

## PROJECT CLIMATE AND DISASTER RISK ASSESSMENT

### I. Basic Project Information

<b>Project Title:</b> Additional Financing for Tonle Sap Poverty Reduction and Smallholder Development Project
<b>Project Budget:</b> Grant of \$4,275,000 from ADB's Special Funds resources (Asian Development Fund) under the Disaster Risk Reduction Fund, a concessional loan of \$45,725,000 from ADB's ordinary capital resources, and a loan of \$10,000,000 from the International Fund for Agricultural Development (IFAD).
<b>Location:</b> Cambodia (Provinces of Banteay Meanchey, Battambang, Kampong Cham, Kampong Thom, Prey Veng, Siem Reap, and Tboung Khmum).
<b>Sector:</b> Agricultural natural resources and rural development (agricultural production - irrigation).
<b>Theme:</b> Inclusive economic growth (economic opportunities) and environmentally sustainable growth (disaster risk management, global and regional transboundary environmental concerns and natural resources conservation).
<p><b>Brief Description:</b></p> <p>In 2009, the Asian Development Bank (ADB) approved a loan and grant for the Tonle Sap Smallholder Development Project (TSSD). Additional Financing (AF) is proposed to expand climate-responsive productive infrastructure interventions from 196 communes in five provinces, to 271 communes in seven provinces in the Tonle Sap Basin. Consistent with the current project, the AF will enhance agricultural productivity and improve access to markets, resulting in better livelihoods and higher incomes in the project area with the added benefit of enhanced resilience to disaster and climate risks.</p> <p>The impact of the overall project will be improved livelihoods and resilience in target communes in seven provinces in the Tonle Sap Basin. The outcome of the overall project will be agricultural productivity increased, climate resilience strengthened, and access to markets improved in 271 communes in seven provinces in the Tonle Sap Basin. The AF will directly benefit 75,000 rural households with improved livelihoods, and a further 400,000 households with indirect benefit from improved roads, reduced disaster risk and information and communication technology (ICT). The project's three outputs are summarized below:</p> <ol style="list-style-type: none"> <li><b>Output 1: Rural productive infrastructure and livelihood improved with capacity in disaster risk management enhanced.</b> For infrastructure, the AF will rehabilitate 450 kilometer (km) of roads incorporating disaster risk reduction (DRR) measures in the design, and 6,000 hectares (ha) of irrigation for at least two crops per year. Training on DRR and climate-resilient rice production and crop diversification will be provided.</li> <li><b>Output 2: Enabling environment for increased agricultural productivity, diversification and climate resilience created.</b> Multi-stakeholder value chain platforms will be developed in every commune. 364 market improvement groups and 200 paddy selling groups will be created. Training on climate-smart agriculture practices will be provided through 200 paddy selling groups. Four climate-resilient rice varieties will be trialed and if trials are successful, contracts will be made for 2,500 tons of rice seed with existing rice seed producer groups.</li> <li><b>Output 3: Project management strengthened.</b> The executing agencies will continue to provide project oversight. Support for project management will include (i) strengthening the capacity of the added commune councils; (ii) continued support of project staff at national, provincial, district, and commune levels; (iii) providing extended support for implementation through the use of special service providers; and (iv) an integrated project performance monitoring system for both executing agencies.</li> </ol> <p><b>Infrastructure subprojects.</b> Feasibility studies and due diligence reports have been prepared for two subprojects, considered representative of future subprojects, an irrigation scheme in Lvea commune in Prey Veng Province and a rural road scheme in Batheay and Chbar Ampov Communes in Kampong Cham Province. A candidate list of future infrastructure subprojects has also been developed. These include: concrete roads; bituminous roads; laterite roads; earth roads; irrigation canal construction and rehabilitation; earth dam/dyke construction/rehabilitation; bridge construction; and pond construction/rehabilitation.</p>

## II. Summary of Climate and Disaster Risk Screening and Assessment

### A. Sensitivity of project component(s) to climate/weather conditions and sea level

The Cambodia Climate Change Strategic Plan, 2014 – 2023 identifies two strategic objectives to enhance adaptation to the impacts of future climate change. Strategic Objective 1 (Promote climate resilience through improving food, water and energy security) includes a provision to “*Rehabilitate and build water infrastructures including small-, medium- and large-scale irrigation schemes*”. Strategic Objective 2 (Reduce sectoral, regional, gender vulnerability and health risks to climate change impacts) includes “*Enhance the quality of rural infrastructure (roads, irrigation, wells and culverts) to be resilient to flood and drought*”. The implementation of the project will be in line with these strategic objectives.

The project will include interventions in seven provinces in the Tonle Sap basin. Cambodia’s climate is dominated by an annual tropical monsoon cycle of alternating wet and dry seasons. The main wet season, the southwest monsoon, occurs between June and October, when reduced air pressures over Central Asia cause air to be drawn landward from the Indian ocean. Approximately 80% of all rainfall occurs during this season. Conversely, during the cooler months between November and May, air flows over Cambodia originate from Central Asia and are drier, resulting in cooler and less rainy weather. Average annual rainfall is around 1,500 millimeter (mm). However, total rainfall can vary considerably from year to year, resulting in occasional years of severe flooding and conversely, years of significantly low rainfall. Temperatures are fairly uniform throughout the Tonle Sap Basin area, with only small variations from the average annual mean of around 25°C. The maximum mean is about 28.0 °C; the minimum mean, about 22.98 °C. The more eastern project provinces, Kampong Thom, Kampong Cham, and Prey Veng show a greater diurnal difference in temperatures with maximum temperatures generally hotter and minimum temperatures cooler. Maximum temperatures of higher than 32 °C are common and, just before the start of the rainy season, they may rise to more than 38 °C. The eastern provinces have slightly lower rainfall in the wet season and a later peak rainfall period (in October).

Flooding is a regular phenomenon in Cambodia, with rainfalls commonly exceeding 500 mm per month in the rainy season. Recent flooding has been very damaging and the Mekong River Commission records show an increasingly shorter return period for major floods. The two largest flood events, recorded in the last 20 years, occurred in 2011 and 2013. Thoung Khmum Province experienced minimal flood, whilst all other project provinces experienced more severe flood impacts, Banthaey Meanchey and Kampong Thom provinces were the most severely affected by these flood events, particularly in 2011. The Climate and Disaster Risk Assessment (CDRA, see **Annex 2**) provides National Committee for Disaster Management data for the 2011 and 2013 flood events, including the number of affected families and flood damage to buildings and impacts on agricultural production by province. Although major tropical cyclone originating in the South China Sea rarely penetrate Cambodia, cyclonic effects in central Cambodia have been more common in the last decade.

**Flood events and water availability are the major climate risks to the project.** Climate change impacts are likely to compound existing flood, water and food security issues. For the representative road subproject in Kampong Cham, local accounts of annual floods indicate that the road is overtopped by flood waters between 0.3 meter (m) to 2 m (for up to a period of 30 days) and the impassibility of the road during and after these periods constrains agriculture, commercial activities and access to services.

Project components and key climate sensitivities include:

Project component:	Sensitivity to climate/weather conditions:
<ol style="list-style-type: none"> <li>1. Irrigation canal and regulating structures;</li> <li>2. Road pavement;</li> <li>3. Earth dam/dyke;</li> <li>4. Bridge construction;</li> <li>5. Embankment slopes;</li> <li>6. Drainage infrastructure;</li> <li>7. Construction activities;</li> <li>8. Frequency of maintenance; and</li> <li>9. Disaster response capacity of commune.</li> </ol>	<ol style="list-style-type: none"> <li>1. Increase in frequency and intensity of flood;</li> <li>2. Increase in peak flood height;</li> <li>3. Increased occurrence of drought conditions;</li> <li>4. Reduced dry season water availability; and</li> <li>5. Increased frequency and intensity of regional tropical cyclones and typhoons.</li> </ol>

## B. Climate Risk Screening

Climate risk screening was carried out using AWARE for projects and climate change risk was identified as **medium** based on a high risk of increased frequency and intensity of flood events and a medium risk of future water stress (see Annex 1). Projected climate change effects are increased risk of flood, damage to road and irrigation infrastructure, disruption of access and water supply and reduced agricultural productivity. Engineering design standards for infrastructure and irrigation water requirement may need to be altered and maintenance frequency increased. Extreme weather response and planning capacity of the communes may need to be strengthened.

Risk topic:	Description of the risk
<ol style="list-style-type: none"> <li>1. Unpredictable seasonal weather changes;</li> <li>2. Increased risk of flood;</li> <li>3. Reduced water availability;</li> <li>4. Increased incidence of drought;</li> <li>5. Temperature increase.</li> </ol>	<ol style="list-style-type: none"> <li>1. Traditional cropping patterns no longer productive;</li> <li>2. Increase in populations of vector-carrying pest species and establishment of new pest species;</li> <li>3. Pavement, road embankments, slopes, culverts, bridges, canals and regulating structures at increased risk of failure;</li> <li>4. Bridge, culvert and drainage design standards and irrigation water requirements do not take account of projected changes in rainfall intensity, volume and increased incidence of drought as a result of climate change;</li> <li>5. Infrastructure may experience more regular damage from floodwater requiring more regular routine and major maintenance at greater cost;</li> <li>6. Severe weather events may result in increased incidence of damage to crops and disruption of access to markets and services; and</li> <li>7. Increased need to respond to flood-induced emergencies and disasters.</li> </ol>

## Climate Risk Classification

Medium (**Annex 1** includes AWARE climate risk screening report)

## C. Climate and Disaster Risk Assessment

The CDRA was carried out for rural road and irrigation infrastructure interventions proposed under Output 1 (see **Annex 2**).

**Climate Change Scenarios.** The study reviewed climate change projection methodologies used for other similar projects in Cambodia and considered their application to the project:

(1) The Intergovernmental Panel on Climate Change (IPCC) Special Report on Emission Scenarios (SRES) uses the A1, A2, B1 and B2 scenarios describing differing emission rates and geopolitical settings and the IPCC's latest "radiative" scenarios adapted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (2013) in its Conformal Cubic Atmospheric Model (CCAM). The regional downscaling techniques used in CCAM increases resolution to the provincial level and allows analysis of local extreme events such as one day and five days rainstorm intensities, risk factors that are of most importance in infrastructure design.

(2) SRES projections for Cambodia used in the Initial National Communication (INC) and the Second National Communication (SNC) of the Cambodian National Climate Change Committee can be applied readily to water balances by computing changes in temperature, seasonal rainfall, evaporation to calculate future irrigation needs for crops.

(3) The USAID Mekong Adaptation and Resilience to Climate Change Study (2014) compared the output of 12 general circulation models (GCMs) and chose the six that most accurately replicated historical data across the basin for the period of 1980–2005. Downscaled projections for the A1 scenario were derived to predict regional changes in temperature and rainfall and to calculate changes in drought periods under future climate change which is very relevant to assessing risk and vulnerability for future irrigation. ICEM (International Centre for Environmental Management) developed these projections further as part of a technical assistance (*TA 8719-CAM: Mainstreaming Climate Resilience into Development Planning*).

## Projections

**Temperature.** The SRES projections indicate that Cambodia's mean surface temperature has increased by 0.8°C since 1960, and that it will continue to increase at a rate of between 0.013°C and 0.036°C per year up

to 2099. CCAM also projects warming of 0.003°C to 0.06°C. The rate of temperature increase will be higher in low altitude areas such as the project provinces which are between 10 m and 20 m above sea level.

**Rainfall.** The SRES scenarios used to inform the INC/SNC have uncertain projections in respect of wet season rainfall. Under elevated CO<sub>2</sub> with low rate of emission scenarios (SRES-B2) it is likely that wet season rainfall will continue to increase in future, and then might decrease again after 2050. However, under a high emission scenarios (SRES-A2), the direction of change may reverse. CCAM projects a dryer wet season of - 8.4 mm/year in the central and south lowlands and an increase at the start of the wet season of +1.2 mm/year and no change to the dry season. The USAID/ICEM models project that average rainfall will increase.

**Flood.** Kampong Cham, Prey Veng, and Tboung Khmum Provinces are located in the floodplain of the Lower Mekong and are subject to annual flood events from the Mekong. The main climatic drive of the magnitude of Mekong floods are the strength/weakness of the south-west monsoon and the extremity and frequency of typhoons and tropical storms from the South China Sea. The general regional trend for the Lower Mekong from all models indicate a wetter south-west monsoon period, later starts to the wet season (by 2-4 weeks) and a higher and increasing intensity of precipitation. Kampong Thom Province is located in the floodplain of Tonle Sap lake. In addition to seasonal catchment flooding, projected increases in rainfall in the wet season will increase the risk of localized flash flood events. The CDRA reviews likely vulnerability of irrigation and road subprojects in each of the project provinces based on projected wet season rainfall change, one day rainfall event change and 5-day rainfall event change. Subprojects located in seasonal flood catchments will be most vulnerable to increased flood as a result of climate change, however, climate change will also exacerbate localized flood impacts.

**Drought.** The USAID/ICEM models project that annual drought is expected to lengthen, with up to a 30% increase in the number of drought days each year in some provinces, particularly in the Mekong floodplain. Of the project provinces, the upland areas of Battambang, Kampong Cham, Kampong Thom, Siem Reap, and Tboung Khmum are expected to be most affected with an increase of up to 0.5 months of drought.

**Water availability.** The CDRA includes a water balance for a dry season crop for the representative irrigation subproject in Lvea Commune, Prey Veng Province. This shows that adequate water is available but in a dry year, extraction for irrigation will take about 17% of the available water which indicates a significant vulnerability to increased crop water demand and reduced rainfall due to climate change. For the candidate irrigation subprojects, the CDRA estimated crop water demand based on evapotranspiration measurements for irrigated crops in the various provinces and calculated how this might change with increases in temperature.

#### **Key impacts on project performance**

1. **Agricultural productivity.** An increase in temperature is likely to affect agricultural productivity. The International Rice Research Institute report that rice grain yields decline by 10% for each 1°C increase in minimum (night) temperatures during the growing period in the dry season. Floods and extreme weather events can damage crops and cut off access to markets.
2. **Irrigated water requirements.** The irrigation subprojects aim to support a dry season rice crop. The projected changes in rainfall and temperature will affect future irrigated crop water demand which will need to be taken into account when determining seasonal water availability and suitability of sites for a dry season crop.
3. **Road and irrigation infrastructure.** Potential increases in flood intensity and duration have implications for road and canal design standards and specifications, for example, appropriate road surface, embankment and canal reinforcement, size and number of culverts, height of bridges, resilience to inundation and increases in maintenance frequency and costs.
4. **Increase in extreme flood events.** An increase in the incidence and intensity of extreme flood events would require improved DRR planning and response capacity.

### **III. Climate Risk Management Response within the Project**

The CDRA describes the climate resilience measures integrated in the project design for the two representative subprojects and also makes recommendations for future candidate subprojects:

1. **Irrigation water requirement adaptation.** The design irrigation water requirements (IWRs) for the irrigation subproject in Lvea Commune, Prey Veng Province, exceed the additional water requirements predicted for 2020 and 2050 by between 10% and 20%, so already take account of changes in water availability as a result of climate change. However, close planning, monitoring and management of water use will be needed to ensure that the level of extraction does not compromise other users in the dry season should there be a reduction in flow level. The water balance for the subproject was based on an irrigation efficiency of 40%, so should there be future supply issues, there are opportunities for adaptive management, either to improve irrigation efficiency or to modify the irrigated area.
2. **Irrigation canals and regulating structures.** Canal walls will be reconstructed and strengthened to withstand flood flows. Sluice gates will be provided with erosion/scour protection and dissipation basins to maintain the integrity of control structures against high energy flood flows. The crest height of control gates will be adjusted above the 1 in 100 year level to provide the option of directing flood waters to control release sluices rather than overtopping and scouring the secondary canals. Canal rehabilitation along high flow sections may be lined to prevent flood scour and failure.
3. **Village roads.** It is not possible, within the funding limitations of the project, to design and engineer subproject roads to be fully flood resistant in the context of the maximum floods reported. However, a suite of flood design resilience measures are recommended: (i) raising the road above the flood level, particularly in sections particularly susceptible to inundation, where possible; (ii) reinforce road surfaces (natural stone or concrete); (iii) embankment batters will be at a slope no greater than one in two and will use imported material to replace soft, erosion-prone sections; (iv) embankment will be turfed and planted with local shrubs to increase stability and resistance to fast flowing water; (v) road surface will have a drainage slope of 2% from the center-line on the concrete surface of the priority section and 5% on other sections to shed water; (vi) road will have multiple through-drainage structures (culverts and pipes) to ensure that it will not be a flood barrier; (vii) culverts will be designed to exceed the height of the existing road level by a factor reflecting the projected increase in rainfall amount and intensity and local flood data; and (viii) where paddy field directly abuts the road embankment, culverts will have bunds or water gates at each end which will allow inundation of adjoining paddy fields but which can also be overtopped by floodwaters.
4. **Improved administrative structures.** The project will also put in place local administrative structures within commune councils, including, livelihood improvement groups (LIG) and marketing improvement groups (MIG) which could in the future undertake adaptive management.
5. **DRR capacity development.** The project will support DRR training for subproject commune councils and development of Commune DRR action plans to improve planning and response to flood events. The ICT training component will also improve DRR and extension information transmitted through radio, TV and mobile access devices.

**Climate adaptation and disaster risk reduction finance.** Climate adaptation and disaster risk reduction measures are estimated to cost around \$10.25 million, through a combination of structural interventions (design of irrigation and road infrastructure) and non-structural interventions (application of climate-smart agricultural practices, adoption of climate-resilient rice varieties, improved structures and increased capacity for adaptive management planning and DRR and disaster risk management). Following the detailed engineering design, the measures adopted and their incremental costs will be confirmed.

**Climate adaptation assurances and indicators.** The project Loan Agreement will include a loan covenant on detailed design of climate resilient infrastructure. The project design and monitoring framework includes performance indicators in respect of roads that incorporate DRR measures, production of climate-resilient rice seeds and introduction of climate smart agricultural practices for rice and non-rice crops.

**Annex 1: AWARE Climate Risk Screening Report**

# 01

## Introduction

This report summarises results from a climate and geological risk screening exercise. The project information and location(s) are detailed immediately below.

The screening is based on the Aware<sup>TM</sup> geographic data set, compiled from the latest scientific information on current geological, climate and related hazards together with projected changes for the future where available. These data are combined with the project's sensitivities to hazard variables, returning information on the current and potential future risks that could influence its design and planning.

## Project Information

**PROJECT NAME:** SERD CAM Tonle Sap Smallholder Development Project - Additional Financing

**SUB PROJECT:** Batheay Commune Rural Road

**PROJECT NUMBER** 41435-054

**/ REFERENCE:**

**SECTOR:** Transport

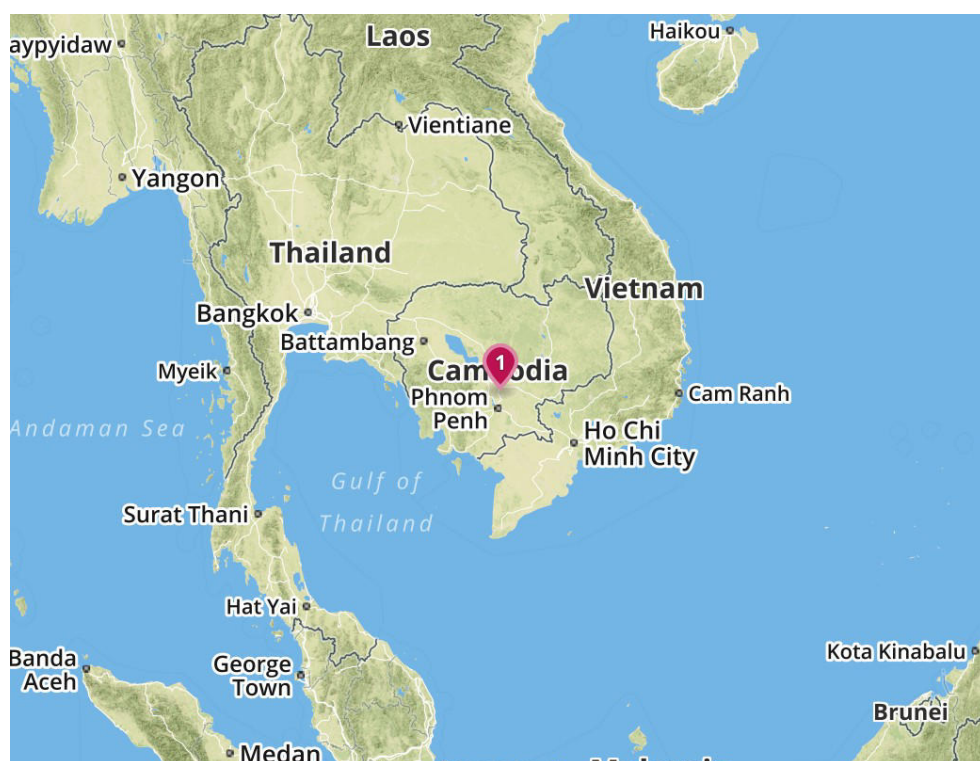
**SUB SECTOR:** Rural transport (nonurban)

**DESCRIPTION:** Rehabilitation of a 7.6 km long rural road which starts at Highway 6 in Batheay Commune and finishes in Chbar Ampov village, Chbar Ampov Commune. The road will be rehabilitated in 4 sections. The first priority will be the section across the floodway, spanning the border between Banthaey and Chbar Ampov communes

# 02

## Chosen Locations

1) Batheay Rural Road



# 03

## Project Climate Risk Ratings

Below you will find the overall climate risk level for the project together with a radar chart presenting the level of risk associated with each individual climate risk topic analysed in Aware™. Projects with a final “High risk” rating are always recommended for further more detailed climate risk analyses.

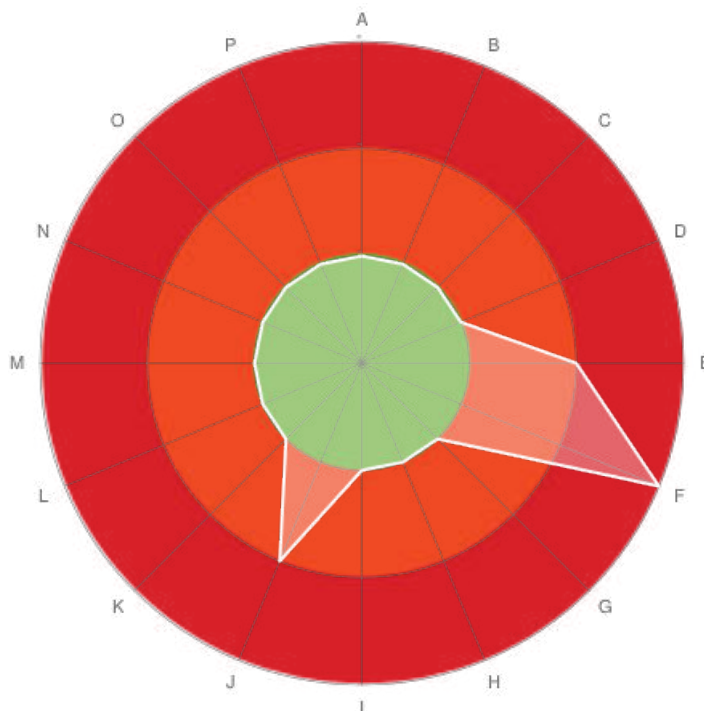
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher level of risk in relation to a risk topic. The green band (inner circle) suggests a lower level of risk in relation to a risk topic.

In the remaining sections of this report more detailed commentary is provided. Information is given on existing and possible future climate conditions and associated hazards. A number of questions are provided to help stimulate a conversation with project designers in order to determine how they would manage current and future climate change risks at the design stage. Links are provided to recent case studies, relevant data portals and other technical resources for further research.

### Final project climate risk ratings

## Medium Risk

### Breakdown of climate risk topic ratings



A) Temperature increase
B) Wild fire
C) Permafrost
D) Sea ice
E) Precipitation increase
F) Flood
G) Snow loading
H) Landslide
I) Precipitation decrease
J) Water availability
K) Wind speed increase
L) Onshore Category 1 storms
M) Offshore Category 1 storms
N) Wind speed decrease
O) Sea level rise
P) Solar radiation change



# 04

HIGH  
RISK

## FLOOD

### ACCLIMATISE COMMENTARY



• Our data suggest that the project is located in a region which has experienced recurring major flood events in the recent past. A high exposure in Aware means that between 1985 and 2016 there have been at least one significant, large-scale flood event in the region. This is based on post-processed data from the Dartmouth Flood Observatory at the University of Colorado.

- The risk and type of flooding is dependent on local geographical factors including:
  - Proximity to the coast and inland water courses
  - Local topography
  - Land use characteristics, including land use in upstream catchment area
  - Design and maintenance level of drainage infrastructure
  - Vulnerability of exposed assets
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's [Global Risk Data Platform](#) and Dartmouth Flood Observatory's [Global Active Archive of Large Flood Events](#).

#### 1. What does this mean for the design and construction of my project?

- If floods are identified as a potential problem for the project, it is recommended that:
  - More localized information is collected on past floods and their consequences in the exact project location, especially since flood hazard can change significantly over short distances; depending on the findings, a site-specific flood risk assessment (including flood modelling) might be required that provides a good understanding of the current and future flood risk level
  - Information is collected on land use and building regulations, such as flood zonation ordinances
  - The project siting, design and construction features ensure that site-specific flood risk management measures are undertaken. Such measures could include a combination of grey infrastructure (such as flood defence infrastructure) and green infrastructure (such as restoration of wetlands) to reduce flood risk, as well as measures to manage the residual flood risk (such as through flood early warning, flood preparedness planning, flood insurance etc.)

#### 2. What does the science say could happen in the future and what does this mean for the design of my project?

- Climate change is projected to influence the frequency and intensity of flood events.
- Existing engineering designs may not take into consideration the impact of climate change on the risks from flooding. See "Critical thresholds" in the "Help & glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

#### 3. As a starting point you may wish to consider the following questions:

- Q1** Would the expected performance and maintenance of the project be impaired by flooding?
- Q2** Is there a plan to integrate climate change into a flood risk assessment for the project?
- Q3** Does the project siting consider flood risk to ensure the proposed project will not be impacted by flooding and will not increase risk of flooding?
- Q4** Does the project design and construction features incorporate measures to manage flood risk, both in the immediate term and as risk of flooding changes as a consequence of climate change?
- Q5** Will the project include emergency management plans which make provision for continued successful operation in the event of floods?

#### 4. What next?

- See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
- Click [here](#) or [here](#) for the latest news and information relating to floods and climate change.

☐ I have acknowledged the risks highlighted in this section.

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# 05

## MEDIUM RISK

### PRECIPITATION INCREASE

Would an increase in precipitation require modifications to the design of the project in order to successfully provide the expected services over its lifetime?

#### Chosen Answer

Yes - a little.

The design of the project may have to be slightly modified to cope with the impact of increased precipitation.

### ACCLIMATISE COMMENTARY

#### 1. What does this mean for the design of my project?

- There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.
- The design, operational and maintenance standards should be reviewed - take into consideration current impacts of heavy precipitation events as well as potential future changes.

#### 2. How could current heavy precipitation affect the project even without future climate change?



- Seasonal runoff may lead to erosion and siltation of water courses, lakes and reservoirs.
- Flooding and precipitation induced landslide events.
- In colder regions, seasonal snow falls could lead to overloading structures and avalanche risk.
- If our data suggests that there are existing hazards associated with heavy precipitation in the region, they will be highlighted elsewhere in the report. This may include existing flood and landslide risks.

#### 3. What does the science say could happen by the 2050s?

- Climate model projections agree that annual average precipitation will increase in the project location. This indicates a relatively low degree of uncertainty that precipitation will increase in the region.
- If you want to know more about projected changes in the project location across a range of GCMs and RCPs please refer to USGS's [CMIP5 Global Climate Change Viewer](#) for detailed maps.

#### 4. What next?

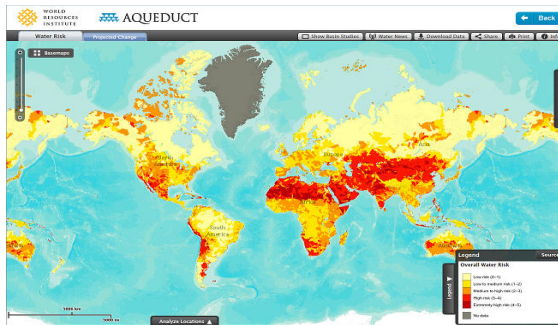
1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
2. Click [here](#) or [here](#) for the latest news and information relating to water and climate change.

# 06

MEDIUM  
RISK

## WATER AVAILABILITY

### ACCLIMATISE COMMENTARY



• Our data suggest that the project is located in a region where there may be future water stress (2020s - 2050s). A high exposure in Aware means that either water stress is 'extreme' or high seasonal temperatures coincide with relatively low rainfall. Extreme water stress is defined as 'less than 0.5 million litres available per person per year' based on climate information as well as the effects of income, electricity production, water-use efficiency and other driving forces. This is post-processed data from Alcamo et al., 2007. Away

from populated regions, high exposure also occurs where high seasonal temperatures (above 28 degrees Celsius average over 6 months) coincide with low rainfall (less than 100mm per month average over 6 months). This is based on post-processed data from the Global Precipitation Climatology Centre (GPCC), Climatic Research Unit (CRU) and a range of GCM projections.

- The situation may be exacerbated if there is increased competition for water with other users in the area and changes in local demographics.
- An associated reduction in water quality could also have a negative impact on the project.

#### 1. What the science says could happen in the future and what does this mean for the design of my project?

- Climate change is projected to influence water availability. Regions that are already dry may suffer further if future precipitation is projected to decrease. Increased evaporation due to rising temperature will further impact on water availability. Seasonal availability of water may also change whereby there may be a shift in the timing of its availability.
- Existing engineering designs may not take into consideration the impact of climate change on the risks from water availability and design standards may not be met. See "Critical thresholds" in the "Help & glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.
- If water availability is identified as a potential problem for the project, it is recommended that a more localised and in-depth assessment is carried out. This information can then be used to inform the project design process if necessary.
- If you want to know more about projected changes in water availability in the project location, please refer to: the World Resources Institute's [Aqueduct](#).

#### 2. As a starting point you may wish to consider the following questions:

- Q1** How would a lack of water impact the expected performance of the project?
- Q2** Would a reduction in water supply have consequences for the expected maintenance of the project?
- Q3** Will there be a water shortage continuity strategy in place for the project?
- Q4** Will it be necessary to carry out water availability risk assessments in any of the project locations? If so, these assessments should take into account climate change?
- Q5** Will there be an investment in water efficient technology or practices to help minimise the quantities of water required for its operational processes?

#### 3. What next?

- See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
- Click [here](#) or [here](#) for the latest news and information relating to water and climate change.



# 07

LOW  
RISK

## TEMPERATURE INCREASE

Would an increase in temperature require modifications to the design of the project in order to successfully provide the expected services over its lifetime?

### Chosen Answer

No - modifications are not required.

The design of the project would be unaffected by increases in temperature.

## ACCLIMATISE COMMENTARY

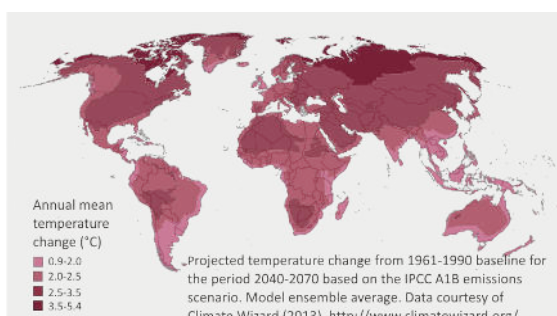
### 1. What does this mean for the design of my project?

- Even though you have suggested that project designs would not be sensitive to rising temperatures, it is worth considering existing temperature related hazards in the region where the project is planned.
- There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.
- The design, operational and maintenance standards should be reviewed - take into consideration current impacts of high temperatures as well as potential future changes.

### 2. How could current high temperatures affect the project even without future climate change?

- Heatwaves put stress on buildings and other infrastructure, including roads and other transport links. In cities, the 'urban heat island' can increase the risk of heat related deaths.
- Warm weather can raise surface water temperatures of reservoirs used for industrial cooling. In addition, this could impact local eco-systems, improving the growing conditions for algae and potentially harmful micro-organisms in water courses.
- Heatwaves can have an impact on agricultural productivity and growing seasons.
- High temperatures can have implications for energy security. Peak energy demand due to demand for cooling can exceed incremental increases on base load in addition to the risk of line outages and blackouts.
- Human health can be affected by warmer periods. For example, urban air quality and disease transmission (e.g. malaria and dengue fever) can be impacted by higher air temperatures.
- Wildfire risk is elevated during prolonged warm periods that dry fuels, promoting easier ignition and faster spread.
- Permafrost and glacial melt regimes as impacted by warm periods.
- If our data suggests that there are existing hazards associated with high temperatures in the region, they will be highlighted elsewhere in the report. This may include existing wildfire risks as well as areas potentially impacted by permafrost and glacial melt.

### 3. What does the science say could happen by the 2050s?



- Climate model projections do not agree that annual average temperature increase will reach 2°C in the project location.
- If you want to know more about projected changes in the project location across a range of GCMs and RCPs please refer to USGS's [CMIP5 Global Climate Change Viewer](#) for detailed maps.

### 4. What next?

- 
1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
  2. Click [here](#) or [here](#) for the latest news and information relating to temperature and climate change.

☐ I have acknowledged the risks highlighted in this section.



# 08

LOW  
RISK

## PRECIPITATION DECREASE

Would a decrease in precipitation require modifications to the design of the project in order to successfully provide the expected services over its lifetime?

### Chosen Answer

No - modifications are not required.

The design of the project would be unaffected by decreases in precipitation.

## ACCLIMATISE COMMENTARY

### 1. What does this mean for the design of my project?

- Even though you have suggested that designs would not be affected by a decrease in precipitation, it is worth considering existing precipitation related hazards in the region where the project is planned.

### 2. How could reduced precipitation affect the project even without future climate change?



- Decreased seasonal runoff may exacerbate pressures on water availability, accessibility and quality.
- Variability of river runoff may be affected such that extremely low runoff events (i.e. drought) may occur much more frequently.
- Pollutants from industry that would be adequately diluted could now become more concentrated.
- Increased risk of drought conditions could lead to accelerated land degradation, expanding desertification and more dust storms.

storms.

- If our data suggests that there are existing hazards associated with decreased precipitation in the region, they will be highlighted elsewhere in the report. This may include water availability and wildfire.

### 3. What does the science say could happen by the 2050s?

- Climate model projections do not agree that annual average precipitation will decrease in the project location which could indicate a relatively high degree of uncertainty (see the section "Model agreement and uncertainty" in "Help and glossary" at the end of this report). On the other hand, this could also mean precipitation patterns are not expected to change or may even increase (see elsewhere in the report for more details of projections related to precipitation increase).
- If you want to know more about projected changes in the project location across a range of GCMs and RCPs please refer to USGS's [CMIP5 Global Climate Change Viewer](#) for detailed maps.

### 4. What next?

1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
2. Click [here](#) or [here](#) for the latest news and information relating to water and climate change.



## 09

The sections above will provide details on all high and medium climate hazard risks from Aware™ where these are suggested by the climate sensitivities of the project and / or the underlying data. Selected Low risks may also be detailed. Local conditions, however, can be highly variable, so if you have any concerns related to risks not detailed in this report, it is recommended that you investigate these further using more site-specific information or through discussions with the project designers.

# 10

## Project Geological Hazard Risk Ratings

Below you will find the overall geological hazard risk level for the project together with a radar chart presenting the level of risk associated with each individual geological risk topic analysed in Aware™. Projects with a final “High risk” rating are always recommended for further more detailed geological risk analyses.

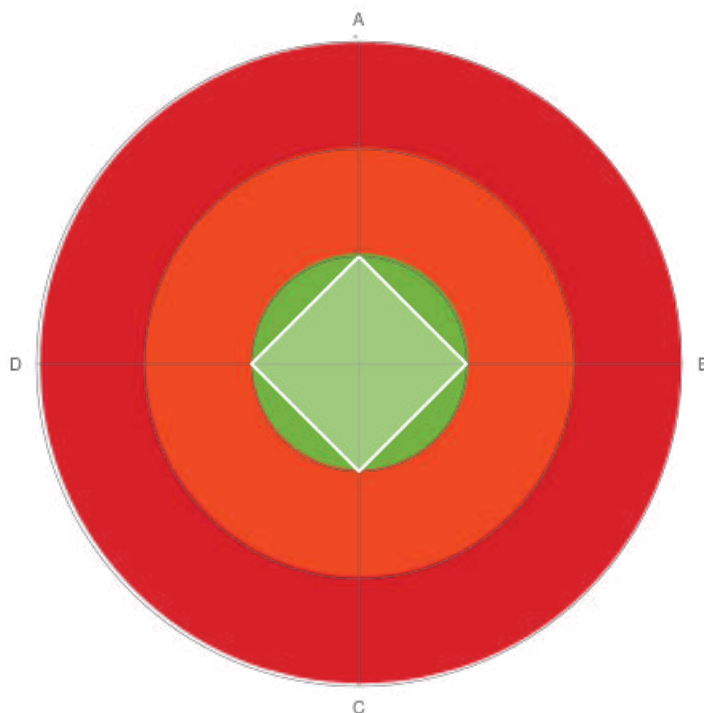
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher level of risk in relation to a risk topic. The green band (inner circle) suggests a lower level of risk in relation to a risk topic.

In the remaining sections of this report more detailed commentary is provided. Information is given on existing geological conditions and associated hazards. A number of questions are provided to help stimulate a conversation with project designers in order to determine how they would manage geological risks at the design stage. Links are provided to recent case studies, relevant data portals and other technical resources for further research.

### Final project geological hazard risk ratings

Low Risk

### Breakdown of geological hazard risk topic ratings



- A) Earthquake
- B) Seismic landslide
- C) Tsunami
- D) Volcano

# 11

The sections above will provide details on all high geological hazard risks from Aware™ where these are suggested by the underlying data. Local conditions, however, can be highly variable, so if you have any concerns related to risks not detailed in this report, it is recommended that you investigate these further using more site-specific information or through discussions with the project.

## HELP AND GLOSSARY:

### Model agreement and uncertainty:

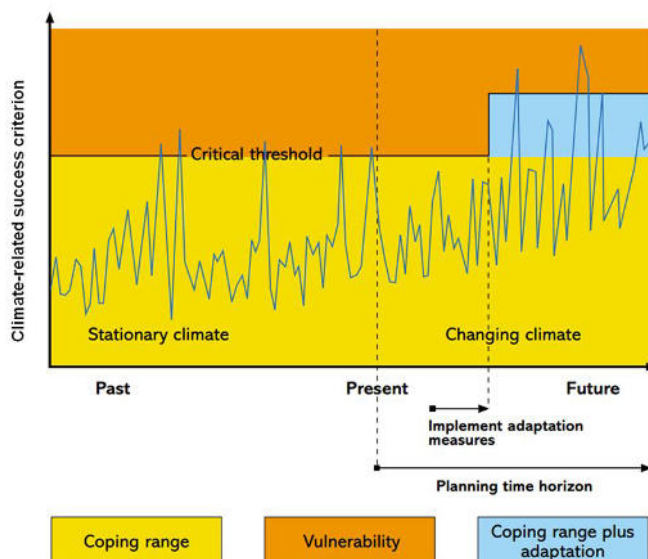
Although climate models are constantly being improved, they are not good enough to predict future climate conditions with a degree of confidence which would allow precise adaptation decisions to be made. Outputs from different climate models often differ, presenting a range of possible climate futures to consider, and ultimately a wide range of possible actions to take. In Aware, climate projections make use of GCM ensemble percentiles to determine: for temperature increase, whether 75% of CMIP5 GCM ensemble agree on a magnitude of change; for precipitation increase and decrease, whether 75% of CMIP5 GCM ensemble agree on the direction of change.

Even with improvements in climate modelling, uncertainties will remain. It is likely that not all the climate statistics of relevance to the design, planning and operations of a project's assets and infrastructure will be available from climate model outputs. The outputs are typically provided as long-term averages, e.g. changes in average monthly mean temperature or precipitation. However, decisions on asset integrity and safety may be based on short-term statistics or extreme values, such as the maximum expected 10 minute wind speed, or the 1-in-10 year rainfall event. In such cases, project designers or engineers should be working to identify climate-related thresholds for the project (see "Critical thresholds" section below) and evaluate whether existing climate trends are threatening to exceed them on an unacceptably frequent basis. Climate models can then be used to make sensible assumptions on potential changes to climate variables of relevance to the project or to obtain estimates of upper and lower bounds for the future which can be used to test the robustness of adaptation options.

**The key objective in the face of uncertainty** is therefore to define and implement design changes (adaptation options) which both provide a benefit in the current climate as well as resilience to the range of potential changes in future climate.

### Critical thresholds:

A key issue to consider when assessing and prioritising climate change risks is the critical thresholds or sensitivities for the operational, environmental and social performance of a project. Critical thresholds are the boundaries between 'tolerable' and 'intolerable' levels of risk. In the diagram below, it can be seen how acceptable breaches in a critical threshold in today's climate may become more frequent and unacceptable in a future climate.



**The relationship between a critical threshold and a climate change related success criterion for a project.** [Source: Willows, R.I. and Connell, R.K. (Eds.) (2003). *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report, UKCIP, Oxford].

Climate change scenarios can be used to see if these thresholds are more likely to be exceeded in the future. The simplest example is the height of a flood defence. When water heights are above this threshold, the site will flood. The flood defence height is the horizontal line labelled 'critical threshold'. Looking at the climate trend (in this case it would be sea level or the height of a river) – shown by the blue jagged line – it can be seen that the blue line has a gradual upward trend because of climate change. This means that the critical threshold is crossed more often in the future – because sea levels are rising and winter river flows may be getting larger. So, to cope with

this change, adaptation is needed – in this case, one adaptation measure is to increase the height of the flood defence.

### Further reading and resources:



Report detailing changes in global climate:  
[The Global Climate 2001 - 2010](#)



IPCC report on climate-related disasters and opportunities for managing risks:  
[Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation \(SREX\)](#)



IPCC report on impacts, adaptation and vulnerability:  
[Climate Change 2014: Impacts, Adaptation, and Vulnerability](#)



IFC report on climate-related risks material to financial institutions:  
[Climate Risk and Financial Institutions. Challenges and Opportunities.](#)



Nationally Determined Contributions (NDCs) submitted under the COP21 Paris Agreement:  
[NDC Registry.](#)



ADB report on investment in disaster resilience:  
[Investing in Resilience: Ensuring a Disaster-Resistant Future.](#)



UNISDR's report on disaster risk success stories:  
[Disaster risk reduction: 20 examples of good practices from Central Asia.](#)



UNISDR's review and analysis of data and information on disaster risk patterns and trends:  
[Global Assessment Report on Disaster Risk Reduction.](#)



CRED's International Disasters Database:  
[EM-DAT.](#)



Pacific Risk Information System of national-level hazard and risk information for 15 countries:  
[PCRAFI.](#)

	DesInventar Project's historical disaster impact catalogues: <a href="#">DesInventar</a> .
	National progress reports to UNISDR on DRM commitments: <a href="#">HFA National Progress Reports</a> .
	National documents DRM policy and strategy documents and studies: <a href="#">Disaster risk reduction in the world</a> .
	National-level factsheets based on the Global Assessment Report: <a href="#">Country Profiles</a> .
	GEM NEXUS Building and population inventory : <a href="#">GED4GEM database</a> .
	GAR analysis tool of exposure including population, capital stock and economic indicators: <a href="#">Risk Data Platform CAPRAViewer</a> .

#### Aware data resolution:

The proprietary Aware data set operates at a resolution of 0.5 x 0.5 decimal degrees (approximately 50 km x 50 km at the equator). These proprietary data represent millions of global data points, compiled from environmental data and the latest scientific information on current climate / weather related hazards together with potential changes in the future. Future risk outcomes are based on projections data from the near- to mid-term time horizons (2020s or 2050s, depending on the hazard and its data availability).

Global climate model output, from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (Meehl et al., 2007) and 5 (CMIP5) multi-model dataset (Taylor et al., 2012), were resampled to a 0.5 degree grid.

[Taylor, K.E., R.J. Stouffer, G.A. Meehl (2012) "An Overview of CMIP5 and the experiment design." Bulletin of the American Meteorological Society, 93, 485-498.

[Meehl, G. A., C. Covey, T. Delworth, M. Latif, B. McAvaney, J. F. B. Mitchell, R. J. Stouffer, and K. E. Taylor: The WCRP CMIP3 multi-model dataset: A new era in climate change research, Bulletin of the American Meteorological Society, 88, 1383-1394, 2007]

#### Aware data application:

In some instances Risk Topic ratings are only based on Aware data, including:

- Flood
- Permafrost
- Landslides – precipitation induced
- Earthquake
- Landslides – seismic induced
- Volcano
- Tsunami

#### Country level risk ratings:

These are generated from the data points within a country's borders. For single locations, site-specific data are used, and for multiple locations or countries, composite data across the portfolio of locations are used.

#### Glossary of terms used in report

"Climate model projections agree": for temperature, defined as 75% of CMIP5 GCM ensemble members agreeing that annual average temperature increase will reach 2°C; for precipitation increase or decrease, defined as 75% of CMIP5 GCM ensemble members agreeing on the direction of annual average precipitation change.

"Climate model projections do not agree": for temperature, defined as only 25% of CMIP5 GCM ensemble members agreeing that annual average temperature increase will reach 2°C; for precipitation increase or decrease, defined as only 25% of CMIP5 GCM ensemble members

agreeing on the direction of annual average precipitation change.

The overall climate risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high climate risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium climate risk if between 1 and 2 individual risk topics score high. A project scores overall low climate risk if none of the individual risk topics score high.

The overall geological risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high geological risk if greater than or equal to 2 individual risk topics score high. A project scores overall medium geological risk if 1 individual risk topic scores high. A project scores overall low geological risk if none of the individual risk topics score high.

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# 01

## Introduction

This report summarises results from a climate and geological risk screening exercise. The project information and location(s) are detailed immediately below.

The screening is based on the Aware<sup>TM</sup> geographic data set, compiled from the latest scientific information on current geological, climate and related hazards together with projected changes for the future where available. These data are combined with the project's sensitivities to hazard variables, returning information on the current and potential future risks that could influence its design and planning.

## Project Information

**PROJECT NAME:** SERD CAM Tonle Sap Smallholder Development Project - Additional Financing

**SUB PROJECT:** Lvea Commune irrigation rehabilitation in Prey Veng Province

**PROJECT NUMBER** 41435-054

**/ REFERENCE:**

**SECTOR:** Agriculture, Natural Resources, and Rural Development

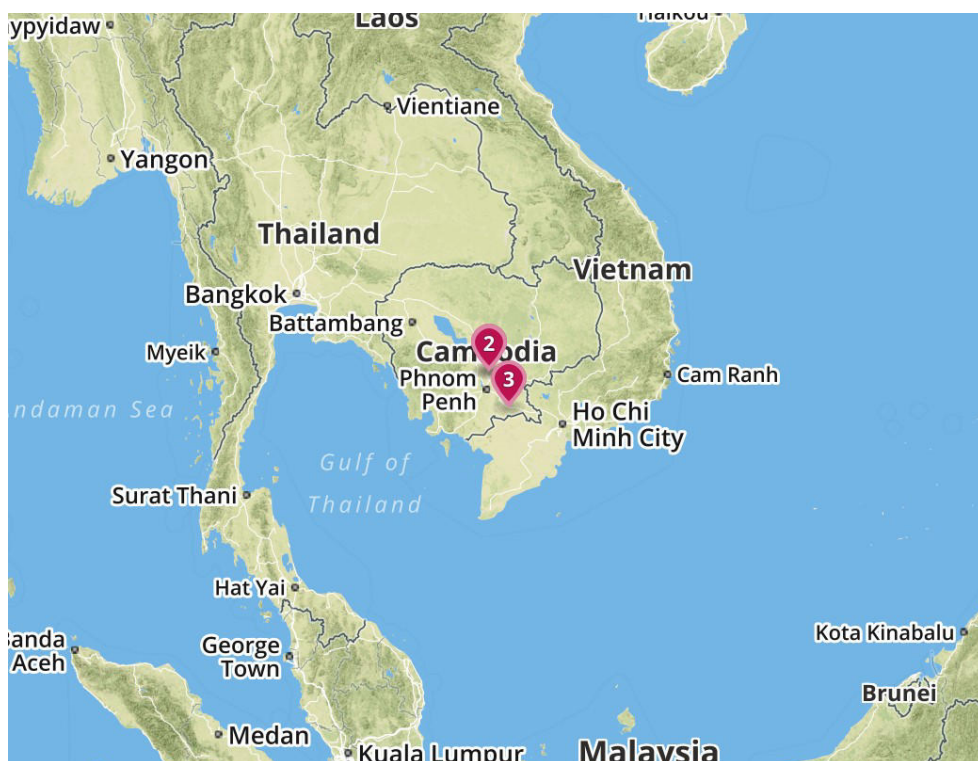
**SUB SECTOR:** Irrigation - surface, sprinkler, drip, trickle

**DESCRIPTION:** Under this sub-project it is proposed to rehabilitate 3 secondary canals (SC) with a total length of 4km. Water will come from primary and secondary canals supplied by Pumping Station No. 2 on the Traebek River.

# 02

## Chosen Locations

- 1) Batheay Rural Road Section 3
- 2) Batheay Rural Road Section 4
- 3) Lvea irrigation scheme



# 03

## Project Climate Risk Ratings

Below you will find the overall climate risk level for the project together with a radar chart presenting the level of risk associated with each individual climate risk topic analysed in Aware™. Projects with a final “High risk” rating are always recommended for further more detailed climate risk analyses.

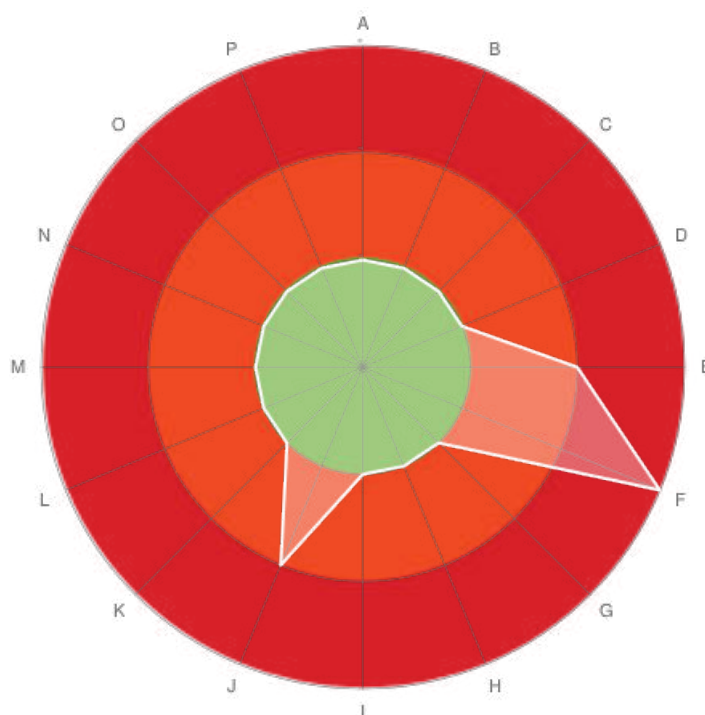
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher level of risk in relation to a risk topic. The green band (inner circle) suggests a lower level of risk in relation to a risk topic.

In the remaining sections of this report more detailed commentary is provided. Information is given on existing and possible future climate conditions and associated hazards. A number of questions are provided to help stimulate a conversation with project designers in order to determine how they would manage current and future climate change risks at the design stage. Links are provided to recent case studies, relevant data portals and other technical resources for further research.

### Final project climate risk ratings

## Medium Risk

### Breakdown of climate risk topic ratings



A) Temperature increase
B) Wild fire
C) Permafrost
D) Sea ice
E) Precipitation increase
F) Flood
G) Snow loading
H) Landslide
I) Precipitation decrease
J) Water availability
K) Wind speed increase
L) Onshore Category 1 storms
M) Offshore Category 1 storms
N) Wind speed decrease
O) Sea level rise
P) Solar radiation change

# 04

HIGH  
RISK

## FLOOD

### ACCLIMATISE COMMENTARY



• Our data suggest that the project is located in a region which has experienced recurring major flood events in the recent past. A high exposure in Aware means that between 1985 and 2016 there have been at least one significant, large-scale flood event in the region. This is based on post-processed data from the Dartmouth Flood Observatory at the University of Colorado.

- The risk and type of flooding is dependent on local geographical factors including:
  - Proximity to the coast and inland water courses
  - Local topography
  - Land use characteristics, including land use in upstream catchment area
  - Design and maintenance level of drainage infrastructure
  - Vulnerability of exposed assets
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's [Global Risk Data Platform](#) and Dartmouth Flood Observatory's [Global Active Archive of Large Flood Events](#).

#### 1. What does this mean for the design and construction of my project?

- If floods are identified as a potential problem for the project, it is recommended that:
  - More localized information is collected on past floods and their consequences in the exact project location, especially since flood hazard can change significantly over short distances; depending on the findings, a site-specific flood risk assessment (including flood modelling) might be required that provides a good understanding of the current and future flood risk level
  - Information is collected on land use and building regulations, such as flood zonation ordinances
  - The project siting, design and construction features ensure that site-specific flood risk management measures are undertaken. Such measures could include a combination of grey infrastructure (such as flood defence infrastructure) and green infrastructure (such as restoration of wetlands) to reduce flood risk, as well as measures to manage the residual flood risk (such as through flood early warning, flood preparedness planning, flood insurance etc.)

#### 2. What does the science say could happen in the future and what does this mean for the design of my project?

- Climate change is projected to influence the frequency and intensity of flood events.
- Existing engineering designs may not take into consideration the impact of climate change on the risks from flooding. See "Critical thresholds" in the "Help & glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

#### 3. As a starting point you may wish to consider the following questions:

- Q1** Would the expected performance and maintenance of the project be impaired by flooding?
- Q2** Is there a plan to integrate climate change into a flood risk assessment for the project?
- Q3** Does the project siting consider flood risk to ensure the proposed project will not be impacted by flooding and will not increase risk of flooding?
- Q4** Does the project design and construction features incorporate measures to manage flood risk, both in the immediate term and as risk of flooding changes as a consequence of climate change?
- Q5** Will the project include emergency management plans which make provision for continued successful operation in the event of floods?

#### 4. What next?

- See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
- Click [here](#) or [here](#) for the latest news and information relating to floods and climate change.

☐ I have acknowledged the risks highlighted in this section.

---

# 05

**MEDIUM  
RISK**

## PRECIPITATION INCREASE

Would an increase in precipitation require modifications to the design of the project in order to successfully provide the expected services over its lifetime?

### Chosen Answer

Yes - a little.

The design of the project may have to be slightly modified to cope with the impact of increased precipitation.

## ACCLIMATISE COMMENTARY

### 1. What does this mean for the design of my project?

- There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.
- The design, operational and maintenance standards should be reviewed - take into consideration current impacts of heavy precipitation events as well as potential future changes.

### 2. How could current heavy precipitation affect the project even without future climate change?



- Seasonal runoff may lead to erosion and siltation of water courses, lakes and reservoirs.
- Flooding and precipitation induced landslide events.
- In colder regions, seasonal snow falls could lead to overloading structures and avalanche risk.
- If our data suggests that there are existing hazards associated with heavy precipitation in the region, they will be highlighted elsewhere in the report. This may include existing flood and landslide risks.

### 3. What does the science say could happen by the 2050s?

- Climate model projections agree that annual average precipitation will increase in the project location. This indicates a relatively low degree of uncertainty that precipitation will increase in the region.
- If you want to know more about projected changes in the project location across a range of GCMs and RCPs please refer to USGS's [CMIP5 Global Climate Change Viewer](#) for detailed maps.

### 4. What next?

1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
2. Click [here](#) or [here](#) for the latest news and information relating to water and climate change.

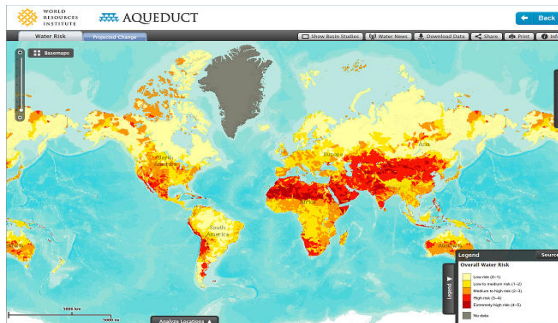


# 06

MEDIUM  
RISK

## WATER AVAILABILITY

### ACCLIMATISE COMMENTARY



• Our data suggest that the project is located in a region where there may be future water stress (2020s - 2050s). A high exposure in Aware means that either water stress is 'extreme' or high seasonal temperatures coincide with relatively low rainfall. Extreme water stress is defined as 'less than 0.5 million litres available per person per year' based on climate information as well as the effects of income, electricity production, water-use efficiency and other driving forces. This is post-processed data from Alcamo et al., 2007. Away

from populated regions, high exposure also occurs where high seasonal temperatures (above 28 degrees Celsius average over 6 months) coincide with low rainfall (less than 100mm per month average over 6 months). This is based on post-processed data from the Global Precipitation Climatology Centre (GPCC), Climatic Research Unit (CRU) and a range of GCM projections.

- The situation may be exacerbated if there is increased competition for water with other users in the area and changes in local demographics.
- An associated reduction in water quality could also have a negative impact on the project.

#### 1. What the science says could happen in the future and what does this mean for the design of my project?

- Climate change is projected to influence water availability. Regions that are already dry may suffer further if future precipitation is projected to decrease. Increased evaporation due to rising temperature will further impact on water availability. Seasonal availability of water may also change whereby there may be a shift in the timing of its availability.
- Existing engineering designs may not take into consideration the impact of climate change on the risks from water availability and design standards may not be met. See "Critical thresholds" in the "Help & glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.
- If water availability is identified as a potential problem for the project, it is recommended that a more localised and in-depth assessment is carried out. This information can then be used to inform the project design process if necessary.
- If you want to know more about projected changes in water availability in the project location, please refer to: the World Resources Institute's [Aqueduct](#).

#### 2. As a starting point you may wish to consider the following questions:

- Q1** How would a lack of water impact the expected performance of the project?
- Q2** Would a reduction in water supply have consequences for the expected maintenance of the project?
- Q3** Will there be a water shortage continuity strategy in place for the project?
- Q4** Will it be necessary to carry out water availability risk assessments in any of the project locations? If so, these assessments should take into account climate change?
- Q5** Will there be an investment in water efficient technology or practices to help minimise the quantities of water required for its operational processes?

#### 3. What next?

- See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
- Click [here](#) or [here](#) for the latest news and information relating to water and climate change.



# 07

LOW  
RISK

## TEMPERATURE INCREASE

Would an increase in temperature require modifications to the design of the project in order to successfully provide the expected services over its lifetime?

### Chosen Answer

No - modifications are not required.

The design of the project would be unaffected by increases in temperature.

## ACCLIMATISE COMMENTARY

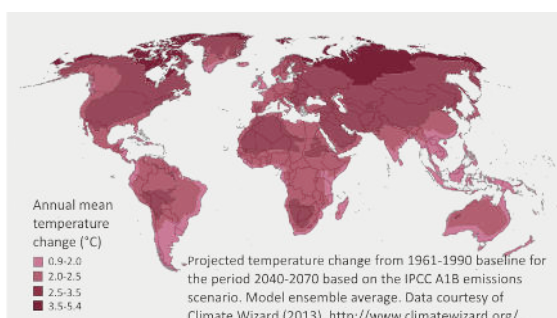
### 1. What does this mean for the design of my project?

- Even though you have suggested that project designs would not be sensitive to rising temperatures, it is worth considering existing temperature related hazards in the region where the project is planned.
- There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.
- The design, operational and maintenance standards should be reviewed - take into consideration current impacts of high temperatures as well as potential future changes.

### 2. How could current high temperatures affect the project even without future climate change?

- Heatwaves put stress on buildings and other infrastructure, including roads and other transport links. In cities, the 'urban heat island' can increase the risk of heat related deaths.
- Warm weather can raise surface water temperatures of reservoirs used for industrial cooling. In addition, this could impact local eco-systems, improving the growing conditions for algae and potentially harmful micro-organisms in water courses.
- Heatwaves can have an impact on agricultural productivity and growing seasons.
- High temperatures can have implications for energy security. Peak energy demand due to demand for cooling can exceed incremental increases on base load in addition to the risk of line outages and blackouts.
- Human health can be affected by warmer periods. For example, urban air quality and disease transmission (e.g. malaria and dengue fever) can be impacted by higher air temperatures.
- Wildfire risk is elevated during prolonged warm periods that dry fuels, promoting easier ignition and faster spread.
- Permafrost and glacial melt regimes as impacted by warm periods.
- If our data suggests that there are existing hazards associated with high temperatures in the region, they will be highlighted elsewhere in the report. This may include existing wildfire risks as well as areas potentially impacted by permafrost and glacial melt.

### 3. What does the science say could happen by the 2050s?



- Climate model projections do not agree that annual average temperature increase will reach 2°C in the project location.
- If you want to know more about projected changes in the project location across a range of GCMs and RCPs please refer to USGS's [CMIP5 Global Climate Change Viewer](#) for detailed maps.

### 4. What next?



- 
1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
  2. Click [here](#) or [here](#) for the latest news and information relating to temperature and climate change.

☐ I have acknowledged the risks highlighted in this section.

# 08

LOW  
RISK

## PRECIPITATION DECREASE

Would a decrease in precipitation require modifications to the design of the project in order to successfully provide the expected services over its lifetime?

### Chosen Answer

No - modifications are not required.

The design of the project would be unaffected by decreases in precipitation.

## ACCLIMATISE COMMENTARY

### 1. What does this mean for the design of my project?

- Even though you have suggested that designs would not be affected by a decrease in precipitation, it is worth considering existing precipitation related hazards in the region where the project is planned.

### 2. How could reduced precipitation affect the project even without future climate change?



- Decreased seasonal runoff may exacerbate pressures on water availability, accessibility and quality.
- Variability of river runoff may be affected such that extremely low runoff events (i.e. drought) may occur much more frequently.
- Pollutants from industry that would be adequately diluted could now become more concentrated.
- Increased risk of drought conditions could lead to accelerated land degradation, expanding desertification and more dust storms.

storms.

- If our data suggests that there are existing hazards associated with decreased precipitation in the region, they will be highlighted elsewhere in the report. This may include water availability and wildfire.

### 3. What does the science say could happen by the 2050s?

- Climate model projections do not agree that annual average precipitation will decrease in the project location which could indicate a relatively high degree of uncertainty (see the section "Model agreement and uncertainty" in "Help and glossary" at the end of this report). On the other hand, this could also mean precipitation patterns are not expected to change or may even increase (see elsewhere in the report for more details of projections related to precipitation increase).
- If you want to know more about projected changes in the project location across a range of GCMs and RCPs please refer to USGS's [CMIP5 Global Climate Change Viewer](#) for detailed maps.

### 4. What next?

1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
2. Click [here](#) or [here](#) for the latest news and information relating to water and climate change.

## 09

The sections above will provide details on all high and medium climate hazard risks from Aware™ where these are suggested by the climate sensitivities of the project and / or the underlying data. Selected Low risks may also be detailed. Local conditions, however, can be highly variable, so if you have any concerns related to risks not detailed in this report, it is recommended that you investigate these further using more site-specific information or through discussions with the project designers.

# 10

## Project Geological Hazard Risk Ratings

Below you will find the overall geological hazard risk level for the project together with a radar chart presenting the level of risk associated with each individual geological risk topic analysed in Aware™. Projects with a final “High risk” rating are always recommended for further more detailed geological risk analyses.

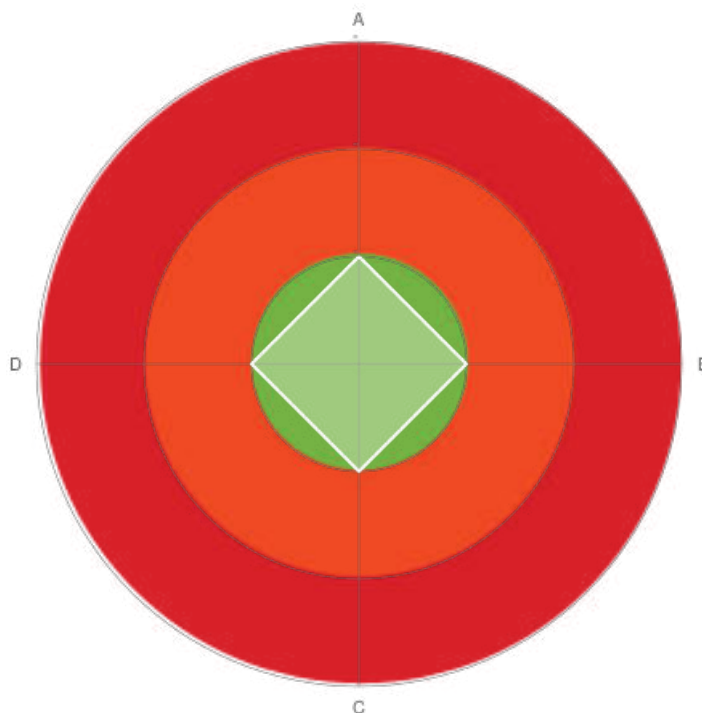
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher level of risk in relation to a risk topic. The green band (inner circle) suggests a lower level of risk in relation to a risk topic.

In the remaining sections of this report more detailed commentary is provided. Information is given on existing geological conditions and associated hazards. A number of questions are provided to help stimulate a conversation with project designers in order to determine how they would manage geological risks at the design stage. Links are provided to recent case studies, relevant data portals and other technical resources for further research.

### Final project geological hazard risk ratings

Low Risk

### Breakdown of geological hazard risk topic ratings



- A) Earthquake
- B) Seismic landslide
- C) Tsunami
- D) Volcano

# 11

The sections above will provide details on all high geological hazard risks from Aware™ where these are suggested by the underlying data. Local conditions, however, can be highly variable, so if you have any concerns related to risks not detailed in this report, it is recommended that you investigate these further using more site-specific information or through discussions with the project.

**ADDITIONAL SECTORAL GUIDANCE:**

**Agriculture sector further reading and resources:**



UN FAO's programme for observations, modelling, and analysis of terrestrial ecosystems to support sustainable development: [GTOS](#).



UN FAO's software tool-box for crop yield forecasting: [AgroMetShell](#).

## HELP AND GLOSSARY:

### Model agreement and uncertainty:

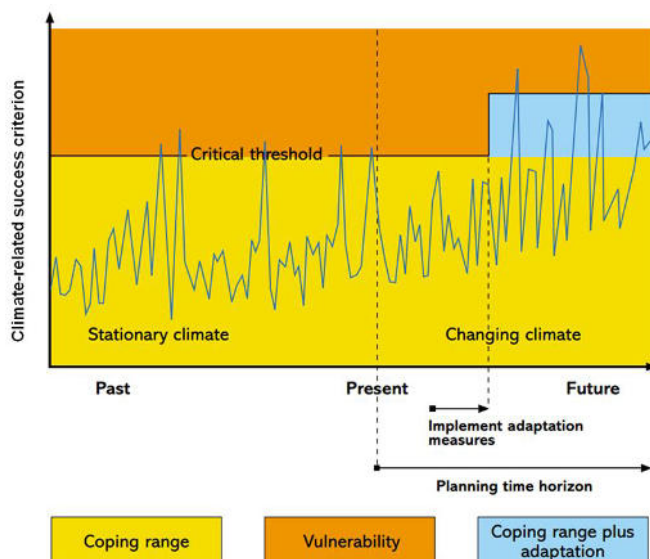
Although climate models are constantly being improved, they are not good enough to predict future climate conditions with a degree of confidence which would allow precise adaptation decisions to be made. Outputs from different climate models often differ, presenting a range of possible climate futures to consider, and ultimately a wide range of possible actions to take. In Aware, climate projections make use of GCM ensemble percentiles to determine: for temperature increase, whether 75% of CMIP5 GCM ensemble agree on a magnitude of change; for precipitation increase and decrease, whether 75% of CMIP5 GCM ensemble agree on the direction of change.

Even with improvements in climate modelling, uncertainties will remain. It is likely that not all the climate statistics of relevance to the design, planning and operations of a project's assets and infrastructure will be available from climate model outputs. The outputs are typically provided as long-term averages, e.g. changes in average monthly mean temperature or precipitation. However, decisions on asset integrity and safety may be based on short-term statistics or extreme values, such as the maximum expected 10 minute wind speed, or the 1-in-10 year rainfall event. In such cases, project designers or engineers should be working to identify climate-related thresholds for the project (see "Critical thresholds" section below) and evaluate whether existing climate trends are threatening to exceed them on an unacceptably frequent basis. Climate models can then be used to make sensible assumptions on potential changes to climate variables of relevance to the project or to obtain estimates of upper and lower bounds for the future which can be used to test the robustness of adaptation options.

**The key objective in the face of uncertainty** is therefore to define and implement design changes (adaptation options) which both provide a benefit in the current climate as well as resilience to the range of potential changes in future climate.

### Critical thresholds:

A key issue to consider when assessing and prioritising climate change risks is the critical thresholds or sensitivities for the operational, environmental and social performance of a project. Critical thresholds are the boundaries between 'tolerable' and 'intolerable' levels of risk. In the diagram below, it can be seen how acceptable breaches in a critical threshold in today's climate may become more frequent and unacceptable in a future climate.



**The relationship between a critical threshold and a climate change related success criterion for a project.** [Source: Willows, R.I. and Connell, R.K. (Eds.) (2003). *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report, UKCIP, Oxford].

Climate change scenarios can be used to see if these thresholds are more likely to be exceeded in the future. The simplest example is the height of a flood defence. When water heights are above this threshold, the site will flood. The flood defence height is the horizontal line labelled 'critical threshold'. Looking at the climate trend (in this case it would be sea level or the height of a river) – shown by the blue jagged line – it can be seen that the blue line has a gradual upward trend because of climate change. This means that the critical threshold is crossed more often in the future – because sea levels are rising and winter river flows may be getting larger. So, to cope with

this change, adaptation is needed – in this case, one adaptation measure is to increase the height of the flood defence.

### Further reading and resources:



Report detailing changes in global climate:  
[The Global Climate 2001 - 2010](#)



IPCC report on climate-related disasters and opportunities for managing risks:  
[Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation \(SREX\)](#)



IPCC report on impacts, adaptation and vulnerability:  
[Climate Change 2014: Impacts, Adaptation, and Vulnerability](#)



IFC report on climate-related risks material to financial institutions:  
[Climate Risk and Financial Institutions. Challenges and Opportunities.](#)



Nationally Determined Contributions (NDCs) submitted under the COP21 Paris Agreement:  
[NDC Registry.](#)



ADB report on investment in disaster resilience:  
[Investing in Resilience: Ensuring a Disaster-Resistant Future.](#)



UNISDR's report on disaster risk success stories:  
[Disaster risk reduction: 20 examples of good practices from Central Asia.](#)



UNISDR's review and analysis of data and information on disaster risk patterns and trends:  
[Global Assessment Report on Disaster Risk Reduction.](#)




CRED's International Disasters Database:  
[EM-DAT.](#)



Pacific Risk Information System of national-level hazard and risk information for 15 countries:  
[PCRAFI.](#)



	DesInventar Project's historical disaster impact catalogues: <a href="#">DesInventar</a> .
	National progress reports to UNISDR on DRM commitments: <a href="#">HFA National Progress Reports</a> .
	National documents DRM policy and strategy documents and studies: <a href="#">Disaster risk reduction in the world</a> .
	National-level factsheets based on the Global Assessment Report: <a href="#">Country Profiles</a> .
	GEM NEXUS Building and population inventory : <a href="#">GED4GEM database</a> .
	GAR analysis tool of exposure including population, capital stock and economic indicators: <a href="#">Risk Data Platform CAPRAViewer</a> .

#### Aware data resolution:

The proprietary Aware data set operates at a resolution of 0.5 x 0.5 decimal degrees (approximately 50 km x 50 km at the equator). These proprietary data represent millions of global data points, compiled from environmental data and the latest scientific information on current climate / weather related hazards together with potential changes in the future. Future risk outcomes are based on projections data from the near- to mid-term time horizons (2020s or 2050s, depending on the hazard and its data availability).

Global climate model output, from the World Climate Research Programme's (WCRP's) Coupled Model Intercomparison Project phase 3 (Meehl et al., 2007) and 5 (CMIP5) multi-model dataset (Taylor et al., 2012), were resampled to a 0.5 degree grid.

[Taylor, K.E., R.J. Stouffer, G.A. Meehl (2012) "An Overview of CMIP5 and the experiment design." Bulletin of the American Meteorological Society, 93, 485-498.

[Meehl, G. A., C. Covey, T. Delworth, M. Latif, B. McAvaney, J. F. B. Mitchell, R. J. Stouffer, and K. E. Taylor: The WCRP CMIP3 multi-model dataset: A new era in climate change research, Bulletin of the American Meteorological Society, 88, 1383-1394, 2007]

#### Aware data application:

In some instances Risk Topic ratings are only based on Aware data, including:

- Flood
- Permafrost
- Landslides – precipitation induced
- Earthquake
- Landslides – seismic induced
- Volcano
- Tsunami

#### Country level risk ratings:

These are generated from the data points within a country's borders. For single locations, site-specific data are used, and for multiple locations or countries, composite data across the portfolio of locations are used.

#### Glossary of terms used in report

"Climate model projections agree": for temperature, defined as 75% of CMIP5 GCM ensemble members agreeing that annual average temperature increase will reach 2°C; for precipitation increase or decrease, defined as 75% of CMIP5 GCM ensemble members agreeing on the direction of annual average precipitation change.

"Climate model projections do not agree": for temperature, defined as only 25% of CMIP5 GCM ensemble members agreeing that annual average temperature increase will reach 2°C; for precipitation increase or decrease, defined as only 25% of CMIP5 GCM ensemble members

agreeing on the direction of annual average precipitation change.

The overall climate risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high climate risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium climate risk if between 1 and 2 individual risk topics score high. A project scores overall low climate risk if none of the individual risk topics score high.

The overall geological risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high geological risk if greater than or equal to 2 individual risk topics score high. A project scores overall medium geological risk if 1 individual risk topic scores high. A project scores overall low geological risk if none of the individual risk topics score high.

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## Annex 2: Climate and Disaster Risk Assessment Report

### I. OVERVIEW

#### A. Background

1. This report is prepared as part of Asian Development Bank (ADB) project preparatory technical assistance (PPTA) TA-9167 CAM, for additional financing (AF) to the Tonle Sap Poverty Reduction and Smallholder Development Project (TSSD). The TSSD project, which is coming to end of its implementation phase, focused on (i) commune development; (ii) enabling policy environment improvement; and (iii) project management. The small infrastructure interventions of TSSD (less than \$20,000 per intervention) mainly involved the rehabilitation or construction of commune market centers, rehabilitation and upgrading of feeder roads and drainage structures, rehabilitation and upgrading of small embankments, reservoirs and canals. The AF project will carry on the infrastructure development in irrigation and roads, but an equal focus will be on capacity building at the local level and climate change adaptation strategies and disaster risk reduction (DRR) at the commune level.

2. ADB requires the assessment of climate risks for all projects. The assessment of climate risks is initiated in the rapid environmental assessment (REA) undertaken by ADB during project identification. This included a *Checklist for Preliminary Climate Risk Screening* for irrigation projects (Attachment 1) which assigned a medium climate risk rating. In addition, TSDD-AD will be partly financed through Asian Development Fund (ADF) DRR funding, which requires projects to undertake a disaster risk assessment in order to identify the DRR measures to be supported by the project. This document therefore covers both aspects – of climate risk and vulnerability assessment and disaster risk assessment.

3. Climate risk and adaptation and disaster risk and risk reduction considerations have been incorporated into the project's environmental safeguards documents (initial environmental examination and environmental management plan) recommendations for detailed design and are based upon the findings of this Climate and Disaster Risk Assessment (CDRA).

4. The Bank has issued guidelines for climate proofing projects and the appropriate guidelines used for TSSD-AF are *Guidelines for Climate Proofing Investments in Agriculture, Rural Development and Food Security (2012)* and *Guidelines for Climate Proofing Investments in the Transport Sector: Road Infrastructure Projects (2011)*.

#### B. Project Components

5. TSSD-AF will modify the ongoing project scope by strengthening activities in the existing 196 communes of the TSSD project and scale up the current project activities in an additional 75 communes. With the additional financing, the overall project impact will be improved livelihoods in target communes in seven provinces in the Tonle Sap Basin. Banteay Meanchey, Kampong Cham, Kampong Thom, Siem Reap, and Tboung Khmum provinces are in the current project. These five provinces, plus Battambang and Prey Veng are proposed to be included in the AF project.

6. The impact of the overall project, which is aligned with the Cambodia Country Partnership Strategy 2014-2018, ADB's Assessment, Strategy and Roadmap for the Agriculture, Natural Resources and Rural Development Sector, and the Government Rectangular Strategy for Growth, Employment, Equity, and Efficiency Phase III, will be: improved livelihoods and resilience in target communes in seven provinces (Banteay Meanchey, Battambang, Kampong Cham, Kampong Thom, Prey Veng, Siem Reap, and Tboung Khmum) in the Tonle Sap Basin by 2023. The outcome of the overall project will be: agricultural productivity increased, climate and disaster

resilience strengthened and access to markets improved in 37 districts in seven provinces in the Tonle Sap Basin. This will include improved rural infrastructure, improved agricultural support and rural financial services, increasing diversification of household economic activities, and the creation of on- and off-farm livelihood opportunities.

7. The project will focus on assisting communities establish livelihood improvement strategies for resource-poor farming households with assets that give them the potential to increase their farm based income. Outcomes will be measured on the basis of (i) average rice yields increasing to more than 3.50 t/ha; (ii) average rice yields of identified poor households in target communes increased to minimum 3 t/ha for wet season rice production; (iii) diversified farming systems reduce share of household income from rice by 20%; (iv) marketed farm and off-farm products increased by 25%; and (v) awareness of climate smart agriculture and DRR planning increased.

8. The project has three major Outputs:

Output 1: Rural productive infrastructure and livelihood improved with capacity in disaster risk reduction enhanced.

- Rural roads, small scale irrigation, and other production related infrastructure;
- Support to new and old LIGs; and
- Value chain support.

Output 2: Enabling environment for increased agricultural productivity, diversification and climate resilience created

- Quarterly value chain cluster meetings;
- ICT/Commune Mobile Access program;
- Support to farmer water user groups (FWUGs); and
- Developing capacity to service agricultural machinery at commune level.

Output 3: Project management strengthened.

9. The output with most relevance to the CDRA is Output 1, since it includes civil works for the construction of irrigation and rural road infrastructure which must factor disaster risk considerations and be adapted to future climate change. The capacity building outputs of Output 2 (and part of Output 1) support the sustainability of investment in irrigation and roads. Two areas of capacity building will support the recommendations of the CDRA in particular: these are the support for climate smart agriculture and DRR. In Cambodia almost all disasters are flood-related disasters.<sup>1</sup> The TSSD-AF provinces are among the worst affected by floods, especially Prey Veng, Kampong Thom and the Tonle Sap lake border areas of Banthaey Meanchey, Siem Reap and Battambang. The incorporation of disaster risk and climate adaptation measures to the location, design and operation of subprojects will contribute to the sustainability of the infrastructure investments and the safeguarding of the communities they service.

10. Climate smart agriculture capacity building will introduce a national climate smart agricultural curriculum, work with farmers to train them in the curriculum with rice and other diversified production elements, and trialling four new climate resilient rice varieties on selected plots and brokering supply contracts where trials are successful.

11. The National Committee for Disaster Management (NCDM), established in 1995, is the country's focal agency for disaster risk management. A commune level training and planning program has been developed and TSSD-AF will support the NCDM Secretariat (NCDMS) to scale this program up into all 271 TSSD-AF target communes. The training and planning process will gradually support the commune councils in identifying, planning and implementing DRR-related

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<sup>1</sup> CAM 46009-003 Additional Financing for Flood Damage Emergency Reconstruction Project RRP Linked Document.

infrastructure improvement, thereby strengthening disaster resilience at commune level.

12. The TSSD-AF project will coordinate in particular with TA 8669-CAM: Strengthening Coordination for Management of Disasters, and with Grant 9178-CAM: Community-Based Disaster Risk Reduction, to integrate DRR in the planning process of the target commune councils. It will also coordinate with the forthcoming Climate-Friendly Agribusiness Value Chains Sector Project in capacity strengthening for climate smart agriculture and agribusinesses, and Loans 3006/3007/8271 and Grants 0349/0350-CAM: Climate-Resilient Rice Commercialization Sector Development Project (Rice-SDP) by developing secondary and tertiary canals to connect with the main canals developed by the Rice-SDP, and adopt climate resilience measures in rural road construction developed in Loan 42334-CAM: Rural Roads Improvement Project – Phases I and II.

### C. Scope of the Climate and Disaster Risk Assessment

13. The methodology for this assessment is derived from the six step process described in the ADB Guidelines for Climate Proofing Investment (in agriculture and roads) Steps for disaster risk assessments have been added, where needed. The six steps are:

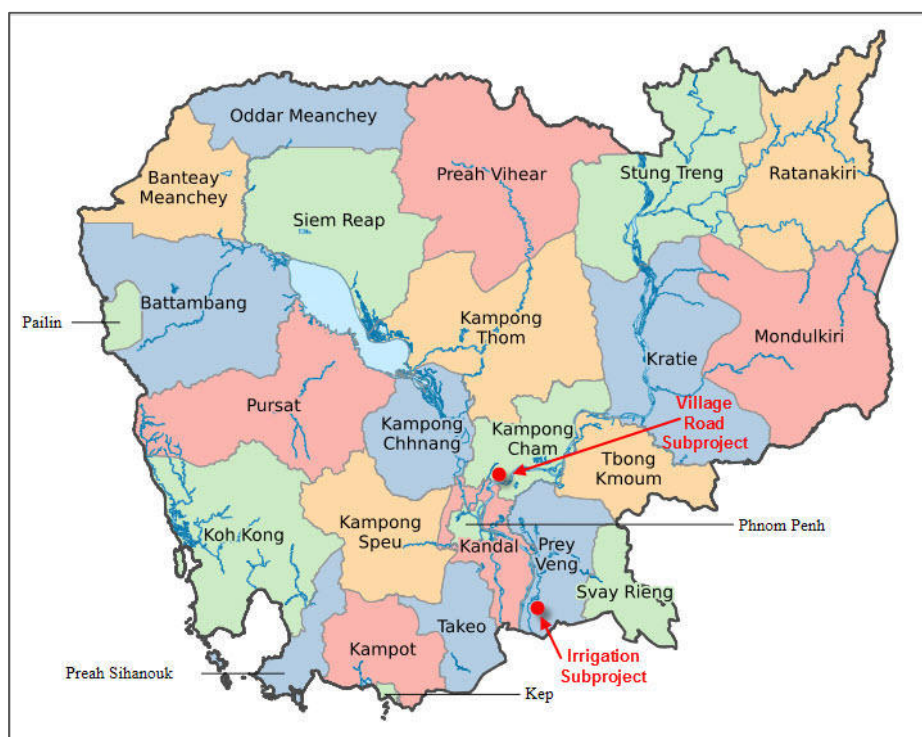
- (i) Project risk screening and scoping;
- (ii) Impact assessment;
- (iii) Vulnerability assessment;
- (iv) Adaptation assessment and disaster risk assessment;
- (v) Implementation arrangements; and
- (vi) Monitoring and evaluation.

14. A long list of candidate subprojects for infrastructure construction or rehabilitation under Output 1 was developed during the course of the PPTA. These are located in 19 Districts and 130 communes in Banteay Meanchey, Battambang, Kampong Cham, Kampong Thom, Prey Veng Siem Reap, and Tboung Khmum provinces selection criteria were developed for identifying the preferred ones. These criteria identified the first two subprojects to be funded (called “core” subprojects). These are the **Lvea Commune irrigation rehabilitation** in Prey Veng Province and the **Banthaey to Chbar Ampov village road rehabilitation** in Kampong Cham Province.

15. This CDRA addresses the climate and disaster risk and vulnerability of the two core subprojects in detail because the exact locations, specifications and environmental context of them are known. The DRR and climate change adaptation (CCA) measures identified in the CDRA for these two subprojects are also specific to the local situation. Risk and vulnerability is also considered for the other provinces for which a long list of candidate infrastructure subprojects has been identified. For these, a combination of methodological guidelines for identifying adaptation and DRR measures and reference to measures developed for the core subprojects which might have wider application, is provided. The environmental review and assessment framework, which will guide the environmental due diligence of future subprojects for funding, references the recommendations of this CDRA as a necessary part of environmental due diligence.

#### 1. Core subprojects

16. The specifications of the proposed core subprojects comprise works to improve selected secondary canals of an irrigation command area in Lvea commune and to rehabilitate and provide enhanced flood resilience of a small road running between villages in Banthaey and Chbar Ampov communes Figure 1).

**Figure 1: Location of Core Subprojects**

Source: NIRVn - Map created using QGIS, CC BY-SA 3.0, <https://en.wikipedia.org/w/index.php?curid=43121523>.

#### **a. Irrigation Rehabilitation in Lvea Commune**

17. Irrigated agriculture in Prey Veng province is wet season rice-based. If sufficient irrigation water is available a second crop of rice is sown. At the subproject site in Lvea commune, poor design, silting up and sometimes blockage of secondary canals constrains irrigation penetration into large areas and during dry season, many lands are observed to be fallow. In general, lands are quite level.

18. Under this subproject it is proposed to rehabilitate three secondary canals with a total length of 4 km. Water will come from primary and secondary canals supplied by Pumping Station No. 2 on the Traebek River. These are:

**Secondary canal 1:** a 1 km canal north of Highway 1 in Thnaot village, flowing south from a secondary canal: adding a command area of 57 ha for a dry season crop.

**Secondary canal 2:** a 3 km long canal south of Highway 1, starting at an intake gate on main canal (no. 10) and flowing eastward through Boeung Snao and Takork villages and finishing at a ruined Pol Pot era gate: adding 179 ha for a dry season crop.

**Secondary canal 3:** a 1 km long canal south of Highway 1, starting at an intake gate on main canal (no. 10) and flowing westward: adding 69 ha for a dry season crop.

19. Expected increases in dry season cropping areas from the rehabilitation of these three secondary canals is 305 ha:

- (i) 57 ha at Thnaot Village
- (ii) 179 ha at Boeung Snao and Takork Villages
- (iii) 71 ha at the western extension of the Boeung Snao and Takork canal



## b. Village Road Rehabilitation in Bathaey-Chbar Ampov Communes

20. Under this subproject it is proposed to rehabilitate a 7.6 km long rural road which starts at Highway 6 in Bathaey Commune and finishes in Chbar Ampov village, Chbar Ampov Commune. The road will be rehabilitated in four sections. The first priority will be the section across the floodway, spanning the border between Banthaey and Chbar Ampov communes. The remaining sections will be implemented as separate future subprojects and in an order and schedule yet to be finalized.

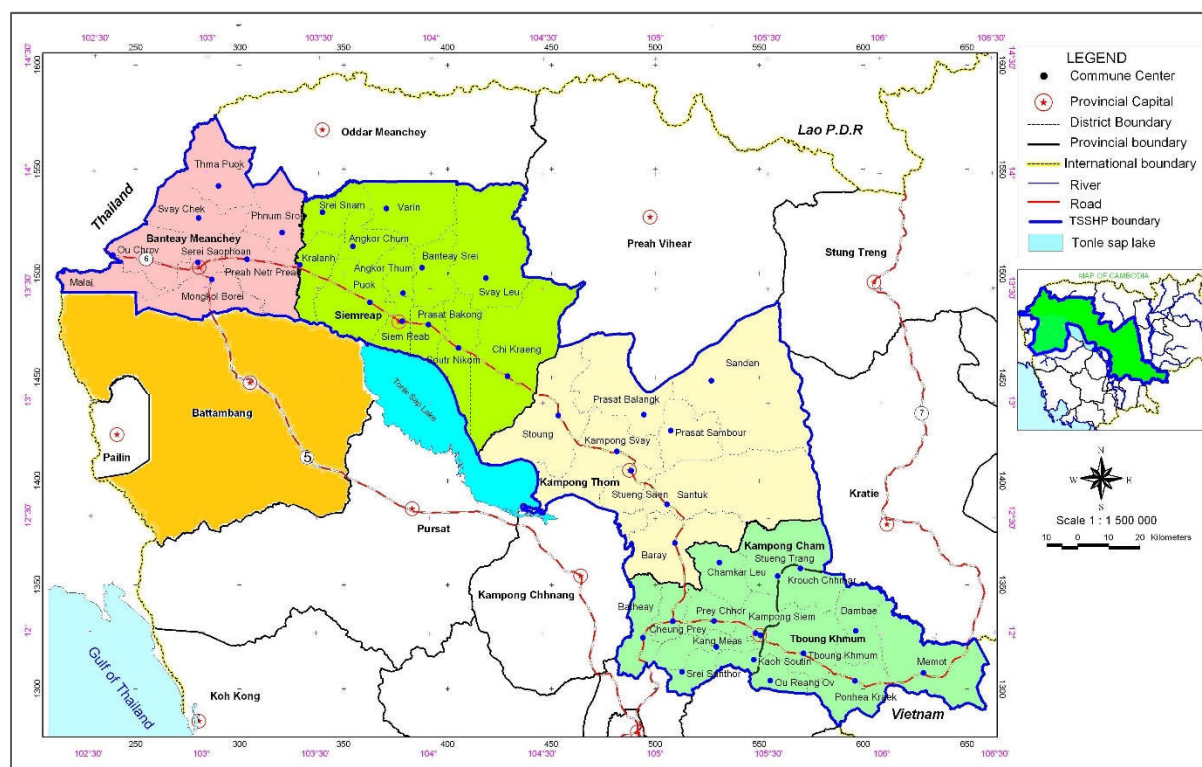
21. The major constraint which is considered during subproject design is that every year up to 3.5 km of the road floods to a depth of about 0.5 m and twice in the last 20 years sections of the road have flooded to a depth of 2 m.

22. Design of the road and structures will conform to the NCDD's Project Implementation Manual (2009), Volume II: Specification for Construction Materials and Works and any other relevant guidelines and specifications.

## 2. Long List of Future Subprojects

23. The long list of candidate subprojects includes infrastructure development in seven provinces including 19 Districts and 130 communes. It is probable that this list will expand during the course of project implementation.

**Figure 2: Provinces with Long List Candidate Subprojects to be considered during Project Implementation**



Source: TSSD IEE 2009 adapted by TSSD-AF PPTA team.

24. The range of candidate subprojects collated to date comprises the following infrastructure developments:

- Concrete road construction (RC)



- Bituminous road construction (SBST)
- Laterite road construction/Rehabilitation (L)
- Earth road construction/Rehabilitation (E)
- Canal construction/Rehabilitation (C)
- Earth dam/Dike construction/Rehabilitation (D)
- Bridge construction (B)
- Pond construction/Rehabilitation (P)
- Concrete structure (Irrigation) (S)

## II. CLIMATE RISKS

25. **Project risk screening and scoping.** During project identification, the REA *Checklist for Preliminary Climate Risk Screening* for irrigation projects (Attachment 1) was completed to assign a climate risk rating.

26. The screening identified **flood risk** as the key risk area affecting siting/design, maintenance and performance of infrastructure. Floods were identified as a danger to infrastructure and the importance of taking account of hydrometeorological parameters in the design to ensure flood resilience was emphasised.

27. The screening checklist summarized the potential climate risks as follows:

Screening Questions		Score	Remarks
<b>Location and design of project</b>	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	1	Infrastructure will be strengthened to withstand anticipated floods.
	Would the project design (e.g., the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc)?	1	Hydro-meteorological parameters essential for design.
<b>Materials and maintenance</b>	Would weather, current and likely future climate conditions (e.g., prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g., construction material)?	0	Irrigation infrastructure Improvements based on technical best practices and not affected. Material selection will suit current climate variability.
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Floods may affect infrastructure maintenance if not designed to withstand those.
<b>Performance of project outputs</b>	Would weather/climate conditions, and related extreme events likely affect the performance (e.g. annual power production) of project output(s) (e.g., hydro-power generation facilities) throughout their design life time?	0	The project provides water during the dry season for additional cropping.

28. The overall score for potential climate risk was three (with no individual score of two) and was assigned a medium risk category.

29. Initial screening of subprojects against the selection criteria by the PPTA team emphasized the sustainability of irrigation schemes and in particular, the adequacy of available

water without causing water use conflicts. Drought due to climate change was therefore identified as an additional climate risk.

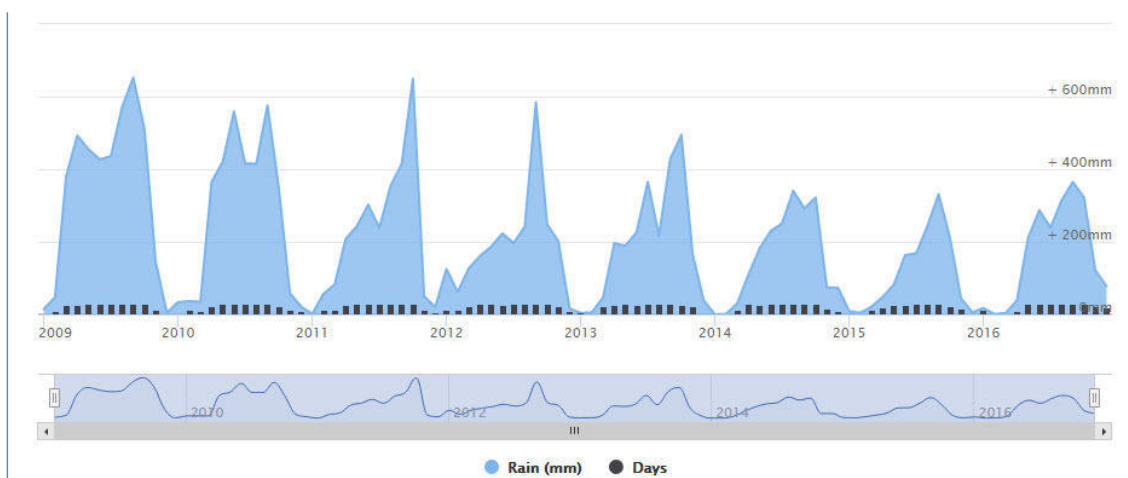
## A. Current Climatic and Hydrological Trends

### 1. Core Subprojects

30. The climates of Prey Veng and Kampong Cham provinces are characterized by distinct rainy and dry seasons. The southwest monsoon starts early in April/May and lasts till October, while from November to March the dry northeast weather patterns predominate.

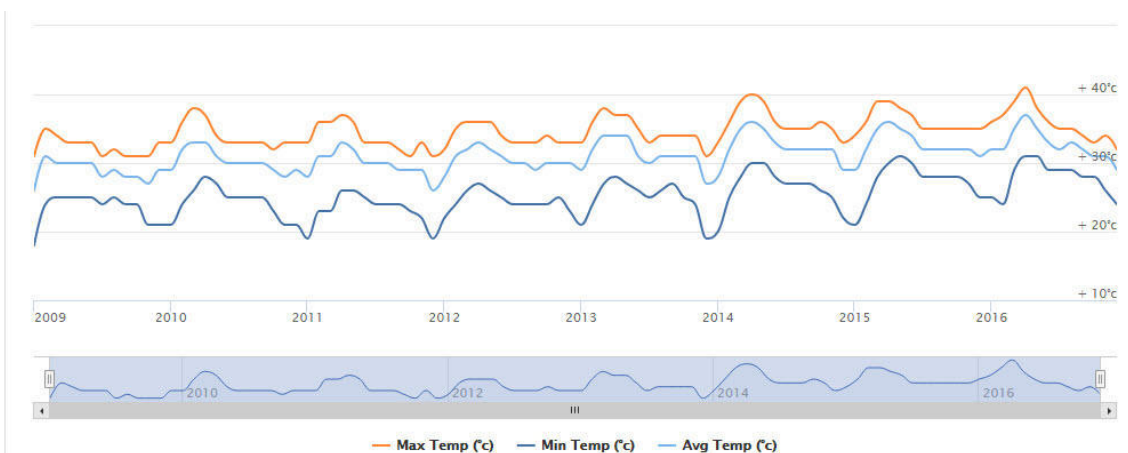
31. For Prey Veng, the average annual rainfall ranges from 1300 mm to 1400 mm, with peak rainfall occurring in September-October and the lowest rainfall in January. Temperature is lowest in December-January with an average minimum temperature of 23°C and the highest in April with an average maximum of 36°C. The wind direction during the rainy season is prevalent from south-west to north-east and from the south-west during the dry season.

**Figure 3: 8-Year Rainfall Data for Prey Veng**



Source: <https://en.climate-data.org>

**Figure 4: 8-Year Temperature Data for Prey Veng**

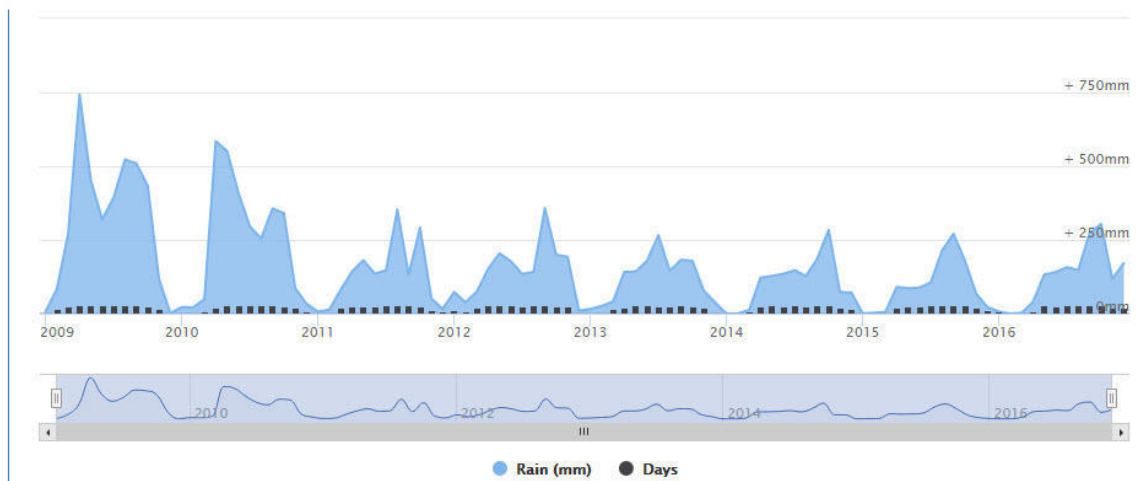


Source: <https://en.climate-data.org>

32. For Kampong Cham, the rainfall is lower, with average annual falls of 1200 mm to 1300 mm, with peak rainfall occurring in September/October and the lowest rainfall in February.

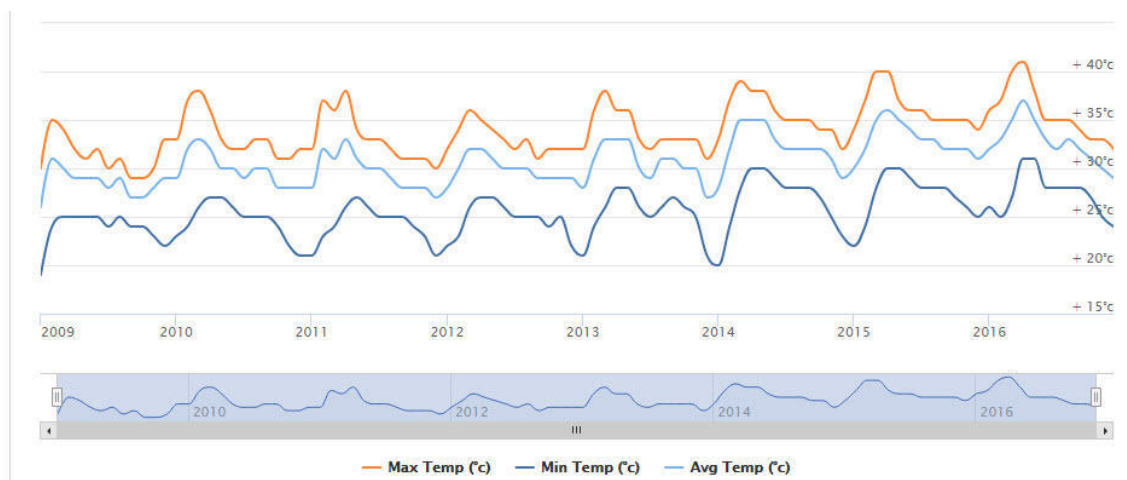
Temperature and wind patterns are similar to those of Prey Veng.

**Figure 5: 8-Year Rainfall Data for Kampong Cham** (<https://en.climate-data.org>)



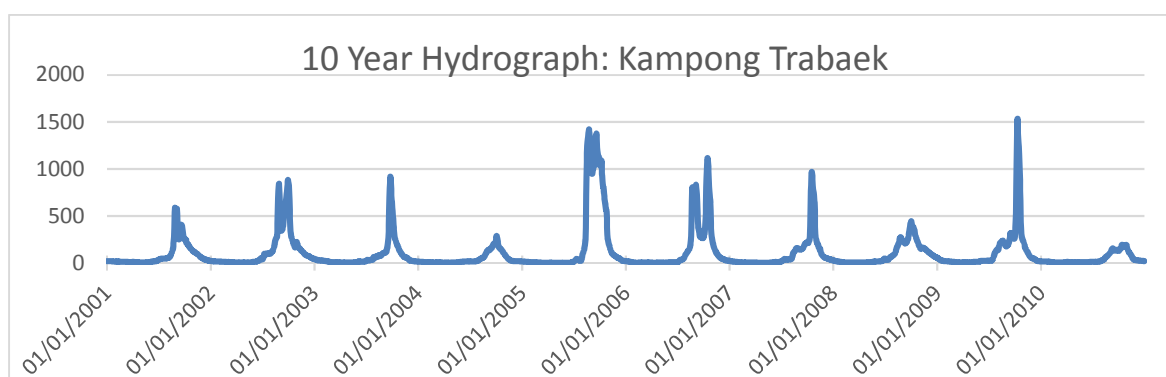
Source: <https://en.climate-data.org>

**Figure 6: 8-Year Temperature Data for Kampong Cham**



Source: <https://en.climate-data.org>

33. Total flows of the Trabaek River, which provides water for the irrigation subproject in Prey Veng are taken from a 10-year hydrographic data (2001-2010) recorded near the mouth of the Trabaek with the Mekong River (Figure 7). The Trabaek is a distributary of the Mekong, with water flowing “upstream”, away from the Mekong. From this data flows were calculated for a wet year (2005), dry year (2010) and an average year (2001). These are presented in Table 1. Low seasonal river flows are apparent in all years in March-April-May.

**Figure 7: Trabaek River Flows 2001 – 2010** (vertical units are m<sup>3</sup>/s)

Source: Hydrographic data provided by MOWRAM.

**Table 1: Wet, Dry and Average Year Flows in the Trabaek River**

Wet Year 2005			Dry Year 2004		Average Year 2001	
Month	Ave Flow (m <sup>3</sup> /sec)	MCM	Ave Flow (m <sup>3</sup> /sec)	MCM	Ave Flow (m <sup>3</sup> /sec)	MCM
Jan	13.39096774	35.86637	12.05938	32.020704	18.56419355	48.40992
Feb	8.315	20.11565	7.991034	20.022336	13.91785714	34.982496
Mar	4.64516129	12.4416	6.400968	17.144352	10.92967742	29.274048
Apr	4.417666667	11.45059	4.443667	11.517984	8.673666667	23.071392
May	3.441612903	9.218016	8.293871	22.214304	7.944193548	20.68848
Jun	5.359333333	13.89139	15.87467	41.147136	18.98866667	49.218624
Jul	30.81419355	82.53274	19.55871	52.386048	45.10774194	120.816576
Aug	786.4254839	2106.362	66.93871	179.28864	184.0087097	492.848928
Sep	1140.133333	2955.226	170.1667	441.072	354.3	918.3456
Oct	731.7419355	1959.898	167.6087	448.923168	185.0322581	495.5904
Nov	110.7236667	286.9957	44.78333	116.0784	92.266	239.153472
Dec	36.32419355	97.29072	19.48355	52.184736	35.38258065	94.768704
<b>Total</b>		<b>7591.288</b>		<b>1433.999808</b>		<b>2567.16864</b>

m<sup>3</sup>/sec = cubic meter per second, MCM = million cubic meter.

Source: Calculated from raw daily hydrographic data.

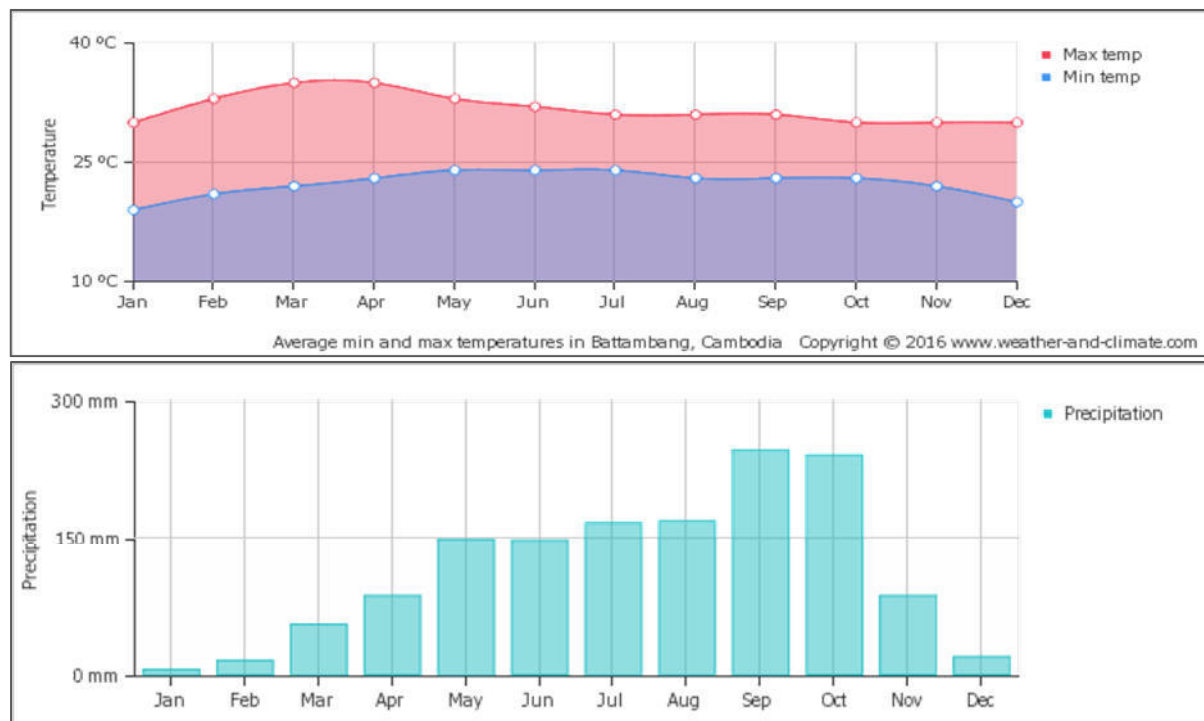
34. The data shows that the annual flows in a wet year can be three times higher than an average year and up to 5-6 times higher than a dry year. In the dry season however, flow rates for a wet, dry and average year are all uniformly low.

## 2. Long List Candidate Subprojects

35. Generally, over the TSSD-AF project provinces the climate features warm to hot temperatures throughout the year and an annual monsoon cycle of alternating wet and dry seasons. The main wet season, the southwest monsoon, occurs between June and October, when reduced air pressures over Central Asia cause air to be drawn landward from the Indian ocean. Approximately 80% of all rainfall occurs during this season. Conversely, during the cooler months between November and May, air flows over Cambodia originate from Central Asia and are drier, resulting in cooler and less rainy weather. Average annual rainfall is around 1,500 mm. However, total rainfall can vary considerably from year to year, resulting in occasional years of severe flooding and conversely, years of significantly low rainfall. Temperatures are fairly uniform throughout the Tonle Sap Basin area, with only small variations from the average annual mean of around 25°C.

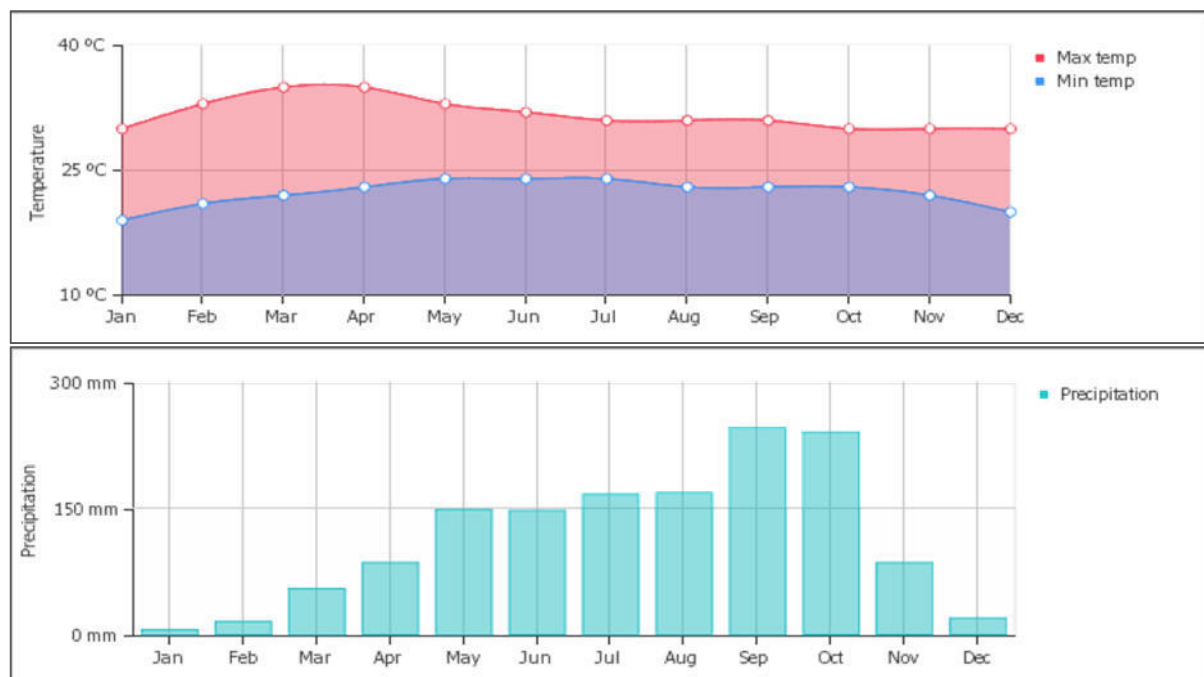
36. Typical temperature and rainfall profiles for these provinces are shown below for Battambang, Siem Reap and Kampong Thom (Figures 8, 9, and 10). The western locations, Battambang and Siem Reap, show similar temperature and rainfall profiles.

**Figure 8: Temperature and Rainfall Averages for Battambang**



Source: 2016. [www.weather-and-climate.com](http://www.weather-and-climate.com)

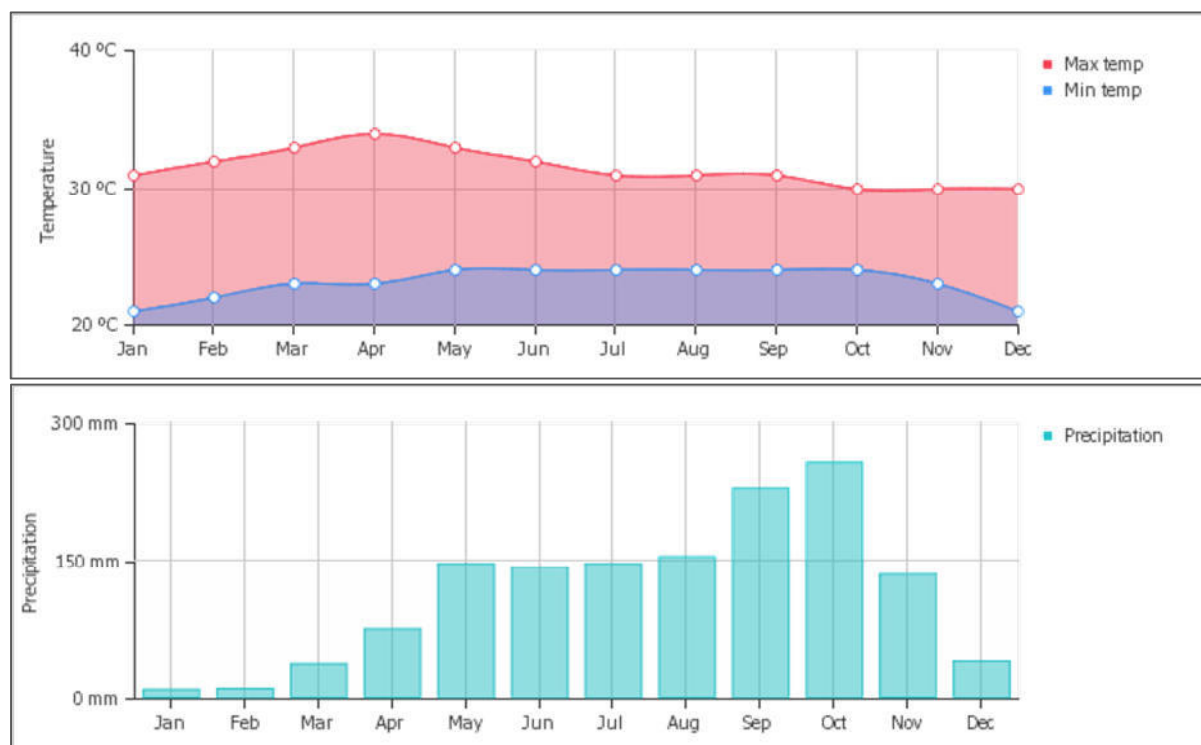
**Figure 9: Temperature and Rainfall Averages for Siem Reap**



Source: 2016. [www.weather-and-climate.com](http://www.weather-and-climate.com)

37. The more eastern locations, represented here by Kampong Thom below (and also by Kampong Cham and Prey Veng in the description of climate of the core subproject areas above) show a greater diurnal difference in temperatures with maximum temperatures generally hotter and minimum temperatures cooler. The rainfall profile for the eastern provinces with slightly lower rainfall in the wet season and a later peak rainfall period (in October).

**Figure 10: Temperature and Rainfall Averages for Kampong Thom**



Source: 2016. [www.weather-and-climate.com](http://www.weather-and-climate.com)

### III. NATURAL HAZARDS AND DISASTER IMPACTS

38. The Cambodian Strategic National Action Plan for Disaster Risk Reduction, 2008 – 2013 (SNAP) records that the main natural hazard to which Cambodia is exposed to is floods followed by drought, occasional epidemics and storms. During the twenty one year period from 1987 to 2007, floods have affected the greatest number of people and caused the greatest amount of damage. Floods have also been the cause of the greatest number of fatalities. Table 2 below gives a summary of the disasters that have occurred in the country during the period 1987 to 2007.

**Table 2. Summary of Disasters in Cambodia, 1987-2007**

	No. of Events	Killed	Injured	Homeless	Population Affected	Damage \$ (in 000's)
<b>Flood</b>	12	1,125	53	275,805	9,514,614	327,100
avg. per event		94	4	22,984	792,885	27,258
<b>Drought</b>	5	0	0	0	6,550,000	138,000
avg. per event		0	0	0	1,310,000	27,600
<b>Epidemic</b>	8	788	0	0	413,570	0

	No. of Events	Killed	Injured	Homeless	Population Affected	Damage \$ (in 000's)
avg. per event		99	0	0	51,696	0

Source: EM-DAT: The OFDA/CRED International Disaster Database, [www.em-dat.net](http://www.em-dat.net) - Université catholique de Louvain - Brussels – Belgium.

39. It can be seen that floods damage the community by directly impacting the people, their assets and livelihood, and infrastructure. Droughts have a more indirect impact by affecting rural economies.

## A. Flood

40. Flooding is a regular phenomenon in Cambodia - both regular Mekong floods and flash floods.

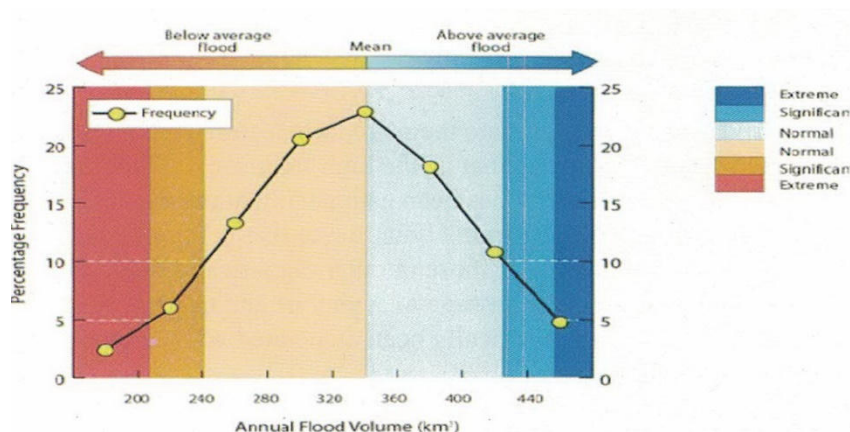
41. **Mekong flood.** Cumulative rainfall in the upper catchments throughout the rainy season causes a slow but steady rise in water levels lasting for several days. This can be aggravated by two factors. First, when this combines with heavy rains around the Tonle Sap Lake, which affect the provinces around the lake and the southern provinces. Secondly, the most severe floods occur when heavy rains coincide with the arrival of tropical depressions and storms. Mekong river floods are common occurrences in the provinces of Kampong Cham and Prey Veng.

42. **Flash floods** – Repeated heavy rainfall in mountainous areas, which flows to streams and tributaries of the Mekong River branch of river often results in flash floods. These floods are swift and last only for a few days but often cause severe damage to crops and infrastructure especially in tributaries around the Tonle Sap Lake. Flash floods have been reported to affect the provinces of Battambang, Siem Reap, and Banthaey Meanchey.

43. Both the irrigation and village road core subprojects and those long list candidate subprojects in Kampong Cham and Prey Veng are located on the floodplain of the Lower Mekong. Floods here are as a result of (i) the annual flood event of the Mekong (major contribution); and (ii) localized rainfall events (minor contribution).

44. **Annual flood event.** The Mekong's annual flood pulse lasts for several months and defines a distinct hydrological season. The annual flood is predictable in terms of its occurrence and timing and defines a transition from a terrestrial phase during the dry season to an aquatic phase during the wet season, when huge areas are inundated naturally. Under these circumstances the annual flood is not a "hazard" in that it is expected and planned for through long experience. Only when the normal range of the annual flood volume and peak discharges are significantly exceeded do negative impacts occur (Figure 11).

**Figure 11: Normal Distribution of Mekong Yearly Pulse showing Extremes of Flood and Drought**



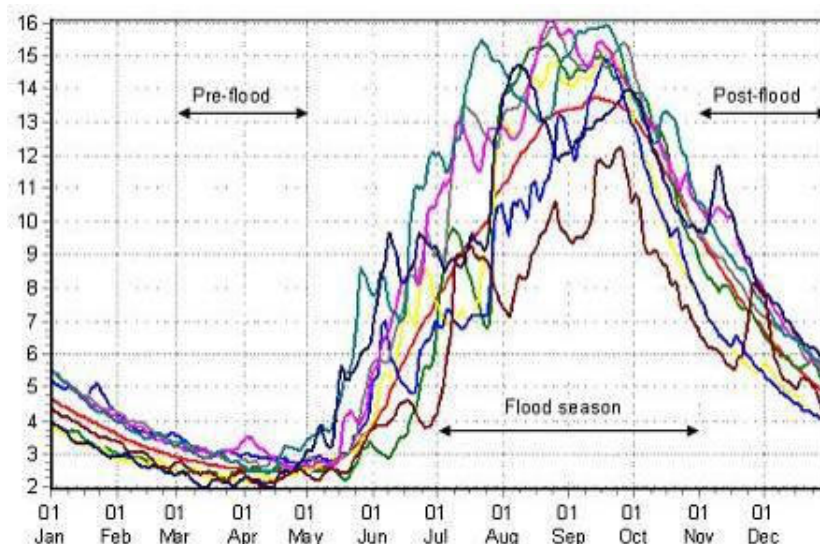
Source: Mekong River Commission (MRC). 2011, Annual Mekong Flood Report 2010.

45. The average annual peak discharge is about 45,000 m<sup>3</sup>/s at Phnom Penh while the lowest discharge is about 1,500 m<sup>3</sup>/s (Figure 24). The year 1978 flood is considered as the highest flood ever regarding discharge which is about 77,000 m<sup>3</sup>/s at Kratie (MRC, 2007c). The year 2000 flood had a discharge of about 50,000 to 55,000 m<sup>3</sup>/s and a volume of about 475 km<sup>3</sup>. The recurrence periods for the discharges are about 50 years for the year 2000 flood and about 10,000 years for the year 1978 flood.<sup>2</sup> During the eight years from 2003 to 2010, the annual flood volume has not risen above average, but in 2011 and 2013, major floods affected Cambodia generally, and the subproject sites in particular.

<sup>2</sup> Cited in: Douven, W.J.A.M., M. Goichot and H.J. Verheij (2009), *Best Practice Guidelines for the Integrated Planning and Design of Economically Sound and Environmentally Friendly Roads in the Mekong Floodplains of Cambodia and Viet Nam*, synthesis report of the 'Roads and Floods' project (part of MRC-FMMP Component 2. MRC Technical Paper No. 35, Mekong River Commission, Office of the Secretariat in Phnom Penh. 143 pp.



**Figure 12: Mekong Flood Hydrographs at Kampong Cham (1998 until 2005)**

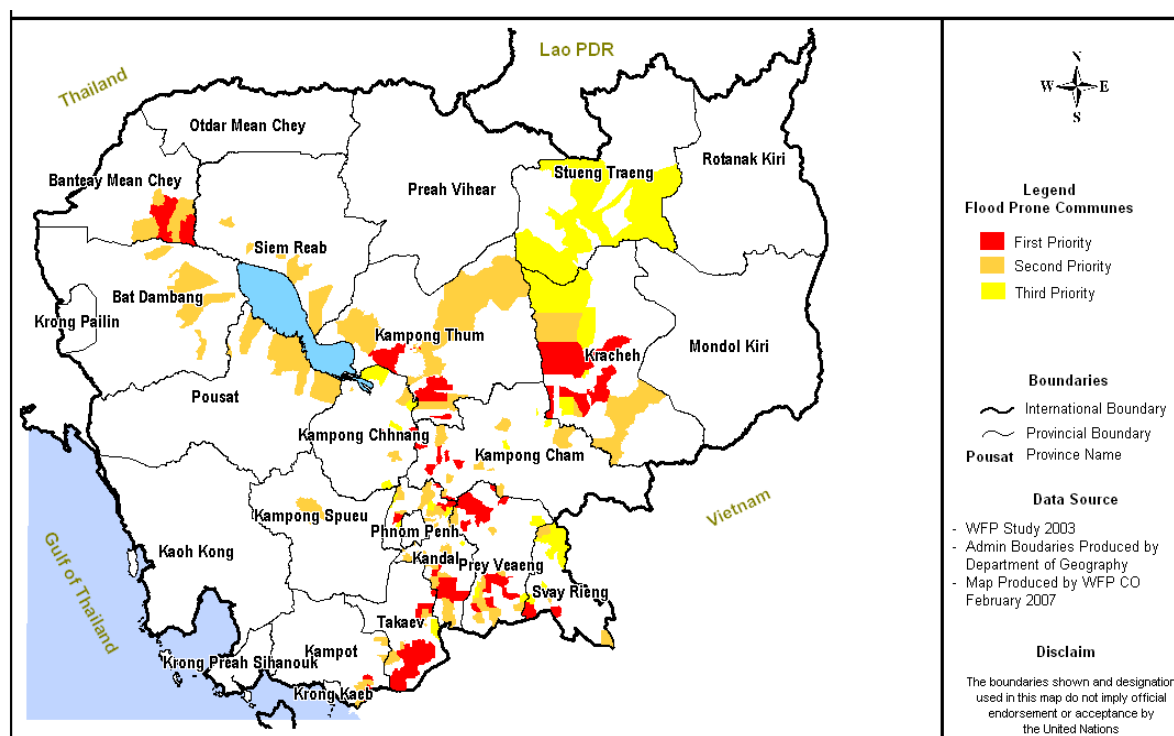


<sup>a</sup> On the vertical axis the peak discharges in 1000 m<sup>3</sup>/s.  
Source: MRC 2011, Annual Mekong Flood Report 2010.

46. The SNAP report records major flooding events affecting a significant population occur every five years or so (in 1961, 1966, 1978, 1984, 1991, 1996, 2000, 2001 and 2002). One of the worst floods in the country's history occurred in the year 2000 where the NCDM reported that an estimated 750,618 families representing 3,448,624 people, including 85,000 families or 387,000 people were temporarily evacuated from their homes and villages. Three hundred forty seven (347), 80% of whom was children were killed and total physical damage was estimated at US\$150 million. In 2001, floods caused the death of 62 people (70% children) and an estimated US\$20 million damages, and in 2002, 29 people (40% children) were killed where estimated damages were US\$14 million.

47. In 2003 the World Food Program<sup>3</sup> prepared maps of priority areas for flood interventions (i.e. help) based upon recorded floods to date and the amount of damage to planted rice caused by those floods, at the commune scale (Figure 13).

<sup>3</sup> NCDM and WFP 2003, *Mapping Vulnerability to Natural Disasters in Cambodia*, Phnom Penh.

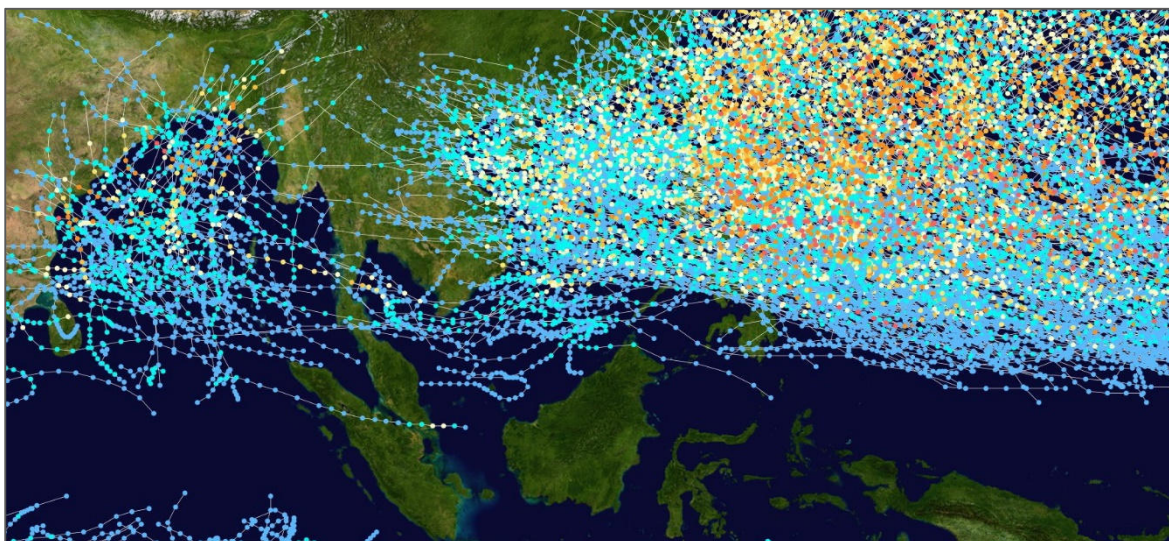
Figure 13. Map of Flood-affected Communes<sup>4</sup>

Source: Cambodian Strategic National Action Plan for Disaster Risk Reduction, 2008 – 2013, after NCDM and WFP 2003

48. However, recent flooding in the Mekong region has been very damaging and the Mekong River Commission records show an increasingly shorter return period for major floods. The 2011 and 2013 floods have been the highest recorded and damage resulting from them is summarized in Tables 3 – 8 below. The ADB responded to both devastating floods with loan and administrative grant funds for Flood Damage Emergency Reconstruction Projects.

49. Additionally, though major tropical cyclones originating in the South China Sea rarely penetrate into Cambodia (see Figure 14), cyclonic effects in central Cambodia have been more common in the last decade.

<sup>4</sup> Priority 1: areas have been flooded in 1996, 2000 and 2001 with greater than 20% rice planted areas damaged; Priority 2: areas have been flooded in 1996 and 2000 with greater than 20% rice planted areas damaged; Priority 3: areas have been flooded in 2001 by flash floods with greater than 20% rice planted areas damaged

**Figure 14: Tropical Cyclone Tracks<sup>5</sup> 1985-2005**

Source: National Hurricane Center and the Central Pacific Hurricane Center.

### 1. Core Subprojects

50. The flood statistics for the two core subproject provinces (in Table 3) for the last major flood in 2013 illustrate the levels of damage.

**Table 3: Impact of Flooding in 2013**

Province		Kampong Cham	Prey Veng
Affected Districts		13	13
Affected communes		72	84
Affected Families		51,376	44,764
Affected people		236,330	205,914
Evacuated families		3,546	866
Evacuated people		16,312	3,984
Houses affects		43,759	32,193
Victims	Deaths	29	26
	Injured		
Flood Affected	Schools	268	155
	Pagodas	144	53
	Health centers and hospitals	17	8

Source: Humanitarian Response Forum (HRF), Situation Report No.4, 23 October 2013.

51. Table 4 below compares data collected by NCDM in 2013 and 2011, which have been ranked as the two biggest flood events in the last 20 years, at the peak of the floods in each year, for the core subproject provinces. Changes in the number of affected or evacuated families in 2013 compared to 2011, are highlighted.

<sup>5</sup> Tracking data for storms within the Atlantic and Eastern Pacific basins is taken from the National Hurricane Center and the Central Pacific Hurricane Center's Northeast and North Central Pacific hurricane database.

**Table 4: Affected and Evacuated Families in 2013 and 2011**  
(Kampong Cham and Prey Veng)

Province	2013	2011	2013	2011
	affected families	affected families	evacuated families	evacuated families
Kampong Cham	51,376	33,436	3,546	6,085
Prey Veng	44,764	40,615	866	10,227

Source: Humanitarian Response Forum (HRF), Final Report No.07, December 2013.

52. The effects of flooding on rice production is an important part of the Lvea subproject due diligence. The following table, taken from the HRF Situation Report of October 2013 covering the devastating floods of September that year, show that the agriculture of the subproject provinces were among the worst hit.

**Table 5: Damage to Agriculture Sector by Floods in 2013**

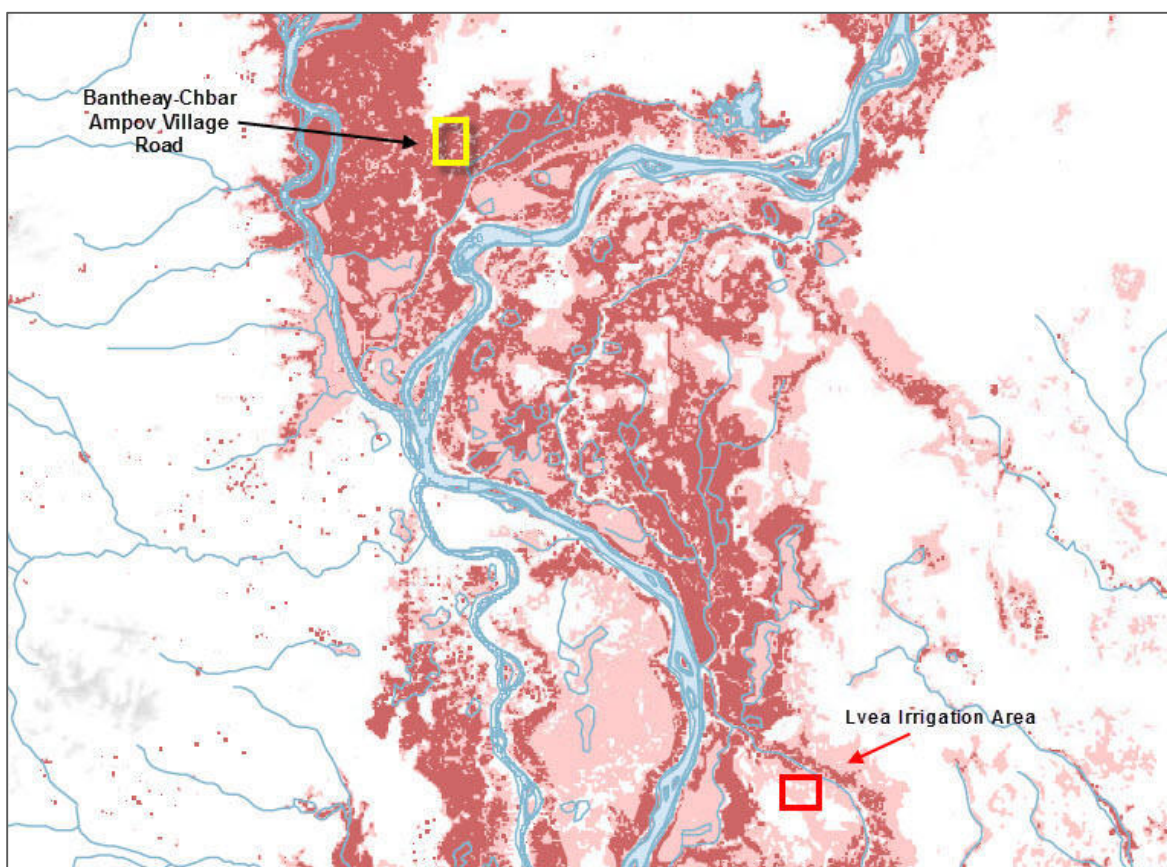
Province	District	Commune	Agriculture sector					
			Cattle/Livestock		Rice transplanting		Rice seedling	Secondary crop
			Evacuated	Death	affected (ha)	damaged (ha)	damaged (ha)	damaged (ha)
Kampong Cham	13	72	2,398		10,798	60	28	166
Prey Veng	12	65	4,555		45,528			203
<b>All Provinces</b>	<b>101</b>	<b>416</b>	<b>21,051</b>	<b>39</b>	<b>221,476</b>	<b>101</b>	<b>357</b>	<b>11,508</b>

ha = hectare.

Source: Humanitarian Response Forum, Final Report No.07, December 2013.

53. Data on flooding in the subproject communes is unavailable, but national mapping of the 2011 and 2013 floods (Figure 15) shows that the village road subproject in Kampong Cham was fully affected by both floods, but that the Prey Veng irrigation subproject area was mainly affected by the 2011 flood, and only partly.



**Figure 15: Flood Map Detail for 2011 and 2013 Floods showing Core Subproject Areas**

Source: World Food Programme. Cambodia. 2013.

## 2. Long List Candidate Subprojects

54. The flood statistics for the provinces included in the long list of candidate subprojects (in Table 6) for the last major flood in 2013 illustrate the levels of damage.

**Table 6: Impact of Flooding of 2013 Flood**

Province		Kampong Thom	Siem Reap	Battambang	Banthaey Meanchey	Tboung Khmum
Affected Districts		7	10	14	9	Figures combined with Kampong Cham
Affected communes		61	60	102	59	
Affected Families		17,463	19,022	74,160	54,463	
Affected people		80,330	87,501	341,136	250,530	
Evacuated families		1,114	3,550	4,504	8,902	
Evacuated people		5,124	16,330	20,718	40,949	
Houses affects		17,463	3,645	62,451	15,027	
Victims	Deaths	24	15	17	9	
	Injured	3	2	4	1	
	Schools	121	39	77	249	

Province		Kampong Thom	Siem Reap	Battam-bang	Banthaey Meanchey	Tboung Khmum
Flood Affected	Pagodas	41	8	14	128	
	Health centers	4	7	9	21	

Source: Humanitarian Response Forum (HRF), Situation Report No.4, 23 October 2013.

55. Table 7 below compares data collected by NCDM in 2013 and 2011, at the peak of the floods in each year, for the long list candidate subproject provinces. Changes in the number of affected or evacuated families in 2013 compared to 2011, are included.

**Table 7: Affected and Evacuated Families in 2013 and 2011**  
(Kampong Cham and Prey Veng)

Province	2013	2011	2013	2011
	affected families	affected families	evacuated families	evacuated families
Kampong Thom	17,463	54,414	1,114	2,448
Siem Reap	19,022	23,198	3,550	0
Battam-bang	74,160	13,921	4,504	1,194
Banthaey Meanchey	54,463	13,008	8,902	5,372
Tboung Khmum				

Source: Humanitarian Response Forum (HRF), Final Report No.07, December 2013.

56. The effect of flooding on rice production is an important consideration for candidate irrigation subprojects. The following table, taken from the HRF Situation Report of October 2013 show that the agriculture of Battambang and Banthaey Meanchey were severely damaged, in terms of area affected, 15% and 12% respectively of the sector affected.

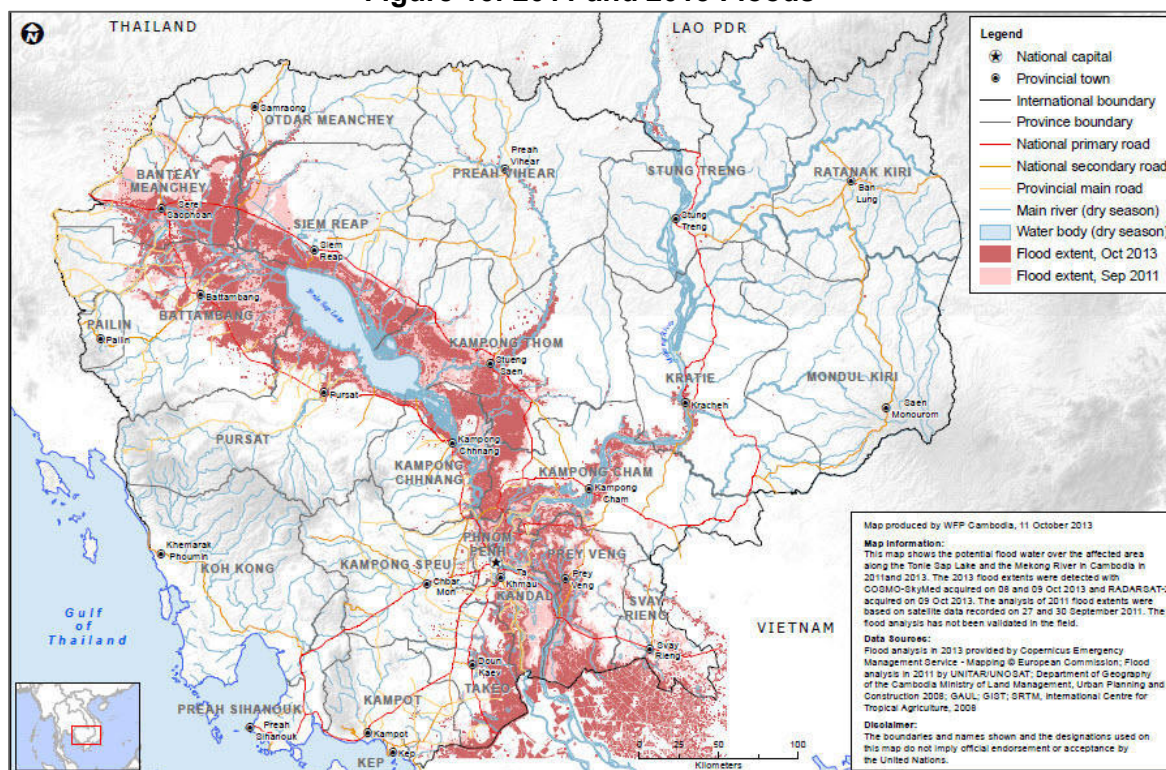
**Table 8: Damage to Agriculture Sector by Floods – 2013.**

Province	District	Commune	Agriculture sector					
			Cattle/Livestock		Rice transplanting		Rice seedling	Secondary crop
			Evacuated	Death	affected (ha)	damaged (ha)	damaged (ha)	damaged (ha)
Kampong Thom	6	20	4361	0	2802	0	0	0
Banthaey Meanchey	9	9	0	0	25,943	30	0	3,389
Siem Reap	6	40	0	5	8,800	0	0	72
Battambang	8	0	0	0	33,367	0	0	1,622
Tboung Khmum	Results merged with Kampong Cham							
<b>All Provinces</b>	<b>101</b>	<b>416</b>	<b>21,051</b>	<b>39</b>	<b>221,476</b>	<b>101</b>	<b>357</b>	<b>11,508</b>

57. Data on flooding in the long list candidate subproject communes is unavailable, but national mapping of the 2011 and 2013 floods (Figure 16) shows that Thoung Khmum was minimally affected by the floods with only the immediate floodplain bordering the Mekong being inundated. Siem Reap and Battambang experienced both floods along their floodplain fringing Tonle Sap. Banthaey Meanchey and Kampong Thom were both significantly affected by the two

flood events.

**Figure 16: 2011 and 2013 Floods**



Source: World Food Programme Cambodia 2013.

## B. Droughts

58. There are four characteristics of agricultural drought in Cambodia:

- (i) Unpredictable delays in rainfall onset in the early wet season
- (ii) Erratic variations in wet season rainfall onset, amount, and duration across different areas
- (iii) Early ending of rains during the wet season
- (iv) Common occurrence of mini-droughts of three weeks or more during the wet season, which can damage or destroy rice crops without irrigation

59. Localized drought is also becoming increasingly apparent and significant - again throughout many areas of the country, including areas that are also flood-affected. Drought has impacted in a number of areas in 2001, 2002, and 2003. The direct impact has predominantly been in terms of water stress on agricultural crop production, especially rice and vegetable production, with 80% of agricultural fields lying idle in most areas for six months and to a somewhat lesser extent in terms of increased rates of water-related disease mortality and morbidity.

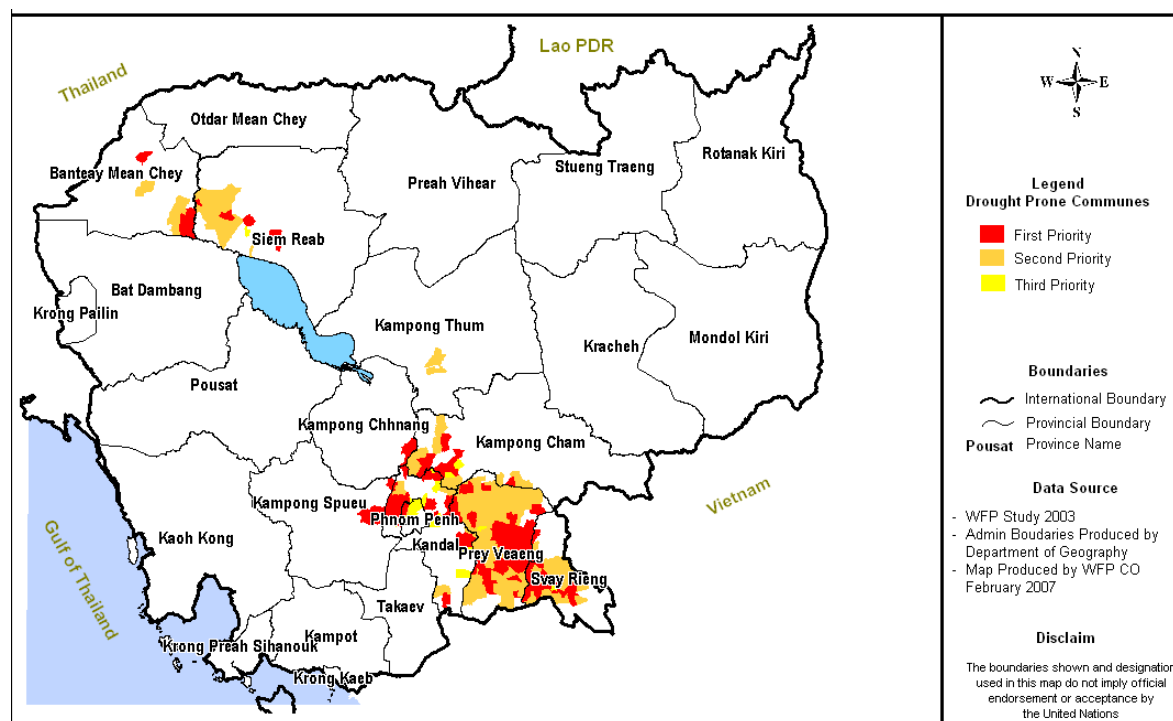
60. In 2003 the World Food Program<sup>6</sup> prepared maps of priority areas for drought interventions combining drought affected areas from records to date, degree of rice

<sup>6</sup> NCDM and WFP 2003, *Mapping Vulnerability to Natural Disasters in Cambodia*, Phnom Penh.



dependency and food security situation, at the commune scale (Figure 17).

**Figure 17: Map of Drought-affected Communes**



Source: Cambodian Strategic National Action Plan for Disaster Risk Reduction, 2008 – 2013, after NCDM and WFP 2003.

61. The last major drought in the country took place in 2002 when unusually dry weather during the rainy season affected some 420 communes in 76 districts located in the 10 provinces. Project provinces affected included Prey Veng, Kampong Thom, Kampong Cham, and Banteay Meanchey. The drought prevailed until the onset of rains in mid-August and covered 62,702 hectares. Statistics from the NCDM indicate that the drought had affected 2,047,340 people or 442,419 families and was the worst recorded drought to affect the country. The cost of the drought was estimated to be more than US\$21.50 million in 2003 values. A recent drought influenced by the 2015-2016 El Nino also greatly impacted rural communities, but statistics indicating its impact have not yet been released.



## IV. ASSESSMENT OF FUTURE IMPACTS

### A. Applicable Climate Change Models

62. In recent relevant climate change analyses for agriculture and roads in Cambodia<sup>7</sup> two climate change projection methodologies have been used. These comprise the IPCC Special Report on Emission Scenarios (SRES) using the A1, A2, B1 and B2 scenarios describing differing emission rates and geopolitical settings and the IPCC's latest "radiative" scenarios adapted by the CSIRO (2013) in its Conformal Cubic Atmospheric Model (CCAM) and have been used to project future climatic determinants for project design.

63. **Special Report on Emission Scenarios (SRES).** The SRES projections for Cambodia were used in the modelling studies in the Initial National Communication (INC) and the Second National Communication (SNC) of the Cambodian National Climate Change Committee indicated that Cambodia's mean surface temperature has increased by 0.8°C since 1960, and that it will continue to increase at a rate of between 0.013°C and 0.036°C per year up to 2099. The rate of temperature increase will be higher in low altitude areas such as the subproject sites which are between 10 m and 20 m above sea level.

64. Most recently promoted by UNDP (2008), Mekong River Commission (2014) and Ministry of Water Resources and Meteorology (MOWRAM) (2013). The SRES models are statistically downscaled, by calibrating against current climate data sets, to 50 km scale and usually focus on two SRES scenarios for projecting future temperature and precipitation (A2 and B2).<sup>8</sup> These scenarios and projections have been used in the Loans 3006/3007/8271 and Grants 0349/0350-CAM: Climate-Resilient Rice Commercialization Sector Development Project (Rice-SDP).

65. **Conformal Cubic Atmospheric Model (CCAM).** The CCAM projections use bias-corrected sea surface temperatures from six CMIP5 general circulation models (GCMs) to drive a global atmosphere-only model at 50 km horizontal resolution (CCAM). Downscaling for the Loans 2839/8254 and Grant 0278-CAM: Provincial Roads Improvement Project was carried out by using the 50 km simulations to drive a regional model at a 10-km grid spacing. Two emissions scenarios were considered: Representative Concentration Pathways (RCP) 4.5 (lower greenhouse gas concentrations) and RCP 8.5 (higher greenhouse gas concentrations).<sup>9</sup>

Modeling	Comments
<b>MOWRAM</b> <i>Carried out by</i> TA7610–CAM: Supporting Policy and Institutional Reforms and Capacity Development in the Water Sector Project	The modeling was carried out in 2010 Data from nine general circulation models (GCMs) (pixels 125-400 km) was downscaled to smaller pixels (data from World Bank web portal) Using statistical downscaling final pixel size 50 km Older generation Intergovernmental Panel on Climate Change (IPCC) models
<b>Mekong River Commission</b> <i>Carried out with assistance from</i> The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and The Southeast Asia SysTEM for Analysis,	The modeling was carried out in 2012 Data from one GCM - Max Planck Institute for Meteorology's ECHAM4 (pixels ~250 km) was downscaled to smaller pixels Using a regional climate model final pixel size of 50 km

<sup>7</sup> Loans 3006/3007/8271 and Grants 0349/0350-CAM: Climate-Resilient Rice Commercialization Sector Development Project and Loans 2839/8254 and Grant 0278-CAM: Provincial Roads Improvement Project

<sup>8</sup> A2: Comprises a more divided world: (i) operating independently, self-reliant nations; (ii) continuously increasing population; and (iii) regionally oriented economic development; B2: scenario describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. The scenario is oriented toward environmental protection and social equity.

<sup>9</sup> RCPs are four greenhouse gas concentration (not emissions) trajectories adopted by the IPCC for its Fifth Assessment Report (AR5) in 2014. It supersedes SRES projections published in 2000.

Modeling	Comments
Research and Training Regional Center (SEA START).	Older generation IPCC models
<b>ADB TA 7459-REG: Greater Mekong Subregion Biodiversity Conservation Corridors Project – Pilot Program for Climate Resilience Component – Cambodia</b> <i>Carried out by</i> The Commonwealth Scientific and Industrial Research Organisation (CSIRO)	The model was developed and run in 2012 CCAM - This is a regional model that was run specifically for Southeast Asia. It uses six GCMs selected for best performance in Southeast Asia The model has a pixel size of 10 km It uses the latest IPCC standard set of model simulations
<b>USAID Mekong Adaptation and Resilience to Climate Change</b> <i>Carried out by</i> International Centre for Environmental Management (ICEM)	The modeling was carried out in 2014 Historical data across the basin for the period of 1980 – 2005 which fitted six GCMs was downscaled to 5 km grid using statistical calibration. Modeled SRES A1 scenario only Older generation IPCC models

66. The different scenario generators have particular advantages for the different sectors of the project:

- (i) The SRES scenarios can be applied readily to water balances by computing changes in temperature, seasonal rainfall, evaporation to calculate irrigation future water needs for crops. It is therefore most helpful in analyzing adaptation requirements for future irrigation needs.
- (ii) The Mekong basin wide study, the USAID Mekong Adaptation and Resilience to Climate Change (2014), used downscaled projections for the SRES A1 scenario to project regional changes in temperature and rainfall and was able to calculate changes in drought periods under future climate change which is very relevant to assessing risk and vulnerability for future irrigation.
- (iii) The IPCC radiative scenarios regional downscaling techniques used in CCAM not only increase resolution to the provincial level, but also allow analysis of local extreme events such as one day and five-day rainstorm intensities. Thus, in addition to general climate change, the scenarios can address flooding and extreme events, scenarios most relevant to road and infrastructure design.

67. **USAID Mekong Adaptation and Resilience.** An additional Mekong basin wide study, the USAID Mekong Adaptation and Resilience to Climate Change (2014), compared the output of 12 GCMs and chose the six that most accurately replicated historical data across the basin for the period of 1980–2005. Downscaled projections for the A1 scenario were derived using in-house developed statistical downscaling. This study projected regional changes in temperature and rainfall and was able to calculate changes in drought periods under future climate change.

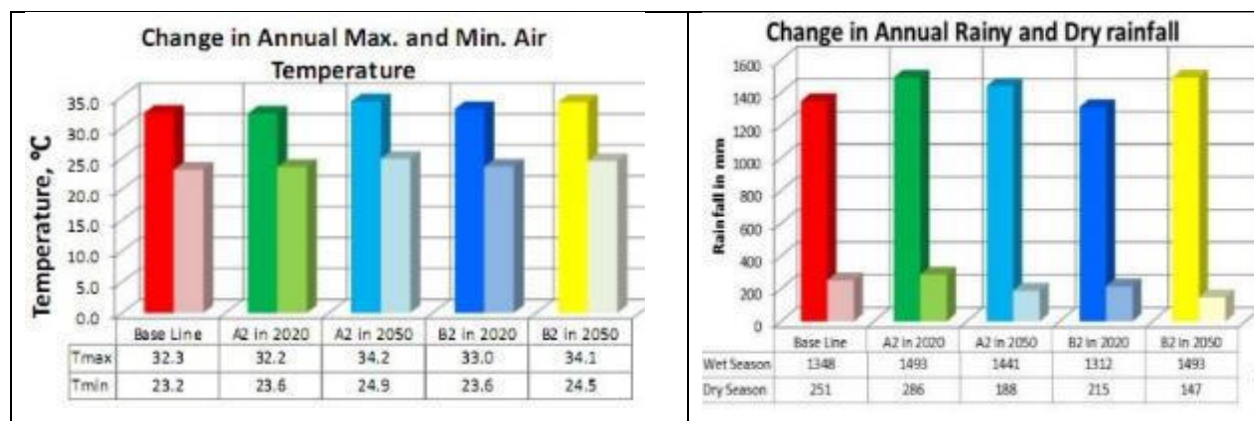
## B. Future Temperature, Rainfall and Crop Water Requirements

68. SRES scenarios (MOWRAM Model) under elevated CO<sub>2</sub> with low rate of emission scenarios (SRES-B2)<sup>10</sup> showed that it is likely that wet season rainfall will continue to increase in future, and then might decrease again after 2050. But under high emission scenarios (SRES-A2),

<sup>10</sup> IPCC's Special Report on Emission Scenarios (SRES) has four scenarios A1, A2, B1 and B2 describing differing emission rates and geopolitical settings. In summary; A is economics driven rather than environmental; B is more environmentally drive. One is countries operating in concert; Two is countries pursuing their own aims.

the direction of change will reverse.<sup>11</sup> An increase in the temperature is likely to affect agricultural productivity. According to the International Rice Research Institute, rice grain yields decline by 10% for each 1°C increase in minimum (night) temperatures during the growing period in the dry season.<sup>12</sup> The magnitude of these changes are illustrated in the following graphs (Figure 18), and their implications for crop water demand in Figure 19.

**Figure 18: Future Scenarios for the Critical Agricultural Parameters of Temperature and Rainfall<sup>a</sup>**



<sup>a</sup> Scenarios are A2 (a more divided world) and B2 (a world more divided, but more ecologically friendly). Source: Soparith, 2015.<sup>13</sup>

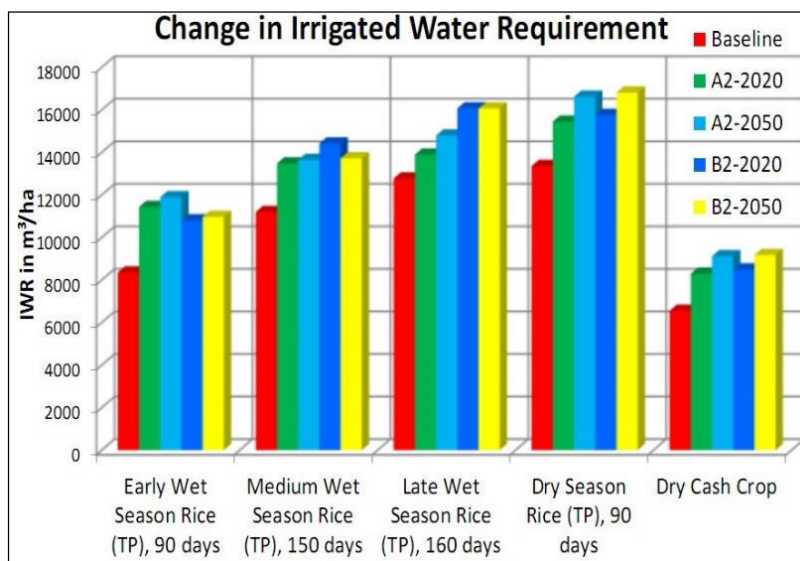
69. The projected changes in rainfall and temperature will combine to affect future irrigated water requirements (IWR). Soparith, 2015, used five cropping patterns in 20 irrigation schemes in Kampong Thom, hydrological data (1997-2011), and derived values for evapotranspiration (EOT), percolation and irrigation efficiency to develop baseline water balances for irrigated rice. Projected changes in maximum and minimum temperatures, EOT and rainy and dry season rainfall under SRES A2 and B2 scenarios to derive future IWR projections. Figure 19 below shows predicted IWR for SRES projections for nation states acting in isolation (A2 and B2 scenarios).

<sup>11</sup> National Climate Change Committee. 2013. Cambodia Climate Change Strategic Plan 2014-2023.

<sup>12</sup> [irri.org/news/hot-topics/rice-and-climate-change](http://irri.org/news/hot-topics/rice-and-climate-change)

<sup>13</sup> Tes, Soparith. January 2015. Assessment of Water Resources for Improved Water Governance under Climate Change: Stung Chinit River Catchment. Presentation to Third Steering Committee Meeting Climate Change and Water Governance in Cambodia. 20 January 2015. Cambodiana Hotel, Phnom Penh.

**Figure 19: Irrigation Water Requirements for Cambodian Rice Cropping Alternatives from IPCC SRES**



Source: Sopharith, 2015.

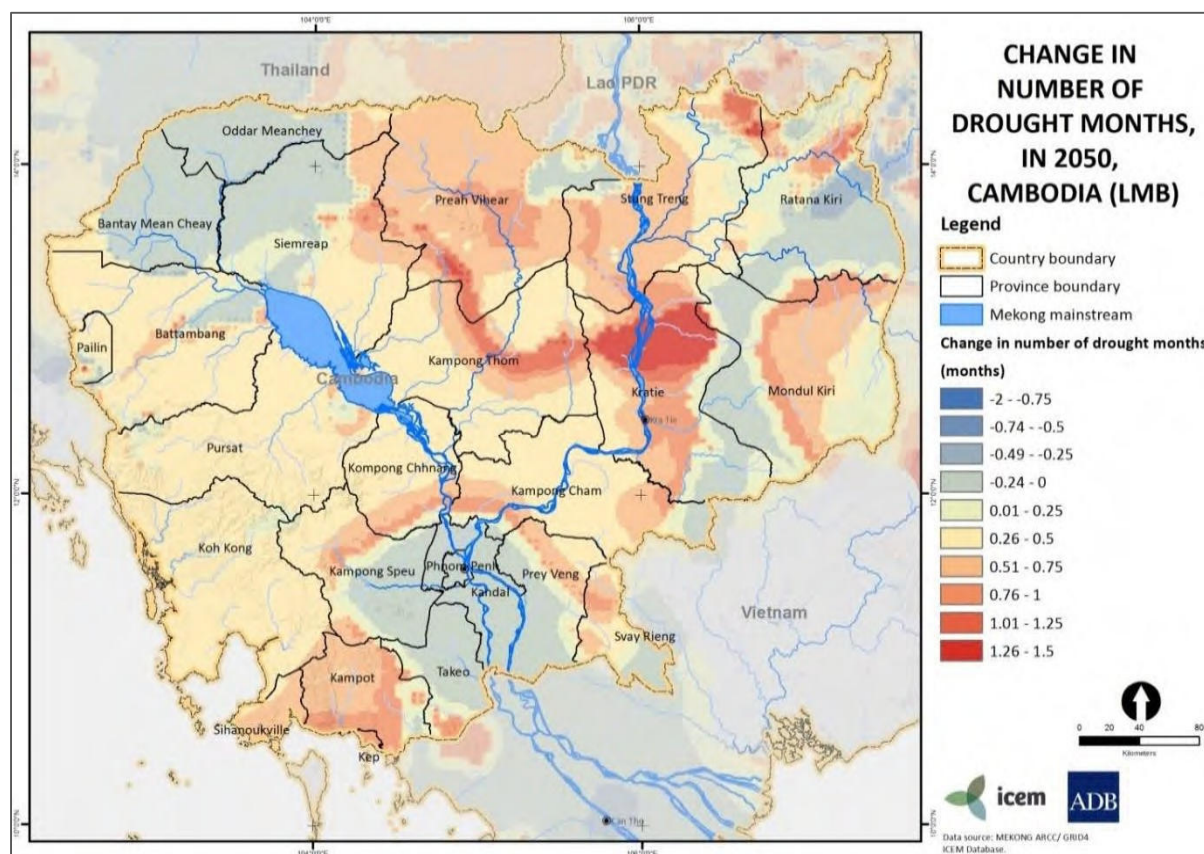
70. The CCAM Scenarios (CSIRO Model) also show warming occurring over Cambodia in the future, projecting warming of 0.03 °C to 0.06 °C per year. This equates to a warming of 0.35°C to 2°C by 2050 and 1°C to 5°C by 2100. The projected change in temperature output by the CSIRO's CCAM model is very similar to the one produced by the MOWRAM modelling carried out in 2010. The CCAM model (at RPC 8.5) downscaled to the sub-provincial level, predicts a dryer wet season of -8.4 mm/yr in the central and south lowlands and an increase at the start of the wet season of +1.2 mm/yr. It predicts no change to the dry season.

### C. Occurrence of Droughts

71. The USAID Mekong Adaptation and Resilience to Climate Change (2014) was refocused by ICEM for Cambodia in TA 8179-CAM: Mainstreaming Climate Resilience into Development Planning and projected changes in temperature, rainfall and changes in drought periods. While it is projected that average rainfall will increase in the basin, periods of annual agricultural drought are also expected to lengthen significantly; particularly in the Mekong floodplain in Cambodia. Cambodia is projected to have up to 30% increases in the number of drought days each year in some provinces (Figure 20).



**Figure 20: Changes in Drought Months (2050)**



Source: TA 8179-CAM: Mainstreaming Climate Resilience into Development Planning.

72. Figure 20 shows that for the upland agricultural parts of Battambang, Kampong Cham, Kampong Thom, Siem Reap, and Tboung Khmum droughts will increase by up to 0.5 months. However for Bantay Mean Cheay, Prey Veng, and the riverside areas of Battambang, Kampong Cham, and Siem Reap, there will be no change or a slight decrease in drought length. The core subproject for irrigation in Lvea commune, Prey Veng, will experience unchanged or slightly shorter drought periods.

#### **D. Mekong Pulse and Rainfall Intensity Leading to Flooding**

73. The main **climatic drivers** of the magnitude of the Mekong floods in any given year are: (i) the strength or weakness of the south-west monsoon; and (ii) the incursion of typhoons and tropical storms from the South China Sea.

74. The general regional trends for the Lower Mekong from all models indicate a wetter south-west monsoon period. Cambodia's "Strategic Program for Climate Resilience"<sup>14</sup> report supports the Mekong River Commission's (MRC's) conclusions that with anticipated climate change, the Lower Mekong Basin<sup>15</sup> will:

- (i) experience later starts to the wet season (by about two to four weeks), which will also be shorter and wetter; and

<sup>14</sup> RGC, 2011, Strategic Program for Climate Resilience, Prepared for the Pilot Program for Climate Resilience.

<sup>15</sup> MRC, 2009, Adaptation to climate change in countries of the Lower Mekong Basin: regional synthesis report, MRC Technical Paper No. 24.

- (ii) experience a higher and increasing intensity of precipitation.

75. Various scenario studies have also been carried out by MRC taking into account not only global climate changes, but also construction of large dams in the Mekong basin upstream of the Lower Mekong Basin, and the expected economic growth.<sup>16</sup> These studies indicated an average maximum future discharge of about 65,000 m<sup>3</sup>/s and an average minimum discharge of about 30,000 m<sup>3</sup>/s.

76. Although major tropical cyclones originating in the South China Sea rarely penetrate into Cambodia, the cyclonic effects (including tropical storms) emanating from them have been more common in central Cambodia in the last decade. Without reliable data on the future frequency of these events, it must be assumed that present trends will continue.

77. **Localized rainfall events.** A consideration of localized rainfall events is made possible by the CCAM model (at RPC 8.5) which is downscaled to the sub-provincial level. This projects a drier wet season of -8.4 mm/yr in the central and south lowlands and an increase at the start of the wet season of +1.2 mm/yr.<sup>17</sup> It projects no change to the dry season.

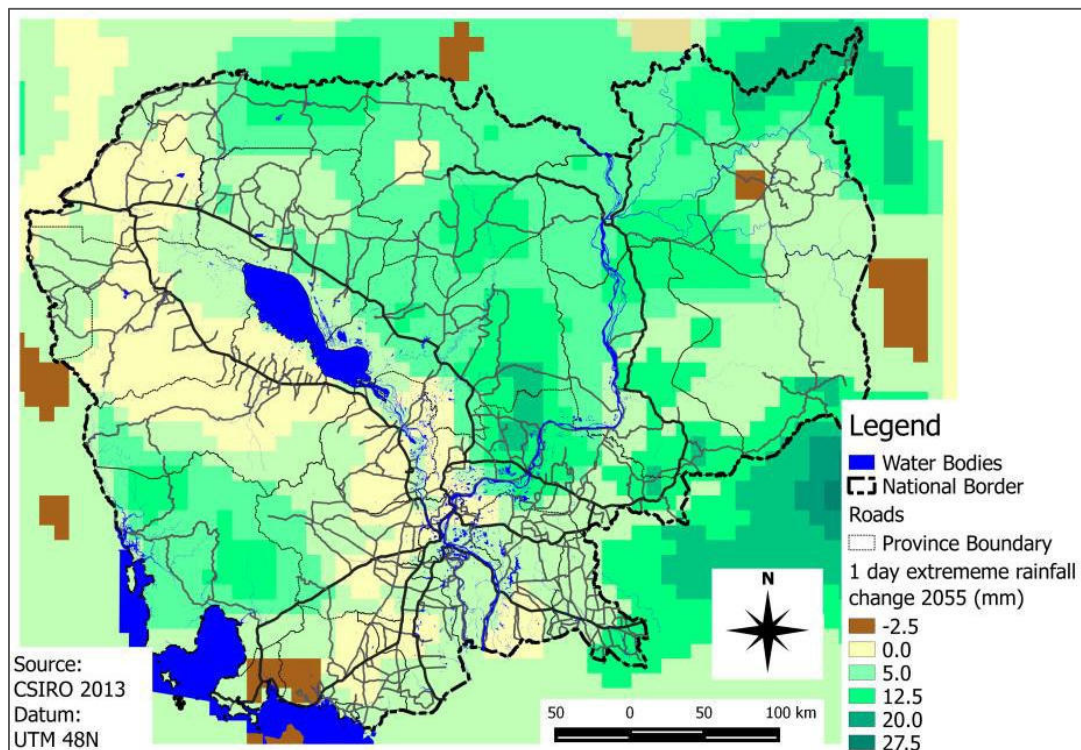
78. The projected extreme rainfall projections in Egis 2016 are the average results from the six CSIRO CCAM model runs for a 20-year period centred on 2055 using an RCP of 8.5. The projected change in one day extreme rainfall is the difference between current and projected 2055 values and the map is at Figure 21. The model projects an increase in one day extreme rainfall over the coastal mountains and over the hilly regions in the north of the country. There is no change or only a small change projected for the central flat areas, except for a small area north east of Phnom Penh. The five-day extreme rainfall map (Figure 22) reflects the spatial distribution of annual rainfall with high values of 300 mm or more in the mountainous region near the coast and in Mondul Kiri and in the far north east. Smaller 5 day extreme events of 150 mm–180 mm occur in the central flat lands and hilly regions in the north. The model shows the lowest values around Tonle Sap.

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<sup>16</sup> Douven et al 2009, op cit.

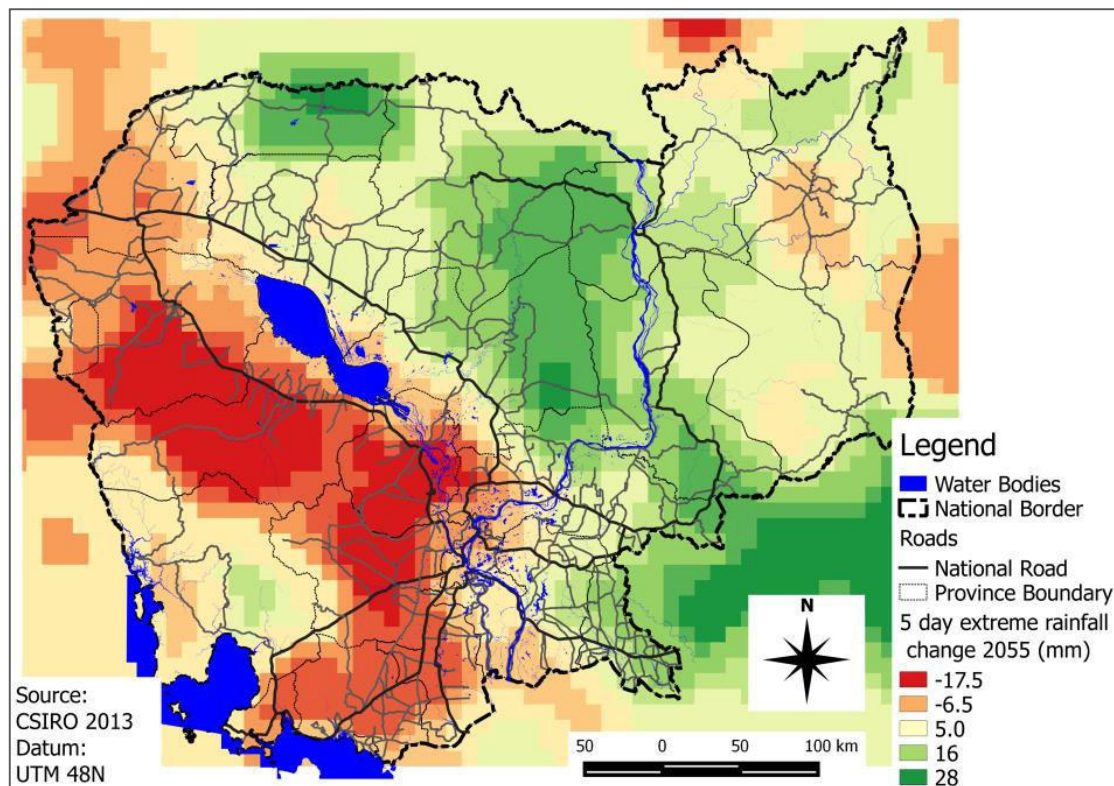
<sup>17</sup> Egis International 2016, *Climate Modeling Report* for Climate Resilience for Provincial Road Improvement Project, ADB Grant 0278-CAM.

**Figure 21: Projected Change in 1 day extreme rainfall for 2055 for RCP of 8.5 from CCAM**



Source: CSIRO 2013 and Egis 2016.

**Figure 22: Projected change in 5 day extreme rainfall for 2055 for a RCP of 8.5 from CCAM**



Source: CSIRO 2013 and Egis 2016.

## V. VULNERABILITY ASSESSMENT

### A. Drought and Crop Water Demand - Irrigation Subprojects

#### 1. Core Subproject – Lvea Commune, Prey Veng

79. The irrigation subproject for a dry season rice crop will increase existing levels of water extraction. The impact of this on existing water resources must be examined through seasonal water balances for each cropping alternative applicable to the subproject schemes.

80. The data for calculating seasonal water balances are based upon (i) local cropping calendars derived from consultation with farmers and the areas to be irrigated; (ii) hydrological data on the water source (river or primary canal); (iii) estimation of water needs and irrigation efficiency.

81. The cropping calendar at Lvea commune approximates the one promulgated by the Ministry of Agriculture, Forestry and Fisheries (MAFF) in that the dry season crop is planted as soon after harvest of the wet season crop as possible. The water needs for the main cropping alternatives, at a range of irrigation efficiencies, and including water requirements for pre-saturation of paddy and establishment of a 100 mm water layer for planting were taken from calculations for irrigated rice cropping in neighbouring Kampong Thom.<sup>18</sup>

82. The following seasonal water balance for a dry season crop in a normal year and a dry year (Table 9) uses inflow data derived from Pumping Station #2, which pumps water from the Trabaek River into the primary canal, at an irrigation efficiency of 40%. It compares seasonal water needs with water supply for the projected expansion of dry season irrigation area to 305 ha.

**Table 9: Water Balance for an Additional 305 ha Irrigation Area of Dryland Cropping at Lvea Commune**

Dry Season			
Year	Crop	Water Need (MCM)	Water Available (MCM)
Dry Season			
Low rainfall year	Short season variety (December-March) 90 day+	4.422	25.182
Normal rainfall year	Short season variety (December-March) 90 day+	4.27	97.87

MCM = million cubic meter.

Note: 90 day+ and 130 day+ refers to the growing period plus land preparation.

Source: PPTA team.

83. The shaded cells in the water balance show where water availability is sufficient for irrigation needs. The balance shows that the dry season rice crop in the additional areas is possible and likely to be sustainable in average years and that surplus water exists for downstream uses. However, in a dry year, the balance demonstrates that the irrigation is possible but that extraction of the water is likely to put pressure on downstream supplies, since it takes about 17% of the available water. The high water need and limited water availability shown in the water balance indicates a significant vulnerability to increased crop water demand and/or reduced rainfall due to climate change. This is not exacerbated by predicted increases in drought. For the subproject area, droughts are projected to remain the same as historical records or decrease slightly in duration.

<sup>18</sup> TA8702-CAM: Uplands Irrigation and Water Resources Management Sector Project.



84. No major new irrigation schemes on the Trabaek downstream (east) of Lvea are currently planned. New schemes in feasibility planning are on the Stung Slot and focus on drainage of late wet season water to provide cropping options. However incremental downstream use of the Trabaek's water in the future may result in water constraints and there is a need to plan future extraction and irrigation areas, accordingly.

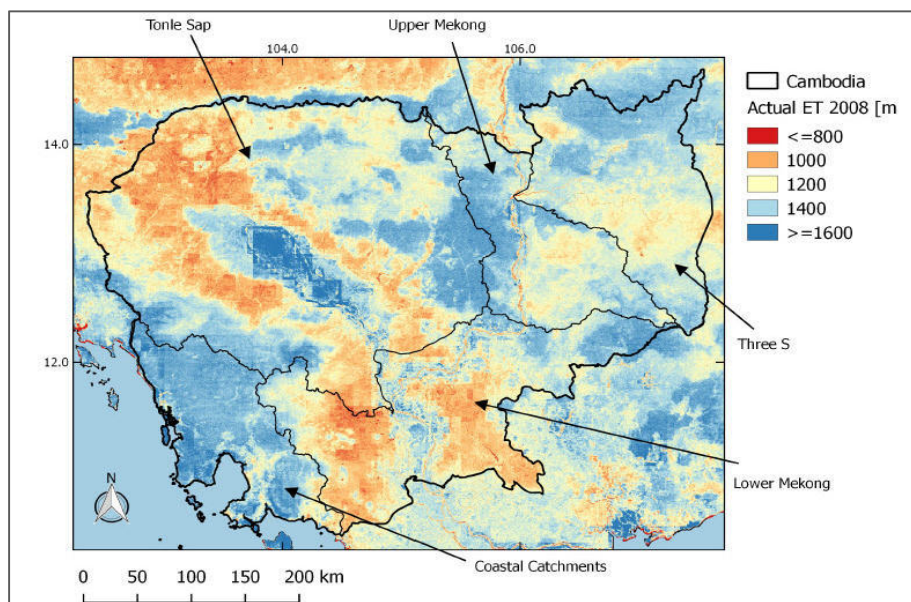
## 2. Long List Candidate Subprojects

85. The crop water demand for long list candidate irrigation subprojects, both currently and in the future under climate change, can be determined by using evapotranspiration measurements for irrigated crops in the various provinces and calculating how this might change with increases in temperature. Crop evapotranspiration is the water demand that must be met by in-season rainfall, irrigation and stored soil water at sowing. It is therefore a useful measure of crop water demand in the dry season when all water must come from irrigation.

86. However, water availability cannot be determined at this stage, since the locations, water sources and planned irrigation areas are not known for the long list candidate irrigation subprojects. Instead, indicated crop water demand in 2050 using evapotranspiration can be an input into the adaptation strategy for the subprojects by ensuring that local water availability (water sources and planned irrigation areas) are matched to these crop water demands in the design of the subproject.

87. The Water Accounting in Selected Asian River Basins: Pilot Study in Cambodia (2017)<sup>19</sup> has divided Cambodia into five basin areas. The Tonle Sap and Lower Mekong basins contain all the project provinces. The study derived estimated actual evapotranspiration for different crops for all Cambodia using remote sensing tied to surface energy balance models developed by IHT-Delft. The actual evapotranspiration for Cambodia's river basins at a pixel size of 250 m is at Figure 23.

**Figure 23: Estimated Actual Evapotranspiration for a Typical Year (2008)**



Source: IHE-Delft 2017.

<sup>19</sup> Salvatore E and W Bastiaansson 2017, *Water Accounting in Selected Asian River Basins: Pilot Study in Cambodia*, IHE-Delft.

88. When the evapotranspiration layer is combined with detailed land cover datasets, evapotranspiration for different crops can be obtained. Actual evapotranspiration for irrigated dry season rice for the project provinces determined in this way are at Table 10.

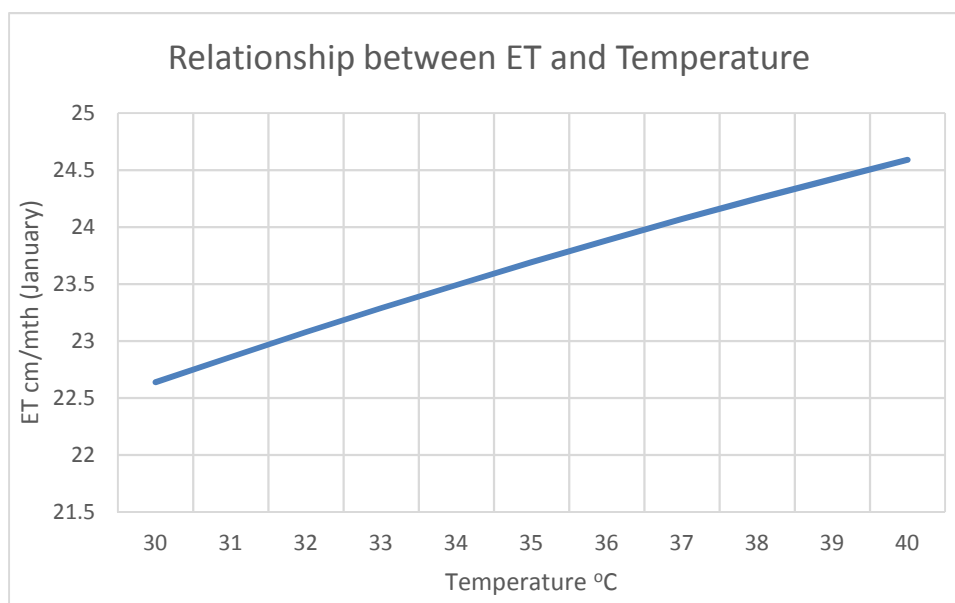
**Table 10: Evapotranspiration for Irrigated Rice**

Basin	Crop Type	Area (km <sup>2</sup> )	ET rate (mm/yr)	ET per unit area (m <sup>3</sup> /ha)
<b>Tonle Sap</b>				
2004 (dry)	Irrigated cereal	9,664	943	9,430
2007 (wet)	Irrigated cereal	9,664	945	9,450
2008 (average)	Irrigated cereal	9,664	1,031	10,310
<b>Lower Mekong</b>				
2004 (dry)	Irrigated cereal	5,637	1,035	10,350
2007 (wet)	Irrigated cereal	5,637	1,095	10,950
2008 (average)	Irrigated cereal	5,637	1,140	11,400

ET = evapotranspiration, km<sup>2</sup> = square kilometre, mm/yr = millimeter per year, m<sup>3</sup>/ha = cubic meter per hectare. Source: IHE-Delft 2017.

89. Using the Penman-Monteith formula<sup>20</sup> for deriving potential evapotranspiration and keeping inputs for radiation, relative humidity, wind speed and atmospheric pressure at constant median values for Cambodia, changes to evapotranspiration with increases in temperature can be calculated (Figure 24).

**Figure 24: Increase in Potential ET with temperature Rise**



cm/mth = centimeter per month, ET = evapotranspiration. Source: PPTA team.

90. The total irrigated water requirement also needs to include the crop preparation period and an allowance of water for pre-saturation of paddy and establishment of a 100 mm water layer for planting. The dry season crop, coming off the end of the wet season, will benefit from already ambient water levels in the paddy soils so an allowance of 1 m<sup>3</sup>/ha for preparatory inundation is

<sup>20</sup> <http://onlinecalc.sdsu.edu/onlinepenmanmonteith.php>.

added. Additionally, actual evapotranspiration estimated through remote sensing and surface energy balance models gives results which reflect optimal water use by a crop. This would approximate a high irrigation efficiency of >60%. To approximate a more realistic irrigation efficiency of 40% achievable in subprojects, the actual evapotranspiration in 2050 is increased by a factor of 1.5 (60/40) to give an indicative crop water demand for an irrigated dry season rice crop.

**Table 11: Evapotranspiration of Dry Season Rice under Irrigation with Temperature Changes**

Basin and Province	Year	ET (m <sup>3</sup> /ha)	Temperature Change in Dry Season 2050*	ET 2050 (m <sup>3</sup> /ha)	ET 2050 plus allowance for planting preparation	Indicative Crop water demand at 40% irrigation efficiency
<b>Tonle Sap Basin</b>						
BTB	2004 (dry)	9,430	2.0 – 2.1 °C	9,594	10,594	15891
	2008 (ave.)	10,310	2.0 – 2.1 °C	10,490	11,490	17235
BMC	2004 (dry)	9,430	1.5 – 2.0 °C	9,586	10,586	15879
	2008 (ave.)	10,310	1.5 – 2.0 °C	10,481	11,481	17222
SRP	2004 (dry)	9,430	2.0 – 2.3 °C	9,610	10,610	15915
	2008 (ave.)	10,310	2.0 – 2.3 °C	10,507	11,507	17261
KPT	2004 (dry)	9,430	2.6 – 2.8 °C	9,649	10,649	15974
	2008 (ave.)	10,310	2.6 – 2.8 °C	10,550	11,550	17325
<b>Lower Mekong Basin</b>						
KPC	2004 (dry)	10,350	2.3 – 2.8 °C	10,590	11,590	17385
	2008 (ave.)	11,400	2.3 – 2.8 °C	11,665	12,665	18998
TBK	2004 (dry)	10,350	2.3 – 2.8 °C	10,590	11,590	17385
	2008 (ave.)	11,400	2.3 – 2.8 °C	11,665	12,665	18998
PRV	2004 (dry)	10,350	2.3 – 2.4 °C	10,556	11,556	17334
	2008 (ave.)	11,400	2.3 – 2.4 °C	11,627	12,627	18941

ave. = average; BTB = Battambang, BMC = Banthaey Meanchey, KPC = Kampong Cham, KPT = Kampong Thom, m<sup>3</sup>/ha = cubic meter per hectare, PRV = Prey Veng, SRP = Siem Reap, TBK = Tboung Khmum.

\*Source: TA 8179-CAM: Mainstreaming Climate Resilience into development Planning adapted by PPTA team.

91. Without data on water availability and other specifications for the future irrigation schemes, the vulnerability of the long list irrigation subprojects to increased crop water demand and/or reduced rainfall due to climate change is unknown, but the indicative crop water demands can be used as a determinant of subproject design, ensuring adaptation of the irrigation to future climates.

## **B. Flooding – All Village Road and Irrigation Subprojects**

92. **Core subprojects.** The CCAM model (at RPC 8.5) projects a small increase (no change to an increase of 5 mm) in one day extreme rainfall for the village road core subproject area in Kampong Cham. The projected five day extreme rainfall model projects a decrease in five day extreme rainfall over the same subproject area of -6.5 mm to -12 mm. For the core subproject for irrigation in Prey Veng province the same model projects a small increase (no change to an increase of 5 mm) in one day extreme rainfall and a decrease of up to 6 mm in five day extreme rainfall.

93. The studies of the drivers of the Lower Mekong floods indicate that, although projected localized rainfall will not increase significantly in climate change scenarios, the annual flood pulse of the Mekong will continue with a variability between 65,000 m<sup>3</sup>/s and 30,000 m<sup>3</sup>/s at Kampong Cham, upstream of both core subprojects – to be exacerbated by the effects of tropical storms and the effects of nearby typhoons at an unknown frequency.

94. Local data on floods and the current frequency of overtopping of canal regulatory structures and canal walls in the Lvea commune is not available. However, there is a yearly long wet season rice crop and the agricultural calendar for the commune indicates a capacity to cope with and use the yearly floods. Data on floods and the current frequency of overtopping of the existing road is currently limited to anecdotal reports from the commune and individual farmers. These reports range from yearly overtopping of a minimum of 0.3 m to an uncommon depth of 2 m, and the impassability of the road during and after these periods seriously constrains agriculture and commercial activities and access to services.

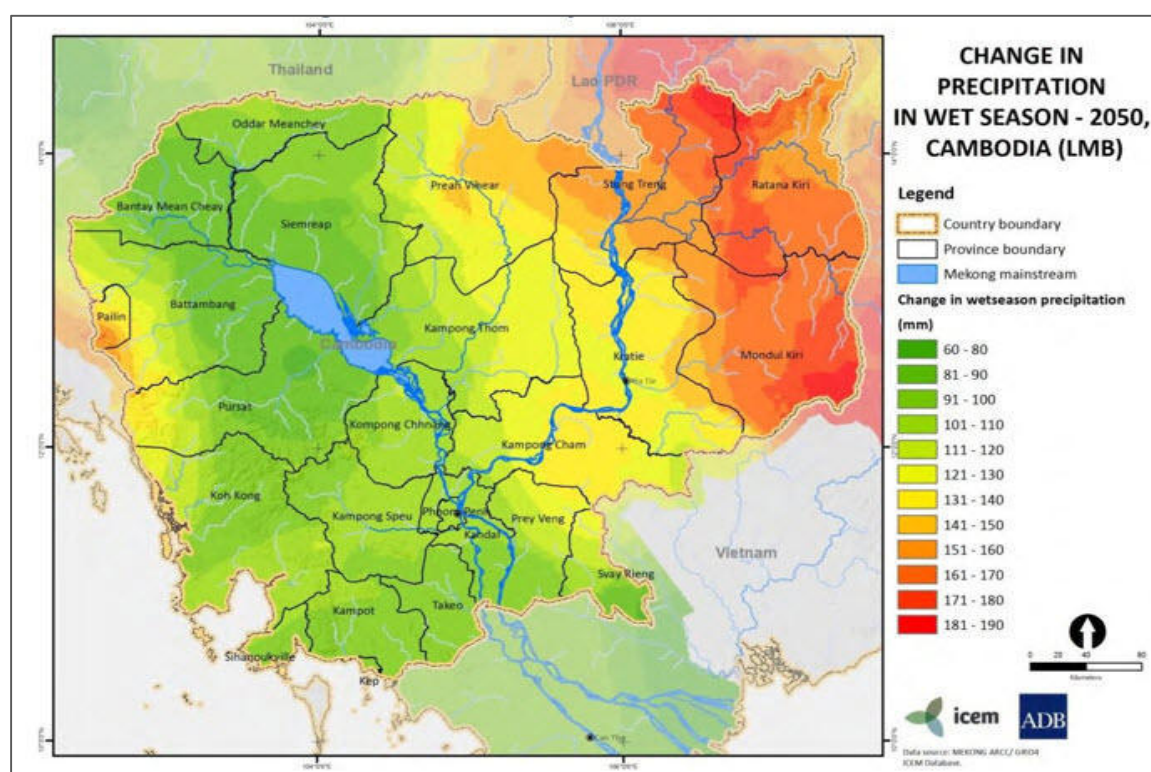
95. These findings indicate that there is a medium vulnerability for the core irrigation subproject and a continued high vulnerability for the core rural road subproject to increased flooding as a result of climate change.

Province	Vulnerability of <u>Core Rural Road Subproject</u>	Vulnerability of <u>Core Irrigation Subproject</u>
Kampong Cham on Mekong floodplain	High	---
Prey Veng on Mekong Floodplain	---	Medium

96. **Long List Subprojects.** All long list candidate subprojects on the floodplain in the Lower Mekong provinces of Prey Veng, and Kampong Cham/Tboung Khmum will have the same vulnerability characteristics as the core subprojects: medium vulnerability for irrigation subprojects (due to long experience with the yearly flooding cycle) and high vulnerability for rural road subprojects to increased likelihood of seasonal flooding.

Province	Vulnerability of <u>Long List Rural Road Subproject</u>	Vulnerability of <u>Long List Irrigation Subproject</u>
Kampong Cham on Mekong floodplain	High	Medium
Tboung Khmum on Mekong Floodplain	High	Medium
Prey Veng on Mekong Floodplain	High	Medium

97. Future flooding potential in Banthaey Meanthey, Battambang, Kampong Thom, Siem Reap, and Tboung Khmum, and those parts of Kampong Cham, Prey Veng, and Tboung Khmum away from the Mekong floodplain, will be affected by future changes in rainfall in the wet season and changes in rainfall intensity (one day and five day rain events). Projected rainfall in these provinces in TA8179-CAM: Mainstreaming Climate Resilience into Development Planning (Figure 25) shows that wet season rainfall will increase in 2050 in all provinces, with the highest ranges in Tboung Khmum (120 mm - 140mm) and Kampong Cham, Kampong Thom, and Prey Veng (100 mm – 130 mm). Projected rainfall intensities (one day and five day rain events) differ with all provinces showing increases in one day events, and mixed projections of large decreases and smaller increases in five day rainfall (Table 12).

**Figure 25: Projected Change in Wet Season Rainfall in 2050**

Source: TA8179-CAM: Mainstreaming Climate Resilience into Development Planning.

**Table 12: Projected Rainfall in Wet Season and Rainfall Intensity in 2050**

Province	Projected Wet Season Rainfall Change (mm)	1 Day Rain Event change (mm) - all increases	5 Day Rain Event change (mm) – increases except where noted
Banthaey Meanchey	81-90 (6-7%)	0.0-2.5 (0-1.9%)	-16.5 to -17.5 (4-10% reduction)
Siem Reap	100-120 (8-8.5%)	2.5-5.0 (2.1-3.4%)	5.0 to 8.0 (3.1-3.3%)
Battambang	81-90 (5-7%)	0.0-2.5 (0-1.7%)	-6.5 to -17.5 (4-9.2% reduction)
Kampong Thom	100-130 (7.3-7.5%)	5.0-12.5 (3.8-7.8%)	5.0 to 28 (2.6-12.7%)
Kampong Cham	100-130 (5.7-7.4%)	5.0-16 (3.1-10%)	5.0 to 20 (2.3-12.7%)
Tboung Khmum	120-140 (6.6-7.7%)	5.0-12.5 (3.1-6.9%)	5.0 to 16 (2.3-7.3%)
Prey Veng	100-130 (7.3-8%)	0.0-5.0 (0-2.9%)	5.0 to 10 (2.3-4.5%)

mm = millimeter.

Source: TA8179-CAM: Mainstreaming Climate Resilience into Development Planning and CCAM Model, CSIRO 2013.

98. Increases in rainfall runoff in the wet season have the potential to increase flood heights and duration, while increases in the intensity of rainfall events can increase potential for flash floods in the future, which can cause significant damage to crops and roads but over a short duration. From these projections, the subproject vulnerability to flood risk has been determined based on type of subproject and geographical location (Table 13).

**Table 13: Vulnerability Assessment of Long List Subprojects to Future Flooding**

Province	Vulnerability of Rural Road subprojects	Vulnerability of Irrigation subprojects
Banthaey Meanchey	Low – medium	Low

Siem Reap	Medium	Medium
Battambang	Low – medium	Low
Kampong Thom	High	High
Kampong Cham <sup>a</sup>	High	Medium - high
Tboung Khmum <sup>a</sup>	High	Medium - high
Prey Veng <sup>a</sup>	Medium	Medium

<sup>a</sup> Areas of province not on Mekong floodplain.

## VI. CLIMATE ADAPTATION ASSESSMENT AND DISASTER RISK ASSESSMENT

### 1. Core Subprojects

99. **Irrigation.** The crop of interest for Lvea commune is dry season rice (90-day crop). The projections from SRES scenarios for irrigation planning (MOWRAM Model – see Figure 17 above) show that the irrigation water requirement (IWR) for these crops will be in the following ranges in 2020 and 2050 (Table 14):

**Table 14: Projected IWRs from Climate Change and IWRs used in Subproject Water Balances for 305 ha Dry Season Crop at Lvea**

Crop	Projected IWR in 2020 for dry year (m <sup>3</sup> /ha)	Projected IWR in 2050 for dry year (m <sup>3</sup> /ha)	IWR used in Water Balances in IEE for dry years (m <sup>3</sup> /ha)
Dry season rice (short season)	15,000-15,500	16,250-16,400	18,000

ha = hectare, IEE = initial environmental examination, IWR = irrigation water requirement, m<sup>3</sup>/ha = cubic meter per hectare.

Source: PPTA team.

100. Table 14 shows that when the IWRs from future climate change scenarios are compared with the IWRs being used for subproject design the project design IWRs are consistently higher and already allow for the eventuality of future increased water demand and increased droughts in both 2020 and 2050.

101. However, that same analysis revealed that, while the irrigation is possible, that rate of extraction of the water will need to be coordinated with downstream schemes and users, since the scheme takes about 17% of the available water in a typical dry year.

102. Floods and extreme weather events can damage crops and irrigation infrastructure. The vulnerability of the Lvea commune irrigation subproject to these impacts has been assessed as medium, since yearly floods are expected and form part of the cropping calendar. Large increases in rainfall intensity are not predicted.

103. Overtopping of irrigation channels and structures and general flooding of the land will continue and flood resistance (i.e., stopping the flooding of the paddy fields) is inappropriate. However, protection of the irrigation infrastructure from flood damage, so that it remains functional for the succeeding dry season, is a necessity.

104. **Village road.** Local rainfall and extreme rainfall events are not predicted to significantly increase in the future, but the annual flooding in the Lower Mekong will continue to affect the area and the effect of tropical storms in the region will also continue, making the core subproject road highly vulnerable to disaster risk and climate change. However, current CCA and DRR capacity and opportunity for locally sourced improvements to the village road subproject is low. According to anecdotal reports the road is cut by flood waters every year. This cutting of the main access between Banthaey commune and Chbar-Ampov commune both of which are agriculture-based communes and often lasts for extended periods, and leaves the road damaged and impassable for a further period. This has a significant impact on livelihoods. The commune lacks the resources to strengthen resilience of the road for the yearly flood impact and relies on outside resources.

### 2. Long List Subprojects

105. The majority of long list candidate subprojects will mirror those of the core subprojects, with cropping systems and infrastructure adapted to wet season inundation and rainfall events, and with communes lacking resources to fully prepare their roads and infrastructure for yearly



flood impacts.

106. **Irrigation.** Adaptation assessment in terms of future water availability for these subprojects to successfully and sustainably irrigate a dry season crop is not possible because the locations, command areas, water sources and cropping calendars of the subprojects are not yet known. However, the calculation of future crop water requirements under changed climate in Section IV.A.2 can be used in the design of these future irrigation schemes to ensure that the proposed cropping regimes and irrigation water availability can match the crop water requirements which already incorporate the effects of future climate change.

107. As with the Lvea core subproject, overtopping of irrigation channels and structures and general flooding of the land will often be a common occurrence and flood resistance (i.e., stopping the flooding of the paddy fields) is inappropriate. However, protection of the irrigation infrastructure from flood damage, so that it remains functional for the succeeding dry season should be the focus of adaptation measures.

108. **Rural roads.** Reducing disaster risk and adaptation to future climate change is a priority for rural road subprojects in Kampong Cham, Kampong Thom, Tboung Khmum and the Mekong floodplain areas of Prey Veng – all of which have been assessed as being highly vulnerable to current and future floods and extreme weather. Local circumstances, when they are known, may also mean that long list road subprojects with predicted lower climate change vulnerabilities in Banthaey Meanchey, Battambang, and Siem Reap will also need to be designed and operated with appropriate DRR and CCA measures.

109. No data on alignments, specifications and hydrological setting is available for the long list road candidate subprojects. However, it is reasonable to assume that the communes that they serve share the same limitations as those of the core subprojects and that the communes lack the resources to prepare their roads for the yearly impact and rely on outside resources.

### 3. Conclusions

110. The outcome of the climate adaptation assessment can result in three different types of decisions:<sup>21</sup>

**Decision of Type 1:** Invest in climate and disaster proofing the project at the time the project is being designed or implemented.

**Decision of Type 2:** Do not invest now in climate proofing but ensure that the project is designed in such a way as to be amenable to be climate proofed in the future if and when circumstances indicate this to be a better option than not climate proofing.

**Decision of Type 3:** Do no changes to project design, monitor changes in climate variables and their impacts on the infrastructure assets, and invest in climate proofing if and when needed at a later point in time.

111. Considering the socio-economic circumstances of the rural communities that the TSSD-AF project is targeting, and the limited capacity and resources in the communes of these areas for forward planning, it is considered most beneficial to invest in climate proofing through design and project implementation (i.e., Decision type 1).

112. The project will also put in place capacity building and local administrative structures commune councils, livelihood improvement groups (LIG) and marketing improvement groups (MIG) which can, in the future, undertake adaptive management – making additional adaptation

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<sup>21</sup> Asian Development Bank 2012, *Guidelines for climate proofing investment in agriculture, rural development, and food security* Mandaluyong City, Philippines: Asian Development Bank.

Type 3 decisions.

113. The outcome of the disaster risk assessment is that there are currently medium to high disaster risks for flood and low to medium disaster risks for drought in the project provinces, and that these risks are likely to increase in the future. This means that disaster risk reduction is needed now in the design and operation of infrastructure and in capacity building and awareness of local communities – and that these measures should be sufficiently robust to also cope with future scenarios.

114. As with climate change adaptation measures, with which there is almost total overlap for flood and drought, the socio-economic circumstances of the rural communities that the TSSD-AF project is targeting, and the limited capacity and resources in the communes of these areas for forward planning, makes it necessary to invest in disaster risk reduction in infrastructure design and inclusion of disaster risk reduction and disaster management training in the project's capacity building of local administrative structures commune councils, livelihood improvement groups (LIG) and marketing improvement groups.

## VII. IMPLEMENTATION

115. The Cambodia Climate Change Strategic Plan, 2014 – 2023 identifies two strategic objectives to enhance adaptation to the impacts of future climate change. Strategic Objective 1 (Promote climate resilience through improving food, water and energy security) includes a provision to ... *Rehabilitate and build water infrastructures including small-, medium- and large-scale irrigation schemes*. Strategic Objective 2 (Reduce sectoral, regional, gender vulnerability and health risks to climate change impacts) includes .... *Enhance the quality of rural infrastructure (roads, irrigation, wells and culverts) to be resilient to flood and drought*. The implementation of the core subprojects will be in line with these strategic objectives.

116. The ADB Climate Proofing Guidelines for agriculture and road projects cover both structural and non-structural adaptation measures. From the foregoing discussion in Section VI, the focus of this CDRA is on infrastructure design (in construction and rehabilitation subprojects) in line with Decision Type 1, and those listed below for irrigation and roads are in line with the climate proofing guidelines. However, the outputs of the TSSD-AF project includes a range of non-structural investments (mainly in the agriculture sector) which also address the approaches listed in the climate proofing guidelines. These include:

- (i) Crop development;
- (ii) Agricultural information systems;
- (iii) Resource management innovations;
- (iv) Agricultural support programs;
- (v) Resource management programs;
- (vi) Crop selection and crop calendar; and
- (vii) Water management.

117. The TSSD-AF project will therefore implement both structural and non-structural adaptation and DRR measures to address the vulnerabilities identified in this CDRA.

### A. Adaptation Response to Drought and Increased Crop Water Requirement

118. **Irrigation.** The PPTA team has confirmed that the IWR calculations used in the core subproject designs are consistently higher than the future increased water demand calculated for climate change scenarios for both 2020 and 2050. This means that IWRs from future climate change scenarios have already been incorporated in subproject designs. Table 15 shows the percentages by which design IWRs exceed projected IWRs.

**Table 15: Projected IWRs from Climate Change and IWRs used in Core Subproject Water Balances**

Crop	Projected IWR in 2020 (m <sup>3</sup> /ha)	IWR used in subproject design are higher by ...	Projected IWR in 2050 (m <sup>3</sup> /ha)	IWR used in subproject design are higher by ...
Dry season rice	15,000-15,500	20%-16%	16,250-16,400	11%-9.75%

IWR = irrigation water requirement, m<sup>3</sup>/ha = cubic meter per hectare.

Source: PPTA team.

119. The design IWRs for the subprojects exceed the additional water requirements projected for 2020 and 2050 by between 10% and 20%, so adaptation for this effect of climate change has been addressed. However, that same analysis revealed that, while the irrigation is possible, that extraction of the water may put pressure on downstream supplies.

120. For long list subprojects, the CDRA has calculated indicative future crop water

requirements (Table 11) which can help ensure that future irrigation subprojects in these provinces will be planned and designed to take account of these conditions and match them to water availability.

**121. Water Use Sustainability and Drought Resilience Measures.** Where crop water requirements and sustainable water availability do not match, for both core and long list subprojects, there are three main activities which are needed to address this. These can be undertaken either individually or in combination:

- (i) Increasing the irrigation efficiency. The water balance for the irrigation was based upon an irrigation efficiency of 40%. This is a combination of conveyance efficiency, distribution efficiency, and field application efficiency. The new irrigation area for a dry season crop is starting from a low level of efficiency, since the focus of the project is the rehabilitation of irrigation infrastructure abandoned or in disrepair, and 40% would be a very significant advance in the first 10 years of operation. Only when the irrigation is well established can field trials be undertaken to investigate the opportunity for improvement in each of the constituent efficiencies.
- (ii) Reducing the irrigated area. This will be a response to water availability in the long term and may occur as a planned response to limited flow in the main water source by pumping station operators and commune officers in very dry years, or as a result of inter-commune user group negotiations (especially with downstream communes). Any decrease in the planned total area for dry season irrigation will improve the adaptation response to future increases in crop IWRs.
- (iii) Operational procedures. for the sustainable and responsible management of irrigation schemes. These will ensure that agreed irrigation and base flows are maintained and other beneficial water users are not disadvantaged. They will provide a clear and detailed extraction plans for the growing seasons. The plans will be prepared by the subproject commune councils in consultation with farmer groups, as a prerequisite for project commencement. Operational plans and operating practices for water allocations and drainage will be documented and approved by the implementing agency and ADB before procurement and construction commences.

## **B. Response to Increased Flood Potential**

**122. Irrigation Subprojects.** Data on floods and the current frequency of overtopping of canal regulatory structures and canal walls for the core subproject is not available. However, modelling of future scenarios indicate that although local rainfall and extreme events are unlikely to significantly increase in the future, the annual flooding in the Lower Mekong will continue to affect the area and the penetration of typhoons and tropical storms into or in the region of this part of Cambodia will continue with an uncertain frequency.

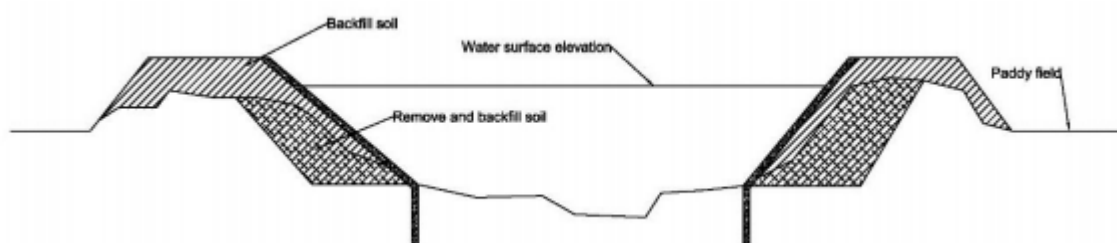
**123.** The CCA and DRR measures of long list candidate subprojects, especially those in Kampong Thom, Kampong Cham, and Tboung Khmum provinces which have been assessed as medium-high and high vulnerability, is the same as for the core subproject. These are described below.

**124. Flood Resilience Measures** Subproject canals are secondary and tertiary structures. Secondary canals lead off the primary canals and it is here that design for flood resilience is required. Canal walls will be reconstructed where needed and strengthened to withstand flood flows. Sluice gates will be provided with erosion/scour protection to maintain the integrity of control

structures against high energy flood flows. The crest height of control gates will be adjusted above the 2011 and 2013 flood levels to provide the option of directing flood waters to control release sluices rather than overtopping and scouring the secondary canals.

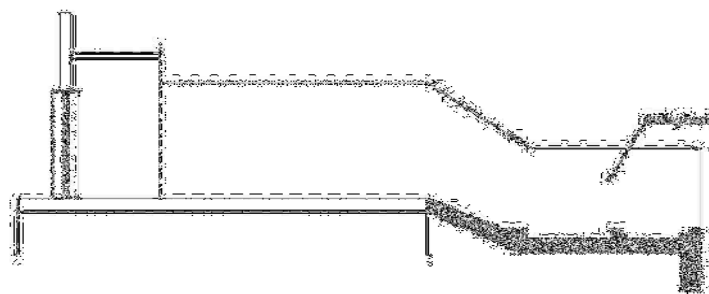
125. Typical canal rehabilitation along high flow sections (closest to offtake from the primary canal) will involve replacement of structurally unsuitable material. This can be combined with an installed lining inside the canal slopes (Figure 26) for the first 20 m - 30 m of the secondary canal which may be affected by high flows from the primary canal. This will retain a natural canal bed and benthic environment for the limited canal fisheries but protect vulnerable side walls from flood scouring and failure.

**Figure 26: Typical Canal Rehabilitation Incorporating Side Wall Lining**



126. All water (sluice) gates controlling water flow from the main canal into secondary canals may be equipped with small energy dissipation basins to ensure that excessive kinetic energy is dissipated before entering the earth channel section of the canals.

**Figure 27: Downstream Erosion and Scour Protection of Area behind Sluice Gates on Secondary Canals**



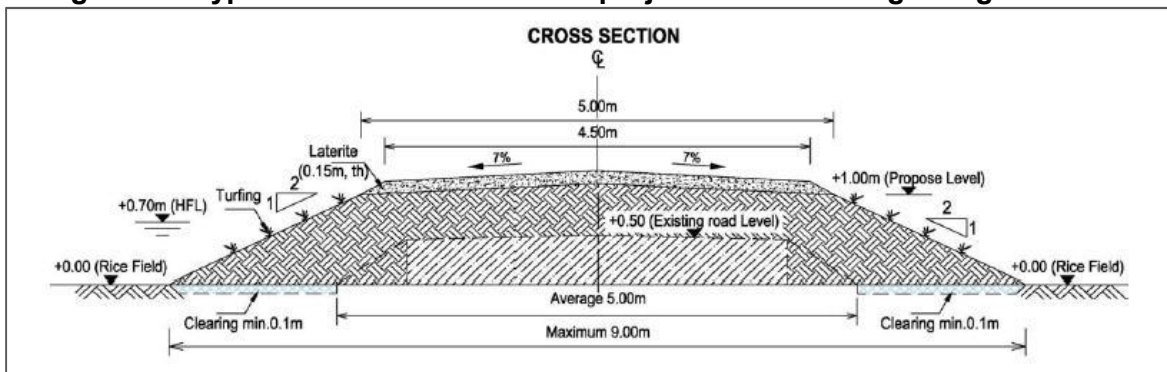
127. **Village Road Subprojects.** It is not possible, within the funding limitations of the project, to design and engineer the subject road to be fully flood resistant in the context of the maximum floods reported. However, a suite of design measures against all floods are recommended. The following design measures, which comply with NCDD standards for rural road design are recommended (Figure 28).

128. **Flood Resilience Measures.** The following flood resilience measures for rural roads apply to current and short term flood disaster risk and those affected by future climate change:

- (i) Within budget constraints, flood resistance of the road (raising the road above recorded flood levels) should be maximized. This will involve identification of high priority flood proofing sections and lower priority sections along the road alignment.
- (ii) Armor road surfaces (natural stone or reinforced concrete) along floodway sections to protect during overtopping by floods.
- (iii) Embankment batters will be at a slope no greater than 30° (1 in 2) and using

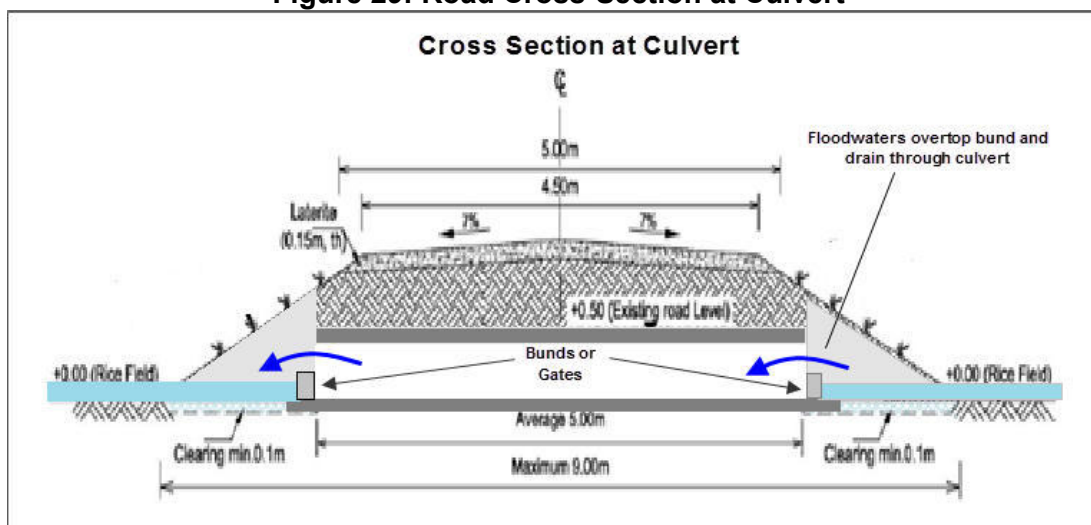
- imported material which is more erosion resistant than local soil.
- (iv) Appropriate granular material for road base and embankments will be used, along with tight construction supervision to ensure adequate compaction.
- (v) The embankment will be turfed and planted with local shrubs to increase stability and resistance to fast flowing water.
- (vi) Armor embankments at the edges of floodways with gabions or other appropriate material.
- (vii) The road surface will have a drainage slope of 2% from the center-line on the floodway section surface and 5% on other sections to shed water.
- (viii) The road will have multiple through-drainage structures (culverts and pipes) to ensure that it will not be a flood barrier, and will reduce overall flood flow velocities.
- (ix) Culverts will be designed to exceed the height of the existing road level by a factor reflecting the projected increase in rainfall amount and intensity (Table 12) and local flood data.
- (x) Where paddy field directly abut the road embankment, culverts will have bunds or water gates at each end which will allow inundation of adjoining paddy fields but which can also be overtopped by floodwaters (Figure 29).

**Figure 28: Typical Cross Section of Subproject Road showing Design Features**



Source: TSSD-AF PPTA Rural Road Technical Report.

**Figure 29: Road Cross-Section at Culvert**



Source: Adapted from TSSD-AF PPTA Rural Road Technical Report..

### **C. Disaster Risk Reduction**

129. The TSSD-AF will improve on designs for roads and irrigation schemes under the project to incorporate climate resilience and to mitigate disaster risks in communes subject to flooding or drought. Two recent ADB projects have also made recommendations to the government on such measures.<sup>22</sup>

130. Commune-based DRR will be supported by the project through the preparation and delivery of a commune training plan for DRR relevant to the irrigation and village road subprojects. This will be integrated with existing Cambodian government national DRR training and planning programme through the National Committee for Disaster Management Secretariat (NCDMS), which aims to undertake all commune level DRR training and planning.

131. A major work area in NCDMS, under the ADB Community-Based Disaster Risk Reduction (CBDRR) Project, is the strengthening of coordination and responsibility sharing among provincial, district and commune level disaster management bodies. The training will be designed to fall within, and complement the existing organizational structures. The training will also make use of material and guidelines developed by NCDMS through the CBDRR Project.

132. Under the terms of a Letter of Agreement between the TSSD-AF Executing Agency and NCDMS, and in cooperation with the District Committees for Disaster Management (DCDMs) and Commune Councils (CCs), NCDMS will plan, prepare and deliver training to commune council staff and village representatives of up to 271 communes in the seven project provinces.

133. Training will essentially continue the commune-level training on DRR already carried out by NCDMS teams under the ongoing CBDRR Project adjusted to link with rural roads, small scale irrigation, and other production related infrastructure financed by the TSSD-AF project and its capacity building outputs. Capacity development in DRR to increase operational knowledge at commune and village levels will also include training applications prepared for commune mobile access workers to deliver, and through the ICT component including improved DRR and extension information transmitted through radio, TV and mobile access devices. At the sub-commune level and with livelihood improvement groups (LIGs) the projects action plan and training will dovetail with Oxfam's DRR delivery.

134. TSSD-AF training in DRR will cover two major areas:

- (i) Commune and village level training and participatory assessment and analysis of disaster risk;
- (ii) Commune and village level training and participatory exercises in DRR planning.

The DRR training will cover a wide variety of disaster preparedness measures from adjustments to and protection of local infrastructure, including community and stock refuges and access, to capacity building and awareness, communications and emergency planning.

### **D. Climate Adaptation and Disaster Risk Reduction Costs**

135. Measures to address current and future flooding and future lower water availability (which combine climate change adaptation and disaster risk reduction) were developed for two core projects (one irrigation infrastructure and one rural road reconstruction) for which full feasibility studies were undertaken during the project TA phase. From these costs, unit costs were derived of \$130/ha for irrigation subprojects and \$14,920/km - \$32,830/km for road subprojects (the range is for using natural stone and cement for surface in floodways or using reinforced concrete for floodways, respectively). Extrapolated over the full project implementation of 6,000 ha of irrigation

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<sup>22</sup> McDonald A, 2016, *ibid*.



and 175 km of flood resilient rural road, this represents combined climate change adaptation and disaster risk reduction totals of \$0.78 million (irrigation) and \$2.61 million to \$5.745 million (rural roads).

136. The project's capacity building packages include DRR training costs estimated at \$1.38 million. A number of other capacity building outputs including training in climate-resilient agriculture, integrated pest management, formation and administration of livelihood groups and value added chains, will also include elements of climate change adaptation and disaster management. These can be costed on the basis of the proportion of the targeted capacity building packages which addresses climate change adaptation and disaster management. This has been estimated by the PPTA team to total an additional \$6.49 million

137. A breakdown of indicative adaptation and disaster risk reduction costs and applicable parts of the capacity building and training costs is at **Attachment 2**.

## **VIII. MONITORING AND EVALUATION**

138. The adaptation and DRR measures identified in this CDRA are incorporated into subproject design and operational management through recommendations made in the core subproject environmental management plans (EMPs) and long list candidate subproject assessments (with either an EMP or environmental code of conduct) guided by the environmental assessment and review framework (EARF).

139. The effectiveness and performance will be monitored in the short term by the compliance monitoring of the subproject EMP by project implementation consultants (to check that measures are actually put in place) and the environmental performance monitoring of the EMP.

140. In the longer term, the effectiveness of the design and operating measures will be monitored through the project's design and monitoring framework (DMF). The DMF includes verifiable outcomes of continuing serviceability and access of rural roads constructed by the project, and successful dry season cropping through sustainable improvements in agricultural infrastructure.

### Attachment 1: Rapid Environmental Assessment (REA) Checklist

**Instructions:**

- (i) The project team completes this checklist to support the environmental classification of a project. It is to be attached to the environmental categorization form and submitted to the Environment and Safeguards Division (SDES) for endorsement by the Director, SDES and for approval by the Chief Compliance Officer.
- (ii) This checklist focuses on environmental issues and concerns. To ensure that social dimensions are adequately considered, refer also to ADB's (a) checklists on involuntary resettlement and Indigenous Peoples; (b) poverty reduction handbook; (c) staff guide to consultation and participation; and (d) gender checklists.
- (iii) Answer the questions assuming the "without mitigation" case. The purpose is to identify potential impacts. Use the "remarks" section to discuss any anticipated mitigation measures.

**Country/  
Project Title:**

CAM: Tonle Sap Poverty Reduction and Smallholder Development Project. AF

**Sector Division:**

SEER/SERD

Screening Questions	Yes	No	Remarks
<b>A. PROJECT SITING</b> Is the Project area adjacent to or within any of the following environmentally sensitive areas?			Subproject selection criteria will preclude candidate subprojects in or adjacent to environmentally sensitive areas
▪ Protected Area		X	
▪ Wetland		X	
▪ Mangrove		X	
▪ Estuarine		X	
▪ Buffer Zone of Protected Area		X	
▪ Special Area for Protecting Biodiversity		X	
<b>B. POTENTIAL ENVIRONMENTAL IMPACTS</b> Will the project cause...			

Screening Questions	Yes	No	Remarks
▪ loss of precious ecological values (e.g. result of encroachment into forests/swamplands or historical/cultural buildings/areas, disruption of hydrology of natural waterways, regional flooding, and drainage hazards)?	X		Weirs are necessary for the functioning of the irrigation systems. To enable aquatic life migration up and downstream, the IEE/EMP will consider appropriate mitigation measures like fish passages, if necessary
▪ conflicts in water supply rights and related social conflicts?		X	
▪ impediments to movements of people and animals?		X	
▪ potential ecological problems due to increased soil erosion and siltation, leading to decreased stream capacity?	X		
▪ Insufficient drainage leading to salinity intrusion?		X	Irrigation systems will be designed to have adequate outfalls to existing waterways
▪ over pumping of groundwater, leading to salinization and ground subsidence?		X	Over pumping of groundwater is unlikely due to the limited availability and high prices of electricity
▪ impairment of downstream water quality and therefore, impairment of downstream beneficial uses of water?	X		Any increased use of agro-chemicals will be offset by training in sustainable practices involving reduced or optimized use of pesticides and fertilizer.
▪ dislocation or involuntary resettlement of people?		X	
▪ disproportionate impacts on the poor, women and children, Indigenous Peoples or other vulnerable groups?		X	
▪ potential social conflicts arising from land tenure and land use issues?		X	
▪ soil erosion before compaction and lining of canals?		X	
▪ noise from construction equipment?	X		Mitigation provided for in EMP
▪ dust during construction?	X		Mitigation provided for in EMP

Screening Questions	Yes	No	Remarks
▪ waterlogging and soil salinization due to inadequate drainage and farm management?		X	Irrigation systems will be designed to have adequate drainage, capacity development for farmers on farm management
▪ leaching of soil nutrients and changes in soil characteristics due to excessive application of irrigation water?		X	capacity development for farmers on farm management
▪ reduction of downstream water supply during peak seasons?	X		The IEE/EMP has to assess minimum flow conditions for downstream users
▪ soil pollution, polluted farm runoff and groundwater, and public health risks due to excessive application of fertilizers and pesticides?	X		Any increased use of agro-chemicals will be offset by training in sustainable practices involving reduced or optimized use of pesticides and fertilizer.
▪ soil erosion (furrow, surface)?	X		
▪ scouring of canals?		X	Appropriate canals will be built to avoid that issue.
▪ clogging of canals by sediments?	X		Some minor risk, but regular maintenance will be encouraged
▪ clogging of canals by weeds?	X		As above
▪ seawater intrusion into downstream freshwater systems?		X	
▪ introduction of increase in incidence of waterborne or water related diseases?		X	Risks will be reduced by appropriate canals which will limit ponding and therefore habitats for insect vectors of disease
▪ dangers to a safe and healthy working environment due to physical, chemical and biological hazards during project construction and operation?		X	Minor risks are considered in the IEE/EMP and mitigated
▪ large population influx during project construction and operation that causes increased burden on social infrastructure and services (such as water supply and sanitation systems)?		X	
▪ social conflicts if workers from other regions or countries are hired?		X	

Screening Questions	Yes	No	Remarks
<ul style="list-style-type: none"> <li>risks to community health and safety due to the transport, storage, and use and/or disposal of materials such as explosives, fuel and other chemicals during construction and operation?</li> </ul>		X	Only minor risk
<ul style="list-style-type: none"> <li>community safety risks due to both accidental and natural hazards, especially where the structural elements or components of the project (e.g., irrigation dams) are accessible to members of the affected community or where their failure could result in injury to the community throughout project construction, operation and decommissioning?</li> </ul>		X	

### A Checklist for Preliminary Climate Risk Screening

**Country/Project Title: CAM: Tonle Sap Poverty Reduction and Smallholder Development Project, AF**

**Sector : Agriculture, Natural Resources and Rural Development**

**Subsector: Agricultural production and Irrigation**

**Division/Department: SEER / SERD**

Screening Questions		Score	Remarks <sup>1</sup>
<b>Location and Design of project</b>	Is siting and/or routing of the project (or its components) likely to be affected by climate conditions including extreme weather related events such as floods, droughts, storms, landslides?	1	Infrastructure will be strengthened to withstand anticipated floods.
	Would the project design (e.g., the clearance for bridges) need to consider any hydro-meteorological parameters (e.g., sea-level, peak river flow, reliable water level, peak wind speed etc.)?	1	Hydro-meteorological parameters essential for design
<b>Materials and Maintenance</b>	Would weather, current and likely future climate conditions (e.g., prevailing humidity level, temperature contrast between hot summer days and cold winter days, exposure to wind and humidity hydro-meteorological parameters likely affect the selection of project inputs over the life of project outputs (e.g., construction material)?	0	Irrigation infrastructure Improvements based on technical best practices and not affected. Material selection will suit current climate variability.
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Floods may affect infrastructure maintenance if not designed to withstand those.
<b>Performance of project outputs</b>	Would weather/climate conditions, and related extreme events likely affect the performance (e.g., annual power production) of project output(s) (e.g., hydro-power generation facilities) throughout their design life time?	0	The project provides water during the dry season for additional cropping

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

<sup>1</sup> If possible, provide details on the sensitivity of project components to climate conditions, such as how climate parameters are considered in design standards for infrastructure components, how changes in key climate parameters and sea level might affect the siting/routing of project, the selection of construction material and/or scheduling, performances and/or the maintenance cost/scheduling of project outputs.



Responses when added that provide a score of 0 will be considered low risk project. If adding all responses will result to a score of 1-4 and that no score of 2 was given to any single response, the project will be assigned a medium risk category. A total score of 5 or more (which include providing a score of 1 in all responses) or a 2 in any single response, will be categorized as high risk project.

**Result of Initial Screening (Low, Medium, High): Medium**

**Other**

**Comments:** \_\_\_\_\_  
\_\_\_\_\_

**Prepared by:** Marco Leidel

## ATTACHMENT 2: ESTIMATE OF CLIMATE CHANGE ADAPTATION (CCA) AND DISASTER RISK REDUCTION (DRR) COSTS

Incremental Adaptation Costs for Core Subprojects			
Climate Adaptation/DRR Measure			Cost (\$)
Irrigation subproject (305 ha)			
Additional length of concrete lining at head regulators to protect walls from high velocity water			2,400
Stone masonry at head regulators to protect walls from high velocity water			9,400
Steel watergates for secondary canals 2 and 3. Built level with main canal crest to retain minor or early flood in main canal (until overtopped)			5,000
Establishment of vegetation on canal levees			17,850
Total			39,650
Rural road subproject (7.45 km)			
Road height will be increased by up to 0.6 m – 0.8 m above existing alignment for the flood prone section of the alignment. Increment is 0.2 m in height for 4,000 m linear (10,800 m³)			14,040
Higher embankments for vegetating due to higher road crest. Increment of embankment slope to vegetate for 4,000 m linear (2,160 m²)			1,382
Reinforced concrete surface over floodway for 2,800 m linear. (1,764 m²)	Natural stone and cement binding over floodway for 2,800 m linear.		211,680111,120
Multiple through-drainage structures (culverts and pipes) to ensure no flood barrier. Additional 10 piped culverts along alignment.			17,500
Total			244.602144.042

Cost per unit for irrigation: \$130/ha

Cost for whole project (6,000 ha): \$0.78 million

Cost per unit for road: \$14,918/km - \$32,832/km

Cost for whole project (175 km): \$2.61 - \$5.745 million

### Total CCA/DRR Costs for Project

Item	Cost (\$ million)	Explanation
Rural Roads	2.61 – 5.745	Incremental climate change adaptation (CCA)/DRR cost (rock/cement – reinforced concrete respectively on floodway)
Small-scale Irrigation	0.78	Incremental CCA/DRR cost
Support to new livelihood improvement groups	4.50	revolving funds to enhance communities' resilience
Disaster risk reduction (DRR) Training for commune councils	1.38	Training for commune councils
Ministry of Agriculture, Forestry and Fisheries (MAFF) – Department of Agriculture letter of agreement (support to value chain development)	0.34	Training on climate-resilient agricultural practices (provincial level)
MAFF- General Directorate of Agriculture letter of agreement (support to value chain development)	0.77	Training on climate-resilient agricultural practices (national level)
At district level - training, meeting, and workshops cost	0.10	Training cost
<b>Total</b>	<b>10.48 – 13.615</b>	