Initial Environmental Examination

Appendix IV, Parts 1-2
March 2019

Cambodia: National Solar Park Project

Appendix IV – Part 1 Climate Risks and Vulnerability Analysis

I. BASIC PROJECT INFORMATION

Project Title: Cambodia National Solar Park Project for Energy Access (CAM NSPP)

Project Budget: US$22.16

Project Location(s): Kampong Chhnang and Kampong Speu provinces of Cambodia

Sector: Energy
Subsector: Renewable Energy Generation - Solar

BRIEF DESCRIPTION OF THE PROJECT

Objective: The National Solar Park Project for Energy Access aims to demonstrate the ability of large-scale solar power to improve the electricity supply and stability of the Government of Cambodia national grid, and substitute for planned fossil-fuel and hydropower generation in the future. The expansion of solar power generation will help diversify the power generation mix and complement the existing base of hydropower plants to meet daytime peak demand and dry season shortages as well as increase the percentage of clean energy supply in line with the Government's stated Green House Gases (GHG) emissions reduction targets.[1] The project will support investments for development of a solar park and transmission interconnection infrastructure.

Location: The proposed project is located in Kampong Chhnang and Kampong Speu provinces of Cambodia.[2]

Impact, Outcome and Outputs:
The project is aligned with the following impact: cost of electricity in Cambodia lowered. The project will have the following outcome: solar energy power generation in Cambodia increased.

C. Outputs

(i) **Output 1: Solar park and transmission interconnection constructed.** The project will support EDC to construct a 100 MW capacity solar power park in Kampong Chhnang Province and a transmission interconnection system to grid substation 6 (GS6), near the Phnom Penh demand center, to supply power to the national grid. The park will initially consist of 75 hectares of land, associated construction works (i.e. fencing, roads, drainage), common facilities and supporting infrastructure to accommodate 30 MW of solar PV plant capacity. The transmission interconnection infrastructure comprises the pooling substation located at the solar park, which will be able to accommodate a total of 100 MW capacity with 2 transformers, 50 megavolt amp each (with room for another 2), switchgear, and ancillary system, and controls; a supervisory control and data acquisition (SCADA) system compatible with EDC's requirements; a dedicated 37-kilometer 115-kilovolt double circuit overhead transmission line between the solar park

[1]According to ADB's solar grid integration report (February 2017), 150-300 MW of PV installed between 2020 and 2030 would single-handedly allow RGC to meet its emissions reduction targets as stated in the country's Intended Nationally Determined Contribution to the Paris Agreement, without any additional investments.
(Source: National Solar Park Project for Cambodia: Pre-Feasibility Study, August 2017).
[2] The solar park infrastructure are located in Tuel Phos district of Kampong Chhnang province. The proposed transmission line will transect through areas of Sameakki Mean Chey district in Kampong Chhnang province and Thpong and Odonk districts in Kampong Speu
province. The GS-6 is located in Outdong district in Khampong Speu province.

substation and GS6; and two new bays with switchgear at GS6.

(ii) **Project management and oversight delivered.** Expert project implementation consultant (PIC) services will be procured to supervise project implementation and management, and in so doing, strengthen EDC's capacity in financial management, contract administration, social and environmental monitoring and reporting, independent power producer procurement and the operation and maintenance of the solar park facility.

Summary of Climate Change Implications:

The project has been screened for climate change risks using the AWARE climate risk-screening tool[3] (Screening results are enclosed as Part 2 of this Appendix IV). The project is classified as being at Medium risk from future climate change impacts.

The screening indicates that the project is located in a region which has experienced recurring major flood events in the recent past; maybe at risk from precipitation induced landslide events; and may experience potential increase in incidences of precipitation and temperature, future water stress and change in solar radiation affecting solar power potential.

While climate change impacts are not anticipated to be significant over the design life of the solar park (25 years), project outputs sensitive to climate change were identified along with climate change risk response (mitigation) measures.

Recommendations include adequate engineering design of sites (e.g. project siting at the highest flood level and suitable slope– solar park and transmission tower footings), all weather road pavement and raising embankment height of access roads, strengthening existing drainage canals and building a water retention pond, high design standard transmission line as well as regular maintenance of drainage canals, retention pond and roads.

The key climate vulnerable project components will be subject to further analysis during the project detailed engineering design to ensure they take account of projected increases in flooding; measures that will permanently become part of the solar park infrastructure will be included within the main civil work contract costs (indicative estimate USD 1.23 million).

II. CLIMATE CHANGE TRENDS AND PROJECTIONS

Cambodia's climate is tropical with characteristically high temperatures and two seasons are recognized: a). Wet season (May-November) arrives with the summer monsoon with the south-westerly winds ushering in clouds and moisture that accounts for between 80-90% of the country's annual precipitation. Mean monthly rainfall at this time of year can be more than 5000 mm in some provinces; and b). Dry season (November-April) has with cooler temperatures, particularly between November and January. Average temperatures are relatively uniform across the country (25 to 27°C) and are highest (26-40°C) in the early summer months before

[3] The screening is based on the Aware™ 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.

the start of the wet season. Yearly variations in climate result from the El Niño Southern Oscillation episodes that influence the nature of the monsoons in the region and generally bring warmer and drier than average winter conditions across Southeast Asia while La Niña episodes that bring cooler than average conditions.[4]

(i) Historical Trends and Projected Changes in Temperature

Analysis of historical climate data (1901-2015) suggest that the rate of temperature increase has been most rapid in the drier seasons (December-February and March-May), increasing 0.20-0.23°C per decade; and slower rate of temperature increase in the wet seasons (June-August and September-November), increasing 0.13-0.16°C per decade.

Observed Trends:[5]

- Mean annual temperatures have increased by 0.8°C since 1960.
- The rate of temperature increase is most rapid in the dry seasons, increasing 0.20-0.23°C per decade and is slow in the wet seasons, increasing 0.13-0.16°C per decade.
- The frequency of 'hot' days per year[6] has increased significantly (+46, with maximum increases noted in September-November) and as has the frequency of 'hot' nights per year (+63, with maximum increases noted in December-February).
- The frequency of 'cold' days per year[7] has decreased (-19, with maximum decreases noted in December-February).

Projected Changes in Temperature

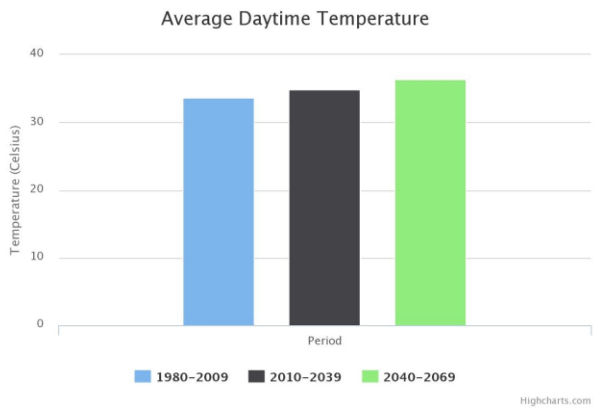
The following insights into future changing climate are derived from a suite of Global Circulation Models (GCMs) used by the Intergovernmental Panel on Climate Change (IPPC).[8]

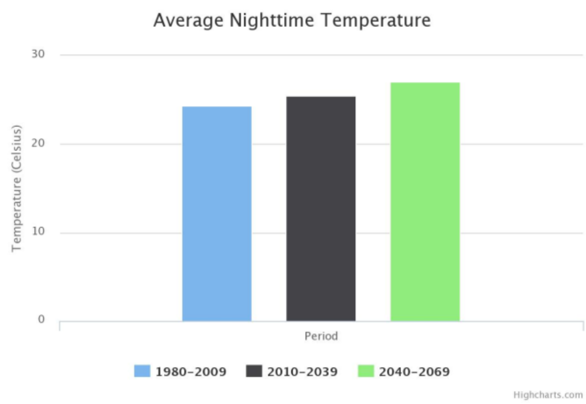
- Mean annual temperatures are projected to increase across Cambodia by 0.7-2.7°C by 2060s and 1.4-4.3°C by 2090s.
- These projections indicate substantial increases in the frequency of days and nights that are considered 'hot' in current climate, with hot days increasing by 14-49% and 'hot' nights increasing by 24-68% by 2060.
- These projections also indicate decreases in the frequency of days and nights that are considered 'cold,' and these events becoming exceedingly rare.

The projected change in temperature for the project area show similar trends as outlined below:[9]

Kampong Chhnang:

[4]World Bank's Climate Change Knowledge Portal.
[5]World Bank's Climate Change Knowledge Portal.
[6]Hot days or nights are defined as the temperature above which 10% of days or nights are recorded in current climate of that region and season.
[7] Cold days or nights are defined as the temperature below which 10% of days or nights are recorded in current climate of that region or season.
[8]World Bank's Climate Change Knowledge Portal
[9] GMS CEP SEA START RC Climate Change Adaptation Platform; http://climatechangeadaptation.gms-eoc.org/home/country



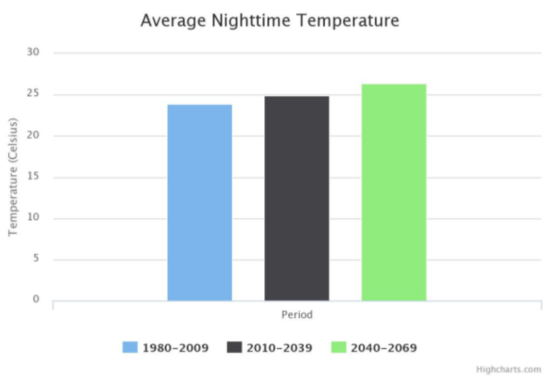


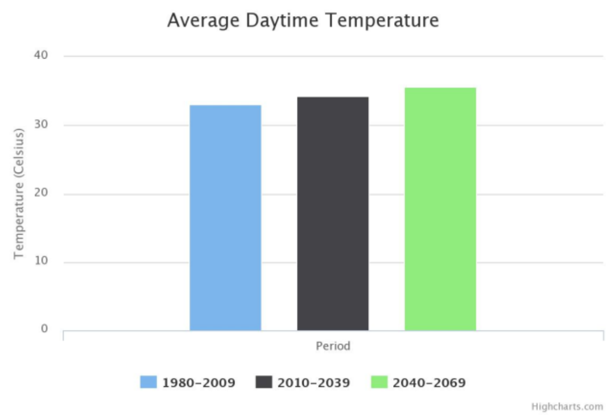
(Scenario Selection: High Temperature Change)

1980 - 2009: 33.7ºC
2010 - 2039: 34.9ºC
2040 - 2069: 36.4ºC

1980 - 2009: 24.4ºC
2010 - 2039: 25.4ºC
2040 - 2069: 27.1ºC

Kampong Speu





(Scenario Selection: High Temperature Change)

1980 - 2009: 33.1ºC
2010 - 2039: 34.3ºC
2040 - 2069: 35.7ºC

1980 - 2009: 23.8ºC
2010 - 2039: 24.9ºC
2040 - 2069: 26.4ºC

(ii) Historical and Projected Changes in Precipitation

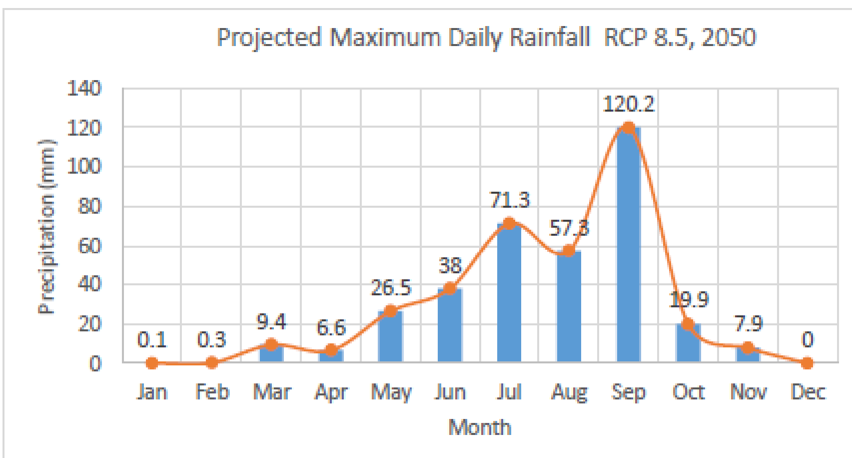
Observed Trends:

Mean rainfall trends in Cambodia are unclear, with some areas experiencing increases and others decreases but these changes are not statistically significant.

Projected Changes in Precipitation:

Climate model projections show that annual average precipitation will increase in the project location, most likely during the wet season.[10]

In the year 2050, the maximum daily rainfall is likely be 120.2 mm at Representative Concentration Pathway (RCP) 8.5[11]

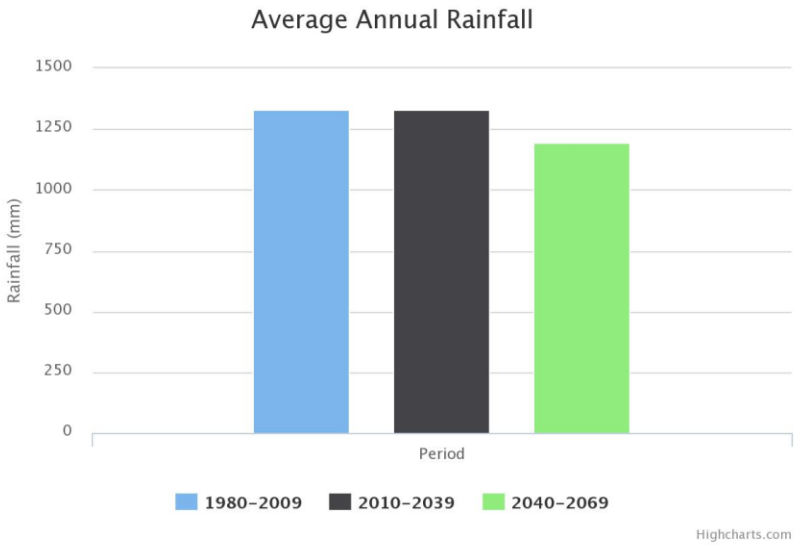


Source: NASA NEX Climate Change data

The projection data for the project areas suggest average annual rainfall increasing until 2039, and then decreasing until 2069.[12]

Kampong Chhnang:

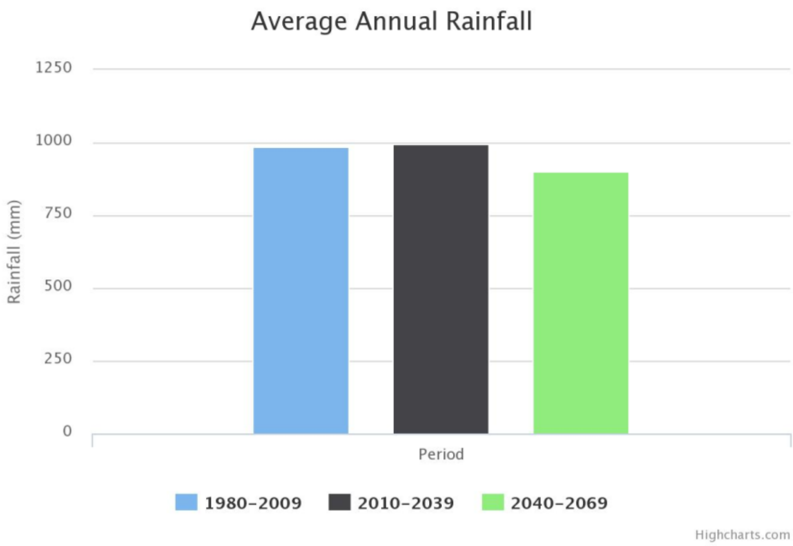
[10] AWARE climate change risk screening tool
[11] Hydrological Study for this project, March 2018 (Work in Progress)
[12] GMS CEP SEA START RC Climate Change Adaptation Platform; http://climatechangeadaptation.gms-eoc.org/home/country



1980 - 2009: 1329.7 mm
2010 - 2039: 1328.3 mm
2040 - 2069: 1193.0 mm

(Scenario Selection: Wet Season)

Kampong Speu:



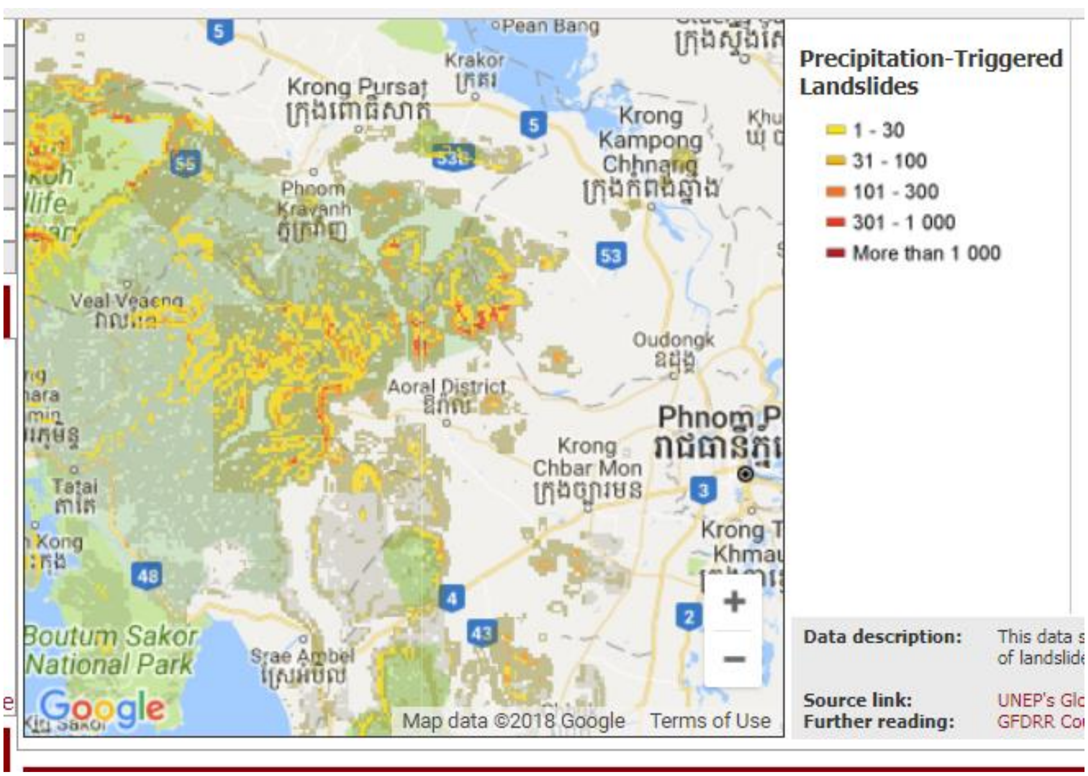
1980 - 2009: 985.9 mm
2010 - 2039: 995.5 mm
2040 - 2069: 902.5 mm

(Scenario Selection: Wet Season)

(iii) Historical and Projected Risk from Precipitation induced Landslide Events

Observed Trends:
Localized landslides are an uncommon hazard phenomenon in the country.[13]

Projected Risk of Landslide Events:
The climate change risk screening results indicate that the project is located in a region that may be at risk from precipitation induced landslide events. Landslide risk is locally influenced by factors such as local slope and vegetation conditions, long term precipitation trends and human actions including excavation of slopes, deforestation, mining, etc. As indicated in Figure 1 below, the landslides triggered by precipitation do not affect the project area. As seen by the red circle in the figure, both sites are outside the landslide areas.



13http://thinkhazard.org/en/report/44-cambodia/LS

Precipitation-Triggered Landslides, near Site 6

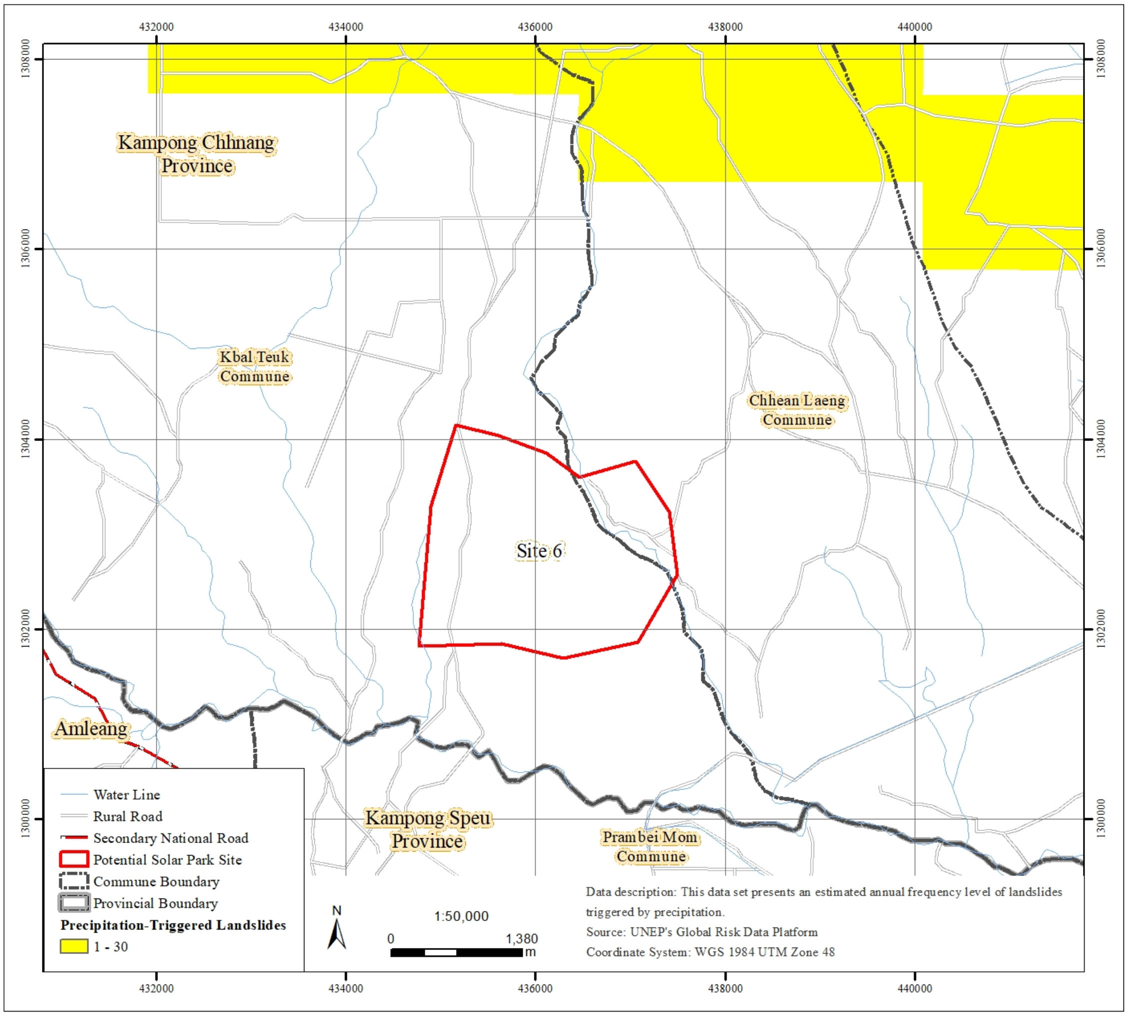


Figure 1

* The data set presents an estimated annual frequency level of landslides triggered by precipitation.

(iv) Historical and Projected Risk from Flood Events:

Observed Trends:

There are two flood types in Cambodia: Mekong River flood and flash floods. The southwest monsoon begins in mid-May and lasts through October and contributes to three-quarters of the country's annual rainfall. Approximately 80% of the country's population lives along the Mekong River that is known for large river flow and discharge fluctuations. Mekong floods affect the provinces of Kandal, Kampong Cham, Kratie, Prey Veng, Stung Treng, Svay Rieng and Takeo. Flash floods in tributaries around the Tonle Sap Lake may affect the project provinces.

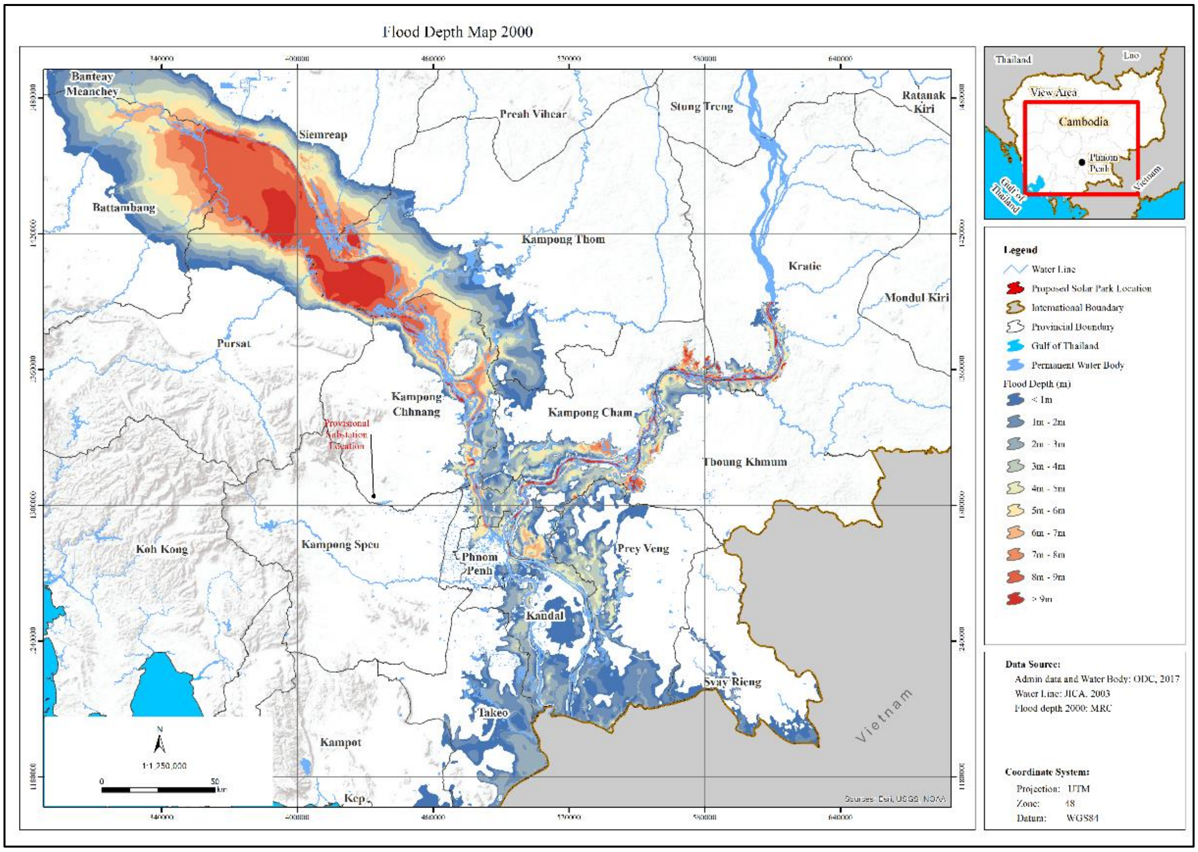
In recent years, a succession of floods has resulted in significant loss of life and economic loss.[14]

Disaster type	Period	Events count	Year of occurrence
Flood	1986- 2000	6	1991, 1994, 1996, 1999 (2), 2000
	2001-2016	11	2001, 2002, 2004, 2005, 2006, 2007, 2010, 2011, 2012, 2013, 2014

Projected Risk of Flood Events:

The climate change risk screening results indicate that the project is located in a region that has experienced recurring major flood events in the recent past. Some parts of Kampong Chhnang and Kampong Speu are prone to flash floods.[15] The maximum flood extent in 2000[16] by the Mekong River flood and the maximum flash flood extent in 2011 and 2013 are shown in Figure 2. As seen in the figure, the proposed project site was out of the flood boundary during these events. The project area communes report heavy precipitation and corresponding floods that affected large areas of rice paddy fields in 2015.

[14]EM-DAT | The international disasters database; weblink: https://www.emdat.be/
[15] Hydrological Study for CAM NSPP, March 2018 (draft, Work in Progress)
[16] The year 2000 is considered as the worst flood in the recent history of Cambodia


Flood Depth Map 2000
Banteay Meanchey
Preah Vihear
Stung Treng
Ratanak Kiri
Siemreap
Battambang
Kampong Thom
Kratie
Mondul Kiri
Pursat
Kampong Chhnang
Provisional Substation Location
Kampong Cham
Tboung Khmum
Koh Kong
Kampong Speu
Phnom Penh
Prey Veng
Kandal
Svay Rieng
Takeo
Kampot
Kep
Vietnam
1:1,250,000
Sources: Esri, USGS, NOAA
Thailand
Lao
View Area
Cambodia
Phnom Penh
Gulf of Thailand
Legend
Water Line
Proposed Solar Park Location
International Boundary
Provincial Boundary
Gulf of Thailand
Permanent Water Body
Flood Depth (m)
< 1m
1m - 2m
2m - 3m
3m - 4m
4m - 5m
5m - 6m
6m - 7m
7m - 8m
8m - 9m
> 9m
Data Source:
Admin data and Water Body: ODC, 2017
Water Line: JICA, 2003
Flood depth 2000: MRC
Coordinate System:
Projection: UTM
Zone: 48
Datum: WGS84

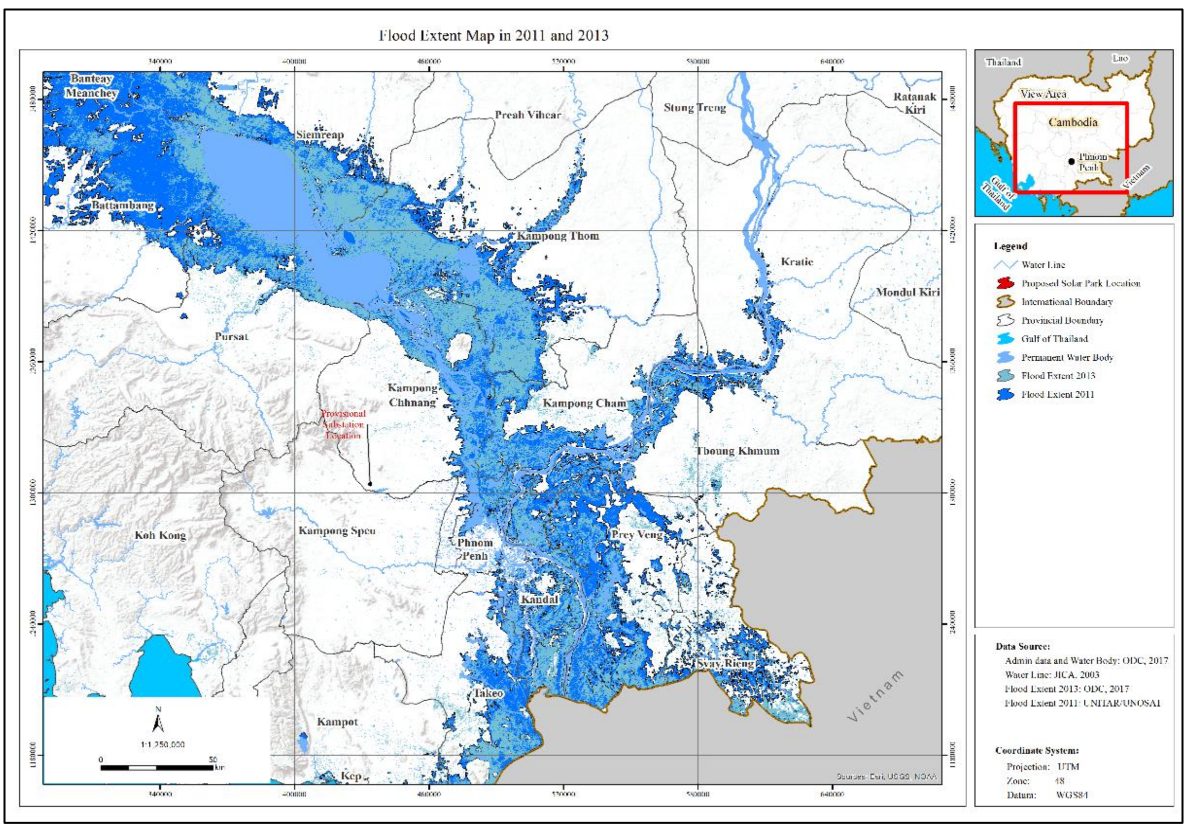

Flood Extent Map in 2011 and 2013
Banteay Meanchey
Preah Vihear
Stung Treng
Ratanak Kiri
Siemreap
Battambang
Kampong Thom
Kratie
Mondul Kiri
Pursat
Kampong Chhnang
Provisional Substation Location
Kampong Cham
Tboung Khmum
Koh Kong
Kampong Speu
Phnom Penh
Prey Veng
Kandal
Svay Rieng
Takeo
Kampot
Kep
Vietnam
1:1,250,000
Sources: Esri, USGS, NOAA
Thailand
Lao
View Area
Cambodia
Phnom Penh
Gulf of Thailand
Legend
Water Line
Proposed Solar Park Location
International Boundary
Provincial Boundary
Gulf of Thailand
Permanent Water Body
Flood Extent 2013
Flood Extent 2011
Data Source:
Admin data and Water Body: ODC, 2017
Water Line: JICA, 2003
Flood Extent 2013: ODC, 2017
Flood Extent 2011: UNITAR/UNOSAT
Coordinate System:
Projection: UTM
Zone: 48
Datum: WGS84

Figure 2

(v) Historical and Projected Changes in Water Availability:

Observed Trends:

Coupled with poor management of water resources including availability, accessibility and quality (of existing water resources) and delays or early ending of the monsoon rains as well as erratic rainfall have contributed to water stress and drought events in Cambodia.[17] For example Svay Reing province is considered one of the most drought prone provinces in the country.

In recent years, a succession of droughts has resulted in significant loss of life and economic loss.[18]

Disaster type	Period	Events count	Year of occurrence
Drought	1986- 2000	2	1987, 1994
	2001-2016	4	2002, 2012, 2015, 2016

As per the National Committee for Disaster Management (NCDM), in 2016 eighteen of Cambodia's twenty-four provinces were affected by drought including Kampong Chhnang province. The drought affected 2.5 million people in 625,000 households. Consultations held with the villagers in project-affected communes suggest no episodes of heavy rains or floods in last 10 years. On the other hand, the project area communes report droughts as recurring phenomena during the dry season including one episode during January 2002 considered as the worst in two decades by the NCDM; this lasted until the onset of rains in mid-August.

Projected Changes in Water Availability:

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 water availability. Seasonal availability of water may also change whereby there may be a shift in the timing of its availability.

(vi) Historical and Projected Changes in Sea Level Rise

The project is located inland and will not be affected by sea level rise.

(vii) Historical and Projected Changes in Solar Radiation

Observed Trends:

Cambodia enjoys some of the highest solar resources in the region, with solar irradiance measuring 1400-1800 kWh/m² per year throughout the country. In the middle of Cambodia, including the load center of Phnom Penh, which is responsible for approximately 70% of national demand, the peak solar resource measures over 1900 kWh/m² per year.

[17] Water stress and drought are different phenomena although they are liable to aggravate the impacts of each other. In some regions, the severity and frequency of droughts can lead to water stress while overexploitation of available water resources can exacerbate the consequences of droughts.

[18] EM-DAT | The international disasters database, web-link: https://www.emdat.be/

Projected Change in Solar Radiation:
Future projections of regional ‘dimming” or ‘brightening are difficult to predict; this is due largely to the large uncertainty surrounding cloud formation under climate change conditions. However, changes in solar radiation will affect the solar power potential.

III. CLIMATE CHANGE RISK AND VULNERABILITY ANALYSIS

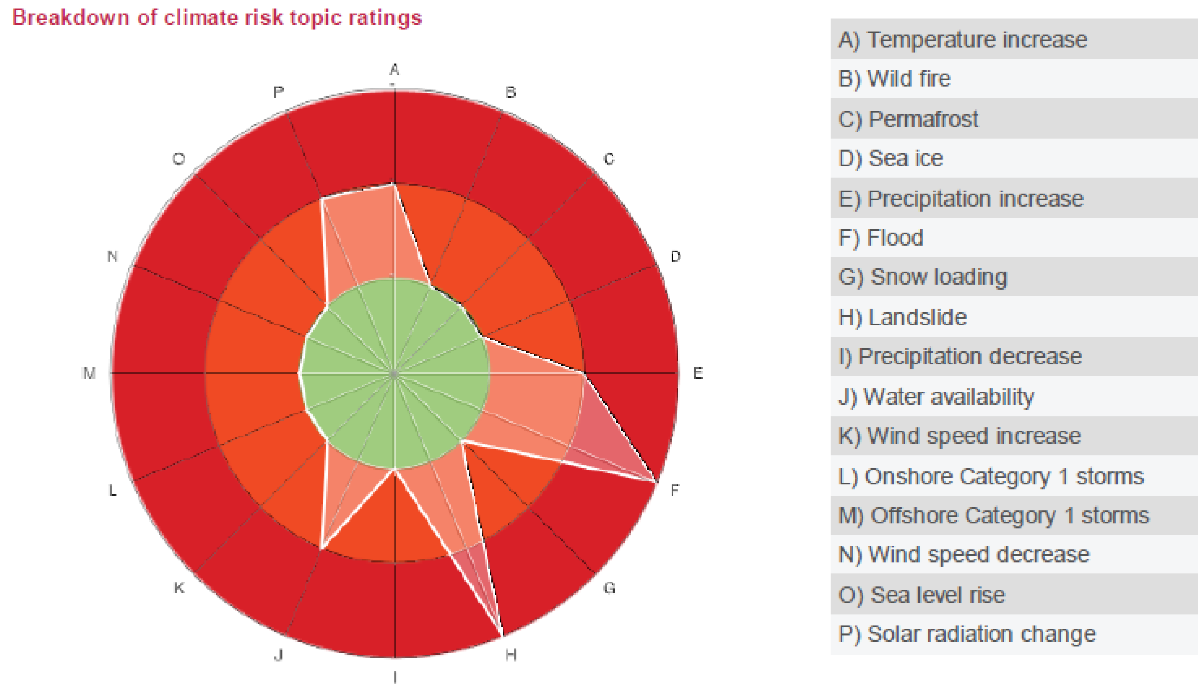
(i) Climate Change Risk Classification as per AWARE

The project has been screened for climate change risks using the AWARE climate risk-screening tool[19] and indicate that the project is located in a region:

- which has experienced recurring major flood events in the recent past
- which may be at risk from precipitation induced landslide events
- which may experience potential increase in incidences of precipitation
- which may experience potential increase in temperature
- which may experience future water stress
- which may experience a change in solar radiation affecting solar power potential

The project region is at low risk for geological hazards such as earthquake, seismic landslide, volcano and tsunami as well as potential decrease in incidences of precipitation. Therefore, these were not further elaborated for the purpose of this assessment. The AWARE report is included in Appendix 1.

[19] The screening is based on the Aware^{TM} 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.



The overall climate change risk classification for the project is Medium. The description of the risks and risk classification for each risk topic (identified by AWARE) are presented below.

S. No	Risk Topic	Description of the Risks	Risk Classification
(i)	Changes in Temperature	Cambodia can expect a projected increase in temperature over longer periods. Heatwaves put stress on infrastructure and buildings. This is not anticipated to be significant over the design life of the solar park (25 years)	Medium
(ii)	Changes in Precipitation	Climate model projections show that annual average precipitation will increase in the project location, most likely during the wet season. This indicates a relatively low degree of uncertainty that precipitation will increase in the region. This may affect the design and operation of the project.	Medium
(iii)	Precipitation triggered Landslide Events	The project is located in a region that is at risk from precipitation induced landslide events. The project site is not located in the area prone to landslides as shown in Figure 1.	High

(iv)	Risk of Flood Events	The project is located in a region that has experienced recurring major flood events in the recent past. Climate change is projected to influence the frequency and intensity of flood events. This may affect the design, construction, operation and maintenance of the project.	High
(v)	Water availability	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 water availability. Seasonal availability of water may also change whereby there may be a shift in the timing of its availability. This may affect the operation and maintenance of the project e.g. for vegetation maintenance, PV panel cleaning, and sanitation.	Medium
(vi)	Changes in sea level	The project is located inland and will not be affected by changes in sea level	-
(vii)	Changes in solar radiation	Future projections of regional ‘dimming” or ‘brightening are difficult to predict; this is due largely to the large uncertainty surrounding cloud formation under climate change conditions. This is not anticipated to be significant over the design life of the solar park (25 years)	Medium

Energy projects are sensitive to projected climate changes such as increases in temperature and precipitation, extreme events such as floods and landslides, stronger / frequent storms and changes in cloud cover (affecting solar radiation). Considering that the lifespan of the solar park is 25+ years, the project investments are not anticipated to be significantly affected by projected climate change impacts.

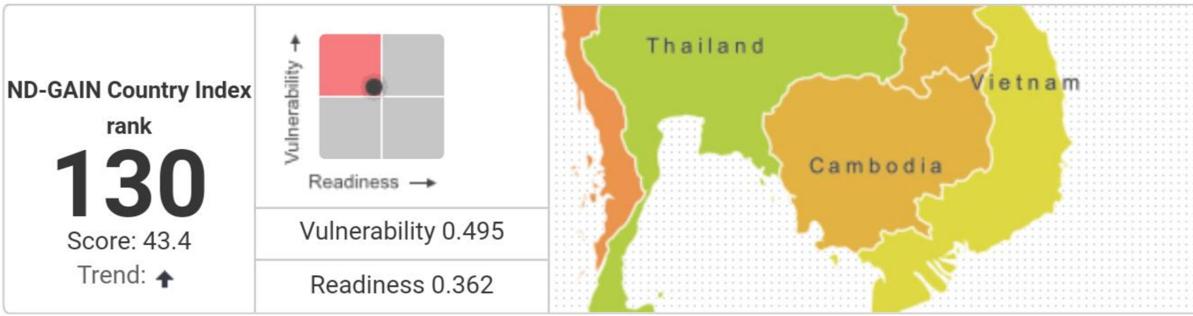
Description of Output	**Activities Sensitive to Climate / Weather Conditions**

Project Output 1	The project components under output 1 are sensitive to increase in precipitation, flood events and water availability as follows: - The project siting, design and construction of the solar park, Solar PV plants and transmission tower footings are sensitive to increases in precipitation and flood events - Operation and maintenance of the solar park and Solar PV Plants are sensitive to changes in water availability (for example water used for landscaping at the solar park and hedge maintenance along the fenced perimeter and for PV panel cleaning) - Water retention pond / drainage canals are sensitive to increases in precipitation, sedimentation load and floods - Access / approach roads and commune tracks are sensitive to increase precipitation and floods
Project Output 2	These activities do not involve construction of physical infrastructure/ assets on the ground. Hence it is not sensitive to climate risk.

(iii) Vulnerability Assessment (Sensitivity, Exposure and Adaptive Capacity)

The Notre Dame Global Adaptation Initiative (ND-GAIN) Country Index, a project of the University of Notre Dame summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead.

The high vulnerability score and low readiness score of Cambodia places it in the upper-left quadrant of the ND-GAIN Matrix. It has both a great need for investment and innovations to improve readiness and a great urgency for action. Cambodia is the 51st most vulnerable country and the 56th least ready country.



The Government recognizes Cambodia as one of the most climate vulnerable countries in the world[20]. As a least developed, agrarian country, Cambodia's vulnerability to climate change is mainly due to its geography, high reliance on the agriculture sector and low adaptive capacity including limited financial, technical and human resources.

(iv) Impact assessment (key impacts on the sector and project) and corresponding Adaptation responses

Impact on Sector:

While the exposure and vulnerability to climate will depend upon the nature and type of infrastructure as well as its location, the power sector is one whose output and efficiency are highly dependent on climate conditions. Projected changes in these conditions are expected to impact the sector significantly. The energy sector is vulnerable to projected changes in mean climate conditions such as temperature and precipitation. Climate variability is expected to increase in a warmer climate; and in the frequency and intensity of weather events such as floods and droughts; and changes in sea level.

The project is located inland therefore it will not be impacted by changes in sea level.

Impact on Project Output 1:

Climate Change Factors	Risk Level as per AWARE	Impact
• More frequent and/or Intense extreme weather Events ○ Recurring flood events ○ Precipitation induced landslides	High	• Increased risk of direct flood damage to solar PV plants, substation, drainage canals, access roads and transmission line tower structures • Increased risk of accelerated surface run-off, soil erosion and sedimentation load at site affecting land and drainage • Access / approach roads could be damaged or washed out or segments

[20]RGC Second National Communication to the UNFCCC, Ministry of Environment (MOE), 13 January 2016

		could be eroded. • Affected life span of solar park infrastructure
• Increase in temperature • Increase in precipitation • Change in solar radiation • Change in water availability	Medium	• Increased operating challenges to solar PV Plants such as lower cell efficiency and energy output • Heat waves stress on roads, buildings and other infrastructure • Reduced electricity carrying capacity of transmission lines • Increased losses within the substation and transformers • Increased risk of corrosion of steel infrastructure (lattice towers) with a corresponding increase in humidity • Increased risk of drought episodes and dust damage to solar PV plants • Less water availability for PV panel cleaning and maintenance of vegetation within the solar park

IV. CLIMATE CHANGE RISK MANAGEMENT RESPONSE (Adaptation Measures)

Project Output 1

Key Mitigation Measures

The project will support the upgrade and climate proofing of solar park infrastructure.

The design, operation and maintenance standards for the solar park infrastructure integrate measures to improve flood resilience. Change in temperature and solar radiation are not anticipated to be significant over the design life of the solar park project (+25 years).

The Feasibility Study recommends the following measures to be integrated into detailed design:

- To maximize flood resilience and minimize impacts on local drainage patterns
- Consider highest flood level and suitable slope in project detailed design – site preparation and civil works for the solar park, substation and placement of tower footings for the transmission line; and type of road surface (all weather) and embankment height for access road construction
- Design improved flood protection measures for all equipment mounted at ground level
- Strengthen existing drainage canals at the solar park site
- Design water retention pond for controlled inflow and overflow and use for operation and maintenance (e.g. landscaping, washing of PV panels, etc.)
- Where extreme weather conditions are expected, adopt higher design standard for the transmission line including building a resilient high capacity transmission system
- Avoid the construction of transmission tower footings near irrigation canals / dykes
- Consider solar modules with a higher temperature coefficient
- Consider selection of appropriate tilt panel angle to clean dust
- Consider selection of module surface conducive to self-cleaning

V. Adaptation Finance

Climate adaptation measures that have been integrated in the main civil work contract costs are in the region of US$1.23 million.

VI. Greenhouse Gas (GHG) Emissions Profile (Country and Sector)

A. Historical Trends of Emissions in the country (based on UNFCCC reports)

GHG emissions in Cambodia are currently extremely low compared to regional and global averages. According to the Second National Communication (SNC) under the UNFCCC (dated 13 January 2016), in 2000 Cambodia emitted 47.6 million tonnes of CO2 equivalent but the forestry sector absorbed 48 million tonnes of CO2 equivalent. Taking into account the important role of forestry in carbon capture, Cambodia was still at a net sink in the year 2000. Over the same period, energy consumption by sector was highest in the transport sector, followed by electricity production, residential and the industrial sectors.

B. Projected emissions by 2030 or 2050

As per estimates in draft SNC, Cambodia's Business As Usual (BAU) per capita emissions in 2050 will be 2.59 tonnes CO2 equivalent. This is less than half of current world per capita emission.

C. Sector-related GHG emissions

As per the Second National Communication to the UNFCCC (13 January 2016): Based on the sectoral approach, the total emissions from fuel combustion are the largest contributing source to energy sector emissions (estimated at 2,767.30 GgCO2-eq) in which the emission of CO2 contributes approximately 74% of total emissions, CH4 only contributes approximately 21% and N2O contributes approximately 5% for this category.

VII. GHG Mitigation Response and Reduction Benefit Assessment

No data is available on an increase in GHG emissions by the project. The Project will construct a 100 MW capacity solar park in phases with Phase I as 30 MW Phase II as the remaining capacity – A 30 MW project (Phase I) will avoid at least 44,398 tons of carbon dioxide-equivalent (tCO_2e) annually. When the anticipated100 MW capacity (Phase II) is achieved there will be at least 148,650 tCO_2e annual emission savings or approximately 3.864 million tCO_2e over a 25-year project lifetime.

VIII. Mitigation Finance

Climate mitigation is attributed to the entire project cost of $22.16 million. ADB will finance 28.3% of mitigation costs. Details are in the PAM

Report generated by: Genevieve O'Farrell, Asian Development Bank | Date created: 07.04.2018 05:43

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^{TM} 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:	CAM Solar Power Project
SUB PROJECT:	Site 6
PROJECT NUMBER / REFERENCE:	51182-001
SECTOR:	Energy
SUB SECTOR:	Renewable energy generation - solar
DESCRIPTION:	Site 6

02

Chosen Locations

1) Location 10
2) Location 11
3) Location 12
4) Location 13
5) Location 2
6) Location 2
7) Location 3
8) Location 4
9) Location 5
10) Location 6
11) Location 7
12) Location 8
13) Location 9

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.

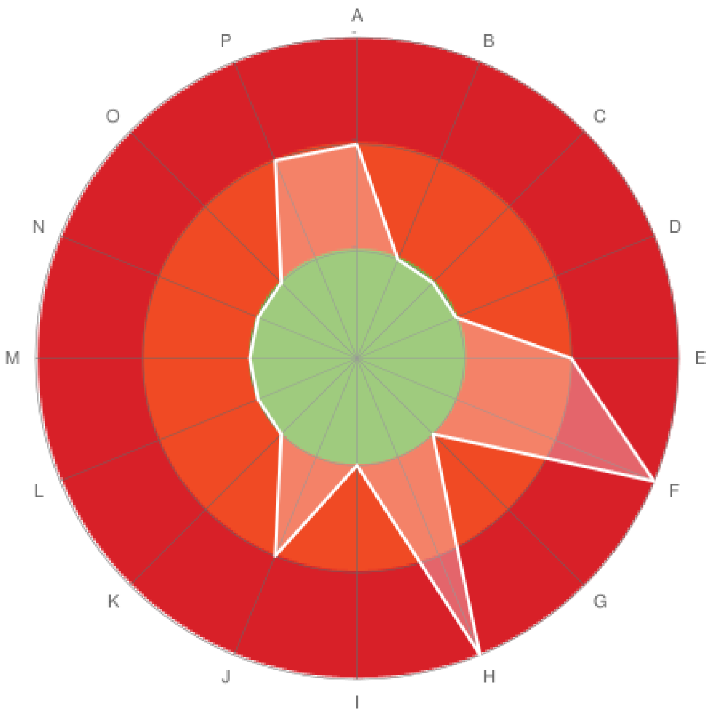
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

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 for the latest news and information relating to floods and climate change.

I have acknowledged the risks highlighted in this section.

05
HIGH
RISK

LANDSLIDE

ACCLIMATISE COMMENTARY

• Our data suggest that the project is located in a region which is at risk from precipitation induced landslide events. A high exposure in Aware means that based on slope, lithology, geology, soil moisture, vegetation cover, precipitation and seismic conditions the area is classed as 'medium' to 'very high' risk from landslides. This is based on post-processed data from UNEP/ GRID-Europe.
• Landslide risk is locally influenced by other factors, for example local slope and vegetation conditions, long term precipitation trends and human actions, such as excavation of slopes, deforestation, mining etc. If landslides are 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 design process if necessary.
• Up to date information on landslide risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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

• If landslides are identified as a potential problem for the project, it is recommended that:
- More localized information is collected on past landslides and highly susceptible areas
- Information is collected on local land use and building regulations, such as landslide zonation ordinances
- The project siting, design and construction features ensure that the structures are stable and will not increase landslide risk

2. 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 landslide risk in regions where the frequency and intensity of precipitation events is projected to increase.
• Existing engineering designs may not take into consideration the impact of climate change on the risk of landslides. Previously affected areas may suffer from more frequent and severe events. 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 landslides?
Q2 Will assets or operations associated with the project be in elevated areas or close to slopes?
Q3 Is there a history of landslides in the local area where the project is proposed?
Q4 Are there any plans to integrate climate change factors into a landslide risk assessment for the project?
Q5 Does the project design and construction features incorporate measures to reduce landslide risk, both in the immediate term and as risk of landslides changes as a consequence of climate change?
Q6 Will the project include local early warning measures?

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 for the latest news and information relating to landslides and climate change.

☐ I have acknowledged the risks highlighted in this section.

06

MEDIUM
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

Yes - a little.

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

ACCLIMATISE COMMENTARY

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

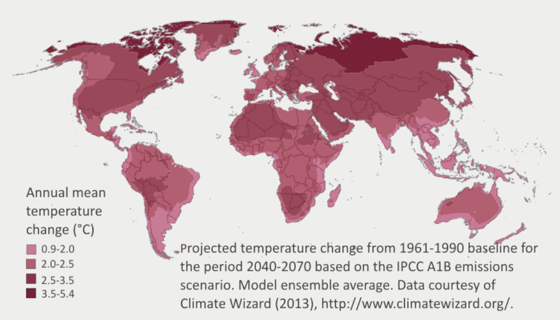
• There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

• The design, operational and maintenance standards should be reviewed - take into consideration current impacts of 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?



Projected temperature change from 1961-1990 baseline for the period 2040-2070 based on the IPCC A1B emissions scenario. Model ensemble average. Data courtesy of Climate Wizard (2013), http://www.climatewizard.org/.

• 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 for the latest news and information relating to temperature and climate change.

I have acknowledged the risks highlighted in this section.

07

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?

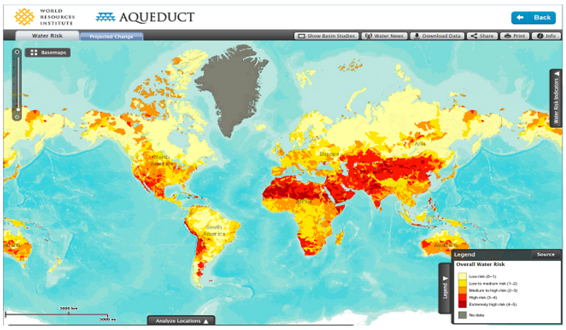
1. See the section "Further reading" in "Help and glossary" at the end of this report which lists a selection of resources that provide further information on a changing climate.
2. Click here for the latest news and information relating to water and climate change.

☐ I have acknowledged the risks highlighted in this section.

08
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?

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 for the latest news and information relating to water and climate change.

☐ I have acknowledged the risks highlighted in this section.

09

MEDIUM RISK

SOLAR RADIATION CHANGE

Would a change in solar radiation 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 changes in solar radiation.

ACCLIMATISE COMMENTARY

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

• There is a potential for incidences where current design standards will not be sufficient or met. 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 fluctuating solar radiation as well as potential future changes.

2. How could changes in solar radiation affect the project even without future climate change?

Medium (yearly, seasonal) or longer term variations in solar radiation at the Earth's surface can affect for example:
• Agricultural yields. Rates of photosynthesis (and therefore growing season) are proportional to the surface solar radiation.
• Solar power potential.
• The rate of degeneration of building materials.

3. What does the science say could happen in the future?

• Future projections of regional 'dimming' or 'brightening' are difficult to predict. This is due largely to the large uncertainty surrounding cloud formation under climate change conditions.
• Given future uncertainty it is advisable to carefully assess past levels of solar radiation in the region, bearing in mind that it could change in the future. The UNEP Solar and Wind Energy Resource Assessment SWERA provides a useful global overview of solar radiation information.

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 for the latest news and information relating to water and climate change.

☐ I have acknowledged the risks highlighted in this section.

10
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 could become more concentrated.
• Increased risk of drought conditions could lead to accelerated land degradation, expanding desertification and more dust 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 for the latest news and information relating to water and climate change.

☐ I have acknowledged the risks highlighted in this section.

11

The sections above will provide details on all high and medium climate hazard risks from Aware^{TM} 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.

12

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.

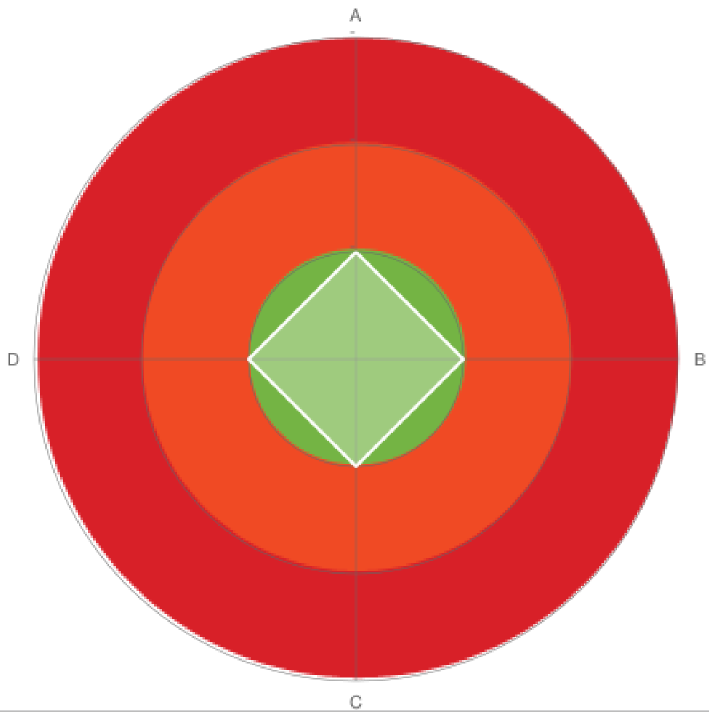
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

13

The sections above will provide details on all high geological hazard risks from Aware^{TM} 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:

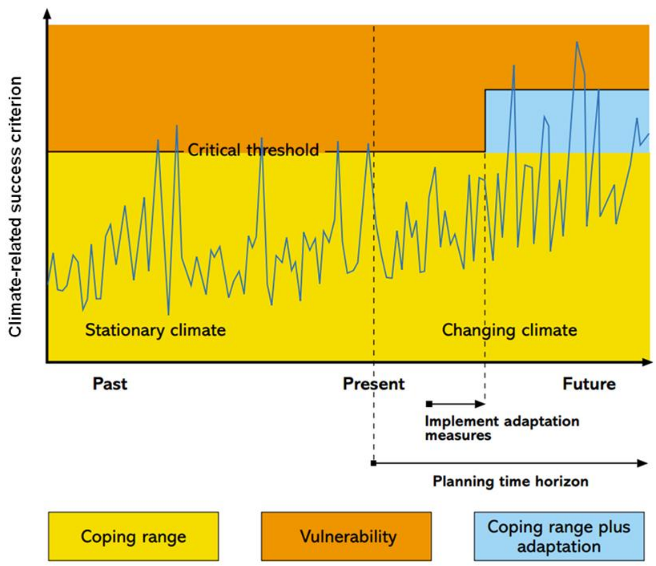
Although climate models are constantly being improved, they are not good enough to predict future climate conditions with a degree of confidence which would allow precise adaptation decisions to be made. Outputs from different climate models often differ, presenting a range of possible climate futures 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.

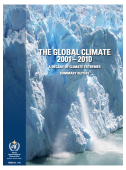
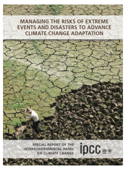
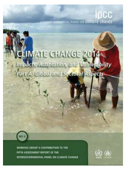
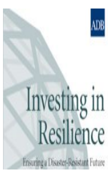
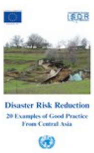


The relationship between a critical threshold and a climate change related success criterion for a project. [Source: Willows, R.I. and Connell, R.K. (Eds.) (2003). *Climate adaptation: Risk, uncertainty and decision-making*. UKCIP Technical Report, UKCIP, Oxford].

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.
	DesInventar Project's historical disaster impact catalogues: DesInventar.

	National progress reports to UNISDR on DRM commitments: HFA National Progress Reports.
	National documents DRM policy and strategy documents and studies: Disaster risk reduction in the world.
	National-level factsheets based on the Global Assessment Report: Country Profiles.
	GEM NEXUS Building and population inventory : GED4GEM database.
	GAR analysis tool of exposure including population, capital stock and economic indicators: Risk Data Platform CAPRAViewer.

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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