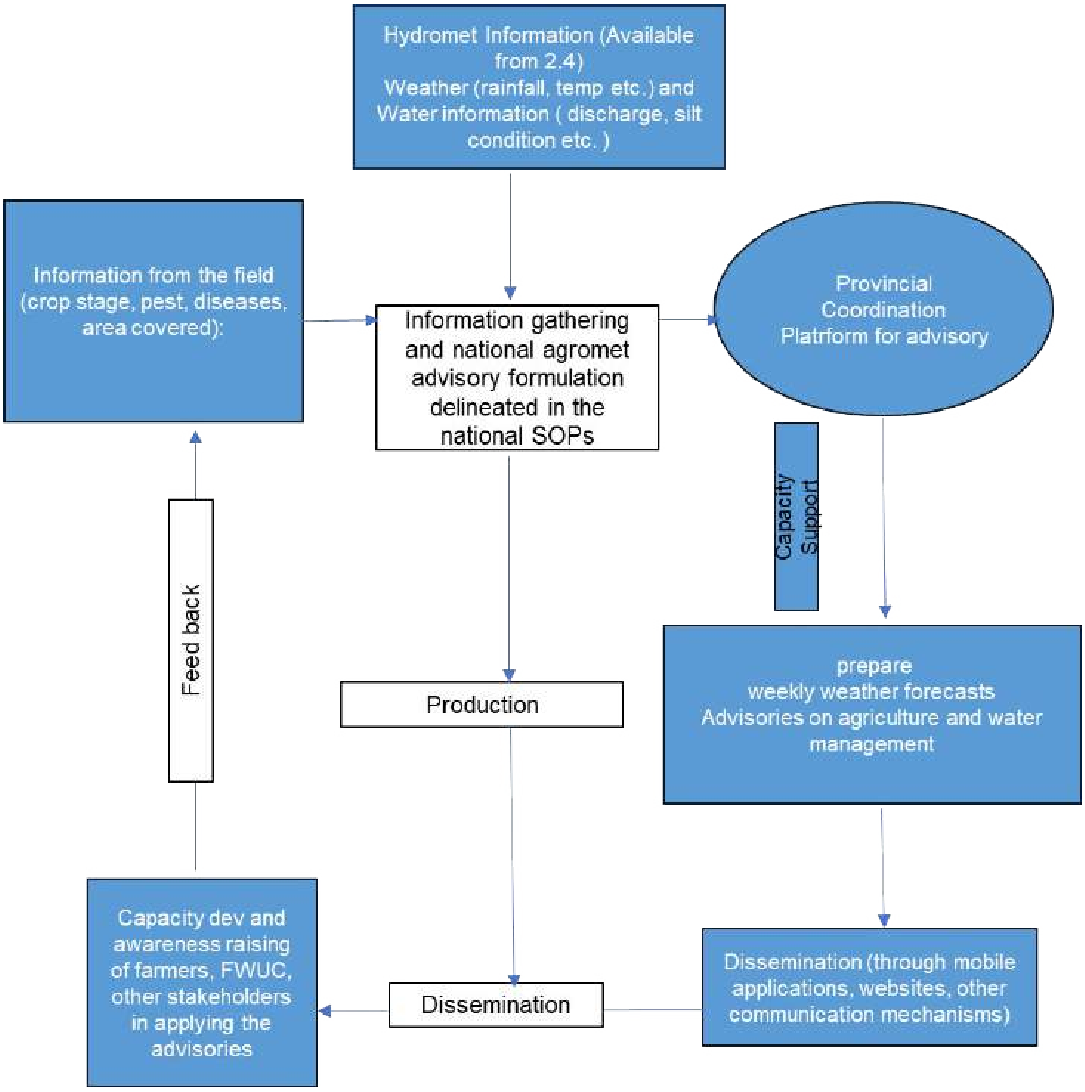


Figure 4-3. Implementation framework for Agrometeorological advisory services

Based on the framework presented above, this sub-component will be implemented executing the following activities.

7.3.1 Activity 1.3.1 Strengthening of Agro-meteorological stations in the project area

This activity will support the procurement and/or rehabilitation of 6 automatic hydromet stations in the areas not covered by the Ou Ta Paong SCADA system described in Sub-component 2.4, the establishment of 4 agrometeorological stations in the project area increasing the coverage of data gathering capacity in the command area, and the rehabilitation/procurement of 4 automatic weather stations. The network of data will generate reliable information to influence decision making at national, provincial, district and local levels. It will also include improving connectivity between different levels and departments, along with mechanisms and procedures for data sharing.

The hydromet system will be equipped with sensors to measure temperature, water level, rainfall and silt (turbidity) in the relevant rivers and canals. The sensors to be applied for the 4 agrometeorological stations will be selected based on an assessment of relevance of the type of information.

The infrastructure will be managed by MOWRAM and the data produced will be sent to the server system developed as part of the SCADA system and will be used for improving the water management at the schemes and for providing quality agrometeorological information to the farmers.

7.3.2 Activity 1.3.2 Establish Provincial-Level Coordination Platform for climate-informed agricultural advisories.

A process to integrate meteorological with agricultural data and produce national level agrometeorological advisory is being developed outside this project. This component will facilitate the translation of national level agrometeorological advisories into district level advisories. Provincial coordination platforms will be established to prepare Agricultural Meteorological Advisory Services (AMAS) at the district level, tailored to specific target crops.

The coordination platform will include provincial departments of water resources and meteorology, agriculture, as well as research institutes, key farmers and NGOs and relevant private sector representatives. It will use weather, climate and water data and information available from Department of Meteorology and combine the necessary information from crop production sector to produce advisory services to the farmers at local level. Detailed TORs and scope for the coordination platform will be developed and agreed upon within the first year of the project. The provincial governors will provide required leadership for the functioning of the platform. In general, the platform will be responsible for the following:

- To organize the collection of climate/weather, soil and crop information from relevant institutions and to amalgamate them into a coherent database, in support and alignment of the National SOPs.
- To formulate and issue crop specific, climate-informed agricultural advisory at district level once in a week
- To conduct verification of past forecasts and provide feedbacks to relevant institutions
- To organize and enhance the advisory dissemination
- To collect feedback from farmers and other users on the applicability of the advisory services and improve them accordingly.

The platform will establish a panel of experts including agrometeorology, agronomist, plant protection specialist and extension specialist, water management specialist who would be responsible for preparing information on weather, general advisory, and crop specific advisory of the respective district and communes. In addition, a high-level advisory committee would be formulated consisting of Subject Matter Specialists from different disciplines at centre level to guide the provincial panel of experts. The expert-based organizations supporting implementation of sub-component 1.1 may also provide technical support to the panel of experts preparing the advisory services.

7.3.3 Activity 1.3.3 Build the capacities to deliver services.

The capacity development will focus on establishing the essential technical capacities of climate data collection and management, translating these data into agricultural advisories through modelling and statistical analyses, and holding simultaneous focus group discussions for implementing the co-creation process across multiple government entities and farming communities. Most of these participants will be staff/professionals responsible for either the production or management of climate and agriculture data, public services, or research and development institutes, NGOs within these sectors. Both structured training programs and on the job training approach will be used for capacity development. It is planned to train about 250 persons in different disciplines across various stakeholder groups and the inclusion of women will be an area of focus.

The training will include:

- Short term training courses (summer course): GIS, data collection, validation
- Advanced training courses (crop modelling etc)

7.3.4 Activity 1.3.4. Establish agrometeorology information and warning systems and the mechanisms including awareness raising.

The products consist of quantitative forecasts for major weather parameters viz., rainfall, maximum and minimum temperatures, wind speed and direction, relative humidity and cloudiness. These products will be used by the experts for the preparation of district level advisories once a week and dissemination to the farming community to help them in taking appropriate decisions for day-to-day farm operations.

The process will involve the following:

Step 1. Collection of weather and water data (DOM/DHRW/MOWRAM, through sub-component 2.4)
Data on temperature, relative humidity, sunshine, wind etc both for past week and next week forecast
Past week precipitation data, next week forecasts (DOM web-site)
River discharge, silt condition

Step 2. Crop data to be locally collected from farmers and local officials. Illustrative data to be collected include:

Commune level cropped area, type of crops
Sowing data (average) and crop growth stage
Soil moisture data
Crop weather/pest relationship
Information on emerging issues in crop cultivation

In addition to local data collection, information available from GDA surveys as well as other relevant platforms like JAXA shall be utilized. These data shall be collected in support of and in alignment with the national SOPs for agromet data collection.

Step 3. Providing the advisory services

National agromet advisories generated through the national SOPs and platforms will be used as the starting point to formulate the district level advisories. The national level advisories will be contextualized to a more granular scale and will include the following information: i) weather forecast (temperature, precipitation, sunshine, wind etc) for a week period and limiting to general advisory only, ii) Crop specific information like crop stage, pests and diseases to be expected at the stage, etc. Gradually, the third type of crop specific advisories will be introduced, which may include timing for fertilization and pest scouting, irrigation scheduling and water balance. The feedback from farmers will be incorporated in providing the next round of advisories. It therefore uses a learning process approach that lessons and feedback are continuously incorporated in the advisory services.

Table 4-3. Sample advisory template.

Agromet Advisory bulletin	
Weather information (1)	
Past week (max, min, average)	Next week forecast
Temperature, precipitation, RH, wind sunshine	Temperature, precipitation, RH, wind sunshine
Discharge, silt, water balance, soil moisture	Discharge, silt, water balance
General advisory (2):	
Crop Information from field	
Crop Specific Advisories (3) 1) 2) 3) 4)	

Step 4. Dissemination and Outreach mechanisms

The advisory services will be delivered in terms of a weekly bulletin and will be disseminated through various approaches as systematic communication and dissemination mechanisms are still lacking in Cambodia. This project will employ multiple approaches so that information is passed to farmers and other relevant stakeholders:

- The advisories will be placed in MAFF, MOWRAM and other relevant websites in local level
- It will be broadcasted in local radios or TV programs as appropriate translating in audio/video programs
- SMS messages to key farmers, commune leaders, FWUC who will then disseminate to the farming community.
- The advisory is made available to all running FFS
- Use of mobile application.

7.3.5 Activity 1.3.5 Awareness raising and capacity building of farmers and stakeholders in applying the services.

Effective mechanism to deliver climate and weather information to men and women farmers through participatory, cross-disciplinary approaches is essential to enhance farmers' awareness of agromet advisories. It is done through organizing farmer's awareness programs, holding seminars that bring together research and development institutions, relevant disciplines, and farmers as equal partners to reap the benefits from weather and climate knowledge. Such programs help to increase the interaction between the local farming communities and all relevant stakeholders representing the coordination platform.

Farmers' and other key stakeholders will be apprised of the weather forecast process, challenges and limitations, reliability and how to use the information and advisory services in the decision-making process. This will require a large number of seminars and interactive programs to be organized for sensitizing farmers about the weather and climate information and its applications in operational farm management. The already available platform like the FFS (1.1.1) and the AP formulation process will be utilized for such awareness raising programs. Specific field days and field visit programs will be organized while implementing the FFBS in sub-component 1.1. During these programmes, farmers will be explained about the importance of the CI and agromet services in simple ways and local language. Also making use of Video/ audio content/ clippings of short duration on success stories of agromet bulletins etc.

In addition, targeted training on "climate informed agriculture decisions and planning will be organized. A total of 16 such training involving 320 key farmers and stakeholders are planned. These key people will act as resource persons to disseminate importance of climate informed agriculture planning during the FFBS and AP process. Lessons and feedback from farmers will be integrated in the advisory services.

7.4 Sub-Component 1.4 - Resilient Rural Roads

Output 1.4: Increased resilience of farm road infrastructure to climate change

Flooded rural roads are the main limitations of rural Cambodians to access services and opportunities and the transportation of agriculture produces. With a total length of more than 47,000 km[105], rural roads account for about 75 percent of Cambodia's road network and about 43,000km are unpaved roads (roughly 91%) and are highly vulnerable to increasing flood hazards due to a changing climate. This results in poor visibility due to dust during the dry season and disruption due to heavy rains and flooding during the rainy season, adversely impacting the lives of residents and logistics of the affected areas. Most of the roads are in low laying areas which usually flood during the rainy season and the current drainage capacity is poor. They are therefore highly vulnerable to increasing flood conditions.

The Rural Roads Master Plan classifies roads into four road hierarchies, with a total length of 46,834 km as shown in Table 4-4. In this aspect, MRD plans to pave a total of 6,000 km of rural roads, increasing the pavement ratio from 9% to 13% by 2030.

Table 4-4.Road Hierarchy [106]

Rural road hierarchy	Description of Road Hierarchy	No of Road	Km	Km/road
Type 1	Roads connecting national roads, provincial roads, local cities, and provinces	550	7705	14.01
Type 2	Roads connecting local cities or provinces with communes	796	6913	8.68
Type 3	Roads connecting communes	2523	12445	4.93
Type 4	Roads connecting communes to villages and villages to villages	12392	19771	1.66
		16261	46834	2.88

In the project target provinces of Pursat and Kampong Chhnang rural roads of type 3 and 4 are still not surveyed or accounted for. In addition, canal embankments and polders are also widely

[105] The country's road network consists of a total of 64,211 km, of which 7,261 km correspond to national roads, 9,031 km to provincial roads, and 47,919 km to rural roads (as of August 2022; source: Ministry of Rural Development [MRD]).
[106] JICA 2023. The Kingdom of Cambodia Data Collection Survey on Rural Road Connectivity Improvement Final Report Summary.

used as rural roads within the irrigation command areas and there is absence of information on canal embankment, flood defense dykes being used as rural roads.

Farm roads play a crucial role in stimulating non-farm activities in rural areas by accelerating and enhancing production and consumption linkages that will eventually multiply employment opportunities for the poor. Current farm road infrastructure in target provinces is highly vulnerable to impacts of climate change. For example, a two-week flooding in 2011 caused losses and damage of nearly $600 million to rural infrastructure, particularly to farm road networks. Upgrading and climate proofing of farm road networks, as per climate projections related to rainfall, evapotranspiration, run-off and temperature in the 2050 horizon, is thus crucial to maintain farmers' connectivity to markets, and to link farms to storage and drying units at agricultural cooperatives.

To address these challenges the project aims to improve climate resilience of up to 100 km of farm roads. This will involve using appropriate design standards and construction materials tailored to traffic volumes and community needs), ensuring a safer and more cost-effective rural road network that provide year-round access to markets and essential services. Upgrading these roads will facilitate timely operation and maintenance of irrigation systems outlined in Component 2, further enhancing agricultural productivity.

Where feasible, we will incorporate flood defense embankments in Sub-component 2.2, allowing canal embankments to serve a dual purpose of flood control and rural road support. This approach not only bolsters climate resilience but also promotes cost-effectiveness in road construction. The targeted roads are vital local connectors linking farms to larger transport networks and market centers, while also reducing dust pollution and improving public health.

Overall, the rehabilitated road network will benefit farmers providing improved access for agricultural and other livelihood activities in disadvantaged rural provinces. This project represents a significant investment in creating a disaster-resilient, safe, and accessible rural infrastructure that supports sustainable development and economic growth in these communities.

7.4.1 Activity 1.4.1 Identification, selection and Initial planning.

A list of potential farm roads has been identified and is shown in Table 4-5 with indication of additional roads associated with canal or polder embankment. The rural roads have been selected based on the established criteria. First, the selected roads should serve multiple purposes, such as combining embankments with roads or canals. Priority will be given to roads that maximize beneficiary impact, effectively connect various communes, and do not interfere with historical or cultural sites. It is also essential that the selected roads require no changes in alignment or additional land acquisition, as existing road widths should suffice for Type 3/4 roads. Furthermore, the roads should facilitate market access and ease the maintenance of irrigation and flood control systems while aligning with local and regional development priorities. Finally, community commitment for ongoing management and monitoring is crucial. Additional details of the identified Type 3 and 4 roads are provided in Table 4-6.

Table 4-5.Key roads features

Description	Ou Ta Paong	Lum Harch	Krapeu Trom	Yotasast	Stoeng Krang Bat	Brambei Mom	Total	Comp
Rural road improvement (Type 3/4	18.6	19.6	17.4	6.4	9.3	15.6	86.9	1.4
Road -Polder embankment	22	-	-	-	5.3	-	27.3	2.2

Road – canal embankment	51.8	31.7	17.9	23.7	-	6.4	131.5	2.1

Initial planning will involve organizing consultative meetings with local communities and relevant stakeholders. This engagement will allow the consulting firm or design experts to gain insights into local contexts, opportunities, and challenges, which will shape the future road design. The Community Participation Framework (ADB 2018), developed under the Rural Roads Improvements Project III, will guide this community engagement process. At the conclusion of these planning sessions, relevant data—including traffic numbers, the impacts of increased precipitation or drought due to climate change, and existing road conditions—will be collected for design purposes, along with future maintenance and resource requirements.

All rural road subprojects will be designed to mitigate climate change impacts while promoting local economic development by improving connectivity between farmers, main roads, and markets. To ensure effective implementation, several primary criteria must be met. Activities should not overlap with those financed by the government or other development partners, and each subproject must undergo economic viability, climate resilience, and impact assessments conducted by design and supervision consultants. The National Committee for Disaster Management (NCDDS) will review these studies, with concurrence from IFAD before contract awards; a full feasibility study will be required for projects at risk of non-compliance. Community support is also essential; subprojects must align with government policies, be included in the commune development plan, and have an Operations and Maintenance (O&M) plan developed in consultation with relevant stakeholders.

The maximum funding for any project is capped at $200,000 (including VAT and contingencies). Projects between $200,000 and $240,000 may receive matched funding from commune sources, while those involving multiple communes may exceed $250,000 per commune. Additionally, the Economic Internal Rate of Return (EIRR) for each project must be at least 12%, as determined by feasibility studies. Land acquisition should impact no more than 5%-10% of any individual's livelihood, with no Category A projects permitted. Consultation with all ethnic groups is required, ensuring equal participation opportunities; if adverse impacts are expected, an Indigenous Peoples Plan must be prepared. Environmental standards dictate that no Category A projects are allowed, and at least 40% of beneficiaries must be female. Finally, road subprojects must ensure connectivity to community centers or other road networks.

Prioritization will be given to subprojects that meet at least two specific criteria. These include benefiting households in the poorest 25% of villages, mitigating risks associated with frequent flooding, providing favorable soil conditions for intended agricultural activities, and enhancing crop production and market access opportunities. Additionally, projects should avoid land acquisition, promote high levels of community engagement in O&M, address the need for improved market access and social interaction, and demonstrate positive or minimal negative environmental impacts. This comprehensive approach will ensure that selected rural road subprojects are economically viable, socially beneficial, and environmentally sustainable, ultimately contributing to enhanced livelihoods in rural communities.

Table 4-5.Details of selected roads

Commune	Village	Estimated Length	Description
Ou Ta Paong	Phar Andet Village	0.74 km	Proposed road connects to the water source for irrigation and the main road. Several community groups (e.g., Beoung Kanseng, Sreykhorn, Kompong Kdey Sereimenchey). Type: DBST, Width: 5m, Length: 740m
Ou Ta	ChamKar	1.84 km	Proposed road connects to the main road, which will be

Paong	Kluy Village		constructed by JICA. Community road for agricultural product transportation. Type: Reinforced Concrete Road, Width: 5m, Length: 1,840m, Thickness: 15cm
Rum Lech	Dok Thla Village	1.6 km	Connects from the main road to the canal. Road for agricultural transportation. Type: DBST, Width: 5m, Length: 1,600m
Rum Lech	Lhong Village	2.2 km	Connects to the main canal and is proposed next to the community pond. Existing agriculture productive group (ASPIRE-Programme). Type: DBST, Width: 5m, Length: 2,200m
Rum Lech	Rum Lech Village	1.8 km	Links from the main road to the canal. Current road condition is poor for transport. Road for agricultural transportation (rice) and daily local traffic. Benefits existing farmer agriculture cooperative. Type: DBST, Width: 5m, Length: 1,800m
Rum Lech	Prasat Village	1.7 km	Proposed road connects to the main road and Ou Tapaong lake. Nearby community markets. Benefits existing farmer agriculture cooperative. Type: DBST, Width: 5m, Length: 1,700m
Svay Doun Keo	Thmey Village	2.37 km	Type of road: Reinforced Concrete Road, Width: 5m, Length: 2,370m, Thickness: 15cm
Svay Doun Keo	Ni Kumleu Village	6.35 km	Proposed road connects to the main National Road No. 5. Type of road: Reinforced Concrete Road, Width: 5m, Length: 1,100m, Thickness: 15cm; DBST, Width: 5m, Length: 4,500m; Proposed new road approximately 750m connecting to the main road.
Sub-total Distance for OTP Scheme:		**18.6 km**	
Banteay Preal	Torb Srov Village	4.7 km	Farm road connecting to the provincial road and water scheme. Type: DBST, Width: 5m, Length: 4,700m
Krang Skea	Krang Leav	10.16 km	Inter-district road from Rolea B'ier to Terk Phors District. Main road for agricultural product transport. One wooden dilapidated bridge (23m) and one spillway (22m) need reconstruction. Type: DBST, Width: 5m, Length: 10,160m
Krang Skea	Krang Leav	3.63 km	Proposed road connecting to the main road for agricultural transport and daily traffic. Type: DBST, Width: 5m, Length: 3,630m
Krang Lvea	Ksach Sar	1.15 km	Proposed road connecting one commune to another. One spillway (30m) needs attention. Type: DBST, Width: 5m, Length: 1,150m
Sub-total Distance for Lum Harch Scheme:		**19.64 km**	
Brambei Mum	Tangpur and Duan Tip Village	6.3 km	Proposed road for agricultural transport. Flood-prone area. Connects to 6 villages and provincial road. Type: DBST, Width: 5m, Length: 6,300m
Brambei Mum	Tang Pur Village	1.61 km	Connects to the main reservoir. Type: Reinforced Concrete Road, Width: 5m, Length: 1,610m, Thickness: 15cm
Rung Roeang	Rolaing thlar Village	3.63 km	Connecting Rung Roeang and Peam Commune, benefiting approximately 10 villages. Directly connects to irrigation scheme. Type: DBST, Width: 5m, Length: 3,630m
Rung Roeang	Rolaing thlar Village	2 km	Connects from the main road to the production area, serving local residents in Peam Commune. Type: DBST, Width: 5m, Length: 2,000m
Rung Roeang	Krang krachor Village	2.1 km	Agriculture transport road connecting to provincial main road No. 136 and market. Directly connects to irrigation scheme. Type: DBST, Width: 5m, Length: 2,100m
Sub-total Distance for Brambei Mum:		**15.64 km**	

Tbaeng Khpos	Khmer Thmey, Rolaing, Ra, Tbaeng Khpos	9.88 km	Connects to Krapeu Truom Regulator for agriculture irrigation. Proposed road connects to Sangkat Veal Pung through Krang Punley for product transport. Type: DBST, Width: 5m, Length: 9,880m, Proposed bridge construction 50m
Tbaeng Khpos	Khmer Thmey, Rolaing, Ra, Tbaeng Khpos	1.72 km	Proposed road within village settlement connecting to provincial road. Type: Reinforced Concrete Road, Width: 5m, Length: 1,720m, Thickness: 15cm
Veal Pung	Borey Rum	4.4 km	Connects to Tbaeng Khpos Commune through Krang Punley. Type: DBST, Width: 5m, Length: 4,400m
Veal Pung	Borey Rum	1.4 km	Connects to Tbaeng Khpos Commune through Krapeu Truom Regulator for irrigation. Type: DBST, Width: 5m, Length: 1,400m
Sub-total Distance for Krapeu Truom:		**17.40 km**	
Svay	Trapaing Buon	1.7 km	Connects to water source for production area (Pur Neang Canal). Flood-prone. Type: DBST, Width: 5m, Length: 1,700m
Svay	Thmei	4.44 km	Road for agriculture products connecting to the main road. Type: DBST, Width: 5m, Length: 4,440m
Sub-total Distance for Yotasast scheme:		**6.14 km**	
Long Vaek	Trapaing Samrorng, Trapaing Chambork, Orknha Pang	5 km	Farm road connecting to water source (Anlung Thbal). Agriculture transport and daily traffic for villagers. Type: DBST, Width: 5m, Length: 5,000m
Long Vaek	Boeng Kok	2.1 km	Connects to national road No. 5. Agriculture transport road. Type: DBST, Width: 5m, Length: 2,100m
Kampong Luong	Peam Chomnich	2.23 km	Connects to Kampong Chhnang Province and Krang Punley Stream for irrigation. Daily traffic for villagers. Type: DBST, Width: 5m, Length: 2,230m
Sub-total Distance for Stoeng Krang Bat scheme:		**9.33 km**	
Grand Total:		**86.75 km**	

The proposed road improvements will include two types of surfaces. The majority of the roads will be constructed with Double Bituminous Surface Treatment (DBST), covering a length of 78,1 km. Additionally, there will be 8,6 km meters of reinforced concrete roads included in the project. This combination aims to enhance durability and improve overall road quality for better connectivity in the targeted areas. This initiative aims to significantly enhance rural connectivity and support local communities in their economic activities.

7.4.2 Activity 1.4.2 Technical survey and design considerations, preparation of cost estimation

The roads will be designed considering the current and future impacts of climate change. The climate change impact on the hydrology of the project areas indicates that both frequency and intensity of flooding will increase in the wet season and increased drought incidents during the dry season. Droughts are significant especially for unpaved roads as dust levels increase and reduce visibility and create poor local air quality. Flooding and soil moisture content is a primary concern for protecting investments in roadworks and will be addressed as a priority in the adaptation strategy.

To enhance resilience and climate proofing, evolving design approaches (IFAD and WB 2023 shall be considered where appropriate. In addition, conventional approaches like embankment raising, surface strengthening, drainage improvements, erosion protection (through vegetation and bio-engineering approaches) will be considered to enhance climate proofing.

Survey and designs shall be carried out in accordance with the design principles mentioned earlier following the standard designs available in the country and available best practices. The design will integrate climate resilience features to ensure that the roads remain usable throughout the year. Key elements of the design approaches including for climate proofing will be:

- Embankments safe from expected maximum precipitation intensity.
- Drainage provisions capable enough for local runoff during the expected intense flooding
- Pavement materials are flexible to adjust both increased heat in line with the increase in temperature and increased precipitation intensity.
- Application of bioengineering and NBS as appropriate and feasible especially for erosion control of embankments, increasing infiltration capacities, etc.

The design features of the three types of roads will be as follows.

7.4.2.1 Roads combined with the polder embankments.

The embankment road is based on future climate scenarios: standard crest width and height based on a return flood period of 1:100 (or 1:200 for large rivers), adequate side-slope protection, and size and number of drainage structures based on climate change. It will synchronize the criteria for roads and embankments with regard to width, side slope, and height. Traffic functions and flood safety will be combined and not compromised. The following will be respected during the DED phase too:

- Synchronize criteria for flood embankment heights, widths, and slopes in line with climate change scenarios.
- Coordinate development of embankment raising and road development
- Use turfing or vegetation with high value, non-palatable crops such as vetiver for side-slope protection
- Measures to protect the side will be incorporated in the initial design of roads or embankment roads and the berms of the embankments. Local vegetation (grass and shrubs, but not trees) should be used to protect the side slope of roads, in particular the embankment roads. Suitable grass species such as vetiver at 0.3 m x 0.3 m spacing, mixed with Ipomoea, Nypa, Typha, and Pandanus may be used. Vegetation on the berm slopes is a barrier against runoff and erosion. Slope protection with grass increases the stability of the slope and decreases road erosion, leading to road stability and flood resistance. Turfing can be combined with the use of jute or coir netting to prevent soil erosion.

For the polder embankment road it is proposed to maintain the top width of minimum 4.5 meters while embankment slope of 1:2.5. The other aspects of design will be in line with the embankment requirement for flood protections and covered in component 2.2. As the road section will be developed after embankment is constructed, only the cost of the top surface design and side protection with bio-engineering works are included in the cost estimation.

7.4.2.2 Canal Embankment as roads.

As in the previous case, selected canals embankments will be converted into the rural roads. In addition to the canal design criteria to be followed, two additional features will be maintained in canal embankments to be used as road: the top width of at least 4.5 m and outer slope of at least 1: 2.5 with grass turfing and other protection as required. Further design considerations will be in line with the canal design as used in component 2.1.

7.4.2.3 Type 3 and Type 4 rural roads.

These roads are standalone roads not serving other purpose roads described in the previous two cases. Several climate resilient design features (e.g., adjusting side slope, paving road surface, cross drainage improvement, scour checks) have been considered: Of these (i) increasing embankment heights; (ii) providing cross drainage; (iii) selecting embankment materials suitable for increased permeability and (iv) green planning (bioengineering) to protect from erosion and landslides were considered for road sections that are exposed to higher risk of damage due to flooding.

Regarding increased embankment heights, an average 0.25 m design height above the conventional road design height has been adopted. However, this will be reconfirmed during the detailed design stage based on detailed hydrological data. As for cross drainage, the preliminary design has considered the adequacy of existing structures (pipe and box culverts, and small bridges of single span) and has included readjustments with additional structures for strengthening cross drainage. This again will be reconfirmed during detailed design while refurbishing the existing structures for their optimal use. For embankment materials, laterite has been cost optimal, again to be reconfirmed during detailed design, especially for road sections that are exposed to higher risk of damage due to flooding. In such cases additional protection will be required and will be explored during the detailed design phase.

7.4.3 Activity 1.4.3 Improve 90 Kilometers of farm roads

The farm roads will be improved based on the planning and design process identified earlier. In addition some bridges and culverts will be rehabilitated in line with the new hydrological requirements resulting from climate change. A consulting firm/experts engaged by the NCDD will be responsible for producing the technical design and cost estimations and will prepare the required bidding documents.

The roads will be upgraded within their existing width, respecting the current land use pattern while avoiding impacts to any historical and cultural sites. Construction will be carried out by qualified local contractors, with oversight provided by both technical experts and community members to ensure ownership of the road once completed.

7.4.4 Activity 1.4.4 Handing over of the completed works

The completed roads will be handed over to MRD. The MRD will commit to the operation and maintenance of the roads in line with the sustainable road maintenance program. This will be agreed prior to construction in an MOU between the project and MRD. The costs of the annual O&M will be estimated and indicated in the MOU. The local communities will be engaged in monitoring and reporting of the construction works and will be trained for the purpose by the consultants.

7.4.5 Implementation Arrangement for the Sub-Component

NCDD will oversee the project by hiring the necessary consulting firms and contractors according to the established procurement plan and methods. A consulting firm, designated as the "design and supervision consultants," will be recruited by the National Committee for Sub-National Democratic Development Secretariat (NCDDS) to manage final site selection, design, bid preparation, and construction supervision. These consultants will conduct preliminary studies for all proposed subprojects to ensure compliance with economic, physical, and safeguard criteria, integrating climate-proof measures as recommended. For projects where selection criteria remain uncertain, full feasibility studies will be carried out.

The design and supervision consultants will also prepare detailed engineering designs (DED) and bidding documents for all approved subprojects. NCDDS and provincial support teams will ensure that these designs receive technical clearance from the relevant provincial technical departments. Additionally, road designs must be approved by the Provincial Department of Rural Development, following the procedures outlined in the Commune/Sangkat Project Implementation Manual (PIM).

To promote long-term maintenance, the design and supervision consultants will facilitate the formation of Operation and Maintenance (O&M) committees and user groups, comprising community volunteers, as soon as a subproject is selected for funding. Training will be provided from the O&M budget, and community participation in procurement may be applied for contracts below $30,000.

Once feasibility studies and designs are approved by NCDDS—and by IFAD for feasibility studies—the consultants will assist commune councils and the Provincial Support Team in preparing tender documents and managing construction contracts. For subprojects costing below $30,000, procurement will follow PIM procedures conducted by the commune council. For those costing $30,000 or more, a procurement review committee (PRC) and a bid evaluation committee at the provincial level will oversee the procurement process, adhering to the government's standard operating procedures, which will be submitted to IFAD for no objection.

Throughout the project, relevant commune councils will act as project owners, managing contracts and monitoring construction. The design and supervision consultants will assist in maintaining construction standards and will facilitate monthly coordination meetings at the provincial level to prevent delays in implementation and funding flows. The Provincial Support Team (PST) will play a key role in compiling and forwarding financial information related to fund replenishment and will support the design and supervision consultants in ensuring that rural road subprojects are registered with the Ministry of Rural Development's Road inventory. This registration will help secure access to O&M funding and government support beyond the CAISAR project implementation period.

8 Component 2 - Upgrading and climate-proofing water infrastructure for increased resilience

Component 2 will focus on rehabilitating/creating and modernizing hydraulic infrastructure, including canals, ponds, flood-proof infrastructure (river, drain) and to provide high-efficiency climate-resilient irrigation systems for adapting to both increasing flood and drought conditions. It will include support and capacity building to O&M operators at both, Provincial (PdoWRAM) and scheme (FWUC) level, to ensure the sustainability of the scheme. The output will secure and increase farmer's agricultural production by improving the irrigation supply and protect crops from water-related disasters.

These climate adaptation activities will ensure that the projected increase in extreme wet days and more frequent upstream flooding will decrease the damage to the infrastructure, and more importantly to agricultural practices / rural economic activities, but also transform this risk into a green opportunity by storing more water in irrigation ponds, improved drainage facilities to drain the excess flood, create polders to specific schemes to adapt climate change and increased access to water through solar pumping.

It will be implemented through four integrated sub-components:

Sub-Component 2.1. Modernization of irrigation schemes and ponds: Rehabilitating, upgrading and, where water and land resources are available and socially and environmentally possible, constructing new irrigation schemes and storage ponds have a positive climate adaptation and mitigation impact. Thus, this sub-component has two main benefits: (i) increasing water availability and restoring storage capacity for irrigation while decreasing the destructiveness of floods on downstream locations; and (ii) the possibility of implementing crop diversification and new activities to increase farming incomes such as fish farming or poultry breeding. It will also allow for creation of employment opportunities, especially for young people. This measure would be part of integrated and resilient water resources management and climate proofing to secure the sustainability of the overall irrigation system against negative climate impacts of droughts and dry spells as well as floods during the monsoon season.

The implementation will focus on maximizing ecosystem-based solution, reducing energy consumption, and consequently reducing GHG emissions. In addition, current diesel pumps lifting water to tertiary and secondary canals will be replaced by collective solar pumping systems when the pre-conditions are acceptable with low pressure water delivery at the plot level to increase the water efficiency, avoid land losses and improve the water service. The implementation will follow a participatory approach involving farmers right from survey, design, prioritization, and construction implementation. This subcomponent will be financed by AIIB, GCF and Government. Moreover, these technologies will allow to save time and labour, especially for women, and offer opportunities to engage rural youth.

Sub-Component 2.2. Flood-proofing and Drainage improvements: It focuses on improving disaster prevention and protection of farmlands and assets by establishment of early warning systems and improvement of the existing drainage and flood protection systems. Existing drainage and river training networks (especially of Ou Ta Paong and Lum Harch schemes) will be improved based on the results of the hydrological modelling and consultation with stakeholders living in the project areas. The applicability of nature-based solutions in flood management (e.g., revival of old river channels like Ou Ta Paong River, embankment improvement with vegetation strips, etc.) will be reviewed and subsequently used to inform the investment planning under this component. Farmers will be also supported to restore and construct farm level drainages as required while project will install sub surface drainages in needy areas. In addition, it will also support strengthening of river training and their embankments to make them resilient against intensifying flood threat under the changing climate context. These improved embankments will be linked to the flood risk assessments improved in Component 1 and the water-related data will feed into the national database to improve flood early warnings for target areas (delivered through sub-component 2.4). New flood protection embankments will be constructed in Ou Ta Pong and Stoeung Krang Bat irrigation schemes to avoid flood from Tonle Sap on the command area.

Sub-Component 2.3. Establishment and training of FWUC: FWUCs are critical for ensuring the sustainable and effective operation and maintenance of irrigation schemes, in particular at the distributary network system (secondary tertiary and quaternary levels. With the rehabilitation of the irrigation systems and the creation of a flood protection embankment system of the three subprojects, the project will support the establishment and capacity building of the FWUC from the participatory approach of FWUC creation in the design, development and sustainable use of the rehabilitated irrigation schemes to be rehabilitated by the Project as these organisations are crucial for O&M management. This will include investments in improving the capacities in 1) Institutional: dialogue with MoWRAM, legal recognition, responsibility sharing agreement, 2) Organisational: governance, internal operating rules for water and scheme management, agricultural development and marketing, 3) Technical: participation to the design of the irrigation networks, execution of maintenance and servicing tasks, farming practices; 4) Financial: preparation of budgets, fundraising, accounting management, Irrigation Contribution Service (ISC) planning and collection, access to financial institutions, 5) Gender focus with strong action for women’s empowerment and their social participation.

Sub-Component 2.4. Water Information System: This sub-component will consist of establish a SCADA system for the West Pursat irrigation hydraulic system to improve the water availability of Ou Ta Paong Irrigation scheme. The SCADA model is crucial to tackle the significant challenges in the agricultural sector on the inefficiency of irrigation practices, characterised by both indiscriminate and irregular water distribution, leading to substantial water wastage. This approach offers real-time information on water levels and flow rates, enabling more accurate and timely responses to fluctuations in water demand. The SCADA presents a contemporary solution for the modernization of existing irrigation systems, prevent flooding and it does so with a fundamental, cost-effective approach. Implementing the Water Information System for the western hydraulic system of Pursat province allows for command-and-control functionalities while collecting valuable data on irrigation. This, in turn, will rationalise and streamline the irrigation process, significantly mitigating the wastage of water.

Sub-component 2.1 is dedicated to the enhancement, establishment, and modernization of hydraulic infrastructure to elevate irrigation practices within the framework of the three sub-projects. On the other hand, component 2.2 is geared towards enhancing infrastructure that guards against flooding, encompassing rivers, drainage systems, and embankments. Consequently, the project aims to deliver irrigation systems that are highly efficient and resilient to climate changes, catering to both increased flood risks and drought conditions. The outcomes of these two components are essentially the same – they aim to ensure and boost agricultural production by improving irrigation supply and safeguarding crops from water-related disasters.

To facilitate a clearer understanding of the work executed within each scheme, the project presentation for sub-components 2.1 and 2.2 are merged.

The component 2 will be implemented by the Project Management Unit (PMU) at MOWRAM and its Project Implementation Units (PIUs) at the provincial level, including training and capacity development on development partners’ policies and standards, monitoring, evaluation, reporting and verification, including climate rating and climate finance. Thus, PMU and PIUs will actively disseminate knowledge and green solutions in climate adaptation and mitigation among farmers, policy and decision-makers, and rural communities.

8.1 Sub-component 2.1 & 2.2 – Modernized irrigation schemes and ponds & Flood-proofed and Improved Drainage

8.1.1 Ou Ta Paong subproject

8.1.1.1 Rationale

8.1.1.1.1 Opportunities

In this project the major infrastructures including diversion barrage, MCs and some SCs are already constructed. There are other upstream water users (Damnak Ampil irrigation scheme, Wat Loung Irrigation scheme, and Kbal Hong irrigation scheme) which can affect the water delivery, but we can consider the water resources available is enough in the Pursat River considering the new dam under construction (Pursat 1). However, farmers of Ou Ta Paong area are still cultivating rainfed rice and in most cases one wet season rice. Farmers irrigate with the help of pumps. In this project there are ample opportunities to improve agricultural production and improve water production improving distribution systems, water management and soil fertility. Farmers of this project are very active and enthusiastic to improve agricultural productivity by intensifying their cropping area and irrigating their land.

8.1.1.1.1.1 Irrigation and drainage system development

The Ou Ta Paong Irrigation scheme encompasses a command area situated alongside the Ou Ta Paong River, drawing its water supply from various sources. These sources comprise the Pursat River, Svay Donkeov River, and several other rivers that traverse the scheme, including the Ou Ta Paong River itself. This complex water supply system results in the creation of distinct hydraulic zones within the scheme, each characterized by specific water availability levels, which in turn have a direct impact on agricultural output.

The upper part of the scheme, located in south of national Road 5 is mainly supplied by Pursat River, via the Damnak Ampil canal and associated irrigation network. The area presents a general slope direction from south to north. Normally, there is enough gradient in the command area to irrigate by gravity this block from Damnak Ampil Canal. Therefore, due to the existing infrastructure design, this will be challenging. It will be necessary to develop distribution networks and regulating structures.

The eastern part of the scheme, located between Ou Ta Paong River on the West on the East, and the National Road 5 on the north. The area presents a general slope direction from south - north. Hence, the area is supplied by all southern infrastructures which include Damnak Ampil hydraulic system, Kbal Hong hydraulic system, Wat Loung canal but also partially Svay Donkeov and Ou Ta Paong River. The hydraulic gradient is very low and due to the existing infrastructure design, the area cannot be irrigated by gravity and will require one stage pumping. It will be necessary to develop distribution networks and regulating structures.

The western part of the scheme, located between Svay Donkeov River on the west and Ou Ta Paong River on the East, and the National Road 5 on the north. The area presents a general slope direction from south -west to north-East. This explains that the area is mainly supplied by Svay Donkeov River. The hydraulic gradient is low and due to the existing infrastructure design, the area cannot be irrigated by gravity and will require one stage pumping. It will be necessary to develop distribution networks and regulating structures.

In all these blocks there are ample opportunities to develop two wet season rice crops by developing proper canal system. These blocks need proper bed slope of the canal, tertiary canals, regulating structures and most importantly the canal management. As per study there is also an opportunity to develop dry season in 20% of the command area.

8.1.1.1.1.2 System Water Management

There are lots of opportunities to improve agricultural production of this subproject by improving system water management. Pursat Reservoirs are built to provide irrigation water to the Ou Ta Paong IS.; however, there is no proper plan to irrigate the different irrigation block under the Pursat Hydraulic system. Downstream farmers have broken some of the check structures, due to lack of system management. Most part of the Ou Ta Paong irrigation system can be irrigated by gravity; however farmers are irrigating using their individual pump. Farmers have removed gates of some Main canal head regulator and major check structures. There is no Irrigation Service Plan from the FWUC which make the water delivery plan more complex to elaborate. At the same time there is no measuring structure in the whole Pursat River system to ensure water monitoring and fair water distribution among the different schemes. So, there are opportunities to improve water productivity and agricultural production in this system by improving the system water management.

8.1.1.1.2 Objective and scope

The main objective is to improve the agricultural productivity of this system by improving cropping intensity, and yield of the crops by improving distribution system and providing water regulating and measuring structures. The secondary objective is to improve disaster prevention and protection of farmlands and assets by establishment of early warning systems and improvement of the existing drainage and flood protection systems. The tertiary objective is to benefit from improving system water management through proper water management of the system and by strengthening PDoWRAM/FWUC capacity of the system. Farmers should receive adequate quantity of water in the cropping period to make additional cropping season and improve/secure their yields.

The total irrigation demand should match with the 80% reliable available water in the source, considering the required environmental flow and downstream and upstream water demand. Based on available data and new reservoir development, it is considered that the water availability for Ou Ta Paong Scheme is sufficient on these conditions. Agricultural production should also address the various agricultural initiatives like farmer's training, introduction to new varieties. The environmental and social safeguard policy should also match with international practices and guidelines. One of the most important issues in this project is the formation of an Apex FWUC to distribute water between the different schemes, and coordinate with PWDRAM to manage the Pursat Reservoirs and diversion Barrage.

8.1.1.1.3 Identification and description of project elements

8.1.1.1.3.1 Beneficiary identification of parameters for improvement

Several meetings were conducted with the farmers and local authorities during the feasibility study. At the same time, field observations have also been conducted with the farmers. It showed that the water available is not enough for the whole command area at the moment. To ensure adequate water availability in required time it is necessary to improve the following in the system:

- Construction of necessary water distribution canals;
- Construct necessary outlets and check structures and culverts;
- Improve water management.

8.1.1.1.3.2 Identification of agricultural production goals

There are at least four systems of rice cultivation practices by farmers in Cambodia depending on the season and hydrologic condition (e.g. early wet-season, regular wet season, recession rice and dry season). The system of rice cultivation has evolved for many years as adaption measure of farmers to the ecosystem and as the socio-economic condition changes. The most unique system of rice cultivation carried out by farmers in Cambodia is the "recession rice". On the fringes of Tonle Sap Lake, farmers grow rice only after the level of lake water recedes below the paddies of farmers adjacent to the lake. In Takeo, land preparation is done before flooding occurs and they plant immediately when flooding recedes in August.

There is a way to diversify agricultural production. Briefly, the different systems of rice cultivation will be described as follows:

- Early wet season crop: Planting direct-seeded early maturing (90 days) rice variety in late April-early May utilizing the early wet season rainfall in smaller rainfed areas
- Regular wet season crop: Planting in larger areas, this rice crop relies on some form of ponding or reliable pumped water supply and that occurs a bit later in the wet season.
- Dry season crop: Planting in areas where there is reliable source of pumped water to be available as the water demands for irrigation will be much higher than the available rainfall in the dry season
- Recession rice crop: Planting after flood water recedes and with small structures some water is kept on the fields in adequate amount to support the entire cropping season (found mostly on the shores of the Tonle sap lake). In Ou Ta Paong the recession rice cropping is normally in October-November.

Four value chains have been identified for the three sub-projects: Rice, vegetable/fruits, poultry and aquaculture.

8.1.1.1.3.3 Water Security

After the construction of secondary and tertiary canals it will be possible to irrigate all command area of Ou Ta Paong. Most of the command areas of Ou Ta Paong it will be possible to irrigate by gravity or collective solar pumping system if the pre-requisites are respected. If there is good management of upstream water infrastructures this will provide more water during the water scarce period to the Ou Ta Paong scheme.

8.1.1.1.3.4 General technical and design requirements

The general technical requirement is to match the command area Ou Ta Paong to the available 80% reliable flow of the Pursat river for irrigation considering the advantage of the existing (Pursat 3 and 5) and future (Pursat 1) reservoirs. The next design requirement is to match the canal size as per the crop water requirement. Another important design requirement is that the water level of the canal should command the cultivated land under the project boundary when possible.

8.1.1.1.3.5 Agricultural Extension Support

See component 1.

8.1.1.1.4 Limitations and constraints

There are lots of benefits from this project. However, there is some limitations and constraints as follows:

- Ou Ta Paong scheme is located at the tail end of a complex hydraulic system of the Pursat province.
- Ou Ta Paong irrigation scheme is supplied by different sources of water: Pursat river, Svay Donkeov river and other rivers crossing the scheme including Ou Ta Paong River.
- The existing water infrastructure design is not well known and could affect the water delivery and availability of the scheme.
- Most of the infrastructure does not allow for gravity irrigation in the command area. By consequence, pumping will be necessary for the farmers to irrigate their plot.

- Although there are ample opportunities to use the Pursat River Reservoir for Ou Ta Paong IS, still the operation and maintenance capacity of the reservoirs are limited.
- Some of the existing water infrastructures (check structures) are broken or damaged by the downstream farmers, so there is a water right issue, which must be addressed in future.

8.1.1.2 Project features

8.1.1.2.1 Selection of command area

The selected area has been delimited at early feasibility stage, with an approximate size of 15 776 ha. The command area has now been adjusted to 14 874 ha.

The water requirements are mainly dependent on the net command areas and future cropping patterns. The main water consuming crops are early wet season rice, late wet season rice, wet season rice and 10% dry season rice. So, these crops are considered in the water balance study. It is not possible to start cultivation of the whole command area in a single day due to lack of manpower and water, so starting of cultivation is staggered in three different stages and each start stage is one decade apart. The head reach farmers will cultivate in the beginning, then middle reach and then, in the end the tail reach farmers. For the initial estimate the 10-day 80% reliable flows have been used. The crop water requirements are calculated by using the Penman method for the calculation of ET. It is assumed that the diversified cropping will be developed through agricultural extension program.

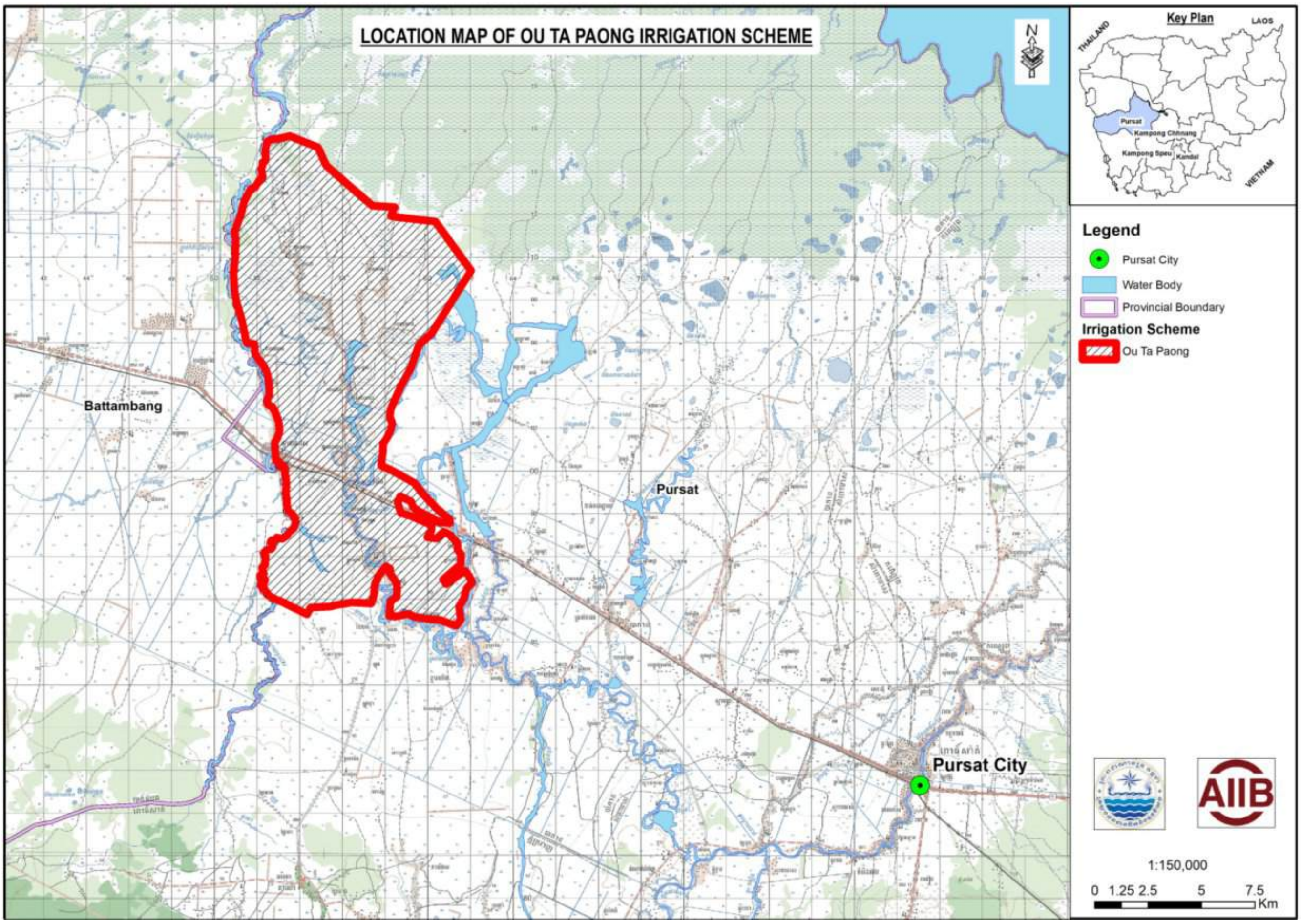


Figure 5-1. Command area of Ou Ta Paong irrigation scheme

8.1.1.2.2 Cropping patterns "with project" and water requirement

The proposed cropping for Ou Ta Paong is presented as follows:

- Early WS 70% planting <100 days variety in April (harvest in July).
- WS 70% 2nd crop in August <100 days variety (harvest in late October).
- DS 80% planting <100 days variety in late November (harvest in Jan)
- Short-term (<60 days) vegetables 10% leafy and 10% fruit

The geographic location of Ou Ta Paong command area relative to Tonle Sap Lake has influenced the development of rice-based cropping system within the six communes comprising the command area. The small difference in elevation between the target communes located on the left side of Highway 5 and those communes adjacent to Tonle Sap Lake creates hydrologic condition that influences the rice-cropping system of farmers.

Ou Ta Paong farmers generally practice mono-cropping system, with more than 90% planting by direct seeding. The wet season crop is planted in May and harvested in September, yielding 2.0-2.5 t/ha. About 5% of the farmers plant 150-160 days variety (aromatic, photo-period sensitive) yielding 2.5-3 t/ha. Planting this fragrant photoperiod variety is preferred as a long tradition. Besides, the confidence developed among farmers for several years of farming, that these varieties are known to survive long period of relatively poor-rain wet seasons and where many upland crops suffer from drought. It is believed that the long duration of this variety allow its root system to penetrate deeper where there is still moisture to extract.

There are only a few households engaged in vegetable production for the market. Some farmers maintain small scale horticulture activities or home garden around their homestead but mainly for their own consumption, where water can be used from wells and ponds. In Rum Lech Commune, farmers plant horticulture crops, such as watermelon on their dry paddies.

In the wet season, when rainfall is generally abundant, the whole area is planted with paddy. Where at least some irrigation water is available and there is no annual flood, fields can produce two direct seeded early maturing wet season rice crops. An early direct dry-seeded rice crop planted in April or shortly before the rains start, and the regular WS crop which is planted during the rainy season but will still have to stand on the field for some weeks after the rains have stopped. For this, varieties with a short growth period (120 days or less) need to be used. Popular are 'OM varieties. For example, OM 5451 is a high-yielding long-grain cultivar of fragrant rice grown in the Mekong Delta. It has a good pest and disease resistance. A dry season paddy crop of same variety may be grown as a third crop, as possible near to natural streams or ponds which usually provide some of water.

Where there is no irrigation, the fields can produce just one crop, which is planted when the rains are well on their way. For this, varieties with a medium growth period (120 -150 days) are used. These are commonly photoperiod sensitive and typically can be harvested in early November. Medium maturity rice has a better local marketability and only to a lesser extent face the risk of drought damage, because they flower in mid-October, when rainwater is still readily available.

Where the area tends to flood to a low level only, farmers usually plant just one paddy crop, with preference for a long growth duration paddy (more than 150 days; flowering after mid-November) which can stand flooding better. However, this crop normally has a higher risk of drought damage during the last stage but because they are inherently deep-rooted, they have better chance of surviving if previous rains have been able to penetrate to lower depths of the soil.

Where the area annually floods to a high level, the farmers still try to grow two crops, but with a higher risk: an early short-duration rain- dependent crop (non- photo-sensitive) can be planted before the flood. These fields may (need to) have some minimum flood protection by a system of low dikes/elevated roads/natural riverbanks, which delays the water during the very early stage of the flood rise from entering the area early, to provide sufficient time to harvest the crop. When the flood has come down sufficiently, they plant a second short growth duration paddy crop (non-photo-sensitive): "flood recession rice". This crop will run well into the dry season and is indeed classified in the statistics as dry-season paddy (DS rice). When there is no rain or irrigation water, this crop runs a high risk of drought damage. This flood recession rice is widespread in the large tail-end area of the Ou Ta Paong scheme adjacent to Tone Sap Lake.

The CAISAR team conducted field surveys from October 31 to November 3, 2023 and found from the discussions with commune representatives that during the periods that the crop requires irrigation, conflicts about water sometimes tend to arise. Irrigation water-related issues are main causes for financial losses. This causes much stress, because of the risk of drought damage to the crop, the cost of pumping from low water levels. The risks reduce farmers' motivation to invest in new technologies and climate-smart agriculture.

Figure 5-2. Proposed Crop Pattern with project for Ou Ta Pong Scheme

PROPOSED CROPPING SYSTEM IN WET AND DRY SEASON

No.	Variety name	Variety name	Duration (days)	Variety type	Crop area (% of CA)	Crop area (ha)	Source of varieties	Growing Method	Irrigated (Y/N)	Average Yield (t/ha)
1.1	Early WS rice	OM5451, Sra Ngae., Champei Sar 70/Sen Kra Ob,	90-110	Short NPS Variety	70%	10,412	Certified/ Good seeds	BC or Drum Seeder	Y	4.0
1.2	WS rice - Crop 1	Sen Kra Ob, Sra Ngae, OM5451, Champei Sar 70	90-110	Short NPS Variety	68%	10,114	Certified/ Good seeds	BC or Drum Seeder	Y	4.0
1.4	DS rice	Sra Ngae, OM5451, Sen Kra Ob, Champei Sar 70	90 - 110	Short NPS Variety	80%	11,899	Certified/ Good seeds	BC or Drum Seeder	Y	5.0
1.5	Diversified Crops (Legumes)	Leafy vegetable - Lettuce, Pak choy, mustard greens	60 - 80	-	10%	1,487	Seeds from PDAFF	DS	Y	15.0
1.6		Fruit vegetable - Cucumber, eggplant, Chili, long beans	30 - 60	-	10%	1,487	Seeds from PDAFF	DS	Y	15.0

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DS			Early WS				Late WS				DS

CULTURAL OPERATIONS:
Varieties: NPS - Non photoperiodic sensitive, PS - Photoperiodic sensitive
LP: Land Preparation
BC: Broadcasting (BC) Directy Seeding (DS)
GS: Growing stage after seeding
H: Harvesting

Crop water requirement for the project was determined on a detailed level for engineering planning purposes, for planning of crop management and for economic calculation of irrigation and overall project profitability by assessing the utilized water quantities.

8.1.1.2.3 Irrigation duties

At this stage, canals are planned to design for the **duty of 2l/s/ha**. This could be detailed based on a water delivery rotation selected at the design phase.

See irrigation duties in Appendix 8.

The irrigation will be supplementary irrigation during the water scarce period.

8.1.1.2.4 Water delivery rotation

Rotational distribution of irrigation water means that the whole flow in an irrigation canal is diverted to the branch canal in turn. For instance, in the case of primary and secondary canals, it means that each secondary canal is without water for part of the time and, when supplied, it transports the whole "primary" flow. The same can apply to the distribution of the flow of secondary canals into tertiary canals, and rotational distribution can be carried out within the tertiary canals.

The rotational irrigation system of Ou Ta Paong consists in dividing the total agricultural area to be irrigated into three (more or less) equal blocs. The irrigated areas on the Ou Ta Paong are rice crops. Rice needs a large amount of water over a very short period to develop.

The rotational irrigation system provides for three consecutive days of non-stop irrigation on one of the three agricultural blocs, followed by one rotation every three day to ensure equitable irrigation of the three agricultural blocs. During these three days, farmers of the agricultural blocs can take the amount they need at the time they wish.

During dry season, due to the lack of water only some part of the agricultural land could be irrigated.

8.1.1.2.5 Water resources

At this stage, we can consider the water resource available enough in the Pursat River considering the new dam under construction (Pursat 1).

8.1.1.2.6 Layout description

The WAPCOS' Feasibility Study (FS) 2022-2023 prepared a distribution system layout, in which OTP River features as central main canal. The existing canals were to feature as secondary canals. The proposed layout adds a large number of tertiary canals to the existing canal system. These are provisionally indicated as straight lines branching off from the secondary canals. WAPCOS prepared quite detailed design dimensions and cost calculations.

In the present work it was considered that communities along OTP River have constructed numerous dams on the stream. PDWRAM mentioned that removing these earth dams was not going to be a big issue, because the people had already given their consent, flagging that what they need is an adequate and reliable supply of water via the river and an improved road along the river. PDWRAM anticipated that the construction period might be long. When the ponds have been removed, the people may find themselves temporarily without adequate water for their household use. As a solution, perhaps the project can provide deep-wells and create new ponds. Furthermore, PDWRAM clarified that (i) the meandering cannot be changed, because cutting off meander bends will need land acquisition and resettlement, and because all land in the area has ownership certificates, the cost will be high.

It was reasoned that (i) to the local community, the OTP River ponds are precious assets; and (ii) the strong meandering of the river and its large cross-section (30 m wide, 3-4 m deep) will provide the system with a very low reaction time of the system and this will reduce its effectiveness as a canal.

The team developed an alternative layout, with water supply provided from the West and East sides, as is currently the case. OTP River would not be touched. The design divides the OTP Scheme into three blocks, each with its specific set of water sources.

The overall layout of the Ou Ta Paong River whole system is shown in Figure 5-3. The individual layouts of Block A, Block B and Block C are presented in Figures Figure 5-4. , Figure 5-5., and Figure 5-6. , respectively.

Block A (4,198 ha) is located South of the National Road No. 5 and will be supplied from Pursat River via Damnak Ampil Canal and upstream canals infrastructure. Water will be supplied via an existing secondary canal which may need to be rehabilitated and perhaps enlarged to establish the hydraulic capacity necessary to irrigate the area.

The eastern part of Block A is more difficult to be irrigated by Damnak Ampil existing infrastructures as the Ou Ta Paong River is creating a natural upstream barrier. Two options should be considered at detailed design stage:

- Option 1 will be to release all the water of the Damnak Ampil secondary canal to the Ou Ta Paong River and create necessary work rehabilitation/ construction to divert the extra flow to the eastern area (river rehabilitation under component 2.2 and river diversion).

- Option 2 will be to create a siphon to cross Ou Ta Paong River from a secondary Damnak Ampil River to the area to be irrigate.

At the DED stage, an assessment should be made of the extent to which the existing canal system can bring water from Svay Doun Kaev River to the western side of Block A, and to what extent Block A would need to depend on supply from Damnak Ampil Canal.

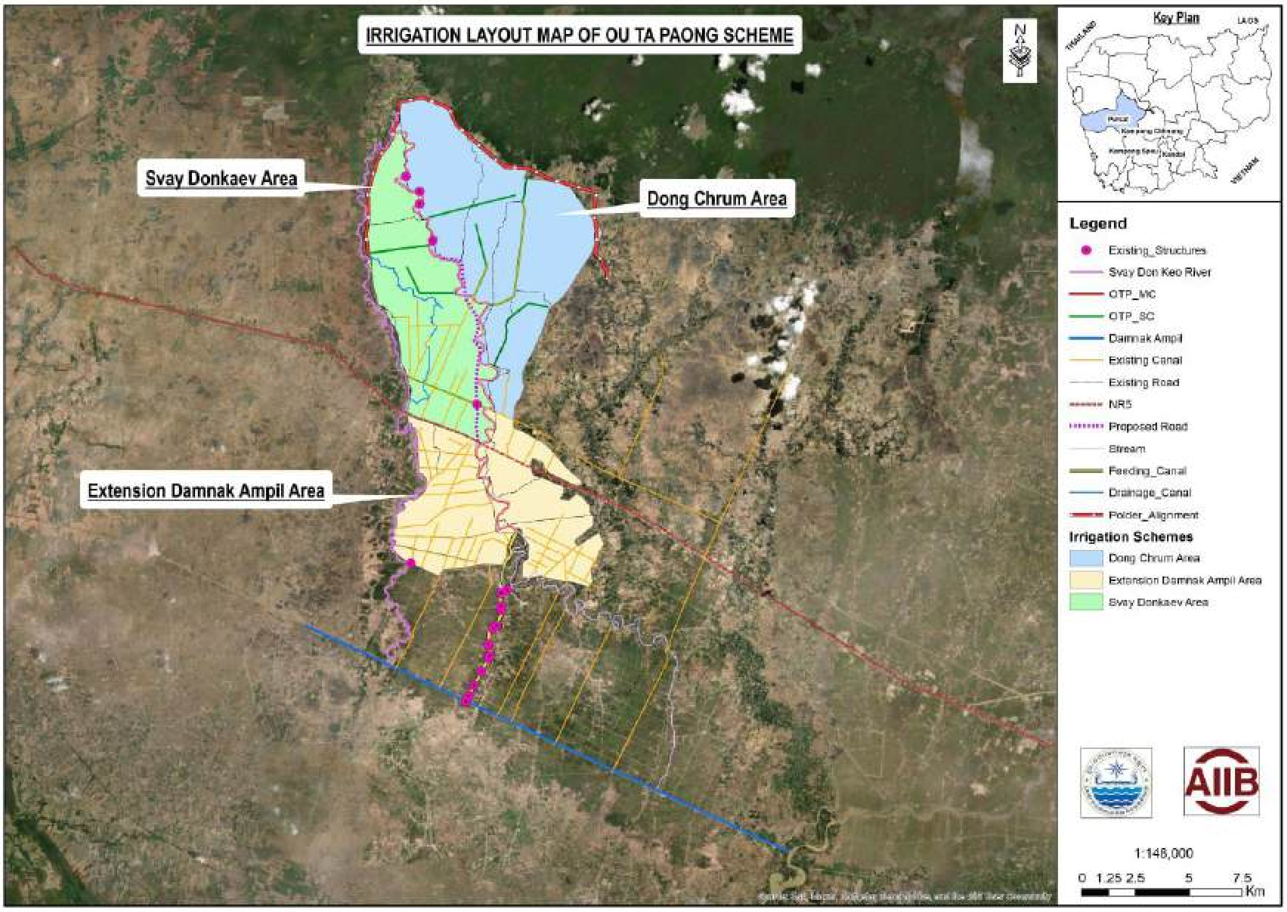


Figure 5-3.Three blocks (sub-scheme) of Ou Ta Paong sub-project

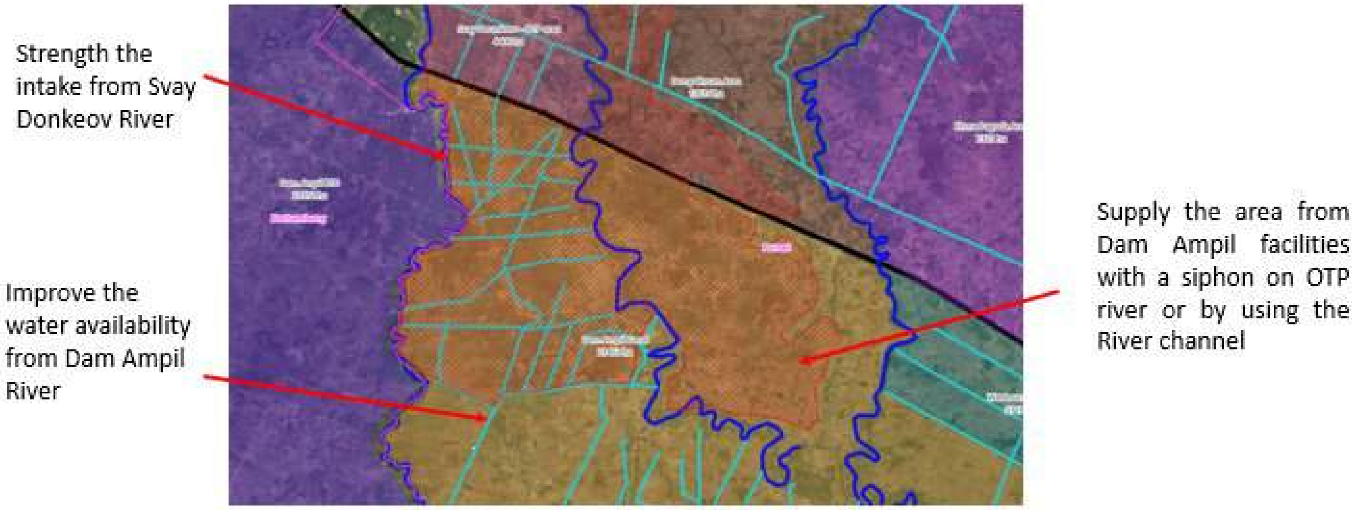


Figure 5-4. Concept design of Block A of Ou Ta Pa Ong Scheme

Block B (4,400 ha) covers the northeast area of OTP and is currently supplied from Svay Doun Kaev river, at existing Kampang weir and Kampang scheme canals. The canals require rehabilitation and upgrading with new cross-check structures. Some new water delivery canals will have to be constructed. The block will receive some drainage overflow from Block A and National Road No 5. It seems difficult and challenging to irrigate Block B from Ou Ta Paong River (topography), Damnak Ampil Main Canal, or Kbal Hong Main Canal (distance).

Figure 5-5. Concept design of Block B of Ou Ta Pa Ong Scheme

Block C (6,276 ha) covers the Northwest area of OTP. This is the most difficult part of OTP to supply. The area currently receives water from several sources: Svay Doun Kaev River, Kbal Hong Main Canal, and from the South from Ou Ta Paong River, Wat Luong Main Canal and Damnak Ampil Main Canal.

The proposed concept for supplying this area is to evaluate the different water supply sources and routes to the Block. For example, water can be diverted from Ou Ta Paong River into Kbal Hong canal. Similarly, from Wat Luong Main Canal and Dam Ampil Main Canal can be collected in Kbal Hong Main Canal and supply the Block's distribution system. The Block's canals require rehabilitation and upgrading, with new cross-check structures. Some new water delivery canals will have to be constructed.

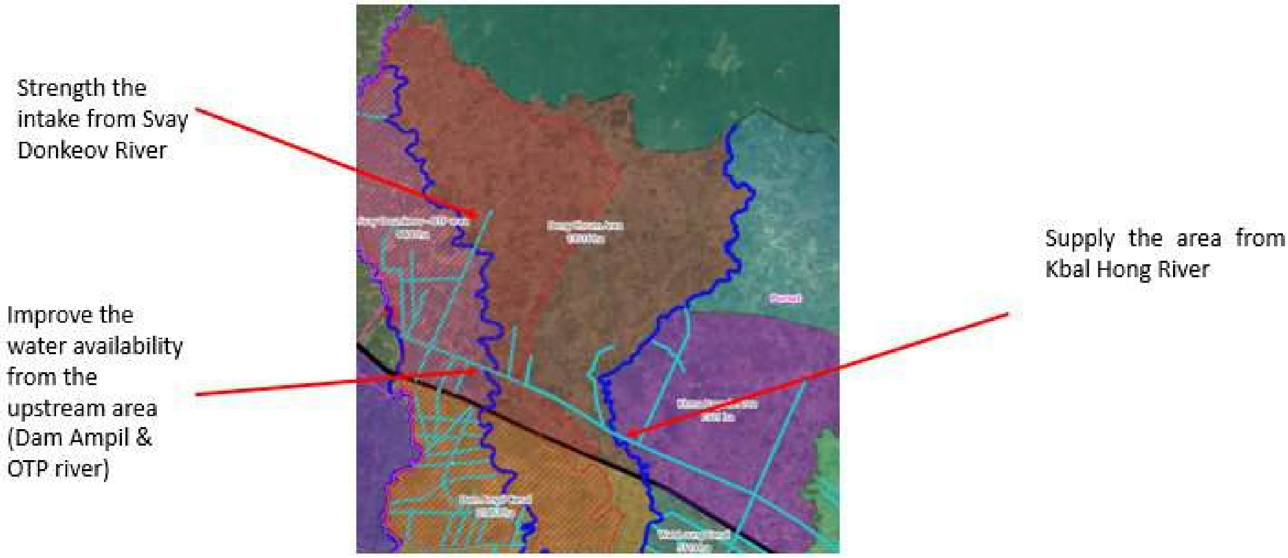


Figure 5-6. Concept design of Block C of Ou Ta Pa Ong Scheme

Based on the present study the WAPCOS Design will be modified as follows:[107]

1. reduce the number of cross regulators on OTP River
2. focus on improving the existing distribution system
3. no new canals (in principle)
4. no lining of canals
5. no construction of the tertiary canals
6. no pump stations, and
7. no canals in fill

Underlying these modifications is in the first place the realisation that the current canal system is an intricate one, developed over decennia and 'owned' by the communities. It is important that the communities maintain a strong ownership over the system, as this provides motivation for its future maintenance and effective operation. Other underlying considerations are to avoid as much as possible any need for land acquisition; to avoid problems that canals in fill tend to cause to drainage; the erosive impact that the annual flooding may have; and the general clayey soil properties, which means that seepage losses in the deep canals will be very minor only.

Needed canal improvement anticipated are (i) earthworks for desilting (all canals have a 0.5-1.0m silt deposit) and reshaping of canals and their embankments, most also functioning as access

107 As discussed in the joint technical meetings of MoWRAM and AIIB in July-August 2024.

tracks/paths to the fields; and (ii) structure work for repair of and construction of additional cross-regulators at a suitable interval, and cross-structures where canals cross roads/tracks or drains. The cross-regulators are important to facilitate diversion of flow into branch canals, and, perhaps even more important, to allow storage of water in the section between two regulators and raise the water surface level as high as is feasible in order to minimise the cost of pumping.

It should also be noted that the currently existing canals in OTP are not dimensioned as in conventional gravity irrigation schemes. Due to the flatness of the terrain, gravity irrigation in the Northern/Northwestern part of the Pursat flood plain is not well possible. Canals are deep so that they 'capture' all surface run-off and they are also wide, so that they have storage capacity. Furthermore, in order to bring irrigation water from these canals onto their fields, farmers pump water. To allow for this combination of functions, CAISAR's canal design with sufficient width and depth.

Presently the preferred option for supplying water to Ou Ta Paong is based on that two secondary canals of Damnak Ampil Main Canal will be converted into feeder canals for Options 1 and 3, with an additional capacity of 7.5 m3/s, above their current capacity. Design adjustments for feeder canals should minimize social impacts and stay within the right-of-way (RoW). Both feeder canals will be lined for durability and water conveyance efficiency. The KHMC extension for Option 5, will remain unlined, such as it originally was. A more detailed description of the Ou Ta Paong options is presented in Appendix 11.

8.1.1.2.7 Dam

8.1.1.2.7.1 Dam safety

Regarding the Pursat dams, there is a need for the motorization of gates (with stand-by generators as observed in the Damnak Ampil Barrage), regular monitoring (especially periodic geodetic surveys of embankment crest profile and installation of seepage measurement device at previously affected locations), flood warning system with sirens, road surface improvement, and removal of excessive vegetation on slopes.

The Dam safety measures will be detailed by the Dam Safety Consulting Firm.

8.1.1.2.7.2 Dam work rehabilitation

There is no major dam work rehabilitation to be undertaken under the three existing Pursat river dams.

8.1.1.2.8 Canals

The proposed canal design aims to serve both irrigation and drainage purposes due to the scheme's topography, limited water resources, and potential land resettlement issues. Whenever feasible, the canal alignment will closely follow the existing path to minimize social impacts. The canal's size will vary based on the irrigated area and topography.

However, it is advisable to construct the canal section as depicted in Figure 5-7 , maintaining a full cutting approach based on the existing conditions. Given the limited water resources and lessons from Cambodia, it is recommended to build main canals with measures to reduce percolation and infiltration. To prevent the loss of valuable clay material for construction, using concrete lining for the main canals or suitable alternatives is suggested. This approach will enhance the infrastructure's long-term sustainability and improve water distribution.

All canals' characteristics will be defined at the detailed Design phase.

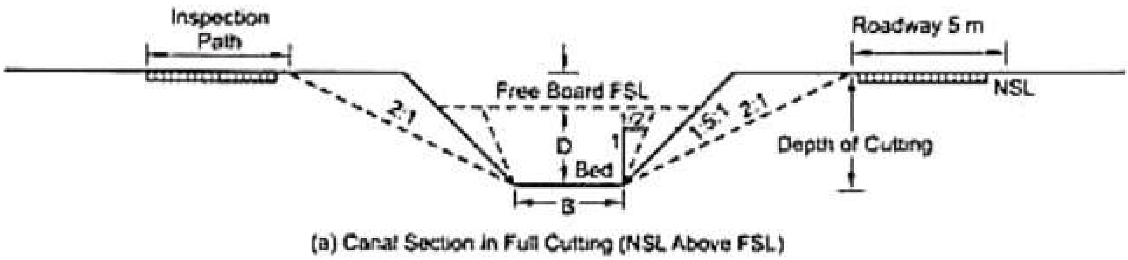


Figure 5-7. Typical canal section in full cutting

8.1.1.2.9 River training and drainage

8.1.1.2.9.1 Determination of drainage system layout

The main natural drainage channels will form the core of the planned system to drain excess runoff during the rainy season and mitigate inundation and waterlogging in the command area. The system will also serve as the outlet for the on-farm drainage system, designed to drain surplus irrigation water and control the groundwater table.

As the project main objective is to develop and increase agricultural production in the area, the drainage system will be designed for a 5-year (5% probability) return period for the main rivers and a 5-year (20% probability) return period for all other drains.

The layout of the drainage system will be based on:

- The main natural drainage channels.
- Incoming sources (watersheds upstream of the proposed main canal, direct rainfall over the command area and water level changes in Tonle Sap).
- Land use (crop types and layout, and field management).
- Planned irrigation systems.

The main drains will be based on the main existing natural river.

The internal drainage system will be proposed as per the requirements and will follow the agricultural plot layout and irrigation systems.

Additional drains will be constructed upstream of and parallel to the main canal as diversion and interception drains to reduce crossings on the main canal and protect it. These drains will divert floodwater as topography permits to the drainage system.

8.1.1.2.9.2 Review of hydrological data

8.1.1.2.9.2.1 *Sources of Floods*

There are three sources of water creating floods in the command area: runoff from the upper watersheds; fluctuations in Tonle Sap and others large stream water level; and runoff created from direct rainfall over the command area. These phenomena are described below.

8.1.1.2.9.2.2 *Runoff from the upper watershed*

According to the hydrological study and field assessment, only watershed is rainfall-runoff to the command area. The table here presents the calculated discharge values in m^3/s for this watershed.

Table 5-1. Ou Ta Paong peak discharges for various return periods in years (m3/s)

Name	Catchment area (km^2)	Peak Discharges for various return periods in years (m^3/s)			
		T=5	T=10	T=25	T=50
Location 10		65,3	78,9	96,8	110,3
Location 9		177,6	207,6	247,6	277,8
Location 5		10,1	11,6	13,5	15,09
Location 35		74,1	102,9	141	169,8

8.1.1.2.9.2.3 *Runoff from direct rainfall over the command area*

Runoff developing in the command area from direct rainfall is supposed to drain through the drainage system, crossing the area generally in a south/north direction. Several obstacles prevent smooth flow towards the main drainage system, namely:

- Undulating terrain caused by the natural movement of sediments on the surface, sinking of clays, and management of farming activities.
- Overtopping of water flowing in the drainage system, which contains sediments that settle on the banks and create parallel mounds, interfering with the inflow from the area.
- Blocking up of the drainage system, due to sliding banks, sediment deposition and the development of secondary gullies.
- Rows of transverse mounds, in east-west direction, which developed on the interface of the lake and the main general flow direction of the area, in the north-south direction.
- Temporary obstacles constructed by the farmers on the drainage system to divert water to their plots.

Considering direct rainfall over the command area, calculations will be performed for the total watersheds contributing to the drain.

8.1.1.2.9.3 Main natural drainage channels

8.1.1.2.9.3.1 *General*

The project includes the rehabilitation of Ou Ta Paong River which crosses the command area.

The characteristic flood flows of Ou Ta Paong River are shown in the Table 5-1.

8.1.1.2.9.3.2 *Design discharge and flood risks*

Considering the catchment area of Ou Ta Paong River, which can be responsible for flooding in the command area, it is proposed to design these channels for discharge of a 5-year return period. This is also necessary to protect the irrigation infrastructure and agricultural fields from flood damage. The road crossings on these rivers will be designed for discharges corresponding to a 25-year return period.

The existing capacity of these channels is very small compared to the design discharge values and it is not practical or economic reasons to excavate these natural channels for a return period discharge values superior of 5 years.

8.1.1.2.9.3.3 *Channel Shapes and Hydraulic Structures: Locations and Types*

In addition to the risks to the agricultural fields, there is a risk for the channels themselves. There is a need to establish their cross sections against erosion and silting. The alignment of the designed channels will follow the natural one. Their general shape is trapezoidal, with side slopes not less than 2:1 (H:V).

8.1.1.2.9.4 Internal drainage system

The preliminary need of a drainage system in an irrigation command area is to remove excess water from the ground surface as well as from the root zone in the sub-soil. The main source of excess water on the land surface is the rain falling over the catchment area.

The surface drainage system is most effective in case of impermeable soils or where infiltration is impeded by an impermeable layer. Considering that the soils are sandy with a good hydraulic conductivity, a surface drainage system or a sub-drainage system could be implemented.

The detailed design will detail the drainage system block by block based on the topography and needs.

8.1.1.2.9.5 Polder

The project includes the creation of 20 km of embankment on the northern part of the irrigation scheme to keep protect land from tidal action and the uncontrolled flooding of the Tonle Sap. This will bring a major landscape change to allow the cultivation of wet season paddy and protect houses and property from the floods.

A polder typically will include the embankment encircling it that keeps out the water from the surrounding water flow from the Tonle Sap, the drainage canals (natural rivers converted to canals when embankments were constructed) inside the polders that remove the excess water particularly at low tide and a sluice that is opened at low water level to release the water from the polder. The sluice also doubles up as an irrigation intake during times of water shortage for instance in the rainy season if there is often a dry spell in between rainy days that can have a major effect on crop yields.

8.1.1.2.10 Structures

The water will be diverted from the different source of water to the main canals, based on water availability and a demand calendar prepared collectively, by FWUC/PDoWRAM according to the crop requirements.

Several cross structures will maintain full supply level in the main canals and in the secondary canals where required. The designed discharge to each canal shall be delivered by operating the gates of the head regulators. The tertiary canals will ultimately deliver water to the fields through pipe outlets, fixed at desired locations.

The gates allow to control the flow delivered to each canal. Head regulator gates will control the water flow in one canal, cross regulator gates will control the water flow inside the same canal.

Then, the farmers will have two choices after the tertiary canal: irrigation plot to plot or through the construction of field ditches.

8.1.1.2.11 Tertiary system

Feasibility study includes the design up to the tertiary canal levels, which is the complete irrigation system. The tertiary canal supply water to quaternary canals, which farmers must construct.

The numbers of tertiary canals and drains in each main canal will be estimated at the detailed design phase.

Two options will be considered: 1) Traditional excavate tertiary canal or 2) collective solar pumping station.

8.1.1.2.11.1 Traditional excavate tertiary canal

The first option will be to create traditional tertiary canal alignment in excavation. The farmers will diesel pump individually to the canal based on their needs.

These tertiary canals require high appropriation from the beneficiaries as the canal alignment needs to be accepted by the farmers without land compensation as per RGC"s regulation. This can lead to inappropriate water delivery to the plots.

8.1.1.2.11.2 Collective solar pumping station

Now across the agriculture sector in Cambodia, those that irrigate do so by pumping from water sources using in the vast majority diesel pumps, thus generating CO2 emissions through the burning of fossil fuels. This is at a high cost for the farmers for the production of agricultural products, especially with the uncertainty of the fuel price.

The project aims to demonstrate replacement of these diesel pumps with collective solar pumping system, with at least test sites at suitable locations (Appendix 10). A move to this low-tech solution that uses only water energy to lift the water will completely eliminate the burning of fossil fuels to irrigate and thus stop this source of CO2 emissions. The technology, solar pumping system, is simple, requires low maintenance and operation. It is potentially suitable for replication in most areas with surface water. In addition to mitigation benefits, the technology could also contribute to adaptation as (unlike diesel pumps) there is no fuel /running cost, so the pump can be used to lift additional volumes of water compared to diesel pumps.

The water solar pumping system could be coupled with a pre-paid system to ensure the sustainability of the system and water delivery at the farmers plot with pipeline to improve the water efficiency (20%) and avoid land issue on the tertiary canal alignment. The water efficiency will also save money on the solar pumping system construction.

On Ou Ta Paong irrigation system, the southern part of the scheme seems more adequate to implement collective solar pumping station as it is more protected from flood and closer to villages to prevent potential damage.

8.1.1.2.12 Operation and Maintenance

The operation and maintenance of the reservoirs, diversion structure, MCs will be done by PWDRAM, while operation and maintenance of SCs, SDs, SSCs and TC/TDs will be done by FWUC with support of PWDRAM.

The capacity strengthening of MoWRAM, PDWRAM, and the FWUC in climate smart irrigation system and asset management is key to operational sustainability. The Project includes technical capacity building and matching financing planning to ensure system durability and climate resilience. Structural interventions incorporate climate adaptability, socio-economic conditions, and sustainability. Climate change, population growth, land-use change, gender, access, and on-farm resilience and financial growth are thoroughly considered, adopting a long-term perspective in the Project design. Enhancing flood and drought resilience through nature-based/ecosystem-based approaches and climate-proofing structures will mitigate the impact of extreme weathers and provides consistent water flows that farmers depend on for multiple cropping.

8.1.1.3 Design criteria

Guidance for design criteria is detailed in Appendix 12.

8.1.1.4 Construction Cost Estimates

The feasibility level cost estimate has been developed for the construction up to tertiary canals. The quaternary canals must be developed by the FWUC themselves. The actual cost estimate for the detail designs should be done after having the topographic and geotechnical studies.

Unit rates were taken from typical rates used in the recent years of MOWRAM for similar work.

The overall estimated cost of the OTP scheme is provided in Annex 4.

8.1.1.5 Schedule

Should the feasibility study for the Ou Ta Paing subproject proceed to detailed design, then allowing for the design process, procurement process and approvals, it has been assumed the following planning as displayed in the Table 5-3.

The following assumptions have been made:

- The detailed design will start in January 2026; it will take two years to get a better understanding of the upstream hydraulic infrastructure, conduct additional survey and propose the best solution for a sustainable water supply of the scheme.
- The procurement process will not take more than three quarters;
- The construction work will start after the rainy season in Cambodia with a mobilization period (last quarter of the year);
- The construction work duration will not last more three dry seasons.

Hence the construction would be able to commence at the last quarter 2028, with completion by mid-2031.

Table 5-3.Tentative implementation schedule of Ou Ta Paong irrigation scheme.

COMPONENTS, SUB-COMPONENTS, OUTPUTS AND ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5				YEAR 6			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24
2.1.1 - Ou Ta Paong	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
Activity 2.1.1.1 - Pursat West Hydraulic system masterplan	●	●	●																					
Activity 2.1.1.2 - Detailed design			●	●	●	●	●	●																
Activity 2.1.1.3 - Procurement									●	●	●													
Activity 2.1.1.4 - Work construction and supervision												●	●	●	●	●	●	●	●	●	●	●		

8.1.2 Lum Hach Subproject

8.1.2.1 Rationale

8.1.2.1.1 Opportunities

In this project there is very limited existing infrastructure. There are very limited water users which can affect the water delivery, but we can consider the water resources available very limited as the command area is only crossed by very small streams. However, farmers of Lum Harch area are still cultivating rainfed rice and in most cases one wet season rice on some limited area. Farmers irrigate with the help of pumps, when possible, by pumping from the streams. In this project there are limited opportunities to improve agricultural production and improve water management and soil fertility due to the natural characteristics. The project will focus on the improvement of the flooding conditions of the area to increase agricultural productivity by restoring the streams crossing the command area.

8.1.2.1.1.1 Irrigation and drainage system development

The Lum Harch Irrigation scheme encompasses a command area situated downstream the old Lum Harch canal built during the Pol Pot period (1975-1977), drawing its water supply from various streams crossing the canal. These sources comprise several other rivers that traverse the scheme and have very limited catchment area and flow. This water supply system results in the creation of distinct hydraulic zones within the scheme, each characterized by specific water availability levels, which in turn have a direct impact on agricultural output.

The area presents a general slope direction from south-west to north-East. This explains that the area is mainly supplied by the supper streams and make it challenging to divert water from other sources. The hydraulic gradient is low and due to the existing infrastructure design (Existing Lum Harch irrigation), the area cannot be irrigated by the existing infrastructure. Gravity irrigation will not be possible and will require one stage pumping.

In all the scheme there is an opportunity to improve the river training and develop two wet season rice crops by developing proper irrigation system adapted to the local context: limited of water resource, soils conditions, lack of road access, low agricultural activities. Some upper land could also diversify crops all along the year.

8.1.2.1.1.2 System Water Management

There are limited opportunities to improve agricultural production of this subproject due to lack of water resources and system to manage it. The old Lum Harch canal built during the Pol Pot regime has never been functional and operated properly due to lack of water resources and poor design. The consequences have been the deterioration of the canal over the years. To take in consideration these aspects, the project concept design proposes a river approach with the rehabilitation of existing ponds to promote the development of irrigation and crops diversification, and protection from the flooding disaster.

8.1.2.1.2 Objective and scope

The main objective is to improve the disaster prevention and protection of farmlands and assets by establishment of early warning systems and improvement of the existing drainage and flood protection systems. The secondary objective is to improve disaster prevention and protection of farmlands and assets by establishment of early warning systems and improvement of the existing drainage and flood protection systems. The tertiary objective will consist of improving agricultural productivity of this system by improving cropping intensity, and yield of the crops by improving distribution system and providing proper water management.

The total irrigation demand should match with the 80% reliable available water in the source, considering the required environmental flow and downstream and upstream water demand. Due to lack of reliable data, it is considered that the water availability will be limited, and only 3 900 ha of the land could be irrigated. Agricultural production should also address the various agricultural initiatives like farmer training, introduction to new varieties. The environmental and social safeguard policy should also match with international practices and guidelines.

8.1.2.1.3 Identification and description of project elements

8.1.2.1.3.1 Beneficiary identification of parameters for improvement

Several meetings were conducted with the farmers and local authorities during the feasibility study. At the same time, field observations have also been conducted with the farmers. It was found that the water available is not enough for the whole command area now due to 1) limited water resources crossing the irrigation scheme (small catchment) and 2) Removal of Boribor river diversion and associated storage for E&S reasons. To ensure the objective of the scheme it is necessary to improve the following in the system:

- Improvement of the water training for water disaster prevention and drainage improvement.
- Rehabilitation/improvement of ponds storage along the scheme.
- Improve water management.

8.1.2.1.3.2 Identification of agricultural production goals

There are at least four systems of rice cultivation practices by farmers in Cambodia depending on the season and hydrologic condition (e.g. early wet-season, regular wet season, recession rice and dry season). This has been described in more detail in the previous section.

Four value chains have been identified for the three sub-projects: Rice, vegetable/fruits, poultry and aquaculture.

Production of poultry will be ideal in Lum Harch because each household, generally, produce chicken as a source of emergency food and with the poultry production activities described under Component 1 this could provide a profitable activity for some farmers. There is a big market for poultry in the urban centers in Pursat, Kampong Chhnang and Kandal.

Vegetable production should be included as another value-chain for Lum Harch. Depending on market and season, varieties of fruit and vegetables should be allocated to 70% of the households. Seeds of fruit vegetables such as cucumber, eggplant, squash, watermelon, and Honeydew should be distributed to the cooperating farmers.

8.1.2.1.3.3 Water Security

After the rehabilitation of the river courses it will be possible to develop small scale irrigation activities in Lum Harch area. Most of the command areas of Ou Ta Paong will be possible to irrigate by individual or collective pumping system. Besides this the improvement of managing of upstream water infrastructure will provide more water during the water scarce period to the Lum Harch scheme.

8.1.2.1.3.4 General technical and design requirements

General technical requirement is to match the command area Lum Harch 2 on the available 80% reliable flow of the streams crossing the scheme for irrigation considering the limited water sources. The next design requirement is to match/verify the water resources as per the crop water requirement.

8.1.2.1.3.5 Agricultural Extension Support

See component 1.

8.1.2.1.4 Limitations and constraints

There are several benefits from this project. However, there is some limitations and constraints as follows:

- Lum Harch scheme has limited water resources following the removal of the Boribor river diversion and associated storage for E&S reasons.
- Lum Harch irrigation scheme is supplied by different rivers crossing the scheme with different characteristics (catchment size, slope, etc).
- There is no existing water infrastructure, except the old Lum Harch Canal.
- Most of the infrastructure does not cover the command area. By consequences, pumping will be necessary for the farmers to irrigate their plot.

8.1.2.2 Project features

8.1.2.2.1 Selection of command area

The selected area has been delimited at early feasibility stage, with an approximate size of 30 000 ha. The command area has been adjusted to 3 900 ha.

This is mainly due to the fact that Lum Harch scheme has limited water resources from small streams and the removal of Boribor river diversion and associated storage for E&S reasons.

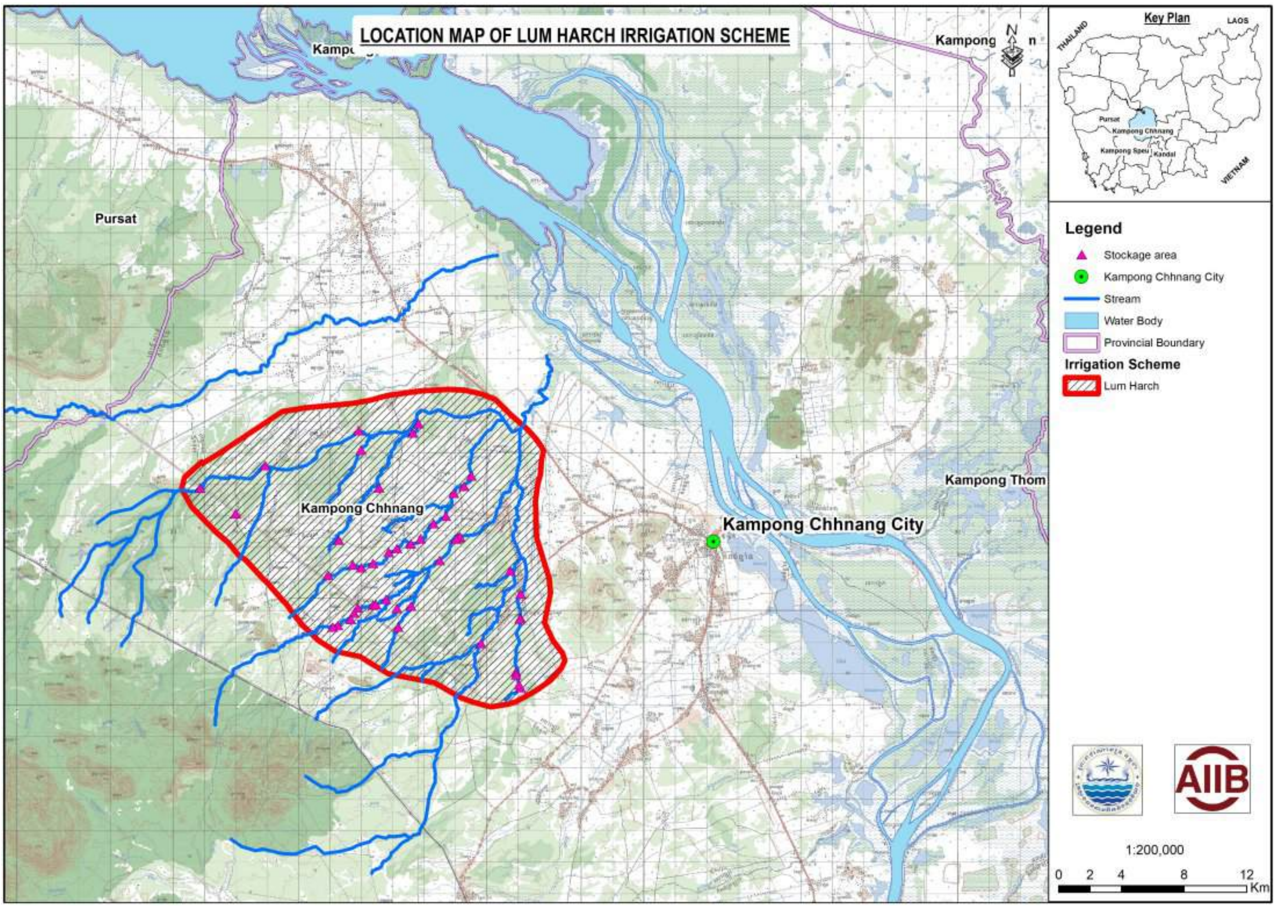


Figure 5-8. Command area of Lum Harch irrigation scheme.

8.1.2.2.2 Cropping patterns "with project" and water requirement

The improvement of irrigation canals and drainage system will permit improvement of cropping system planting with three maturity groups (early, medium. and late but now with the inclusion of non-rice crops of leafy vegetables or fruit vegetables according to the market. There is an expected increase in number of farmers planting early maturing rice varieties with the support of the project for seeds and extension, and that the same farmers will plant the medium and late maturing. There is a limited market for vegetables in Lum Harch, the reason for anticipating only 10% or 390 ha.

PROPOSED CROPPING SYSTEM IN WET AND DRY SEASON

No.	Variety name	Variety name	Duration (days)	Variety type	Crop area (% of CA)	Crop area (ha)	Source of varieties	Growing Method	Irrigated (Y/N)	Average Yield (t/ha)
1.1	Early WS rice	Phka Krovan, OM5451, Sen Kra...	90 - 110	Short NPS Variety	30%	1,170	Own seeds	BC	Y	4.0
1.2	Medium WS rice	Phka Romduol, Krasang Theap, ...	120 - 150	Medium PS Variety	40%	1,560	Own seeds	BC	Y	3.5
1	Late WS rice	Rang Chey, CAR4/5/9	160 - 180	Late WS PS Variety	30%	1,170	Own seeds	BC	Y	4.0
1.5	Diversified Crops (Legumes)	Mungbeans/Soybean/peanut/Cowpea	60 - 80	-	5%	195	Seeds from PDAFF	BC in Drum Seeder	Y	15.0
1.6	Diversified Crop (Vegetables)	Fruit Vegetables - Cucumber/Longbean/Sweetcorn/Leafy vegetables...	30 - 60	-	5%	195	Seeds from PDAFF	BC in Transplanted	Y	15.0

CULTURAL OPERATIONS:
Varieties: NPS - Nonphotoperiodic sensitive; PS - Photoperiodic sensitive
Land Preparation
Broadcasting (BC) Directly Seeding (DS)
Growing stage after seeding

Figure 5-9. Crop Patterns of Lum Harch irrigation scheme with project

Crop water requirement for the project was determined at a detailed level for engineering planning purposes, for planning of crop management and for economic calculations of irrigation and overall project profitability by assessing the utilized water quantities.

8.1.2.2.3 Irrigation duties

At this stage, canals are planned to design for the **duty of 2l/s/ha**. This could be detailed based on a water delivery rotation selected at the design phase.

See Irrigation duties in Appendix 8.

The irrigation will be supplementary irrigation during the water scarce period.

8.1.2.2.4 Water delivery rotation

No specific water delivery rotation will be implemented.

8.1.2.2.5 Water resources

The detailed design phase should conduct an overall water balance study of the river basin to ensure the water availability of the scheme.

8.1.2.2.6 Layout description

The Lum Harch Irrigation scheme covers a command area downstream of the old Lum Harch canal constructed during the Pol Pot period (1975-1977). It draws water from various streams intersecting the canal, including rivers with limited catchment areas and flow. This system creates distinct hydraulic zones within the scheme, each impacting agricultural productivity due to varying water availability.

Low hydraulic gradients and the existing infrastructure design of the Lum Harch irrigation prevent efficient irrigation of the area from the Boribor River too. The area generally slopes from southwest to northeast, mainly relying on upstream streams, making it difficult to divert water from other sources like Boribor River. The initial proposal to divert the water from Boribor River with an option to create an impoundment has been remove due to E&S concern at this stage.

To take in consideration these aspects, the project concept design proposes a “Nature Based Solution” approach with the rehabilitation of existing streams crossing the schemes and ponds to promote the development of irrigation and crops diversification, and protection from flooding.

Hence, the project proposed:

- The rehabilitation of the streams crossing the command area
- The creation/rehabilitation of 50-80 ponds along the scheme to maintain/develop the irrigation on the command area
- The rehabilitation of the old Lum Harch Canal to be used as a reservoir

The stream rehabilitation principles are described on the figure here below.

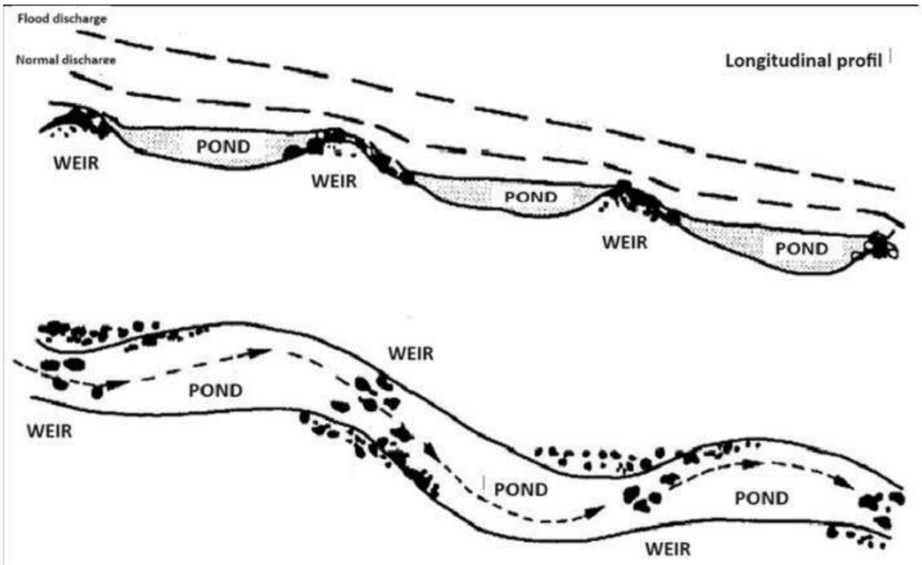


Figure 5-10. Principles of river rehabilitation for Lum harch scheme

8.1.2.2.7 Canals

There is no canal planned for this sup-project.

8.1.2.2.8 River training and drainage

8.1.2.2.8.1 Determination of drainage system layout

The main natural drainage channels will form the core of the planned system to drain excess runoff during the rainy season and mitigate inundation and waterlogging in the command area. The system will also serve as the outlet for the on-farm drainage system, designed to drain surplus irrigation water and control the groundwater table.

As the project main objective is to develop and increase agricultural production in the area, the drainage system will be designed for a 5-year (5% probability) return period for the main rivers and a 5-year (20% probability) return period for all other drains.

The layout of the drainage system will be based on:

- The main natural drainage channels.
- Incoming sources (watersheds upstream of the proposed main canal, direct rainfall over the command area and water level changes in Tonle Sap).
- Land use (crop types and layout, and field management).
- Planned irrigation systems.
- The main drains will be based on the main existing natural river.

The internal drainage system will be proposed as per the requirements and will follow the agricultural plot layout and irrigation systems.

Additional drains will be constructed upstream of and parallel to the main canal as diversion and interception drains to reduce crossings on the main canal and protect it. These drains will divert floodwater as topography permits to the drainage system.

8.1.2.2.8.2 Review of hydrological data

8.1.2.2.8.2.1 *Sources of Floods*

There are three sources of water creating floods in the command area: runoff from the upper watersheds; fluctuations in Tonle Sap and others large stream water level; and runoff created from direct rainfall over the command area. These phenomena are described below.

8.1.2.2.8.2.2 *Runoff from the upper watershed*

According to the hydrological study and field assessment, only watershed is rainfall-runoff to the command area. The table below presents the calculated discharge values in m^3/s for this watershed.

Table 5-4. Ou Ta Paong peak discharges for various return periods in years (m3/s)

Name	Catchment area (km^2)	Peak Discharges for various return periods in years (m^3/s)			
		T=5	T=10	T=25	T=50
Location 63	Unkown	26,1	28,6	31,8	34,23
Location 49	Unkown	23,1	28,6	35,9	41,46
Location 48	Unkown	7,5	9,15	11,3	12,9
Location 56	Unkown	1,2	1,5	2,1	2,4
Location 37	Unkown	0,4	0,6	0,7	1
Location 27	Unkown	0,7	1,3	2	2,6

8.1.2.2.8.2.3 *Runoff from direct rainfall over the command area*

Runoff developing in the command area from direct rainfall is supposed to drain through the drainage system, crossing the area generally in a south/north direction. Several obstacles prevent smooth flow towards the main drainage system, namely:

- Undulating terrain caused by the natural movement of sediments on the surface, sinking of clays, and management of farming activities.
- Overtopping of water flowing in the drainage system, which contains sediments that settle on the banks and create parallel mounds, interfering with the inflow from the area.
- Blocking up of the drainage system, due to sliding banks, sediment deposition and the development of secondary gullies.
- Rows of transverse mounds, in east-west direction, which developed on the interface of the lake and the main general flow direction of the area, in the north-south direction.
- Temporary obstacles constructed by the farmers on the drainage system to divert water to their plots.

Considering direct rainfall over the command area, calculations will be performed for the total watersheds contributing to the drain.

8.1.2.2.8.3 Main natural drainage channels

8.1.2.2.8.3.1 *General*

The project includes the rehabilitation of the streams which crosses the command area.

8.1.2.2.8.3.2 *Design discharge and flood risks*

Considering the catchment area of the streams, which can be responsible for flooding in the command area, it is proposed to design these canals for discharge of a 5-year return period. This is also necessary to protect the irrigation infrastructure and agricultural fields from flood damage. The road crossings of these rivers will be designed for discharges corresponding to a 25-year return period.

The existing capacity of these canals is very small compared to the design discharge values and it is not practical or economic reasons to excavate these natural canals for a return period discharge values superior of 5 years.

8.1.2.2.8.3.3 *Channel Shapes and Hydraulic Structures: Locations and Types*

In addition to the risks to the agricultural fields, there is a risk for the channels themselves. There is a need to establish their cross sections against erosion and silting. The alignment of the designed canals will follow the natural one. Their general shape is trapezoidal, with side slopes not less than 2:1 (H:V).

8.1.2.2.8.4 Internal drainage system

The preliminary need of a drainage system in an irrigation command area is to remove excess water from the ground surface as well as from the root zone in the sub-soil. The main source of excess water on the land surface is the rain falling over the catchment area.

The surface drainage system is most effective in case of impermeable soils or where infiltration is impeded by an impermeable layer. Considering that the soils are sandy with a good hydraulic conductivity, a surface drainage system or a sub-drainage system could be implemented.

No drainage is planned at this stage for Lum Harch scheme.

8.1.2.2.8.5 Polder

No polder is planned for Lum Harch scheme.

8.1.2.2.9 Structures

The project includes the rehabilitation and/or construction of small weir on the rivers crossing the command area of Lum Harch irrigation scheme. A weir is a small barrier built across a stream or river to control and raise the water level slightly on the upstream side, essentially a small-scale dam. The weir will be used for a several functions: prevent flooding, measure water flow, and hold water to be used for irrigation purposes.

The size, characteristics and number of weirs to be built along the rivers will be defined by a consensus between the technical needs (rivers characteristics, flooding issues, etc) and consultative approach with the beneficiaries. This will require a field investigation and beneficiaries' consultation.

Figure 5-11. Typical weir's structure.

8.1.2.2.10 Tertiary system

Due to the access difficulties and low opportunity in terms of agriculture development, it doesn't seem necessary at this stage to invest in tertiary canal.

During detailed design stage, beneficiaries' consultations will be performed to assess the potential of collective solar pumping stations. Indeed, the project aims to demonstrate replacement of diesel pumps with collective solar pumping system (Appendix 10). The water solar pumping system could be coupled with a pre-paid system to ensure the sustainability of the system and water delivery at the farmers plot with pipeline to improve the water efficiency (20%) and avoid land issues on the tertiary canal alignment. The water efficiency will also save money on the solar pumping system construction.

It could be envisaged to develop some pilot projects of solar pumping system among the scheme based on the consultative approach and location of the place.

8.1.2.2.11 Operation and Maintenance

The operation and maintenance of the Reservoirs, Diversion structure, MCs will be done by PWDRAM, while operation and maintenance of SCs, SDs, SSCs and TC/TDs will be done by FWUC with support of PWDRAM.

The capacity strengthening of MoWRAM, PDWRAM, and the FWUC in climate smart irrigation system and asset management is key to operational sustainability. The Project includes technical capacity building and matching financing planning to ensure system durability and climate resilience. Structural interventions incorporate climate adaptability, socio-economic conditions, and sustainability. Climate change, population growth, land-use change, gender, access, and on-farm resilience and financial growth are thoroughly considered, adopting a long-term perspective in the Project design. Enhancing flood and drought resilience through nature-based/ecosystem-based approaches and climate-proofing structures will mitigate the impact of extreme weathers and provides consistent water flows that farmers depend on for multiple cropping.

8.1.2.3 Design criteria

Guidance for design criteria is detailed in Appendix 12.

8.1.2.4 Cost Estimates

The feasibility level cost estimate has been developed for the construction up to tertiary canals. The quaternary canals must be developed by the FWUC themselves. The actual cost estimate for the detail designs should be done after having the topographic and geotechnical studies.

Unit rates were taken from typical rates used in the recent years of MOWRAM for similar work.

The overall cost estimate for the Lum Hach scheme is provided in Annex 4.

8.1.2.5 Schedule

Should the feasibility study for the Lum Harch subproject proceed to detailed design, then allowing for the design process, procurement process and approvals, it has been assumed the following planning as displayed in theTable 5-6.

The following assumptions have been made:

- The detailed design will start in January 2026;
- The procurement process will not take more than three quarters;
- The work construction will start after the rainy season in Cambodia with a mobilization period (last quarter of the year);
- The work construction duration will not last more than three dry seasons.

Hence the construction would be able to commence at the last quarter 2028, with completion by mid-2031.

Table 5-6.Tentative implementation schedule of Lum Harch irrigation scheme.

COMPONENTS, SUB-COMPONENTS, OUTPUTS AND ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5				YEAR 6			
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24
2.1.2 - Lum Harch	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		
Activity 2.1.2.1 - Detailed design	●	●	●	●	●	●	●	●																
Activity 2.1.2.2 - Procurement									●	●	●													
Activity 2.1.2.3 - Work construction and supervision												●	●	●	●	●	●	●	●	●	●	●		

8.1.3 Krang Ponley Subproject

8.1.3.1 Rationale

8.1.3.1.1 Opportunities

In this project the major infrastructures including storage dam, diversion barrage, MCs and some SCs are already constructed. There are other upstream water users which can affect the water delivery, but we can consider the water resources available would be enough in the Anlong Chrey River. However, farmers of Krang Ponley area are still cultivating rainfed rice and in most cases one wet season rice. Farmers irrigate with the help of pumps. In this project there are ample opportunities to improve agricultural production and improve water production improving distribution systems, water management and soil fertility. Farmers of this project are very active and enthusiastic to improve agricultural productivity by intensifying their cropping area and irrigating their land, but also with the opportunity to diversify their crops and source of income.

In this project, we can distinguish between two types of irrigations system:

Irrigation schemes to be constructed: Brambei Mom. In this scheme, the storage dam is already built but the irrigation system needs to be created.

Irrigation schemes to be rehabilitated: Kropeu Trom, Yotasast Scheme and Stoeung Krang Bat. In these schemes, the major infrastructure components, such as the storage dam, diversion barrage, main canals (MCs), and some secondary canals (SCs), have already been constructed.

However, it's notable that farmers in the Krang Ponley area are primarily engaged in rainfed rice cultivation, often limited to a single wet season rice crop. The current irrigation practices rely on individual pumps. In this context, there is abundant opportunities to enhance agricultural production and improve water resources utilization by implementing measures related to distribution systems, water management, and soil fertility.

Farmers in this project area exhibit high levels of enthusiasm and activity, which can be harnessed to elevate agricultural productivity. This can be achieved by expanding cropping areas, adopting irrigation practices, and diversifying crops and income sources. This presents a promising avenue for increasing agricultural sustainability and improving livelihoods.

8.1.3.1.1.1 Irrigation and drainage system development

The Krang Ponley sub-project encompasses four irrigation schemes.

Kropeu Trom
Yotasast
Stoeung Krang Bat
Brambei Mom

All the schemes are located downstream of Anlong Chrey reservoir. Kropeu Trom, Yotasast, Stoeung Krang Bat schemes are cascade irrigation schemes along Krang Ponley stream.

The location scheme is presented on Figure 5-12. Krang Ponley - Location of the sub schemes.

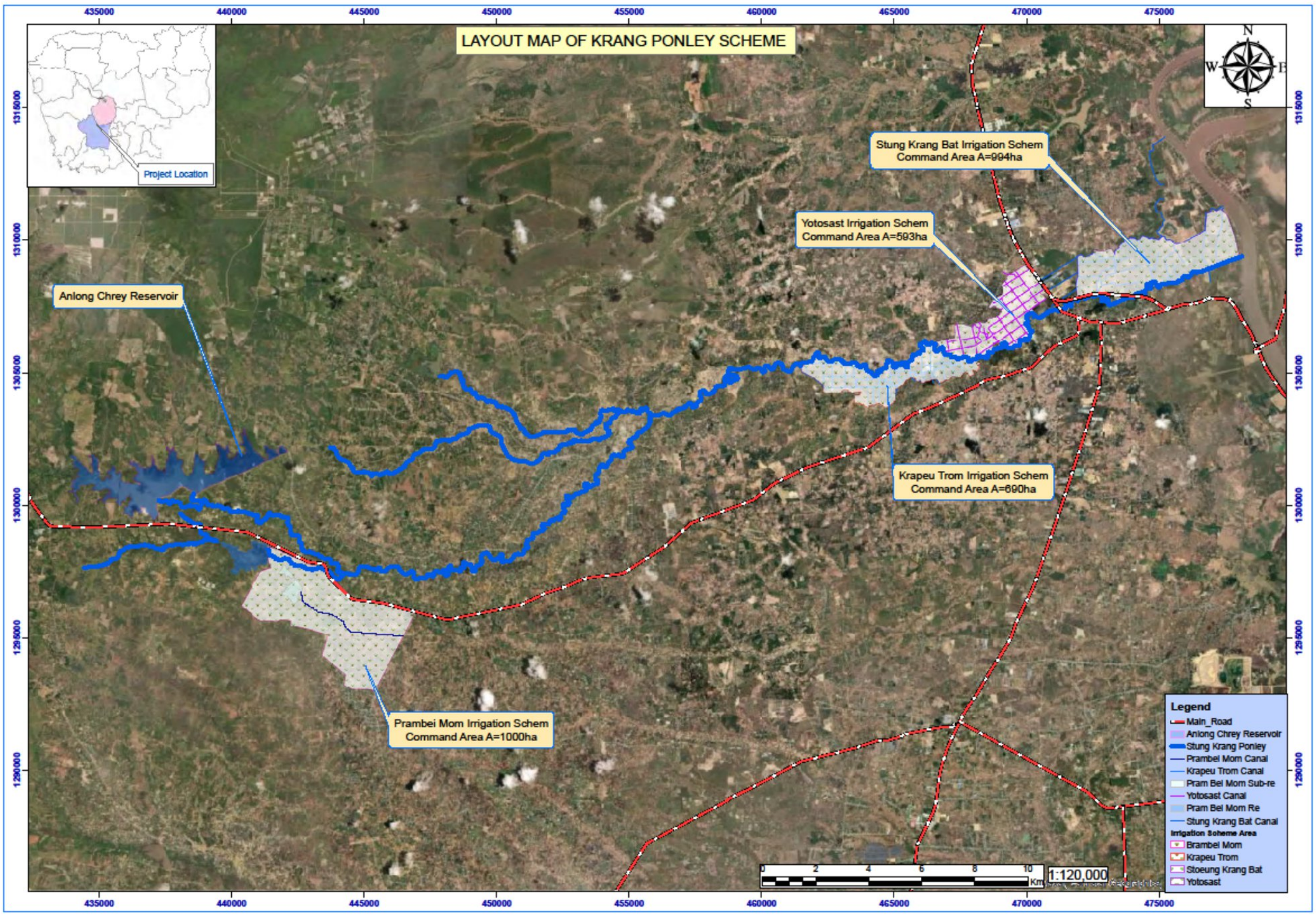


Figure 5-12. Krang Ponley - Location of the sub schemes.

Brambei Mom irrigation schemes is also supplied by Anlong Chrey reservoir but located south of the provincial road.

In all these irrigation schemes there are ample opportunities to develop two wet season rice crops by developing proper canal system. These blocks have a proper canal bed slope, tertiary canals, regulating structures and most importantly the canal management. As per study there is also an opportunity to develop dry season crops in 10% of the command area.

8.1.3.1.1.2 System Water Management

There are significant opportunities to enhance agricultural production within this subproject by focusing on system water management. The Anlong Chrey and Brambei Mom reservoirs were initially designed to serve a dual purpose: to alleviate flood damage and to provide irrigation water to downstream Irrigation Schemes (IS). However, issues have arisen due to inadequate system management.

Downstream farmers have damaged critical check structures, leading to inefficiencies in water distribution. Despite the potential for gravity-based irrigation in most of the Krang Ponley irrigation systems, individual farmers are resorting to using their own pumps. This decentralized approach has led to the removal of gates at certain key points, including the Main canal head regulator and major check structures.

There is no proper Irrigation Service Plan in place from the PDOWRAM and existing FWUC. This absence of an ISP complicates the planning of water delivery. Furthermore, the lack of measuring structures throughout the system hinders effective water monitoring and the equitable distribution of water among the various schemes.

Given these issues, there exists a clear opportunity to improve water productivity and increase agricultural production in this system by implementing effective water management measures.

8.1.3.1.2 Objective and scope

The primary objective of this project is to enhance agricultural productivity within the system by increasing cropping intensity and crop yields. This improvement will be achieved through the enhancement of the distribution system and the implementation of water regulating and measuring structures. The secondary objective is to improve disaster prevention and protection of farmlands and assets by establishment of early warning systems and improvement of the existing drainage and flood protection systems. The tertiary objective is to leverage the benefits of effective system water management. This includes optimizing the management of the water resources within the system and strengthening the capacity of the PDoWRAM and FWUC responsible for the system.

A key outcome of these objectives is to ensure that farmers receive an adequate and consistent water supply during the cropping period. This provision will enable them to introduce additional cropping seasons and, in turn, improve and secure their crop yields. This dual-focused approach seeks to not only increase agricultural productivity but also enhance the resilience and livelihoods of the farming community.

The total irrigation demand must align with the 80% reliable available water from the source, while accounting for environmental flow and both downstream and upstream water needs. Due to data limitations, it is assumed that there is enough water for the irrigation schemes under these conditions. Additionally, agricultural production should consider farmer training and the introduction of new crop varieties. Environmental and social safeguard policies should align with international practices and guidelines. A key project aspect is establishing an Apex FWUC to distribute water among various schemes and coordinate with PWDRAM for reservoir and diversion barrage management.

8.1.3.1.3 Identification and description of project elements

8.1.3.1.3.1 Beneficiary identification of parameters for improvement

Several meetings were conducted with the farmers and local authorities during the feasibility study. At the same time, field observations have also been conducted with the farmers. These showed that the water available is not enough for the whole command area. To ensure the adequate water availability in required time it is necessary to improve the following in the system:

- Construction of necessary water distribution canals;
- Construct necessary outlets and check structures and culverts;
- Improve water management.

8.1.3.1.3.2 Identification of agricultural production goals

There is at least four systems of rice cultivation practices by farmers in Cambodia depending on the season and hydrologic condition (e.g. early wet-season, regular wet season, recession rice and dry season). The system of rice cultivation has evolved for many years as adaption measure of farmers to the ecosystem and as the socio-economic condition changes. The most unique system of rice cultivation carried out by farmers in Cambodia is the “recession rice”. On the fringes of Tonle Sap Lake, farmers grow rice only after the level of lake water recedes below the paddies of farmers adjacent to the lake.

There is a way to diversify agricultural production. Four value chains have been identified for the three sub-projects: Rice, vegetable/fruits, poultry and aquaculture.

8.1.3.1.3.3 Water Security

After the construction of secondary and tertiary canals it will be possible to irrigate all command area of the 4 schemes of Krang Ponley Sub-project. Most of the command areas of Krang Ponley Subproject will be possible to irrigate by gravity or collective solar pumping system if the pre-requisites are respected. Besides these an improved management of upstream water infrastructures will also provide more water during the water scarce period.

8.1.3.1.3.4 General technical and design requirements

The general technical requirement is to match the command area of the Krang Ponley schemes on the available 80% reliable flow of the Anlong Chrey river for irrigation considering the Angok Chrey reservoir. The other design requirement is to match the canal size as per the crop water requirement. Another important design requirement is that the water level of the canal should command the cultivated land under the project boundary when possible.

8.1.3.1.3.5 Agricultural Extension Support

See component 1.

8.1.3.1.4 Limitations and constraints

There is a number of benefits from this project. However, there is also some limitations and constraints which are as follows:

- Anlong Chrey reservoir characteristics are unknown and need to be defined (volume, sedimentation, etc).
- Water resources from Anlong Chrey river basin area are limited and the potential area irrigable need to be assessed.
- The development of Brambei Mom is limited due to the lack of water resources. The other irrigation schemes are better positioned.
- The urban development of Stoeung Krang Bat is not negligible. The area to be irrigated should take in consideration the potential urbanisation of the area.
- Some of the existing water infrastructures (check structures) are broken or damaged by the downstream farmers, so there is a water right issue, which must be addressed in future.

8.1.3.2 Project features

8.1.3.2.1 Selection of command area

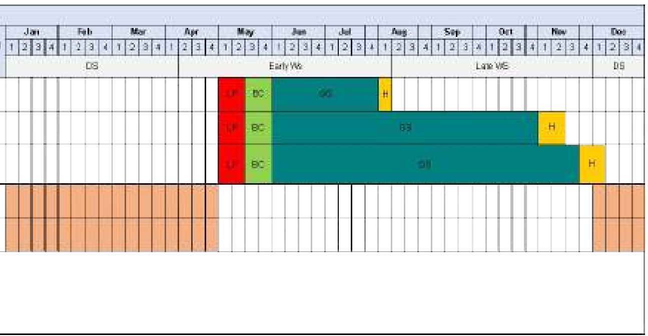
The selected area has been delimited at the early feasibility stage, then adjusted later:

Kropeu Trom: 690 ha
Yotasast: 593 ha
Stoeung Krang Bat: 994 ha
Brambei Mom: 1000 ha

The water requirements are mainly dependent on the net command areas and future cropping patterns. The main water consuming crops are early wet season rice, late wet season rice, wet season rice and 10% dry season rice. So, these crops are considered in the water balance study. It is not possible to start cultivation of the whole command area in single day due to lack of manpower and water, so starting of cultivation is staggered in three different stages and each start stage is one decade apart. The head reach farmers will cultivate in the beginning, then middle reach and then, in the end the tail reach farmers. For the initial estimate the 10-day 80% reliable flows have been used. The crop water requirements are calculated by using the Penman method for the calculation of ET. It is assumed that the diversified cropping will be developed through agricultural extension program.

8.1.3.2.2 Cropping patterns "with project" and water requirement

Rice-based cropping system in Krang Ponley vary among the four (4) areas composing the Krang Ponley irrigation project. Flooding and recession of flood determine what and when to plant rice or dry season non-rice crops. Rice farmers in two out of four locations [totaling 1,690 ha including Brambei Mom and Kropeu Trom prepare the land for sowing wet season rice in May - June and these wet season crops are harvested in November, using medium to late maturing rice crop is harvested in November. The medium to long maturing varieties can survive flood conditions and farmers, in trying to avoid crop loss or yield loss due to flood, have selected these varieties to match the ecological condition, not favorable to growth and development of the early maturing varieties. Slight topographic variation within the area may allow planting in May to April instead of June using late maturing varieties. Farmers produce 2.5 t/ha/crop despite the limited fertilizer inputs an indication that the floodwaters benefit the crops when the dissolved and sedimented materials containing nutrients are constantly deposited from the higher ground-sources. Non-rice crops including vegetables, may still be planted when there is enough moisture in the soil but not under flooded condition.

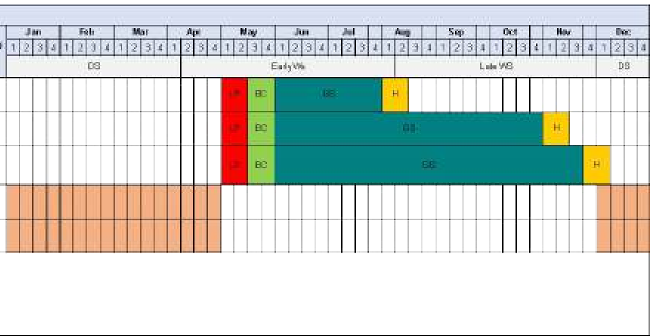


PROPOSED CROPPING SYSTEM IN WET AND DRY SEASON

No.	Variety name	Variety name	Duration (days)	Variety type	Crop area (% of CA)	Crop area (ha)	Source of varieties	Growing Method	Irrigated (Y/N)	Average Yield (t/ha)
1.1	Early WS rice	OM5451, Champei Sar 70/Sen Kra Ob	90-110	Short NPS Variety	50%	345	Certified/ Good seeds	BC or Drum Seeder	Y	4.0
1.2	MWS rice	Phka Romduol, Krasang Theap, Phka Mlis, Phka Rumdeng	120-150	Medium PS Variety	40%	276	Certified/ Good seeds	BC or Drum Seeder	Y	3.5
1.4	LWS rice	Rang Chey, CAR45/9	160-180	Late WS PS Variety	10%	69	Certified/ Good seeds	BC or Drum Seeder	Y	3.0
1.5	Diversified Crops (Legumes)	Mungbeans/soybean/ peanut/ Cowpea	60-80	-	7%	48	Seeds from PDAFF	BC or Drum Seeder	Y	15.0
1.6	Diversified Crop (Vegetables)	Cucumber/Longbean, sweet potato /Sweetcorn/Leafy	30-60	-	7%	48	Seeds from PDAFF	BC or Drum Seeder	Y	15.0

CULTURAL OPERATIONS:
Varieties: NPS - Non-photoperiodic sensitive; PS - Photoperiodic sensitive
Land Preparation
Broadcasting (BC) Directy Seeding (DS)
Growing stage after seeding
Harvesting

Figure 5-13. Proposed Crop Pattern with project for Kropeu Trom irrigation Scheme



PROPOSED CROPPING SYSTEM IN WET AND DRY SEASON

No.	Variety name	Variety name	Duration (days)	Variety type	Crop area (% of CA)	Crop area (ha)	Source of varieties	Growing Method	Irrigated (Y/N)	Average Yield (t/ha)
1.1	Early WS rice	OM5451, Champei Sar 70/Sen Kra Ob	90-110	Short NPS Variety	50%	297	Certified/ Good seeds	BC or Drum Seeder	Y	4.0
1.2	MWS rice	Phka Romduol, Krasang Theap, Phka Mlis, Phka Rumdeng	120-150	Medium PS Variety	40%	237	Certified/ Good seeds	BC or Drum Seeder	Y	3.5
1.4	LWS rice	Rang Chey, CAR45/9	160-180	Late WS PS Variety	10%	59	Certified/ Good seeds	BC or Drum Seeder	Y	3.0
1.5	Diversified Crops (Legumes)	Mungbeans/soybean/ peanut/ Cowpea	60-80	-	9%	53	Seeds from PDAFF	BC or Drum Seeder	Y	15.0
1.6	Diversified Crop (Vegetables)	Cucumber/Longbean, sweet potato /Sweetcorn/Leafy	30-60	-	9%	53	Seeds from PDAFF	BC or Drum Seeder	Y	15.0

CULTURAL OPERATIONS:
Varieties: NPS - Non-photoperiodic sensitive; PS - Photoperiodic sensitive
Land Preparation
Broadcasting (BC) Directy Seeding (DS)
Growing stage after seeding
Harvesting

Figure 5-14. Proposed Crop Pattern with project for Yotasast irrigation Scheme

PROPOSED CROPPING SYSTEM IN WET AND DRY SEASON											
No.	Variety name	Variety name	Duration (days)	Variety type	Crop area (% of CA)	Crop area (ha)	Source of varieties	Growing Method	Irrigated (Y/N)	Average Yield (t/ha)	Jan–Dec (weeks 1–4): DS / Early WS / Late WS / DS
1.1	Early WS rice	OM5451, Champei Sar 70/Sen Kra Ob	90-110	Short NPS Variety	50%	497	Certified/ Good seeds	BC or Drum Seeder	Y	4.0	LP, BC, GS, H
1.2	MWS rice	Phka Romduol, Krasang Theap, Phka Mlis, Phka Rumdeng	120-150	Medium PS Variety	40%	398	Certified/ Good seeds	BC or Drum Seeder	Y	3.5	LP, BC, GS, H
1.4	LWS rice	Rang Chey, CAR4/5/9	160-180	Late WS PS Variety	10%	99	Certified/ Good seeds	BC or Drum Seeder	Y	3.0	LP, BC, GS, H
1.5	Diversified Crops (Legumes)	Mungbeans/soybean/ peanut/ Cowpea	60-80	-	13%	129	Seeds from PDAFF	BC or Drum Seeder	Y	10.0	
1.6	Diversified Crop (Vegetables)	Cucumber/Longbean, sweet potato /Sweetcorn/Leafy	30-60	-	13%	129	Seeds from PDAFF	BC or Transplanting	Y	10.0	

CULTURAL OPERATIONS:
Varieties: NPS - Non-photoperiodic sensitive; PS - Photoperiodic sensitive
Land Preparation
Broadcasting (BC)/ Directly Seeding (DS)
Growing stage after seeding
Harvesting

Figure 5-15. Proposed Crop Pattern with project for Stoeung Krang Bat irrigation Scheme

PROPOSED CROPPING SYSTEM IN WET AND DRY SEASON											
No.	Variety name	Variety name	Duration (days)	Variety type	Crop area (% of CA)	Crop area (ha)	Source of varieties	Growing Method	Irrigated (Y/N)	Average Yield (t/ha)	Jan–Dec (weeks 1–4): DS / Early WS / Late WS / DS
1.1	Early WS rice	OM5451, Champei Sar 70/Sen Kra Ob	90-110	Short NPS Variety	50%	500	Certified/ Good seeds	BC or Drum Seeder	Y	4.0	LP, BC, GS, H
1.2	MWS rice	Phka Romduol, Krasang Theap, Phka Mlis, Phka Rumdeng	120-150	Medium PS Variety	40%	400	Certified/ Good seeds	BC or Drum Seeder	Y	3.5	LP, BC, GS, H
1.4	LWS rice	Rang Chey, CAR4/5/9	160-180	Late WS PS Variety	10%	100	Certified/ Good seeds	BC or Drum Seeder	Y	3.0	LP, BC, GS, H
1.5	Diversified Crops (Legumes)	Mungbeans/soybean/ peanut/ Cowpea	60-80	-	15%	150	Seeds from PDAFF	BC or Drum Seeder	Y	15.0	
1.6	Diversified Crop (Vegetables)	Cucumber/Longbean, sweet potato /Sweetcorn/Leafy	30-60	-	15%	150	Seeds from PDAFF	BC or Drum Seeder	Y	15	

CULTURAL OPERATIONS:
Varieties: NPS - Non-photoperiodic sensitive; PS - Photoperiodic sensitive
Land Preparation
Broadcasting (BC)/ Directly Seeding (DS)
Growing stage after seeding
Harvesting

Figure 5-16. Proposed Crop Pattern with project for Brambei Mom irrigation Scheme

Crop water requirement for the project was determined on a detailed level for engineering planning purposes, for planning of crop management and for economic calculation of irrigation and overall project profitability by assessing the utilized water quantities.

8.1.3.2.3 Irrigation duties

At this stage, canals are planned to design for the **duty of 2l/s/ha**. This could be detailed based on a water delivery rotation selected at the design phase.

See Irrigation duties in annex 10.

The irrigation will be supplementary irrigation during the water scarce period.

8.1.3.2.4 Water delivery rotation

Rotational distribution of irrigation water means that the whole flow in an irrigation canal is diverted to the branch canals in turn. For instance, in the case of primary and secondary canals, it means that each secondary canal is without water for part of the time and, when supplied, it transports the whole "primary" flow. The same can apply to the distribution of the flow of secondary canals into tertiary canals, and rotational distribution can be carried out within the tertiary canals.

The rotational irrigation system of Krang Ponley Irrigation scheme consists in dividing the total agricultural area to be irrigated into three (more or less) equal blocs. The irrigated areas on Krang Ponley are rice crops. Rice needs a large amount of water over a very short period to develop.

The rotational irrigation system provides for three consecutive days of non-stop irrigation on one of the three agricultural blocs, followed by one rotation every three day to ensure equitable irrigation of the three agricultural blocs. During these three days, farmers of the agricultural blocs can take the amount they need at the time they wish.

During the dry season, due to the lack of water only some parts of the agricultural land can be irrigated.

8.1.3.2.5 Water resources

The detailed design phase should conduct an overall water balance study of the river basin to ensure the water availability of the scheme.

8.1.3.2.6 Layout description

The individual layouts of each scheme are presented respectively in the following sections.

8.1.3.2.6.1 Kropeu Trom

The Kropeu Trom proposed project includes several key components:

- Rehabilitation of Intake Structure: Renovation of the intake structure along the Anlong Chrey stream.
- Rehabilitation of Irrigation Distributary Canals: Restoration work aimed at irrigating 690 hectares. This involves the possibility of canal lining for essential infrastructures like main and secondary canals.
- Development of Sub-distributary Canals: Creation of tertiary canals. Additionally, investigations will explore the potential for a collective solar pumping system at the tertiary level.
- Rehabilitation of Drainage Systems: Renovation of the Anlong Chrey stream and the existing main drainage systems to mitigate flooding and prevent water-related problems.

These activities collectively aim to enhance irrigation capabilities, improve water distribution, and mitigate potential water-related hazards in the project area.

Figure 5-17. Concept design of Kropeu Trom irrigation scheme.

8.1.3.2.6.2 Yotasast Scheme

The Yotasast irrigation system consists of:

- The rehabilitation of the intake structure on Anlong Chrey stream.
- The rehabilitation of the irrigation distributary canals to irrigate 593 ha. It is envisaged to have canal lining for the main infrastructures (main and secondary canal)
- The development of sub-distributary canals (tertiary). Investigation will be performed to envisage the possibility of collective solar pumping system at the tertiary level.
- The rehabilitation of the Anlong Chrey and existing main drainage system to prevent flooding and water disaster.

These combined efforts seek to elevate irrigation capabilities, refine water distribution, and alleviate potential water-related risks within the project area.

Figure 5-18. Concept design of Yotasast irrigation scheme

8.1.3.2.6.3 Stoeung Krang Bat

The Steung Krang Bat irrigation system consists of:

- The rehabilitation of the intake structure on Anlong Chrey stream.
- The rehabilitation of the irrigation distributary canals to irrigate 994 ha. It is envisaged to have canal lining for the main infrastructures (main and secondary canal)
- The development of sub-distributary canals (tertiary). Investigation will be performed to envisage the possibility of collective solar pumping system at the tertiary level.
- The rehabilitation of the Anlong Chrey and existing main drainage system to prevent flooding and water related risks.
- The creation of a polder on the eastern side to protect the area from flooding from Tonle Sap.

These joined activities aim to enhance irrigation capabilities, optimize water distribution, and reduce potential water-related risks within the project area.

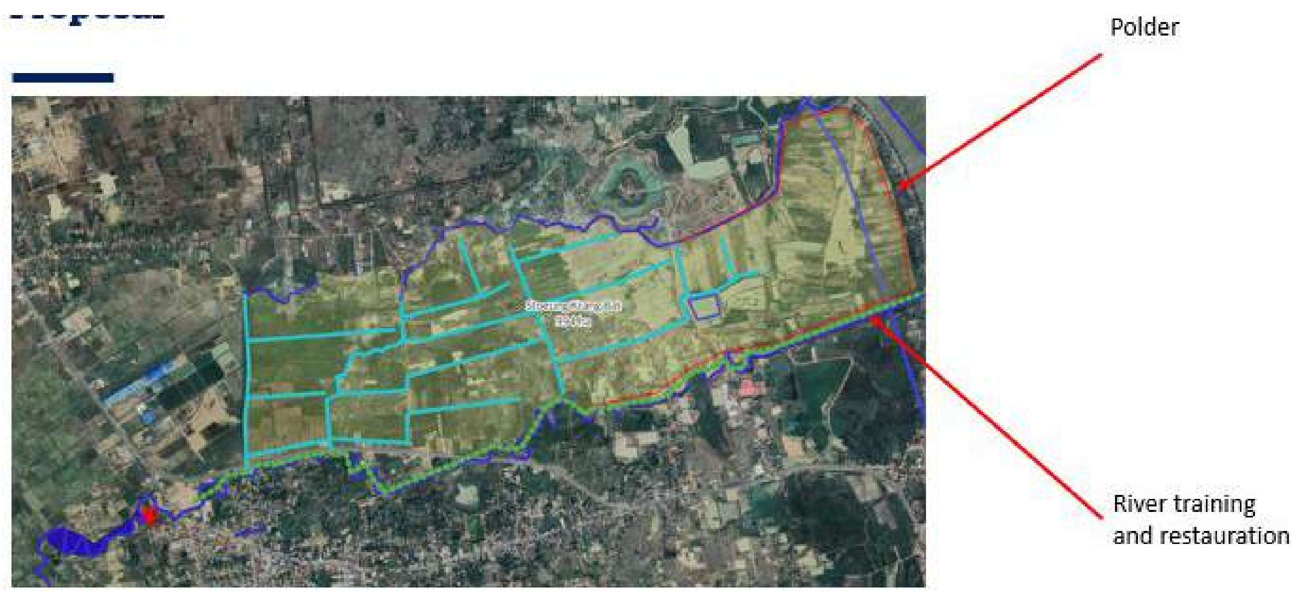


Figure 5-19. Concept design of Stoeung Krang Bat irrigation scheme

8.1.3.2.6.4 Brambei Mom

The Brambei Mom irrigation system consists of:

- Some minor work on the existing dam.
- The creation of the irrigation distributary canals to irrigate 1000 ha. It is envisaged to investigate the possibility of collective solar pumping system at the tertiary level.
- The rehabilitation of the downstream river to prevent flooding and water related risks.
-

These concerted activities aim to enhance irrigation capabilities, optimize water distribution, and reduce potential water-related risks within the project area.

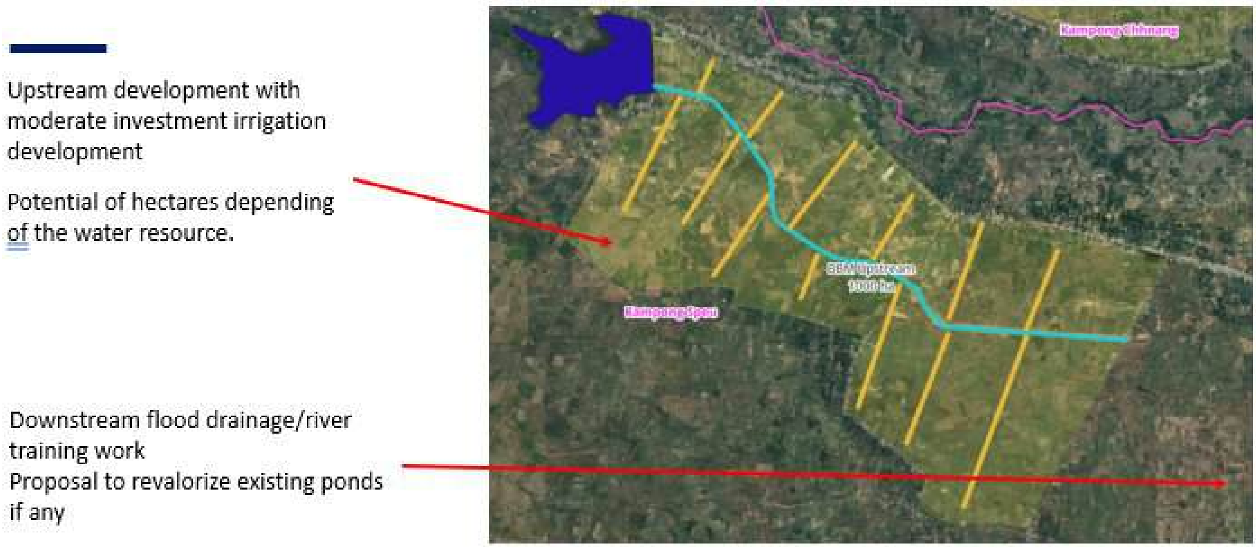


Figure 5-20. Concept design of Brambei Mom irrigation scheme

8.1.3.2.7 Dam

8.1.3.2.7.1 Dam safety

In terms of dam safety, the most urgent measures to be implemented are those pertaining to Anlong Chrey dam. Specifically in relation to the three locations, along the downstream toe, where upward seepage is observed which indicates internal erosion taking place.

Pertinent dam safety measures should include the following.

Immediate actions:

- Delimitate areas affected by sand boils (reportedly three areas).
- Remove top part (0.5 to 1m) and backfill with fine gravel (inverted filter).
- Place sandbags all around.
- Continuously observe how the situation evolves.
- Rise bags level as water upsurges within, if necessary lower reservoir level to further reduce seepage gradient.

Medium term actions:

- Survey the entire downstream toe of the dam, after removing vegetation and debris all along.
- Look for signs of seepage and delimitate them as appropriate.
- Place inverted filters on seepage areas and install seepage measurement devices (e.g., V-notches).
- Monitor seepages weekly and plot values against reservoir levels.
- Level embankment crest, adding material in depression zones and securing proper surface drainage.
- Install survey monuments on dam crest and initiate measurements of vertical movements.

Long term actions:

- Monitor seepage rates and turbidity of seeping water monthly, until trends are adequately understood.
- Survey crest levels bi-annually and correlate with reservoir levels and seepage rates.
- Re-appraise seepage regime annually and assess needed measures.
- Such measures may include, in increasing level of effort: continue monitoring, intensify monitoring at specific locations, add monitoring stations, reduce reservoir level, install positive cut-off in critical areas, etc.

Regarding Brambei Mom and Kdol dams, there is a need for the motorization of gates (with stand-by generators as observed in the Damnak Ampil Barrage), regular monitoring (especially periodic geodetic surveys of embankment crest profile and installation of seepage measurement device at previously affected locations), flood warning system with sirens, road surface improvement, and removal of excessive vegetation on slopes.

The dam safety measures will be detailed by the Dam Safety Consulting Firm.

8.1.3.2.8 Canals

The proposed canal design aims to serve both irrigation and drainage purposes due to the scheme's topography, limited water resources, and potential land resettlement issues. Whenever feasible, the canal alignment will closely follow the existing path to minimize social impacts. The canal's size will vary based on the irrigated area and topography.

However, it is advisable to construct the canal section as depicted in Figure 5-21, maintaining a full cutting approach based on the existing conditions. Given the limited water resources and lessons from Cambodia, it is recommended to build main canals with measures to reduce percolation and infiltration. To prevent the loss of valuable clay material for construction, using concrete lining for the main canals or suitable alternatives is suggested. This approach will enhance the infrastructure's long-term sustainability and improve water distribution.

All canals' characteristics will be defined at the detailed Design phase.

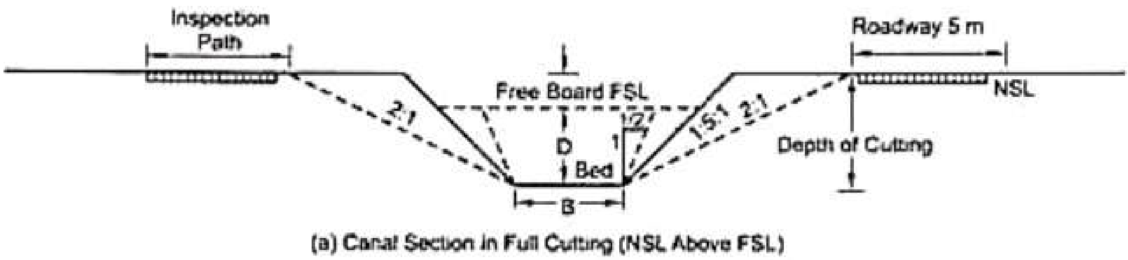


Figure 5-21. Canal section on full cutting section

8.1.3.2.9 River training and drainage

8.1.3.2.9.1 Determination of drainage system layout

The main natural drainage channels will form the core of the planned system to drain excess runoff during the rainy season and mitigate inundation and waterlogging in the command area. The system will also serve as the outlet for the on-farm drainage system, designed to drain surplus irrigation water and control the groundwater table.

As the project main objective is to develop and increase agricultural production in the area, the drainage system will be designed for a 5-year (5% probability) return period for the main rivers and a 5-year (20% probability) return period for all other drains.

The layout of the drainage system will be based on:

- The main natural drainage channels.
- Incoming sources (watersheds upstream of the proposed main canal, direct rainfall over the command area and water level changes in Tonle Sap).
- Land use (crop types and layout, and field management).
- Planned irrigation systems.

The main drains will be based on the existing natural river.

The internal drainage system will be proposed as per the requirements and will follow the agricultural plot layout and irrigation systems.

Additional drains will be constructed upstream of and parallel to the main canal as diversion and interception drains to reduce crossings on the main canal and protect it. These drains will divert floodwater as topography permits to the drainage system.

8.1.3.2.9.2 Review of hydrological data

8.1.3.2.9.2.1 *Sources of Floods*

There are three sources of water creating floods in the command area: runoff from the upper watersheds; fluctuations in Tonle Sap and others large stream water level; and runoff created from direct rainfall over the command area. These phenomena are described below.

8.1.3.2.9.2.2 *Runoff from the upper watershed*

According to the hydrological study and field assessment, only watershed is rainfall-runoff to the command area. The table here presents the calculated discharge values in m^3/s for this watershed.

Table 5-7.Krong Ponley peak discharges for various return periods in years (m^3/s)

Name	Catch ment area (km^2)	Peak Discharges for various return periods in years (m^3/s)			
		T=5	T=10	T=25	T=50
Location 34		255	307,9	377,9	430,9
Location 10		151,7	186,5	232,6	267,4
Location 26		2,2	3,5	5,2	6,5
Location 21		2,4	3,6	5,1	6,2

8.1.3.2.9.2.3 *Runoff from direct rainfall over the command area*

Runoff developing in the command area from direct rainfall is supposed to drain through the drainage system, crossing the area generally in a south/north direction. Several obstacles prevent smooth flow towards the main drainage system, namely:

- Undulating terrain caused by the natural movement of sediments on the surface, sinking of clays, and management of farming activities.
- Overtopping of water flowing in the drainage system, which contains sediments that settle on the banks and create parallel mounds, interfering with the inflow from the area.
- Blocking up of the drainage system, due to sliding banks, sediment deposition and the development of secondary gullies.
- Rows of transverse mounds, in east-west direction, which developed on the interface of the lake and the main general flow direction of the area, in the north-south direction.
- Temporary obstacles constructed by the farmers on the drainage system to divert water to their plots.

Considering direct rainfall over the command area, calculations will be performed for the total watersheds contributing to the drain.

8.1.3.2.9.3 Main natural drainage channels

8.1.3.2.9.3.1 *General*

The project includes the rehabilitation of Anlong Chrey River which crosses the command area.

The characteristic flood flows of Anlong Chrey River are shown in theTable 5-7.

8.1.3.2.9.3.2 *Design discharge and flood risks*

Considering the catchment area of the river, which can be responsible for flooding in the command area, it is proposed to design these canals for discharge of a 5-year return period. This is also necessary to protect the irrigation infrastructure and agricultural fields from flood damage. The road crossings on these rivers will be designed for discharges corresponding to a 25-year return period.

The existing capacity of these canals is very small compared to the design discharge values and it is not practical or economic reasons to excavate these natural canals for a return period discharge values exceeding 5 years.

8.1.3.2.9.3.3 *Canal shapes and Hydraulic Structures: Locations and Types*

In addition to the risks to the agricultural fields, there is a risk for the canals themselves. There is a need to establish their cross sections against erosion and silting. The alignment of the designed canals will follow the natural one. Their general shape is trapezoidal, with side slopes not less than 2:1 (H:V).

8.1.3.2.9.4 Internal drainage system

The preliminary need of a drainage system in an irrigation command area is to remove excess water from the ground surface as well as from the root zone in the sub-soil. The main source of excess water on the land surface is the rain falling over the catchment area.

The surface drainage system is most effective in case of impermeable soils or where infiltration is impeded by an impermeable layer. Considering that the soils are sandy with a good hydraulic conductivity, a surface drainage system or a sub-drainage system could be implemented.

The detailed design will detail the drainage system block by block based on the topography and needs.

8.1.3.2.9.5 Polder

The project includes the creation of 4,5 km of embankment on the northern part of the Stoeung Krang Bat irrigation scheme to keep protect land from tidal action and the uncontrolled flooding of the Tonle Sap. This will bring a major landscape change to allow the cultivation of wet season paddy and protect houses and property from the floods.

A polder typically will include the embankment encircling it that keeps out the water from the surrounding water flow from the Tonle Sap, the drainage canals (natural rivers converted to canals when embankments were constructed) inside the polders that remove the excess water particularly at low tide and a sluice that is opened at low water level to release the water from the polder. The sluice also doubles up as an irrigation intake during times of water shortage for instance in the rainy season if there is often a dry spell in between rainy days that can have a major impact on crop yields.

8.1.3.2.10 Structures

The water will be diverted from the different source of water to the main canals, based on water availability and a demand calendar prepared collectively, by FWUC/PDoWRAM according to the crop requirements.

Several cross structures will maintain full supply level in the main canals and in the secondary canals where required. The designed discharge to each canal shall be delivered by operating the gates of the head regulators. The tertiary canals will ultimately deliver water to the fields through pipe outlets, fixed at desired locations.

The gates allow to control the flow delivered to each canal. Head regulator gates will control the water flow in one canal, cross regulator gates will control the water flow inside the same canal.

Then, the farmers will have two choices after the tertiary canal: irrigation plot to plot or through the construction of field ditches.

8.1.3.2.11 Tertiary system

Feasibility study includes the design of up to the tertiary canal levels, which is the complete irrigation system. The tertiary canal supply water to quaternary canals, which farmers must construct.

The numbers of tertiary canals and drains in each main canal will be estimated at the detailed design phase.

Two options will be considered: 1) Traditional excavate tertiary canal or 2) collective solar pumping station.

8.1.3.2.11.1 Traditional excavate tertiary canal

The first option will be to create traditional tertiary canal alignment in excavation. The farmers will diesel pump individually to the canal based on their needs.

These tertiary canals require high appropriation from the beneficiaries as the canal alignment needs to be accepted by the farmers without land compensation as per RGC"s regulation. This can lead to inappropriate water delivery to the plots.

8.1.3.2.11.2 Collective solar pumping station

Presently across the agriculture sector in Cambodia, those that irrigate do so by pumping from water sources using in vast majority diesel pumps, thus generating CO2 emissions through the burning of fossil fuels. This is well a high cost for the farmers to produce agricultural product, especially with the uncertainty of the fuel price.

The project aims to demonstrate replacement of these diesel pumps with collective solar pumping system (Appendix 10). A move to this low-tech solution that uses only solar energy to lift the water will eliminate the burning of fossil fuels to irrigate and thus stop this source of CO^2 emissions. The technology, solar pumping system, is simple, requires low maintenance and operation. It is potentially suitable for replication in most areas with surface water. In addition to mitigation benefits, the technology could also contribute to adaptation as (unlike diesel pumps) there is no fuel /running cost, so the pump can be used to lift additional volumes of water compared to diesel pumps.

The solar pumping system of water could be coupled with a pre-paid system to ensure the sustainability of the system and water delivery at the farmers plot with pipeline to improve the water efficiency (20%) and avoid land issue on the tertiary canal alignment. The water efficiency will also save money on the solar pumping system construction.

On Krang Ponley Sub-project, the Kropeu Trom, Yotasast and Stoeung Krang Bat schemes seem more adequate for implementation of collective solar pumping stations as it is more protected from flood and closer to villages to prevent potential damage.

8.1.3.2.12 Operation and Maintenance

The operation and maintenance of the Reservoirs, Diversion structure, MCs will be done by PWDRAM, while operation and maintenance of SCs, SDs, SSCs and TC/TDs will be done by FWUC with support of PWDRAM.

The capacity strengthening of MoWRAM, PDWRAM, and the FWUC in climate smart irrigation system and asset management is key to operational sustainability. The Project includes technical capacity building and matching financing planning to ensure system durability and climate resilience. Structural interventions incorporate climate adaptability, socio-economic conditions, and sustainability. Climate change, population growth, land-use change, gender, access, and on-farm resilience and financial growth are thoroughly considered, adopting a long-term perspective in the Project design. Enhancing flood and drought resilience through nature-based/ecosystem-based approaches and climate-proofing structures will mitigate the impact of extreme weathers and provides consistent water flows that farmers depend on for multiple cropping.

8.1.3.3 Design criteria

Guidance for design criteria is detailed in Appendix 12.

8.1.3.4 Construction Cost Estimates

The feasibility level cost estimate has been developed for the construction up to tertiary canals. The quaternary canals must be developed by the FWUC themselves. The actual cost estimate for the detail designs should be done after having done the topographic and geotechnical studies.

Unit rates were taken from typical rates used in the recent years similar work of MOWRAM.

The overall cost of the schemes in the Krang Ponley project is provided in Annex 4.

8.1.3.5 Schedule

Should the feasibility study for the Krang Ponley subproject proceed to the detailed design, then allowing for the design process, procurement process and approvals, it has been assumed the following planning as displayed in the Figure 5-22.

The following assumptions have been made:

- The detailed design will start in January 2026;
- The procurement process will not take more than three quarters;
- The construction work will start after the rainy season in Cambodia with a mobilization period (last quarter of the year);
- The construction work duration will not last more than two dry seasons.

Hence the construction would be able to commence at the last quarter 2026 for the three first schemes (Kropeu Trom, Yotosast, and Stoeung Krang Bat) with total completion by mid-2031 for Brambei Mom irrigation scheme.

	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6			
COMPONENTS, SUB-COMPONENTS, OUTPUTS and ACTIVITIES	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21	Q22	Q23	Q24
2.1.3 Kropeu Trom	X	X	X	X	X	X	X	X	X	X	X	X	X	X										
Activity 2.1.3.1 Detailed design	X	X	X	X																				
Activity 2.1.3.2 Procurement					X	X	X																	
Activity 2.1.3.3 Construction work and supervision								X	X	X	X	X	X	X										
2.1.4 Yotosast	X	X	X	X	X	X	X	X	X	X	X	X	X	X										
Activity 2.1.4.1 Detailed design	X	X	X	X																				
Activity 2.1.4.2 Procurement					X	X	X																	
Activity 2.1.4.3 Construction work and supervision								X	X	X	X	X	X	X										
2.1.5 Stoeung Krang Bat	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X						
Activity 2.1.5.1 Detailed design	X	X	X	X																				
Activity 2.1.5.2 Procurement					X	X	X																	
Activity 2.1.5.3 Construction work and supervision								X	X	X	X	X	X	X	X	X	X	X						
2.1.5 Brambei Mom				X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		
Activity 2.1.5.1 Detailed design				X	X	X	X	X																
Activity 2.1.5.2 Procurement									X	X	X													
Activity 2.1.5.3 Construction work and supervision												X	X	X	X	X	X	X	X	X	X	X		

Figure 5-22. Tentative implementation schedule of Krang Ponley irrigation scheme.

8.1.4 Engineering consultancy

Component 2.1 include the contracting of a consortium of both, international and national companies to prepare the detailed design and tender documents of the 3 sub-projects (6 schemes) for component 2.1 and 2.2, support the MOWRAM in the procurement process, but also undertake the work supervision and commissioning of the scheme's rehabilitation/constructions.

8.1.4.1 Consultants' activities

The Consultant shall collect, review and analyse available documents on the project in order to undertake detailed designs for irrigation schemes and flood protection/drainage improvement.

The Consultant shall also undertake a specific study of the West Pursat hydraulic system of the irrigation schemes to implement the SCADA system.

8.1.4.1.1 Detailed design

8.1.4.1.1.1 Mains tasks for the detailed design studies

The main tasks of the consultancy services to be carried out within the detailed design work for all project components comprise, but are not necessarily limited to the following items:

- Conduct additional geo-technical investigations, topographical survey, hydrological, if required;
- Availability of borrow pits in the volumes and quality sufficient for construction;
- Hydraulic and structural design of head works, reservoir repairs if necessary, its supporting structures, the irrigation scheme including secondary, tertiary and on-farm canals that include distributary canals/ structures, drainage system/structures and associated structure as community requirement: foot bridge, FWUC office, access roads, etc;
- Hydraulic and structural design modelling, computation and design of the irrigation scheme (pipeline/canals system), simulation of operation, etc.
- Structural calculation notes, preparation of detailed plans and drawings in appropriate scale;
- Technical description of the projected system with justification of selected materials and equipment, implementation;
- Specification of the necessary materials and equipment;
- Preparation of technical conditions for delivery of materials, equipment, spare parts, repair material, equipment to be procured under the Project;
- Preparation of technical conditions for the construction and the assembly works;
- Detailed calculation of the overall costs, total calculation of the works (confidential cost estimate), separated in supply and construction works. Based on the findings, the Consultant shall submit a detailed cost breakdown including contingencies and other general costs. The cost estimate shall be divided in local and foreign costs.
- Green House Gas (GHG) reductions: analysis of the potential of green-house gas (GHG) reductions in the frame of the current stage of the investment program.

The Consultant is required to work with the Board of Engineer of Cambodia (BEC) for the Khmer translation of the technical specifications that shall be in accordance to stated and agreed standards and codes of practice, that include also the specifications for environmental, social, health and safety management (ESHS) of the civil works.

Based on the findings, the Consultant shall assess the local/regional/international construction capacities and interest and submit a proposal for contract packaging. It is expected that all construction works shall be submitted to national bidding procedures.

The purpose of the drawings is to convey graphically to the bidders and later on to the construction engineers and contractors the work to be done. All information which can best be shown by reference to drawings and their accompanying dimensions and notes shall be shown on the plans. The consultant shall produce comprehensive engineering drawings to the standards of internationally accepted design practices using CAD. These drawings shall cover all features of the work and be of adequate detail for the bidding and award of contract.

The drawings will consist of general arrangement drawings, detailed drawings, longitudinal and cross-sections which indicate the dimensions of the works and the materials required for the execution. The detailed design drawings will become an integral part of the contract documents.

The confidential cost estimate shall comprise a comprehensive descriptive part which outlines and justifies in detail the assumptions taken and assessments made by the consultant for calculating and/ or defining important unit prices under full consideration of individual geographical and project specific aspects.

The relevant design calculations, supplementary maps and drawings, schedules, charts, notes and reports etc. which support the engineering designs and drawings shall be furnished to the PIU in English.

For irrigated schemes, the recommended criteria to overcome the detailed design study phase for each project, and move to tender preparation and implementation phase, are:

- Output : (i) Detailed design and tender documents, Scheme Design Agreement, (ii) Resettlement framework and COI and schedule (IRC)
- Water/Environment : (i) Water management Apex committee is appointed at basin or sub-basin level if required, (ii) Environmental mitigation measures in design, (iii) IEE is approved by the relevant authority
- Cost/Economic : there is no major increase in construction cost compared with the estimated costs at feasibility level, (ii) Reconfirmation that EIRR is > 9%, (iii) construction cost are around $2,500 per ha cropped in 1 year (including the tertiary canals)
- Social / Poverty : (i) resettlement: DMS is completed by IRC and compensation levels agreed by affected households, (ii) Resettlement framework is approved by RGC/IRC,
- Sustainability : (i) Construction Sub-Committee established, (ii) Design Layout, Beneficiaries' contribution to the construction and O&M costs and FWUC revision/creation are approved by 2/3 of beneficiaries and Local Authorities, (iii) Membership fees paid by 2/3 of the users/members of the FWUC, (iv) Design Agreement signed by local authorities and Construction sub-committee.

8.1.4.1.1.2 Deliverables

For each Irrigation scheme, reports to be delivered are listed here after. These reports should be fully reviewed by MoWRAM to ensure agreement on executive choices regarding the project. However, explicit approval is not required for every report scheduled. The following list gives the review level proposed to be considered for each report.

- Mid-term Detailed Design Report: Review only;
- Detailed Design Report (draft version): Review only;
- Detailed Design Report (final version): Review and approval required.
- Drawings: Design drawings will be submitted throughout the study. In a general way, drawings submitted while the studies are still on-going will be submitted under draft format. Drawings to be submitted as part of Detailed Design Report however will be considered as representative of the project development and submitted as such.

8.1.4.1.2 West Pursat hydraulic system analysis

In addition to the usual work for the rehabilitation/creation of irrigation schemes (FS, DED, procurement, work supervision), it is requested to the Consultant to perform a specific study of the West Pursat hydraulic system to have a better understanding of the hydraulic functioning of this area.

The analysis should include at least:

- An extensive data field collection: size of the structures, hydraulic measurements, etc
- A river basin modelling of the Pursat catchment of the water availability for irrigation, which depends from the basin characteristics (precipitation, runoff), the reservoirs infrastructures and management as well as non-agricultural needs; and,
- A scheme modelling with an adequate software like SIC to be able to identify the structural limitation, which is dependent on the canals and gates capacities along the schemes, and integrate all the schemes within the study area and be a base for the development of the SCADA. The software should be able to design and management of a network of canals and / or rivers with a friendly interface and the calculations of hydraulic unidimensional steady and unsteady flows

The results of the study will be upgraded with the different scenarios to irrigate Ou Ta Paong scheme and confirm the feasibility study and be a base for the development of the SCADA system.

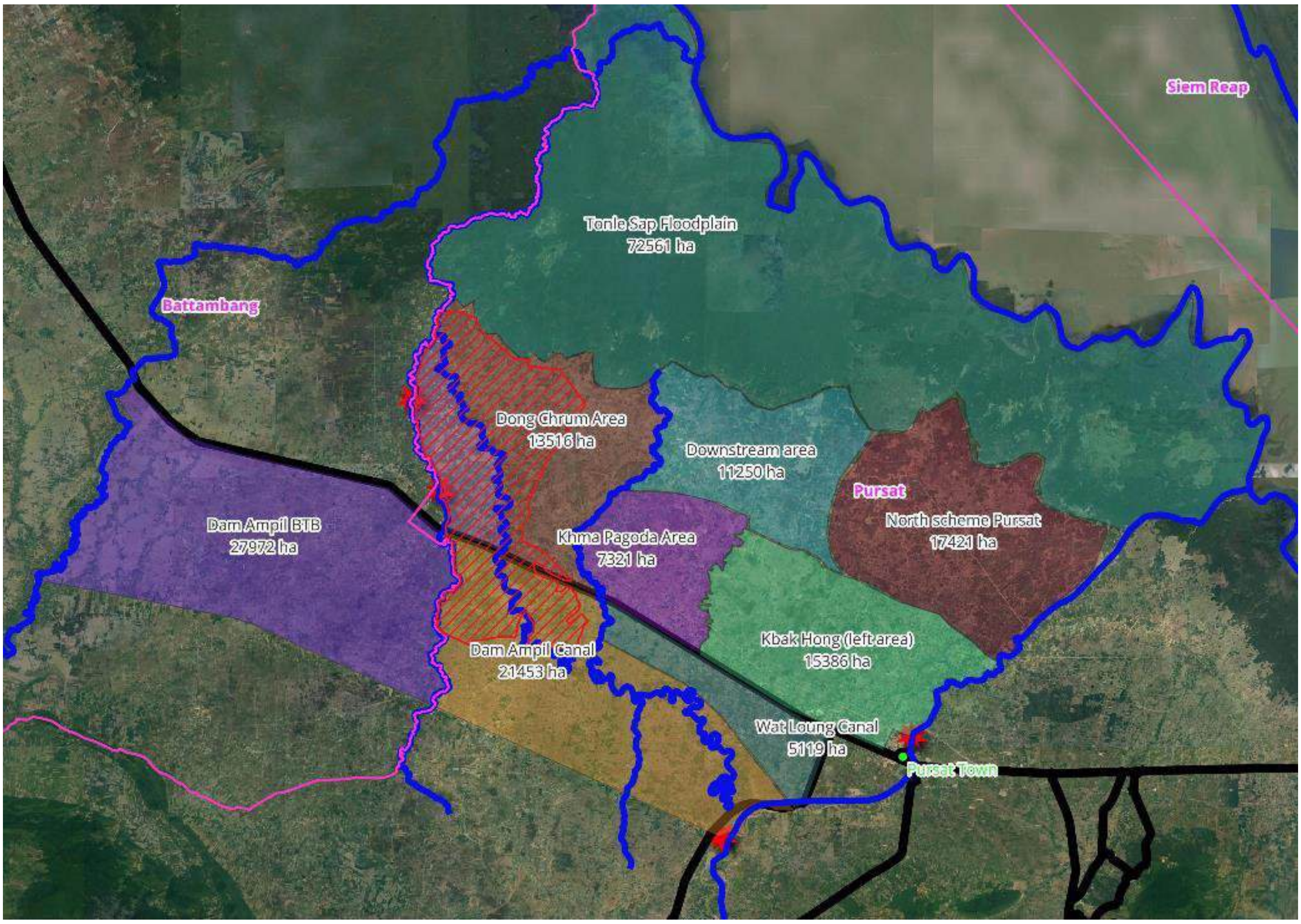


Figure 5-23. irrigation scheme of West Pursat Province

8.1.4.1.3 Preparation of tender documents and procurement support

The tender documents shall be prepared regarding packaging of tenders and based on the Detailed Design study. The tender documents shall be prepared in accordance with Standard Operating Procedures by the Sub-Decree No.74 ANK. BK dated 22 May 2012 which are the standard operating procedures of the Client, as amended from time to time, providing procedures applicable to all externally financed projects and programs.

8.1.4.1.3.1 Preparation of the tender documents

In order to assist in the tendering process, the tender documents should be prepared including clear specifications. The specifications shall describe the work to be done, supplementing the information shown on the drawings. The specifications shall cover all technical provisions of the future construction contracts. The design shall be sufficiently detailed for construction and leave for the Contractors the preparation of Final Design study (drawings). All technical specifications shall be fully described and the tender documents shall include the ESMP to be implemented by the Constructor.

Reference to brand names, catalogues or other details that limit any materials or equipment to a specific manufacturer shall be avoided. Where standard specifications or construction codes and practices are referred to, a statement shall follow that ISO shall be applied and other national or international standards that ensure equivalence will also be acceptable.

The bill of quantities shall provide sufficient information on the quantities of works to be performed in order to enable bidders to prepare accurate cost estimates and the owner or its consultant to make periodic evaluations of the executed works according to the detail provided in the bill of quantities. The bill of quantities shall divide the items into different classes (civil works, mechanical and electrical equipment and materials, etc.) and categories (earth works, concrete works, mechanicals, etc.).

In order to enable the PMU/PIU to allocate a budget for the implementation of the works, including any amounts to be allocated for any physical and price contingencies, the Consultant shall prepare the cost estimates of items listed in the bill of quantities. Similar contracts recently awarded in Cambodia may serve as a guideline for the evaluation of unit costs. The Consultant shall, however, carry out its own investigations on the local market for construction materials available there and the local labour skills and in foreign markets for any equipment and materials to be imported or any skilled labour where necessary.

For each lot, the Tender Documents for the works contractors shall contain at least the following sections:

- Invitation to tender;
- Instruction to tenderers;
- General and specific conditions;
- Form sheets;
- Form of contract agreement;
- Technical specifications;
- Description of works, subdivided in specific lots;
- Bill of quantities for each lot and in total;
- Maps and drawings;
- ESMP

Tender documents to be delivered are listed here after:

- Tender documents (draft version): Review only;
- Tender documents (final version): Review and approval required.

8.1.4.1.3.2 Support on the tender process

The consultant should assist MOWRAM in the following tasks:

- Assistance in Tender Announcement: The Consultant shall assist the Employer in all related activities regarding announcement of the project in national and international gazettes and on internet.
- Assistance in Clarification Meeting: The Consultant shall assist the Employer in the site visits of the bidder and clarification meetings to be held in course of the tender process. Questions which might rise up during the clarification meeting shall be responded by the Consultant via PIU and shall be forwarded to all tenderers.
- Assistance in bids evaluation: The Consultant shall assist the Employer during bid opening, bids evaluation and selection of the technically and financially most favourable offer. The Consultant shall provide up to two members to each Evaluation Committee.
- Assistance in Contract Negotiations: The Consultant shall assist the Employer during contract negotiations for each Work Contract and shall assist the Employer in all preparations up to when the contracts are signed.

The Consultant shall submit inter alia the following:

- Copy of Announcement;
- Tender Opening Protocol for each Works Contract;
- Bids Evaluation Report for each Works Contract;
- Works Contract.

8.1.4.1.4 Work supervision

The Technical Supervisor's role shall include project management, technical, contractual, financial, environmental and social aspects as described in the following sections.

A key objective of the Technical Supervisor role is to ensure that all elements of the project implementation including the construction contracts and ESMP are coordinated, thus minimising the scope for completion and commissioning delays due to programming constraints or incompatibilities between individual components, while making sure that quality of works and equipment respect the final, approved design.

This includes assisting and advising the PMU and PIUs with smooth execution of all works under the investment program for its timely and successful completion without having cost overruns. This applies to supervising all works, surveys, field studies, investigations, trainings, and consulting services packages under the investment program. The consultant shall be responsible for documenting all the design drawings, reports, as-built drawings, and construction monitoring and quality certificates. The consultant shall develop an appropriate documentation plan for this purpose.

Direct liaison with FWUC for on-the-job training regarding work supervision and O&M. Khmer translation of BOQ, technical specification and designed drawings, reports, as-built drawings should be provided to FWUCs to ensure good appropriation by FWUCs of the designs and O&M tasks and to enhance their contribution to temporary and final reception of works.

The Consultant will supervise the construction of the works included under the Contract issued to the Contractor, to the standards and specifications detailed in the construction contract including checking layout and dimensions, quantities, material qualities, workmanship, safety and employment conditions and environmental standards.

The Consultant will keep the PMU fully informed of construction progress with regular monthly progress reports and will ensure that regular interim payment certificates (IPCs) for works completed on the contract are prepared and approved at the end of each period.

- The Consultant will summarize the construction works in (i) a brief monthly report, (ii) technical report including certification that the works were completed in compliance with the Agreement and notice of where works deviated from the Contract and (iii) comprehensive final Completion Report.

- Upon completion of the construction of the works included in the Contract, the Consultant shall notify the PMU in order that they can make a final inspection of the work for acceptance that will trigger the mechanism for release of payments to the Contractor subject to contract conditions.
- The Consultant shall submit detail scope of the service for the supervision of construction works prior to the delivery by PMU of the letter of commencement of work.

The Consultant will help administer the contractual responsibilities and obligations of the Client in the Contract and all related contracts for engineering, supervision, supply, erection and construction, to the extent allowed for in the construction and supply contracts.

Activities to be performed on site for the civil works will consist mainly of the following:

- Approve the contractors' construction methods;
- Check and approve the contractors' work, temporary installations and equipment;
- Coordinate, supervise and inspect all aspects of construction, fabrication and assembly;
- Check the conformity of the drawings with the contractual arrangements on site;
- Monitor defects reports and the corresponding replacement of damaged equipment;
- Check all final layouts of structures built by the contractors, on the basis of the layout drawings;
- Supervise the performance of all tests required to ensure the good quality of all materials used in construction, in particular soils, rocks, aggregates, cement, etc. and analyse test results to ensure good-quality construction;
- Check the quality control and safety procedures proposed by the contractors, paying special attention to the following tasks:
- Checking of preliminary tests prior to the works on the concrete mix designs proposed by the contractors;
- Checking of reinforcement drawings and assembly drawings;
- Perform the necessary checks to assess the progress of works and conformity with the corresponding regulations,
- Approve the equipment acceptance procedures to be followed on site by contractors,
- Issue payment certificates to contractors,
- Recommend any additional modification judged to be necessary in relation to the provisions set forth in the contract,
- Record all site activities,
- Assist the Client with all contractual aspects relating to contractors (guarantees, test certificates, insurance, claims, etc.),
- Check and supervise the measures needed to ensure safety and environmental protection,
- Draw up a Final Report on the works,
- Gather all information concerning the site, drawings and sketches and prepare “as-built” drawings of the civil engineering works,
- Issue completion and pre-commissioning certificates for the equipment,
- Ensure that all arrangements required by the environmental and social management plan have been made by the contractors responsible for carrying out the works.

The consultancy services to be rendered shall include but not be limited to the sub-tasks specified below.

8.1.4.1.4.1.1 *Monitoring of Construction Progress*

The Consultant shall monitor the progress of the construction and pursue compliance with the latest agreed version of the Master Programme for the Project. The Consultant shall arrange periodic co-ordination meetings with the contractors to discuss progress, and to assist in deriving suitable remedial action where necessary to address issues arising.

The Consultant shall report regularly to Client at least monthly and more frequently in the event of specific circumstances requiring immediate consideration.

8.1.4.1.4.1.2 2.2.2.2 Monitoring of Manufacture of Equipment

The Consultant shall monitor the manufacture of the hydro-mechanical equipment, electro-mechanical equipment including main factory acceptance tests. In particular, the Consultant shall:

- Monitor compliance with deadlines for manufacturing, testing, shipping and supplying equipment on site by performing systematic inspections;
- Ensure that equipment conforms with contract specifications and standards;
- Examine any modification in relation to the contract specifications that the contractors may wish to make. Any modification leading to additional costs must be submitted to the Client for approval;
- Examine and approve the programme for testing and works acceptance proposed by the contractors, participate in works acceptance procedures and draw up the reports for each works inspection.
- Ensure that the main items of equipment have been subjected to the prescribed tests on the basis of the corresponding test certificates, which must be submitted to the Technical Supervisor for approval;
- Participate in the routine tests for the main items of equipment.

8.1.4.1.4.1.3 Commissioning Tests and Works Completion Inspection

Commissioning tests shall be witnessed by the Consultant with the participation of the Client's employees. The Consultant shall ensure compliance with the procedures established in the specifications and contracts, and performance levels, check the quality and conformity of test reports, collect all documents, and approve the test reports drawn up by contractors. These reports shall be signed jointly by the Technical Supervisor, Client and the Contractors.

At the end of the construction works and commissioning the Consultant shall:

- Witness the specified acceptance procedures for all the structures and equipment (power generation plant and transmission lines) and issue the corresponding certificates in agreement with the PIU,
- Check and approve the as-built drawings and diagrams provided by contractors,
- Review and approve the operation and maintenance manuals provided by contractors.

8.1.4.1.4.1.4 Certification of Payments

The Consultant shall certify the Contractors' entitlement to payment based on regular monitoring of defined milestones achieved in the construction of the works.

8.1.4.1.4.1.5 Operation and Maintenance Manuals

The Consultant shall review and approve, if appropriate, the Operation and Maintenance Manuals provided by the Contractors and shall ensure that these are provided in good time prior to commissioning of the Works.

8.1.4.1.4.1.6 As-built Drawings of Hydro-mechanical and Electro-mechanical Equipment

The Consultant shall review and approve, if appropriate, the As-built Drawings provided by the Contractors and shall ensure that these are provided within 2 months after commissioning of the Works or as stated in the Contractors' Contracts.

8.1.4.1.4.1.7 Assistance to Client

The Consultant shall assist Client with regard to all questions relating to the Contracts, in particular compliance with performance bonds, insurance and claims, etc.

8.1.4.1.4.1.8 Assistance in Conflict Resolution

The Consultant shall provide assistance to Client in their efforts to settle any conflict arising between the Contractors and the Client.

8.1.4.1.4.1.9 Site Meetings and Reporting

The Consultant shall chair regular site meetings with the Contractors to be held at least once per month. The Consultant shall draw up minutes of meetings, periodic site monitoring reports and acceptance reports and shall issue such reports to the Client without delay.

8.1.4.1.4.1.10 Co-ordination of ESMP

The Consultant shall monitor progress by the Contractors in implementing the ESMP.

The Consultant shall draw the immediate attention of the Client any slippage in the progress of these activities in order that remedial actions may be put in place in a timely manner to allow completion of critical activities prior to the planned date of reservoir impounding of the dam.

8.1.4.1.4.1.11 Supervision of Defect Correction

The Consultant shall supervise the activities of the Contractors in rectifying identified defects in the works and shall ensure that the final works are in accordance with the contract.

8.1.4.1.4.1.12 Reporting to MoWRAM PMU/PIU

The Consultant shall attend and shall chair regular site meetings with the Contractors to be held at least once per month. The Consultant shall draw up minutes of meetings, periodic defects correction status reports and shall issue such reports to the Client without delay. Before taking any action under the contracts designating the Consultant as “Technical Supervisor”, for which action, pursuant to such contracts, the written approval of the Client as “Employer” is required.

8.1.4.1.4.1.13 Reporting

The Consultant shall report regularly to Client. These reports will primarily serve to record the status of each contractual element of the project with regard to progress of all aspects of the project, identifying any impending problems with respect to project coordination, time over-runs or any situations potentially having cost implications.

Reporting include:

- Monthly reports

The Consultant will submit monthly progress reports (hard and soft copies) covering technical and financial matters pertaining to the contracts for construction of the project to the Client throughout the duration of the services. The Consultant shall also provide a monthly report of progress relating ESMP drawing upon information from monitoring of the activities of the implementing agencies. The reports will be submitted by the 7th day of the month following the reporting period. The monthly reports will document services performed by the Consultant during the reporting period. The reports will be structured consistent with the separate contracts under the Consultant’s supervision. Programming interface issues will also be addressed in the reports. The monthly report shall be drawn up in three (3) copies in English + 1 electronic copy.

- Quarterly report

Throughout the duration of the main works, detailed quarterly reports (hard and soft copies) will be submitted two weeks after the end of each quarter. These reports shall be drawn up in three (3) copies in English + 1 electronic copy.

- Preliminary completion report

At the end of the works and after provisional acceptance of the installations under the contracts, the Technical Supervisor shall send a preliminary completion report within a period of two months.

This report shall take into account both technical and financial aspects and will be produced in three (3) copies in English + 1 electronic copy.

- Final completion report

At the end of the guarantee period and after final acceptance under the contracts, the preliminary completion report drawn up after the provisional acceptance of the works shall be updated to form the final completion report for the works. This will then be sent in three (3) copies in English + 1 electronic copy.

8.1.4.2 Estimates budget

The estimated budget for the consultancy services is provided in Annex 4.

8.2 Sub-component 2.3. – Farmer Water User Communities established and trained

The project will support the establishment and capacity building of the FWUC from the participatory approach of FWUC creation in the design, development and sustainable use of the rehabilitated irrigation schemes to be rehabilitated by the Program to the signature of shared responsibility for the management and maintenance of irrigation infrastructure between FWUC and MOWRAM.

The support to the FWUC shall address the following issues:

- Institutional: dialogue with MoWRAM, legal recognition, responsibility sharing agreement,
- Organisational: governance, internal operating rules for water and scheme management, agricultural development and marketing,
- Technical: participation in the design of the irrigation networks, execution of maintenance and servicing tasks, farming practices;
- Financial: preparation of budgets, fundraising, accounting management, Irrigation Contribution Service (ISC) planning and collection, access to financial institutions,
- Gender focus with strong action for women's empowerment and their social participation.

MOWRAM will give a mandate to the consultant for the establishment and support to the FWUCs in the irrigation schemes rehabilitated by the Program, to (i) assist farmers water users to create and organize one FWUC in each of the irrigation schemes to be rehabilitated under the project, and (ii) to build up the capacities of these FWUCs to fulfil their operation and maintenance responsibilities.

The project will bring specific attention on the following topics (but not only):

- Technical design for the rehabilitation of irrigation schemes (i) attempt to accommodate farmers' views in designing the irrigation scheme layout, (ii) define the appropriate consultation procedures with beneficiaries for establishment of farmers' water user community (FWUC) and for system design to enable the envisaged water allocation.
- Social water management: assist in the preparation of operation and maintenance (both routine and periodic) manuals (guidelines and procedures) for the subprojects at the detail design stage, and in their further improvement during the first years of operation and maintenance.

8.2.1 Methodology

The FWUC creation and strengthening methodology is participatory and based upon the Government of Cambodia PIMD strategy that is outlined in the 5 training modules prepared by the FWUC Department (previously the FWUC section of the Dept. Irrigated Agriculture) which were formulated in order to guide implementation required under Circular One and Prakas 306. The FWUC curriculum is shown below and incorporates lessons learned under the Northwest Irrigation Sector Project, the Water Resources Management Sector Program, as well as work undertaken by ISC and also the FWN (where relevant).

Initial project orientation training is provided to the provincial teams and PIU, and this includes the key steps in FWUC development. This training is then provided at community level via dissemination meetings.

One of the first tasks to be addressed in the preparation is a landowner/user map.

Circular One and Prakas 306, in conjunction with the 5 PIMD manuals, specifically Module 5, indicate 10 key steps in FWUC establishment and leading through to IMT (now referred to as RSA):

Table 5-6. FWUC establishment steps according the GoC PIMD

GoC PIMD Steps	Prescribed Tasks
1 – Hold initial meetings at system or sub-system level.	1. FWUC support team conduct orientation meeting about project. FS process. GRM dissemination. 2. Introduce PIMD concept. FWUC. Roles etc, ISF. 3. Participatory mechanisms – CSC, SSC, AG, FWUCC. 4. Conduct PRA meetings to discuss current irrigated farming – water resource and use, distribution and management, identify constraints and opportunities. 5. Meeting to plan next steps
2 – Identify irrigation service area and potential members of the FWUC and conduct PRAs	1. Use preliminary design to identify hydraulic boundaries of prospective FWUC. 2. IDS area mapping, plot and landowner identification, production of land holding map. 3. Identify names of prospective members of FWUC and sub units. 4. Discuss and make preliminary agreement about eligibility criteria for membership in FWUC. 5. Conduct PRA on irrigated agriculture 6. Conduct PRA on irrigation system management and development
3 – Farmers agree to form FWUC and plan organizing activities	1. Meeting to discuss and make decision whether to form FWUC 2. Participatory planning of PIMD activities 3. Agree on farmer actions towards establishment of the FWUC 4. Election of FWUC statute drafting committee 5. Meeting to discuss role and desired characteristics of the FWUC assistant 6. Selection of FWUC assistants by Statute Drafting committee Initial training of FWUC assistants and preparation of work plans 7. Selection of FWUC Board
4 – Farmers prepare and adopt FWUC Statute and By-Laws	1. Orientation and training for Drafting committee members about legal, organizational and managerial aspects of FWUC and PIMD. 2. Committee completes draft Statute and By-Laws 3. Draft Statute and By-Laws reviewed and approved by FWUC Support Team. 4. Draft Statute and By-Laws discussed and revised in a general meeting of prospective members 5. Revised Statute approved and signed by all prospective members. 6. Registration of members.
5 – Farmers establish FWUC and select leaders	1. Election of WUG representatives (block level) 2. Election of Secondary Canal committee Representatives (if needed) 3. Election of FWUC Committee (President and other offices at irrigation scheme level and includes block leaders) 4. Registration of FWUC with MOWRAM and provincial government 5. MOWRAM and provincial government acknowledgement of Statute and By-Laws

	(constitutes formal recognition)
6 – Build capacity of FWUC to prepare an Irrigation Service Plan	1. Training of FWUC officers in water delivery, scheme maintenance, preparation of Irrigation Service Plans and budgets and financial management (most of which should be task oriented, on-job coaching by FWUC Support Team members and other resource persons) 2. Detailed inventory of all infrastructure in the irrigation system and assessment of its current relevance and functional condition. 3. Together with FWUC Support Team prepare an Irrigation Service Plan for current situation (ie: prior to significant repairs and improvements to the irrigation system) 4. With assistance from FWUC Support Team, the FWUC defines the agricultural development objectives of the FWUC. 5. In a general way, the FWUC identifies needs for repairs and improvements of irrigation system infrastructure. 6. With assistance from the FWUC Support Team, the FWUC prepares a draft Irrigation Service Plan for the anticipated situation after repairs and improvements in the irrigation system infrastructure would be made, including estimation of costs for implementing the Irrigation Service Plan and conducting periodic repairs and improvements 7. Recruitment or appointment of FWUC management staff. 8. Additional training of staff and FWUC officers in irrigation management.
7 – FWUC adopts and implements initial Irrigation Service Plan	1. Final preparation of Irrigation Service Plan budget by FWUC Board (with assistance from FWUC Support Team). 2. Calculation of irrigation service fee and determination of charging, collection, bookkeeping and financial management procedures (such a fee may be in money, share of harvest or contribution of labor or materials) 3. Discussion and approval of Irrigation Service Plan, budget and fee in FWUC general assembly meeting. 4. FWUC opens bank account (or makes other arrangements to deposit and manage funds collected) 5. Collection of Irrigation Service Fees (ISF) 6. FWUC Support Team assists FWUC (as needed) in implementation of its first Irrigation Service Plan.
8 – Prepare and adopt Management Transfer Agreement (or Certification of Management Authority)	1. FWUC Management Committee and FWUC Support Team discuss model Management Transfer Agreement (or Certification of Management Authority of the FWUC). 2. Draft transfer agreement is prepared, discussed, revised and approved by FWUC Board, FWUC Support Team and general assembly of FWUC. 3. After one full year of successful implementation of the first Irrigation Service Plan, the Management Transfer Agreement (or Certification of Management Authority of the FWUC) is signed by the FWUC Management Committee, MOWRAM, and the provincial government. Following is list of typical contents of Irrigation Management Transfer Agreements: 1. Service area and membership criteria 2. Updated inventory of infrastructure and equipment (if any) and clarification of ownership or long term use rights in the infrastructure transferred to FWUC, basic rights, authority and obligations of FWUC. 3. Rights, authority and obligations of government toward FWUC (such as to regulate, build capacity and provide support services) 4. Procedure for dispute resolution 5. Purpose and contents of Irrigation Service Plans (and obligation to prepare them) 6. Purpose, procedure and consequences of Irrigation Management Audit. 7. Protocol for relations between FWUC and government 8. Terms and conditions for transfer to be revoked. 9. Procedure for amending the Transfer Agreement (or COMA)
Step 9 – Repair and improvement of the irrigation infrastructure	1. Participatory identification of repairs and improvements needed and simple feasibility study and cost estimation. 2. FWUC and FWUC Support Team prepare, discuss, revise and approve draft design for improvements and plan for implementation (which includes joint financing). 3. For medium scale repairs and improvements for which the FWUC needs assistance, FWUC prepares its proposal for assistance for repair and improvement and submits it to the Provincial Irrigation Improvement Fund for consideration 4. If proposal to PIIF is approved, assistance is provided to the FWUC and the FWUC implements the repairs and improvements. 5. For larger scale rehabilitation or emergency works, special funding and arrangements are made but are always consistent with PIMD principles. 6. MOWRAM implements its role in construction (phased and contingent upon farmer

	contribution). 7. Repaired infrastructure is tested and FWUC Board signs approval of works
Step 10 – Continue capacity building and provision of support services	1. Periodic training for FWUC by the FWUC Support Team and possibly private sector entities. 2. Annual Irrigation Service Audits (to examine performance of FWUC and government). 3. Service Agreements (where scheme is jointly managed by FWUC and government or contractor). 4. Phase out government subsidy for Irrigation Service Plan budget (if applicable). 5. Establishment and functioning of regional or provincial Irrigation Improvement Fund in pilot locations. 6. Evaluation of PIMD.

8.2.2 FWUCs under CAISAR project

Under CAISAR project, it is estimated that the project will require the creation/capacity building of 11 FWUCs.

Table 5-7. List of FWUCs under the project

Sub-Project	Schemes	Numbers FWUCs	Existing (Y/N)
Ou Ta Paong	Svay Donkeov area	1 FWUC	
	Dong Chrum area	1 FWUC	
	Extension Dam Ampil	1 FWUC	Yes (partially)
Lum Harch	4 mains rivers	4 FWUCs	
Krang Ponley	Krapeu Trom	1 FWUC	Yes (partially)
	Yotasast	1 FWUC	Yes (partially)
	Stoeung Krang Bat	1 FWUC	Yes (partially)
	Brambei Mom	1 FWUC	
	TOTAL	11 FWUCs	

8.2.3 Water Social Management Consultant

A Consultant will be hired to provide service for the establishment of the operational FWUC from the participatory approach of FWUC creation in the design, development and sustainable use of the rehabilitated irrigation schemes and Preks to be rehabilitated by the Program to the signature of shared responsibility for the management and maintenance of irrigation infrastructure between FWUC and MOWRAM for all the irrigation schemes under the project area.

The support to the FWUC shall address the following issues:

- Institutional: dialogue with MoWRAM, legal recognition, responsibility sharing agreement,
- Organisational: governance, internal operating rules for water and scheme management, agricultural development and marketing,
- Technical: participation to the design of the irrigation networks, execution of maintenance and servicing tasks, farming practices;
- Financial: preparation of budgets, fundraising, accounting management, Irrigation Contribution Service (ISC) planning and collection, access to financial institutions,
- Gender focus with strong action for women's empowerment and their social participation.

MOWRAM gives a mandate to a Consultant for the establishment and support to the FWUCs in the irrigation schemes and Preks rehabilitated by the Program, to (i) assist farmers water users to create and organize one FWUC in each of the irrigation schemes to be rehabilitated under the project, and (ii) to build up the capacities of these FWUCs to fulfil their operation and maintenance responsibilities.

The consultant will work closely with the DED consultant on the specific topics:

- Technical design for the rehabilitation of irrigation schemes and Preks: (i) attempt to accommodate farmers' views in designing the irrigation scheme layout, (ii) define the appropriate consultation procedures with beneficiaries for establishment of farmers' water user community (FWUC) and for system design to enable the envisaged water allocation.
- Social water management: assist in the preparation of operation and maintenance (both routine and periodic) manuals (guidelines and procedures) for the subprojects at the detail design stage, and in their further improvement during the first years of operation and maintenance.

For each FWUC to be created, the services to be provided by the Consultant shall include the following steps:

<u>Phase 1: Consultation/validation on concept of irrigation system design:</u> The concept and design of irrigation systems will be presented, discussed and validated with and by farmers (or users). The main points to be discussed and agreed upon at this phase are: type of irrigation, irrigation method, canal alignment, scale of irrigation unit, estimation cost of this type of irrigation system per ha. This task will be conducted in close cooperation with the PDOWRAM, DED consultant , who is in charge of the feasibility study and detail design of the schemes. It starts at the feasibility design phase of each scheme with main activities:

- Communicate with DED consultant to get information concerning with type of irrigation, irrigation method, canal alignment, scale of irrigation unit, estimation cost of this type of irrigation system per ha
- Prepare consultation meetings and tools
- Organize and facilitate consultation meetings with potential users and local authority
- Restitution meeting on consultation results with
- Approval by the farmer beneficiaries on design of irrigation system

Phase 2: FWUC establishment/registration and database of land owners: FWUC is established and officially registered with MoWRAM; the data base is built and available; social recognition of farmland ownership, database or list of plot owners. This phase begins immediately after Phase 1 and is scheduled, for each scheme/Prek, to take place during the rehabilitation works with main activities:

- Organize villagers meetings for consultation purpose
- Information sharing within the village concerned
- Coordination with the Service Provider in charge of detail measurement survey and the provincial Department of Land Management, Urban Planning and Construction for official delivery of farming land title to farmer beneficiaries.
- FWUC membership registration
- Draft and validate FWUC organizational structure
- Inform local authorities and organize the dialogue between the authorities and the FWUC
- Draft, validate and form a FWUC's supporting committee
- Organize the FWUC elections
- Validate FWUC election results during the first FWUC general assembly
- Develop a database system (soft and hard copy) including all information about members property and plot location and plot surface (with code system)
- Drawing interactive map by hand and develop into digital map

- Facilitate the process of legal registration from local to national level.

Phase 3: Training and Technical Assistance: FWUC is able to perform its statutory functions (in particular water management) and to collect fees from members (up to a minimum of 70% of fees to be collected). Besides training sessions, there should be study tours organized to visit some FWUC of FWN members as well. The objectives of these study tours are to let farmers see performance of FWUC function and O&M etc. The phase may begin after Phase 2, but mainly after rehabilitation works with and will combine on-site training and technical assistance to the FWUC and groups of water users.

Phase 4: Responsibility sharing agreements support: In an irrigation system, water diversion and conveyance infrastructures are usually large hydraulic structures that the State, through MoWRAM, or the province, through PDWRAM, is in charge of construction and management operation and maintenance. The objective is:

- First to alleviate the burden of the State or the province,
- Second to make the farmer aware that water is a free gift of nature, but water service, that allows to get water on time, in place and in quantity required, requests investment and costs money that water users should pay for, at least partly,
- Third to assume that, once the farmers fully understand that irrigation infrastructures are one of their own production tools, they might take much care of them and take in charge their management operation and maintenance provided they have been involved and heard in the design and construction phases.

The question are: 1/ what are the works the communities are in charge of from on-farm canals up to what canal rank (tertiary, secondary, even primary), 2/ what are they responsible for (management, operation, seasonal maintenance, whole maintenance), 3/ what cost the farmers have to pay for.

These questions will be answered scheme-by-scheme, prek by prek. They will depend on two main factors: the size of the scheme or the prek and the capacity and willingness of the farmers. For those reasons, every scheme or prek will have its own specific Responsibility Sharing Agreement specific conditions that will be discussed and agreed with the local or national authority. Nevertheless general conditions of the RSA will be the same. The program will assist the parties in writing the general conditions and the frame of the specific conditions, possibly in the specific conditions themselves when major issues occur.

The consultant will bring a specific attention to gender during implementation:

- Assess and identify potential gender-differentiated impacts of each irrigation scheme.
- Collect sex-disaggregated baseline data that could be used to monitor potential gender impacts.
- Identify community-based organizations, and women’s associations or groups whose work focuses on gender and the specific area of intervention that the Program can collaborate with during its implementation. Assess their capacity.
- Conduct gender-sensitive analyses to ensure the differential needs, constraints, capacities, priorities of women and men targeted by the Program are understood and addressed;
- Assess the obstacles that prevent women to get actively involved in the FWUC management and commercialisation of agricultural products and propose/implement the alleviation proposals to overcome those issues.

One of the objectives of the program regarding gender is to reach at least one-third of women as FWUC management/board member with roles and responsibilities identified. The consultant is required to support this objective by (i) identifying then providing direct coaching to potential active female candidates, (ii) promoting their candidacy and (iii) ensuring equal opportunity to women board members to attend vocational training in irrigation scheme operation and water management and other related training such as management skills and (iv) promoting female leadership in the water management, services, commercialisation of agricultural products.

8.3 Sub-component 2.4. – Water Information System established and operational in three sub-projects consisting of six schemes namely the Ou Ta Paong (1 scheme), Lum Hach (1 scheme), and Krang Ponley (4 schemes)

This sub-component comprises two primary tasks: (2.4.1) Establishing flood monitoring, information, and early warning systems for the three sub-projects, and (2.4.2) Setting up a SCADA system for the West Pursat irrigation hydraulic system to enhance water availability within the Ou Ta Paong Irrigation scheme.

The implementation of the Climate Information and Early Warning Systems (CIEWS) across these sub-projects aims to empower individuals and communities facing hazards. It enables timely and appropriate actions to reduce the risk of personal injury, loss of life, and damage to property and the environment.

On the other hand, the SCADA model plays a vital role in addressing significant challenges within the agricultural sector. It tackles inefficiencies in irrigation practices, marked by both irregular and excessive water distribution, resulting in substantial water wastage. This model provides real-time data on water levels and flow rates, facilitating more precise and prompt responses to fluctuations in water demand.

The Water Information System (comprising SCADA and CIEWS models) offers a solution for modernizing existing irrigation systems, preventing flooding, and doing so through a fundamental and cost-effective approach.

The CAISAR project will focus on Ou Ta Paong Sub-project for providing a Water Information System (SCADA + EWS)

It is advisable to concentrate the implementation of the SCADA system specifically for the Ou Ta Pong Sub-project due to its significant water management issues. This project stands out as the most impacted among the others. The advantages of deploying SCADA for this particular project will extend far beyond the Ou Ta Paong scheme. Its benefits will reverberate across the broader area (> 100,000 ha) surrounding the schemes, substantially enhancing water management availability. Consequently, this initiative has the potential to substantially boost agricultural productivity in the entire area.

The description of the CIEWS and SCADA principles are described here below. In the case of Ou Ta Paong scheme, the two systems will be merged in one and unique interface.

8.3.1 SCADA

8.3.1.1 Principle

One of the most important problems facing the agricultural sector, irrigation is indiscriminate and others regularly, causing wastage of large quantities of water. This problem can be considerably improved by adopting the SCADA model because of the advantages of real-time information on water levels and flow rates and the possibility to respond to fluctuations more accurately and timely.

This is an emerging approach to the modernization of existing systems with basic low-cost to solve this problem using the SCADA system, which provides command and control and collect data on irrigation to rationalize and streamline the process of irrigation. This model is commonly adopted by the irrigation schemes around the world for the modernization of old manually gated systems.

The development of irrigation systems strongly contributes to the socio-economic development, but there are still many limitations in these systems. For example, although operation and management of the systems play an important role, there is a little concern on this. Also, the systems could not effectively operate to meet the increasing need of water supply due to the lack of the supporting tools and the efficient processes of operation. Furthermore, there is a lack of training and higher education for human resources in the management and operation. Therefore, modernisation for the management of irrigation systems is indispensable.

Water executive and management system development needs meteorological and hydrological data in real time, namely water level of reservoir and irrigation canal, rainfall amount in different watershed areas, etc.

Such information is strictly required to analyse actual hydraulic behaviour of water during management; SCADA and Telemetering system thus is introduced and installed for water management by PDoWRAM/MoWRAM. This course aims to enable understanding on SCADA and Telemetering in irrigation Works among RID officials PDoWRAM/MoWRAM

Figure 5-27. The combination of three models using SCADA, GIS, and hydraulic model.

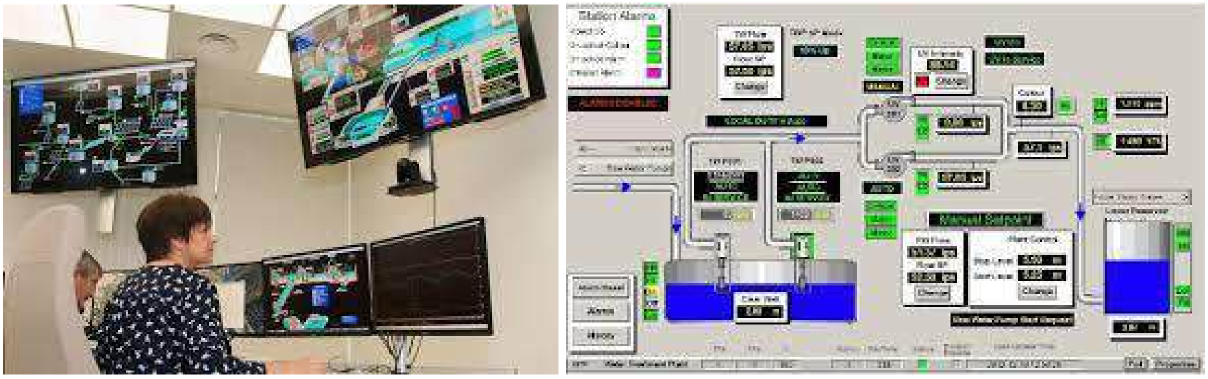


Figure 5-25. Example of SCADA center system

8.3.1.2 Proposed activities

8.3.1.2.1 Area of intervention

The automation of an entire river basin such as Pursat river is necessary, rather than just a single check structure, because the challenges and benefits are much larger.

The proposed area of intervention will cover all the irrigation schemes of the Pursat Hydraulic systems. It includes the irrigation schemes described on the table here below.

Table 5-11. SCADA - Area of Intervention

Name	Area (ha)
Damnak Ampil BTB	27,972
Damnak Ampil Canal	21,453
North scheme Pursat	17,421
Kbal Hong (left area)	15,386
Dong Chrum Area	13,516
Downstream area	11,250
Khma Pagoda Area	7,321
Wat Loung Canal	5,119
Svay Dounkeov - OTP area	4,400
Total	**123,838**

8.3.1.2.2 Detailed activities

This activity requires a sequence of tasks, including the customization of control software, the installation and commissioning of the field devices and central server software, the progressive activation of control throughout the canal system, the measurement of overall performance of the new system, and the training of operations staff. Ongoing operational tasks and system maintenance are also discussed.

The design and installation of a WIS at the Pursat river basin scale will follow the following steps:

- Step 1. Project initiation. The first step in any automation project is to determine the project objectives. These might include the improvement of irrigator service levels, water savings, and better control of water levels, operational cost savings, or rate of return on investment. Clear, quantified objectives help ensure success by aligning the irrigation district and implementation team and allowing for objective measurement of performance.

- Step 2. Design phase: There are no "single answers" as to how and when to implement automation as part of modernization because of the complexity and variety of combinations of the water supplies (surface versus conjunctive use), water allocation policies, water quality, timing of flows, adequacy of the water supplies, topography, aquatic weed problems, soil types as related to seepage and bank stability, usage of return flows, types of existing structures, and so on. There are, however, some basic principles that should be followed to achieve a high level of success in designing, constructing, and implementing a canal automation project. The design phase will include at least the following sequences (i) Defining potential benefits of modernization and automation; (ii) Defining incentives for modernization; (iii) Defining realistic/evolving expectations and costs; (iv) Assessing the existing system; (v) Defining institutional and operational constraints as related to automation; (vi) Selecting the appropriate canal operation strategy; (vii) Developing a plan for emergency response/safeguards; (viii) Defining where automation fits into a modernization plan; (ix) Defining the typical sequence of actions in the modernization process.

- Step 3. Configuration and customization of software. Discussions are provided regarding RTU/PLC software, communications software, SCADA software, water ordering and demand management software, and network representation software.
- Step 4. Procurement phase. Based on the detailed design, technical specification for provision and installation for the necessary equipment of the Water Information System will be prepared and consultation will be launched.

- Step 5. Commissioning. Commissioning is the process by which equipment, a facility, or a plant is tested to verify if it functions according to its design objectives or specifications.

- Step 6. Control rollout and tuning. Once the commissioning of the SCADA system is complete, the next step is to roll out or activate the control system. In this section, rollout of control refers to the control on a network scale as it encompasses the processes involved in rolling out control at each location. Sometimes the behaviour of the actual system may differ from what has been modelled initially. Hence, fine tuning of controller(s) may be required at intermittent stages.

- Step 7. Performance assessment and acceptance. As important as setting the overall project objective is the measurement of the performance of the canal system against those objectives.

- Step 8. Post-acceptance operation and maintenance. Post-acceptance operations and maintenance is an important part of canal automation. It is the analog of a routine maintenance program that irrigation districts generally undertake anyway but includes new equipment like the software and new operating procedures.

- Step 9. Training. An automated canal system requires that operators learn a number of new computer skills and adapt to a new style of operation that involves reacting to operational problems rather than simply implementing routines. This is not dissimilar to the role of a pilot when an airplane is operating in autopilot. The pilot must vigilantly monitor instruments and correct for unforeseen circumstances or deal with alarms.

- Step 10. Manuals. In addition to the training, the WIS operator must be supplied with manuals for every component that makes up its system.

8.3.2 Climate Information Services and Early Warning Systems

The CIEWS of Pursat River Basin will be linked to the SCADA system (See sub-component 1.3).

9 Component 3 - Strengthened institutional and regulatory capacity for low-emission climate-resilient development pathways

9.1 Output 3.1 Strengthened MOWRAM

9.1.1 Capacity building and support to MoWRAM

The Ministry of Water Resources and Meteorology (MOWRAM) is mandated to manage the national water resources, as well as the irrigation subsector. MOWRAM is the ~~executing agency~~Executing Entity for the project. Hence, the capacity of MOWRAM, its PMU, and its provincial departments, the PDOWRAMs is a factor of crucial importance for the success of CAISAR's investment. Although MOWRAM is well equipped for its tasks, developments over time require organisations to now and then review and update their resource allocations and work procedures. Such reviews may indicate the need for making changes or for updating and strengthening staff capacity, for example through refresher courses. CAISAR's Component 3 'Capacity building and support to MOWRAM' will aim at assisting MOWRAM in making sure that it has adequate capacity for carrying out a number of activities that are considered particularly crucial for the CAISAR investment to be successful in the longer term.

Two of MOWRAM's principal roles are of high importance for CAISAR's investment:

A. river basin management: managing water storage and releases, and allocating/distributing/delivering water to the main intakes of irrigation schemes;

B. irrigation scheme management: establishing, training, monitoring, and supporting the State-irrigation scheme management organisations: Farmer Water Users' Communities (FWUCs).

For each of these MOWRAM responsibility areas, capacity in the form of staffing, equipment, work procedures, is already in place. The Feasibility Study concludes that some further strengthening is desirable so that the organisational performance will reach the level needed to achieve the desired project results.

For each capacity building area, this will follow a set of generic steps:

1) Describe the current position:
    a. Inventorise and review current formally stipulated procedures
    b. Inventorise and review the actual practice
2) Define the future position:
    a. Define the objectives to be achieved under this capacity building item (include considerations with regards to climate change projections, adaptation, and mitigation)
    b. Evaluate actual practice and stipulated procedures on their effectiveness in achieving the objectives, thereby also considering what is reasonably possible given available time and resources
    c. What improvements are desired and possible?
3) Plan the changes to be made:

a. Prepare a change plan, indicating the changes to be made and how they can/will be made, the timeline, the resources needed and from where they will be obtained, and

b. Agree on a change plan manager, monitor, and reporter and his/her/their responsibilities/expectations

c. Obtain any needed endorsements

4) Implement the change plan:

a. Acquire the resources

b. Implement the changes

c. Periodically report/review progress and challenges, make/agree adjustments as necessary, until implementation has been completed

Based on reconnaissance-level interviews, the FS identified the following areas where capacity strengthening would be most beneficial to the CAISAR investment:

A. River Basin Management

Activity 3.1.1 Strengthening River basin management and Water Accounting Systems

Adequate water accounting by Cambodia's river basin managers is becoming more and more important with the increasing development of irrigation. CAISAR's investment in irrigation development envisages improved water availability to and throughout each of the schemes. This will require careful management of water resources storage, allocation, and delivery, and careful distribution of delivered water to the farmer/water users. Therefore, CAISAR will support capacity strengthening for water accounting in the river basins where CAISAR will rehabilitate and climate proof the irrigation infrastructure. CAISAR Component 2.4 will support MOWRAM with establishing a water information system, and this will serve and needs to be designed in such a manner that it provides the water accounting systems that will be strengthened with the data these systems need.

The Importance of Water Accounting

In the Greater Mekong Sub-region (GMS) water resources form the basis of agrarian prosperity and economic development. However, increasing water demand due to population growth, rapid industrialisation and urbanisation, as well as a changing climate, are undermining affecting the availability of these water resources. Reports warn that the GMS is facing increased water scarcity, varying in character, cause, and trend across the countries (FAO and AWP, 2023).

In Cambodia seasonal water scarcity predominates during the dry season, while seasonal flooding is common in wet season. Competition for water will in future be emerging where demand is highly concentrated and water

The CAISAR activity will support MOWRAM and the four PDWRAMs in reviewing their current water accounting system in the project-related river basins and to plan/implement improvements where desirable and feasible.

<u>Activity 3.1.2. Communicating with stakeholders</u>

MOWRAM manages the water resources for the benefit of its stakeholders. The largest water users are the irrigation schemes, each managed by an FWUC. The Commune Leadership, the Village Leaders, and the FWUC Leadership (Committee) represent the interests of the citizens/farmers/water users. At a higher level, District and Provincial Leaderships seek for the public interest to be served as good as possible.

MOWRAM's PDOWRAMs participate actively in the various Provincial-level meetings where water-related aspects are relevant in the discussions. Key items are the flood management plan for the wet season and the water allocation plan for the dry season. For MOWRAM/PDOWRAM to prepare and implement these plans properly, it will make use of the water information system and water accounting system mentioned above.

Public Management principles warrant MOWRAM/PDWRAM to keep stakeholders informed of any water-related developments that could be important for them. This can be achieved efficiently and effectively by publishing the water situation on a website that can easily be consulted by the stakeholders. MOWRAM already has such an information website, namely for Flood and Drought Forecasting and is in the process of establishing a water data and information centre, which will result in more data coming available. These are centrally managed, with data being provided by PDWRAMs and other MOWRAM units, closer to 'the field'.

MOWRAM's National Flood Forecasting Center (NFFC)

The Royal Government of Cambodia has a mandate to provide flood and drought information for the well-being of its citizens through the Ministry of Water Resources and Meteorology. To fulfil this mandate, the Ministry of Water Resources and Meteorology, with financial support from the Asian Development Bank under the Greater Mekong Sub-Region Flood and Drought Risk Management and Mitigation Project (GMS-FDRMMP), has strengthened the National Flood Forecasting Centre (NFFC) under the Department of Hydrology and River Works.

The results of this initiative include better forecasts of floods and droughts with the objective of reducing the

At this stage it is not yet clear how far plans have progressed for presenting real-time information on water demand, allocation, and actual gate settings.

The CAISAR activity will support MOWRAM and the four PDWRAMs in reviewing their current system for stakeholder communication in the project-related river basins and to plan/implement improvements where desirable and feasible.

B. Irrigation Scheme Management

Activity 3.1.3. Support to and guidance of Leaders of Commune, Village and FWUCs and Gender Awareness

The Feasibility Study interviewed Commune Leaders, Village Leaders and FWUC Leaders. It became clear that FWUC performance, including their shear 'survival', depends for a very large extent on the support and guidance they receive from the Commune Leadership. Where FWUC and Commune Leadership have succeeded in establishing and maintaining a good mutually beneficial relationship, farmer/water users reap benefits of this. It is not enough for an FWUC to be legally registered. For its legitimation/acceptance by the society and authority, it needs continuous recognition and support from the Commune Leadership. This is important for the following:

1) effectively arranging the water distribution within the scheme and dealing with interference
2) acquiring support for highly necessary infrastructure repairs, which requires FWUC to prepare an annual work plan and share this with the Commune Leadership, which will integrate selected items into its plan and forward larger items to the District and Provincial planning process

3) the FWUC Leadership, when having demonstrated satisfactory performance, can count on the Commune Leadership to support the introduction of an irrigation service fee and support collection of the fee via cooperation between FWUC and Village Leaders.

The Establishment and Training of FWUC (Component 2.3) will be designed with the above in mind. However, it will be a short-term activity only. As observed, FWUC Leadership Boards may experience difficulties which are too challenging for them to overcome. Several of the interviewed FWUC reported that the loss of their chairperson left the FWUC board ineffective, even to the extent that they were not able to organise an election of a new chairperson. And apparently, the Commune Leadership did not reach out. For this reason, it is important that PDWRAM has capacity for monitoring FWUC Board performance and ability to help Commune and FWUC overcome the challenges they face in water distribution, in system maintenance, and in fee collection.

The CAISAR activity will support MOWRAM and the four PDWRAMs in reviewing the current FWUC support system in the project-related schemes and to plan/implement improvements where desirable and feasible. This activity will need to see consultations with District, Commune, Village, and FWUC Leaderships. A next stage of project preparation will identify the capacity building needs in detail, using a participatory assessment approach.

Gender awareness training will be linked, in timing and participants, to the training on FWUC formation and strengthening. It was observed that women farmers are very interested in ensuring water availability for their crops and capable vocal participants in meetings. Some FWUC have highly appreciated women-board members, for example as treasurer. It would be good, if more of such capable women would become FWUG leaders or FWUC Board members. In any FWUC-related training, extra efforts should be made to get adequate women's participation in the program. If women are going to play a more active role in FWUC, they need the knowledge and skills to do so. In the case of training in financial management, administration, and water distribution, particular attention should be given to participation by women. Ideally, the training on water distribution plan and cropping calendar plan, improved crop production practices, and value chain, would include at least approximately 40% women participants. To make participation in training easier for women, the training should be done at the village level and/or on-farm, and consider that often, women's time for attending training is limited. Where training agencies have female staff, it would be good to involve them too in the training sessions.

The Capacity Building will be supported by consultants, as follows:

- **Specialized Expertise:** Offer specialized knowledge and experience in areas where local expertise might be limited or lacking (engineering, surveys, PIMD, SCADA), such as cutting-edge technologies, global best practices, or specific engineering methodologies.
- **Technical Assistance:** Provide technical guidance and advisory services to the PMU, helping in decision-making processes, resolving complex issues, and ensuring project alignment with international standards.
- **Capacity Building:** Conduct training sessions and workshops for local staff, transferring skills and knowledge that enhance their capabilities in project management, engineering, or other relevant domains.
- **Quality Assurance:** Conduct independent reviews and assessments of project components, ensuring adherence to global benchmarks and offering recommendations for improvement.

In addition to their technical expertise, national consultants will bring essential knowledge of the local systems, provide insights into the local context, facilitate communication and engagement with local stakeholders, communities, and authorities. This will help ensure smoother effective implementation of activities and addressing of local concerns. It will also assist in designing strategies that promote sustainability, community ownership, and long-term positive impact, considering the local environment and socio-economic conditions.

The capacity building and support will be implemented by different approaches, such as:

- On-the-job training programs or internships where MoWRAM/PDoWRAM staff can apply learned skills directly to their work environment, ensuring practical knowledge transfer.
- Lessons Learned and Knowledge Transfer: Facilitate sessions to discuss project outcomes, successes, and areas for improvement. Then, prepare document lessons learned and transfer knowledge to future projects.
- Conduct orientation sessions to align consultants with project objectives, methodologies, and reporting protocols.
- Provide guidance, feedback, and approval to ensure alignment with project requirements.

The budget plan includes regular training sessions and at least a yearly workshop to assess the project implementation and disseminate information about CAISAR.

9.1.2 Study tour

Two study tours are scheduled within the project, in Year 2 and Year 5. These tours aim to expose crucial agriculture and water stakeholders to the operation, maintenance, and management of hydraulic infrastructures. The goal is to facilitate knowledge sharing, discussions, and address the aforementioned challenges.

The study tours are expected to yield several outcomes, including fostering an understanding, enhancing capacity, and facilitating the exchange of best practices among relevant stakeholders. These outcomes will focus on the following areas:

- Ensuring dam safety and managing associated risks
- Understanding SCADA Systems
- Effective planning and management of water resources
- Hands-on experience in operating and maintaining irrigation systems
- Transmission, irrigation, and drainage of water
- Utilizing management experiences, controls, operating systems, and monitoring devices for irrigation systems
- Implementing water-saving irrigation models tailored to the Cambodian context
- Exploring design and construction technologies for irrigation works
- Addressing other pertinent topics related to the CAISAR Project.

Participation in these tours will include representatives from various entities such as MEF (1 person), MoWRAM (5 individuals), NCDD (1 person), and PDoWRAM (8 individuals, with 2 representatives per province), among others.

9.2 Output 3.2 NCDDS strengthened at national and provincial level

The National Committee for Sub-National Democratic Development (NCDD) in Cambodia plays a crucial role in promoting democratic development through decentralization and deconcentration of reforms throughout the country. To effectively carry out this mission, the secretariat of NCDD (NCDDS) has been actively engaged in capacity development initiatives aimed at enhancing the skills and knowledge of sub-national government officials.

Activity 3.2.1 Strengthening of NCDDS at the national level

The NCDDS' capacity development efforts will encompass a wide range of areas, including:

Strengthening NCDDS' project management capacity: This includes training on project cycle management, financial management, monitoring and evaluation, human resource management and Climate Change aspect.

Policy formulation and implementation: Enhancing the capacity to develop and implement effective policies and programs at the sub-national level, especially the Sub decree 182 on the functions transferred to the district level. Disseminate and knowledge sharing the role and responsible of district and municipality to support farmers.

Resource mobilization: Strengthening skills in resource mobilization, and planning at the sub-national level. GCF is another window where institutions can access to Climate Fund, so capacity building NCDDS staffs on project feasibility study and preparing full project proposal to GCF can help NCDDS to mobilize more resource.

Institutional strengthening and coordination: Promoting efficient institutional structures, coordination mechanisms, and inter-agency/ministry collaboration at the national level and sub-national level.

Capacity Development Approaches

The NCDDS will employ a variety of capacity development approaches to address the needs of sub-national government officials, including:

Training and workshops: Providing interactive training sessions and workshops on specific topics related to project cycle management, financial management, monitoring and evaluation, human resource management, and governance.

Field trips and demonstrations: Enhance understanding through hands-on field trips and demonstrations of agricultural practices.

E-learning Website: With modules offering self-paced online courses to make the learning process sustainable and long lasting that provide accessible and flexible learning opportunities for national officials on project cycle management, financial management, monitoring and evaluation, work place safety and health and human resource management.

Study Tour: a study tour is scheduled within the beginning of the project, in Year 2. The tour aims to expose crucial climate resilient agriculture technology, market linkage infrastructure. The goal is to facilitate knowledge sharing, discussions, and address the aforementioned challenges.

The study tour is expected to yield several outcomes, including fostering an understanding, enhancing capacity, and facilitating the exchange of best practices among relevant stakeholders. These outcomes will focus on the following areas:

- **Increased awareness:** Broadening understanding of climate change impacts on agriculture and the importance of adaptation.
- **Technology dissemination:** Promoting the adoption of climate-resilient agricultural practices and technologies. Promoting climate resilient infrastructure and CO2 emissions reduction.
- **Market knowledge:** Enhancing understanding of market opportunities and requirements for agricultural products.

Participation in this tour will include representatives from various entities such as MEF (1 individual), NCDD (5 Individuals) Provincial Administration (6 individuals), PDAF (1 individuals), PDOC (1 individuals), and PDWA (1 individuals).

Activity 3.2.2 Strengthening of the provincial teams

As the lead implementer of Component 1, the NCDDS will collaborate closely with the provincial administration and provincial departments, including PDAF, PDOC, PDWRAM, and PDWA, to execute project activities. Strengthening the capacity of these provincial teams is crucial for agricultural development and the success of the project.

NCDD and provincial staff has the responsibility of overseeing and implementing policies and activities aimed at increasing agricultural productivity, better market access and gender smart activities and thereby improving livelihoods of farmers. However, it is often found to have weak links and ineffective due to a lack of resources, skilled personnel, and coordination mechanisms between different levels of government.

Therefore, to upgrade and increase capacity the following sub-activities will be taken -

- Conduct a detailed capacity development needs assessment - The full evaluation of the current capacity of PDAF, PDOC, PDWA to support extension service will be done by a consultant recruited for this purpose. Tools to be developed and administered to provincial staff and a report capturing the findings will be drafted.

Purpose and Objectives The purpose of a capacity development needs assessment is to identify the gaps between the current capacity of the Provincial Staff and the capacity required to achieve its objectives.

- Training in technical concepts and cross-cutting subjects - Training and capacity building for Provincial staff in areas such as policy analysis, project management, market systems development and use of ICT tools. And also support on Adoption of ICT tools to improve the project efficiency, effectiveness, and transparency.

To effectively carry out their duties, Provincial staff need to be well-versed in a wide range of technical concepts and cross-cutting subjects. In addition to the gaps, topics like - Sustainable agriculture, climate change adaptation and Information and communication technology (ICT) and gender analysis to be included in the training. The project will provide structured support to ensure that the participants are able to conduct some of the activities independently. The trainings will be structured to provide skills adequate for the functions that NCDDS staff are expected to complete. The increase in management capacity will be useful for deploying in other areas and the resource mobilization capacity will ensure the generation of resources for scaling up. The strengthening of the provincial teams will enable them to scale up and expand to other areas.

- Refresh Training to provincial and district staffs on the agriculture (rice, vegetable, poultry, aquaculture)

- Refresh Training to the district staffs and Commune councilors on the water management

Training Methods

Workshops and seminars: Provide theoretical and practical knowledge through interactive workshops and seminars.

E-learning modules: Offer self-paced online courses to make the learning process sustainable and long lasting that provide accessible and flexible learning opportunities on technical concepts and cross-cutting subjects based on the assessment findings.

Field trips and demonstrations: Enhance understanding through hands-on field trips and demonstrations of agricultural practices.

10 Cross-cutting issues

Cros-cutting issues such as environment, social, gender and re-dress mechanism are covered in the separate Annex 6 to Annex 8.

11 Project cost and financing

The detailed cost estimate by sub-component is described on Annex 4. This also includes project management cost, project evaluation and auditing costs.

2 Implementation Arrangements

The institutional arrangements for the CAISAR project should be structured to ensure clear lines of authority, coordination among stakeholders, and efficient implementation of project activities. The project will have a Steering Committee chaired by Minister of Water Resources and Meteorology and with Secretary of States from MOWRAM (permanent Secretary), MEF, MOI (NCCD), MAFF, and MOE, all at Secretary of State level and the 4 Governors of the participating provinces and meet at least once a year. The main tasks of the steering committee are to approve the annual project work plans and budgets, as well as monitoring project progress and ensuring compliance with project objectives and donor requirements.

11.1.1 Executing Entity

The AE wil enter into a financing agreement (i.e. a subsidiary agreement) with the Royal Government of Cambodia, acting through the MEF. The MEF is the ministry authorized to enter into financing agreements on behalf of the RGC. The financing agreement will set out the roles and responsibilities of MEF, MOWRAM and NCDDS. Accordingly the Executing Entities are (i) MEF; (ii) MOWRAM; and (iii) NCDDS. MOWRAM will establish a Project Management Unit for the coordination of all components and consolidation of the project planning and reporting. In addition, the National Committee for Sub-National Democratic Development Secretariat (NCDDS) will be responsible for the implementation of component 1 which is designed to improve farm-level climate adaptation, resilience, and water use efficiency. The NCDDS is a Direct Access Accredited Entity (DAE) to the GCF and will have a Project Implementation Unit (PIU) for implementing the component 1 activities. The budget allocation between MOWRAM and NCDD-S will be determined based on prepared cost tables. Designated accounts will be established for both MOWRAM and NCDDS, and funds will be transferred directly by IFAD to MOWRAM and NCDDS.

11.1.2 Implementing Entities

To properly implement their respective components, NCDD and MoWRAM will establish appropriate Program Management Units (PMUs) working as IEs. As such, they will be responsible for:

- Direct program preparation and implementation, including annual work program and budget;
- Overseeing procurement activities, particularly bid opening and evaluation process, and endorse bid evaluation reports for all international and national competitive bidding;
- Consolidating program accounts and financial statements, as well as preparing and submitting drawdown request;
- Conducting proper financial, environmental and social due diligences for relevant subprojects, in line with RGC and DPs requirements;
- Establishing baseline data to monitor program impacts, including regular monitoring of financial and material progresses, as well as a monitoring system for the program implementation, including site inspections;
- Submitting to DPs (i) quarterly progress reports, (ii) regular environmental and social safeguards monitoring reports, (iii) annual audit reports, and (iv) a program completion report to DPs and MEF;
- Ensuring good coordination with IFIs, including the preparation of elements needed for policy dialogue meetings between RGC authorities and IFIs actively working on Water and Agriculture.

The implementation arrangements of the components are described in more detail under each of the components.

At field level, a close cooperation between PDWRAM, NCDD and PDA is crucial since the design, the construction and the management of on-farm canal systems require a high hydraulic qualification (that PDWRAMs can bring due to their experience in design an O&M) and require a strong participation of the beneficiaries as well. Meetings with farmers aiming at a strong participatory approach of conception and management of on-farm systems will require the simultaneous presence of both provincial departments.

11.1.3 Implementation organisation charts

The Figure 9-1 below present the implementation organisation charts.

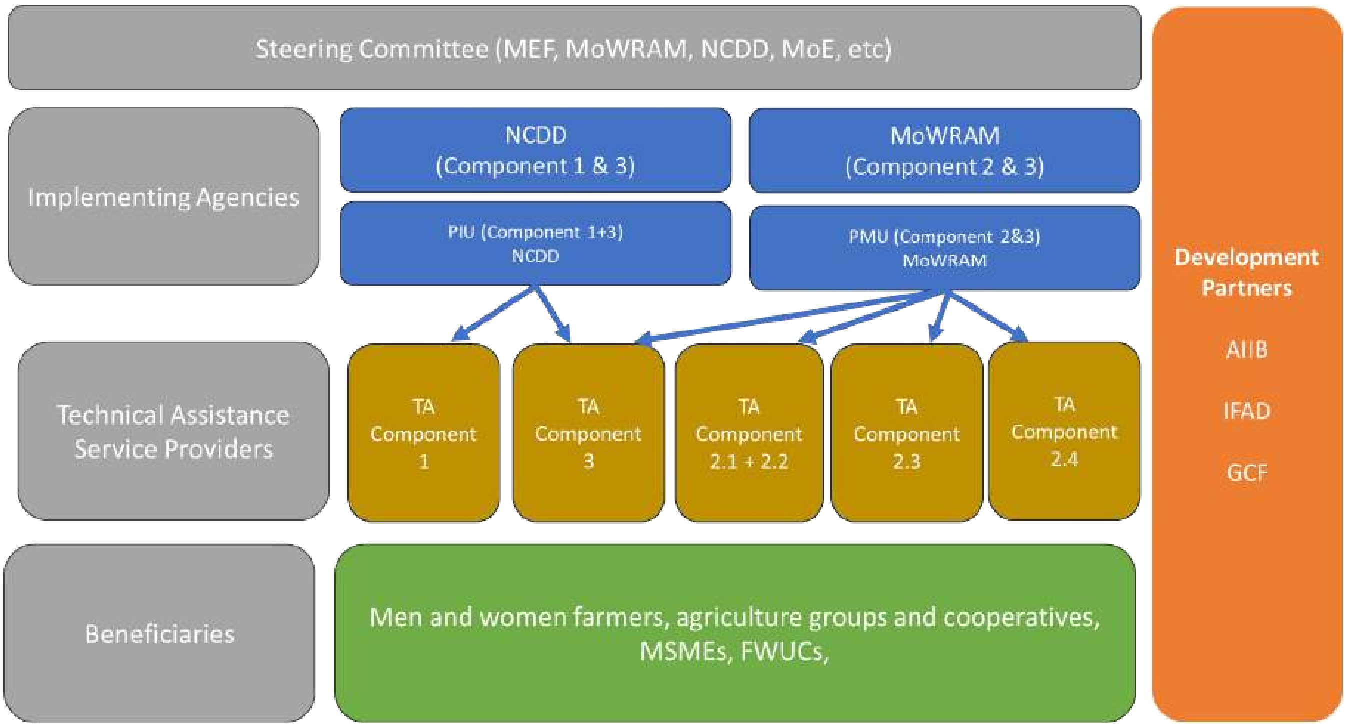


Figure 9-1.Implementation organization of CAISAR project

12 Economic Feasibility Analysis

The analysis was conducted using a 30-year evaluation period, reflecting the lifespan of the irrigation infrastructure, with a 7-year execution phase. Estimates were calculated using a social discount rate of 9.47 percent. Key economic indicators, including the internal rate of return (IRR), expected net present value (ENPV), benefit-cost ratio (B/C), payback period, and switching values, were estimated. The analysis accounted for total project costs, including contributions from beneficiaries and governmental counterparts. Sensitivity and scenario analyses were conducted to evaluate the potential impact of key variable changes on the project's economic viability, considering fluctuations in input and output prices, adoption rates, benefits, costs, social discount rates, and evaluation periods.

The economic analysis of the CAISAR project, considering all costs, indicates promising economic returns over a 30-year evaluation period with a social discount rate of 9.47 percent. The estimated Economic Internal Rate of Return (EIRR) is 16.3 percent, and the Expected Net Present Value (NPV) is projected at USD 143.6 million, with a benefit-cost ratio of 1.26 and a payback period of nearly 12 years. Sensitivity and scenario analyses underscore the robustness of these evaluations, suggesting that the project would remain profitable even with a 20-year evaluation period. The sensitivity analysis shows that the project could become unprofitable if projected benefits decrease by more than 20.7 percent or if costs increase by more than 26.1 percent due to potential shocks during implementation, which is unlikely given the local economic context and macroeconomic trends.

In disaggregated terms, the implementation of activities under Components 1 and 2 is viable, with IRRs of 15.8 percent and 16.5 percent respectively. Moreover, all irrigation schemes demonstrate an IRR higher than the social discount rate used in this analysis, indicating the economic viability of each scheme. This viability is primarily due to the significant reduction in damages caused by annual flooding, both on and off the farms, and significant contribution of the benefits related to the GHG emission reductions.

The financial indicators for the entire operation were estimated from a private sector perspective incorporating the recovery costs of the irrigation infrastructure by estimating a tariff that users should pay per hectare per year. This analysis was further complemented by an assessment of the operation's overall financial sustainability from a public finance perspective, considering both debt service requirements with financiers and the tariff estimated for irrigation system users. Both analyses demonstrate the overall financial viability of the project, with financial internal rates of return of 13.38 percent and 13.94 percent, respectively.

The full details of the analysis are presented in Annex 3.

13 Timeline of the project

The project duration will last 7 years from 2025 to 2031. See separate PIP in Annex 5.