Climate Change Assessment

Project Number: 41076-048
November 2017

PHI: Improving Growth Corridors in Mindanao Road Sector Project

Asian Development Bank

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I. INTRODUCTION

A. Objectives from the Input

1. The Climate Change Specialist undertook an assessment of the vulnerability to climate change of the roads being studied under the Improving the National Roads for Inclusive Growth in Mindanao Project. This involved initial climate change risk screening, impact and vulnerability assessments and the preparation of an adaptation plan to increase climate resilience in the design of the project roads.

B. Background

2. The Government of the Philippines has instigated over the years the following mechanisms to respond to the challenges of climate change:

- In 1991 the establishment of the Inter-Agency Committee on Climate
- In 2007 the creation of the Presidential Task Force on Climate Change
- In 2009 to strengthen the support for better climate governance the Climate Change Act (RA 9729) was passed which included the establishment of the Climate Change Commission
- The Act was supported in 2010 by the development of the National Framework Strategy on Climate Change for the period 2010 - 2022 and the National Climate Change Action Plan issued in 2011
- In 2010 the Disaster Risk Reduction and Management Act (RA 10121) was passed which integrated climate change adaptation and disaster risk management. Most importantly it included funds for disaster risk management, also covering climate change adaptation initiatives and civil society's participation in disaster risk reduction and management activities.

3. Resulting from RA 10121 all municipalities now have the responsibility to prepare a Disaster Risk Reduction and Management Plan up to the year 2028, which includes analysis of climate change impacts and adaptation planning. However the current Region IX Development Plan reports that only 70% of the municipalities have so far complied with this request[1]

4. Moreover, giving priority to the mainstreaming of Disaster Risk Reduction and Climate Change Adaptation into the Provincial Development and Physical Framework Plans covering the period 2010-2020 encourages institutional capacity to adapt to the projected climate changes and related hazards.

5. Within DPWH Central Office the Environment and Social Safeguards Division has one member of staff specifically tasked with the responsibility for dealing with climate change issues. At the Regional level the one Environmental Specialist in post covers climate change matters amongst all other duties.

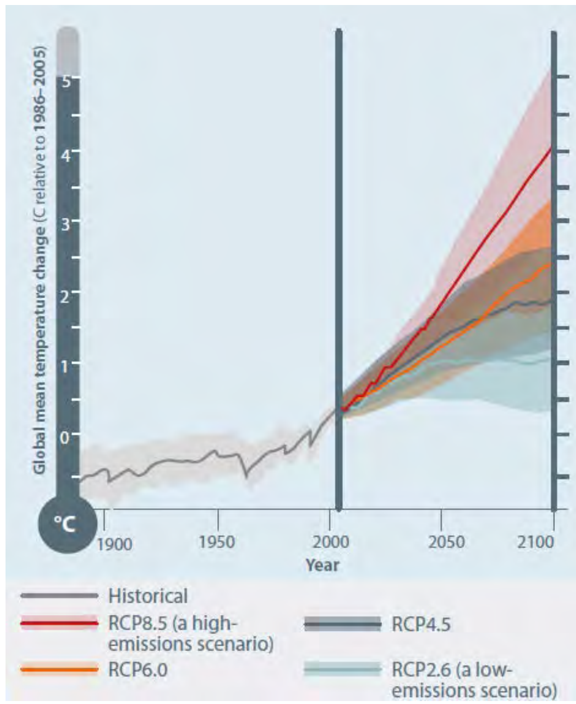
[1] Regional Development Council Region IX, 2014: Zamboanga Peninsular Regional Development Plan 2014-2016.

II. CLIMATE CHANGE THREATS IN REGION IX

A. Modelling Climate Change Projections

Climate change impacts are derived using General Circulation Model outputs (GCMs) to project future changes in climate. These are complex, physically based models that incorporate cutting-edge understanding of the climate system and key physical processes. Future scenarios of greenhouse gases are used as an input to these models to explore how differing global concentrations of greenhouse gases are likely to affect important climatic variables such as temperature and precipitation.

Figure FII.1: Projected Climate Change Impacts



In assessing future climate change, the Fifth Assessment Report presents four scenarios, known as Representative Concentration Pathways (RCP)[2]. See Figure F2.1. The scenarios represent the impacts of different levels of emissions of greenhouse gases on global warming, from the present day up to 2100. However the Intergovernmental Panel on Climate Change (IPCC) does not indicate which policy and behavioural choices society could make that would lead to these scenarios.

In all scenarios, carbon dioxide concentrations are higher in 2100 than they are today. The low-emissions scenario (RCP2.6) assumes substantial and sustained reductions in greenhouse gas emissions. The high-emissions scenario (RCP8.5) assumes continued high rates of emissions. The two intermediate scenarios (RCPs 4.5 and 6.0) assume some stabilisation in emissions.

There are a large number of different climate models that have subtle differences in how they are formulated and different models give different results. The models agree that increases in greenhouse gases will result in increases in temperatures. However, the specific amount of warming expected for an equivalent increase in greenhouse gases varies between models. For precipitation though, there is greater disparity among models and therefore greater uncertainty in future projections. In order to give a best estimate averages across different models are usually taken to derive an estimate across the ranges of changes projected by the different models.

Downscaling of GCMs to generate projected local climate scenarios introduces further uncertainties depending on the strength of the databases used and computing power available to run the models. Awareness of these risks in generating climate change projections has to be taken into account.

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[2] Intergovernmental Panel on Climate Change (IPCC). 2014. *Climate Change Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects for Asia*. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

B. IPCC Assessment Reporting

The recent Fifth Assessment Report (AR5)[3] by the Intergovernmental Panel on Climate Change (IPCC) builds on and updates the work published in their Fourth Assessment Report in 2007. It reports globally on the assessments developed for climate-change impacts, adaptation, and vulnerability based on the recent modelling projections..

Their Asian region report summarizes the climate change impacts as follows[4]:

- Warming trends and increasing temperature extremes have been observed across most of the Asian region over the past century.
- Increasing numbers of warm days and decreasing numbers of cold days have been observed, with the warming trend continuing into the new millennium.
- Precipitation trends including extremes are characterized by strong variability, with both increasing and decreasing trends observed in different parts and seasons of Asia.
- Coastal and marine systems in Asia are under increasing stress from both climatic and non-climatic drivers.
- It is likely that mean sea level rise will contribute to upward trends in extreme coastal high water levels and increased rates of coastal erosion.
- Records show that the global mean sea level has been rising over the period 1993 to 2010 at approximately 3.2mm/yr
- Mangroves, salt marshes, and seagrass beds may decline unless they can move inland, while coastal freshwater swamps and marshes will be vulnerable to saltwater intrusion with rising sea levels.
- Widespread damage to coral reefs correlated with episodes of high sea surface temperature has been reported in recent decades and there is high confidence that damage to reefs will increase during the 21st century as a result of both warming and ocean acidification.

To avoid the impending threats from climate change, IPCC have stressed that mitigation measures remain the first priority in order to slow down the build-up of atmospheric greenhouse gas concentrations[5]. These include:

- more efficient use of energy
- greater use of low and no-carbon energy
- improved carbon sinks
- life style and behavioural changes

However the implementation of adaptation measures is also essential to build up resilience in infrastructure systems. The IPCC underlines the critical importance of linking adaptation with broader development objectives. Infrastructure investment represents a large portion of government and international donor resources dedicated to reducing poverty and stimulating

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3 IPCC. 2014. Summary for policymakers. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectorial Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

4 IPCC. 2014: Climate Change Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects for Asia. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change

5 IPCC. 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.

growth in developing countries. Infrastructure expands access to basic services and creates new economic opportunities, for example, through increased trade following new transport routes that connect municipalities and cities.

In the Philippines there is long experience in adapting to extremes and much of what has worked well can form the basis of good practice guidance within the roads sector. For example, bioengineering approaches and community management to be promoted in ways which provide lessons for building more resilient infrastructure.

C. Climate Projections for Region IX

The only current available data on climate change projections for the Philippines[6] is the results from the PRECIS model run in 2010 by PAGASA[7]. Downscaling to a grid resolution of 25km x 25km allowed detailed Regional profiles to be prepared for each region. Climate data over the period 1971-2000 was used as the baseline data and formed the control run to establish the model's bias.

Three future greenhouse gas emission scenarios were used, based on the outputs from the fourth Assessment Report by IPCC[8]

- A1 High Range: -due to continuously increasing population. CO_2 emissions high
- A1B Medium range: -population peaks mid-century. CO_2 emissions lower
- B2 Low range: -population rate only slowly increases. CO_2 emissions stabilized

The boundary conditions needed to produce these local climate change projections were based on outputs from the following GCMs:

- **For the high and low range scenarios the ECHAM4 ocean-atmosphere general circulation model was used**

- **For the middle range scenario the HadCM3Q0 version 3 model was used**

In the climate simulations two time slices were used centered on 2020 (for the period 2006-2035) and 2050 (2036-2065).The 2020 and 2050 outputs were mathematically corrected to account for any observed model bias.

The outputs from the climate model relating to seasonal temperature and rainfall change and frequency of extreme events for the medium range emission scenario within Region IX, are given in Table 2.1 below:

[6] The World Bank Philippine Climate Change Adaptation Project is presently using the CECAN model to prepare downscaled regional projections based on a 8km x 8km grid using baseline data from 1980 to 2010.
[7] PAGASA, February 2011: Climate Change in the Philippines
[8] IPCC, 2000: Summary for Policy Makers. Emissions Scenarios. A Special Report of Working Group III for the Intergovernmental Panel on Climate Change

Table FII.1: Climate Change Projections for Region IX

PROVINCE	Baseline (1971-2000)				Change 2020 (2006-2035)				Change 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
SEASONAL TEMPERATURE INCREASES (in ^{O}C)												
Zamboanga Del Norte	27.0	27.9	27.6	27.5	1.0	1.1	1.1	1.0	2.0	2.1	2.2	2.0
Zamboanga Del Sur	26.8	27.8	27.3	27.2	0.9	1.1	1.0	1.0	1.9	2.1	2.0	1.9
Zamboanga Sibugay	27.1	27.9	27.5	27.5	1.0	1.0	1.0	1.0	2.0	2.0	1.9	2.0
SEASONAL RAINFALL CHANGE (in %)												
Zamboanga Del Norte	324.5	279.7	599.1	718.1	11.0	3.2	-3.2	13.8	2.6	1.7	-0.7	5.4
Zamboanga Del Sur	294.5	298.7	593.8	663.2	11.2	2.2	-0.4	13.8	3.6	0.0	9.9	7.1
Zamboanga Sibugay	284.1	290.5	597.2	674.1	9.9	6.6	6.5	14.8	4.8	10.3	22.0	8.9

FREQUENCY OF EXTREME EVENTS

PROVINCE	STATION	No of Days Maximum Temperature >35^{O}C			No of Dry Days			No of Days with Rainfall >300mm		
		OBS	2020	2050	OBS	2020	2050	OBS	2020	2050
Zamboanga Del Norte	Dipolog	217	2155	4004	7481	5384	5470	0	5	2
Zamboanga Del Sur	Zamboanga	54	114	714	8531	7058	6781	0	1	4

PROVINCE	Baseline (1971-2000)				Change 2020 (2006-2035)				Change 2050 (2036-2065)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON

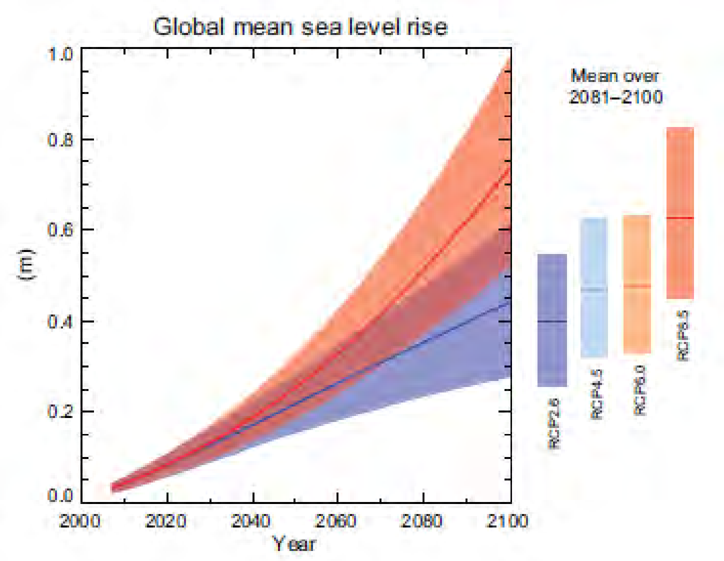
Summarizing the above climate modelling projections it is expected that when considering the medium range emissions scenario by 2050:

- Annual mean temperatures will have risen by some 2.0^{O}C
- The number of days the maximum temperature will exceed 35^{O}C will increase in Dipolog from some 7 days per year at present to 133 days per year whilst for Zamboanga corresponding increases will be from some 2 days per year to 24 days
- Average seasonal rainfall will increase in Zamboanga Sibugay by some 22% during the south west monsoon but in Zamboanga Del Sur by only some 10%, whilst in Zamboanga Del Norte there is projected to be no increase
- The number of dry days will decrease in Dipolog by some 27% whilst in Zamboanga the corresponding decrease will be some 21%
- The number of days with rainfall greater than 300mm/day will increase in Dipolog from none to 2 days whilst in Zamboanga the corresponding increase will be some 4 days

Also relevant to those roads studied, that are adjacent to the coasts, is the projected rise in sea levels. Greenhouse gas emission scenarios presented in the IPCC AR5 Technical Working Group

1 report9 indicated that the range of future sea level rises could be considerable depending upon the RCP taken as shown in Figure 2.2. The median value for the low emission scenario range (RCP2.6) being 40cm whilst for the high emission scenario range (RCP8.5) it is 63cm. In the models used estimated thermal expansion due to warming of the oceans made up to 55% of this sea level rise whilst up to 35 % was attributed to glacier melt10. The remainder being due to the projected retreating of the Greenland and Antarctic ice sheets and reduced land water storage.

Figure FII.2: Climate Change Projections for Region IX



As there is still some lack of consensus in the scientific community on the future trends in the reductions of these ice sheets there is only medium confidence in its contribution to the overall sea level rise. However bearing the above factors in mind it is considered prudent for the risk assessment in this road study for Region IX to take the upper projection for the RCP8.5 scenario giving a maximum sea level rise of 82cm by 2100.

[9] IPCC, 2013: Working Group 1 Report: The Physical Science Basis. Summary for Policy Makers. Fig. SPM 9. Projections of Mean Sea Level Rise over the 21st Century Relative to 1986-2005

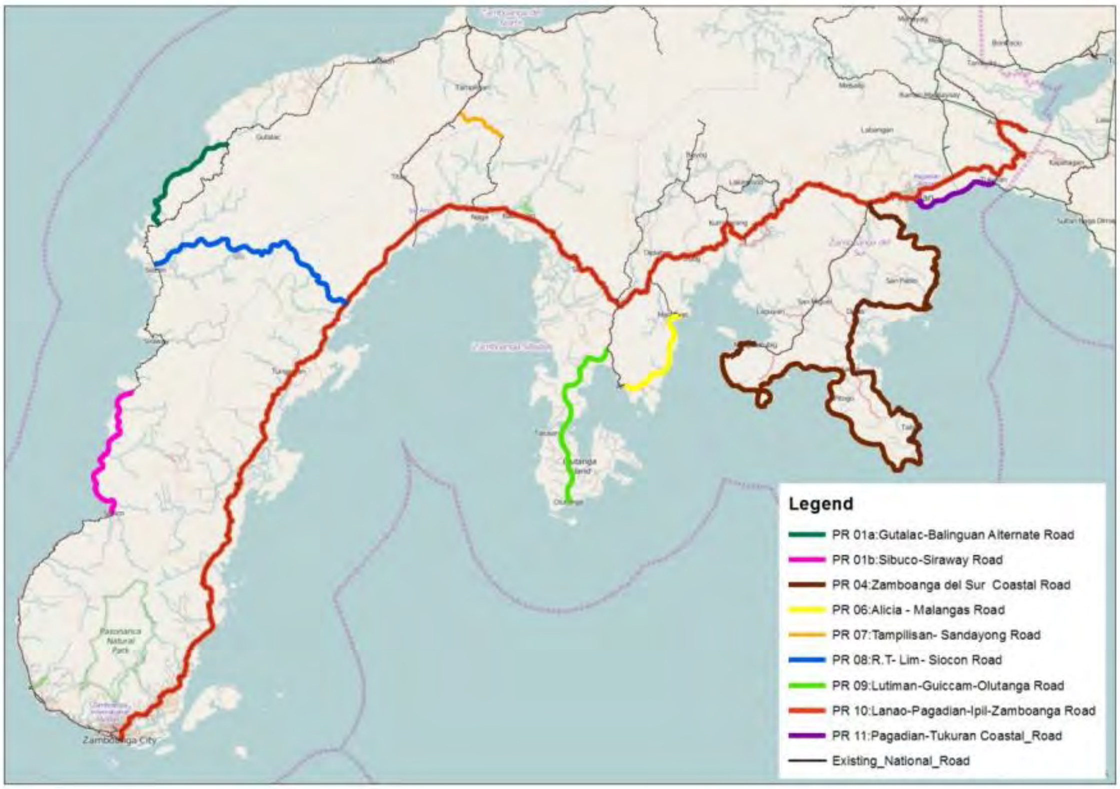
[10] IPCC, 2013: Working Group 1 Technical Summary. Long Term Projections of Sea Level Change

III. CLIMATE RISK SCREENING

A. Project Roads

The project roads being studied are shown in Figure F3.1 and the salient details of the proposed works along each road have been set out in the main Draft Final Report document.

Figure FIII.1: Project Roads



B. Preliminary Climate Risk Screening

Each Project road was subjected to a preliminary risk screening to determine the risk level on the proposed works as a result of the climate change projections identified earlier in Section 2.3. Field visits were made to PR 11, 04 and parts of 10 to assist in this screening exercise. Due to time constraints and security issues the other roads were not visited but relevant information was collected from secondary sources and the road alignments visited using Google Earth imagery.

The results of the preliminary risk screening are presented in Table F3.1 and the data sheets compiled for each road placed in Annex A.

Table FIII.1: Preliminary Risk Screening Scores

Road	Risk Score	Climate Risk Level
PR 01a	4	Medium
PR 01b	4	Medium
PR 04	5	High
PR 06	3	Medium
PR 07	4	Medium
PR 08	5	High
PR 09	5	High
PR 10	5	High
PR 11	6	High

C. Climate Risk Assessment

All roads with either a high or medium risk to climate change were then screened further using the ADB AWARE programme. The outputs from this programme ranked the risks for the different climate change hazards and presented advice for the next steps to be followed.

The AWARE programme outputs are presented in Annex B. A summary of the breakdown of the risk ratings are given in Table F3.2.

The AWARE programme downgraded the risk level from the preliminary screening exercise to medium for all roads except PR09 (the Lutiman to Olutanga road) and PR11 (the Pagadian to Tukuran Coastal road).

However a qualification needed to be made in the overall high risk conclusion for PR11. A high risk rating for landslides was given when site inspections of this road alignment indicated no such potential threat as the alignment is along the flat coastal plain.

Table FIII.2: Climate Risk Assessment Summary from the AWARE Programme

Road	Output of the individual risk levels affecting the road						Overall climate risk level
	Flood	**Landslide**	**Sea level rise**	**Temperature rise**	**Increasing precipitation**	**Increased wind**	
PR 01A	N/A	High	N/A	Medium	Medium	N/A	Medium
PR 01B	High	High	N/A	Medium	Medium	N/A	Medium
PR 04	High	High	N/A	Medium	Medium	N/A	Medium
PR 06	High	High	N/A	Medium	Medium	N/A	Medium
PR 07	High	High	N/A	Medium	Medium	N/A	Medium
PR 08	N/A	High	N/A	Medium	Medium	N/A	Medium
PR 09	High	High	High	Medium	Medium	Medium	High
PR 10	High	High	N/A	Medium	Medium	N/A	Medium
PR 11	High	High(n/a)[11]	High	Medium	Medium	Medium	High

To study in more depth the climate risks, vulnerability assessments were undertaken and adaptation options proposed for the two high risk roads (PR 09 and11) as well as PR 04, 08, and 10 which were taken as representative of the medium risk roads.

[11] This risk was downgraded to not applicable as the proposed road alignment is to be along the flat coastal plain

IV. VULNERABILITY ASSESSMENT

The vulnerability assessment is a function of the road asset's exposure to climate change effects, its sensitivity to climate effects, and its adaptive capacity to deal with these impacts.

A. Exposure to Climate Threats

The exposure of the assets to climate threat focuses on its nature and extent and how it could affect the asset. These threats are summarized as follows:

- temperature increasing in magnitude throughout the year and how it could affect pavement integrity and thermal expansion of bridges
- rainfall amounts increasing and the likelihood of more frequent flooding of low-lying infrastructure, damage to roads, and drainage infrastructure capacities being exceeded
- rainfall intensities increasing and the likelihood of increased flash floods damaging roads, bridges and support structures and generating landslide events
- wind speeds increasing associated with more severe storm events affecting road infrastructure and exposed bridge loading and road transport movements
- sea level rise together with storm surges inundating coastal road embankments and damaging culverts and bridges.

B. Sensitivity to the Climate Threat

The sensitivity focuses on the degree to which the road asset could be affected by, or responsive to the climate change exposure.
Factors considered are:

- the choice of road alignment or bridge relocation where new or upgraded roads are being considered
- the integrity or operation of the road asset looking at its design effectiveness, the materials used, construction quality, and the levels of maintenance and protective systems included
- the level of disruption and the length of time it could take to return to normal traffic flow conditions.

C. Impact of the Climate Threat

The product of exposure and sensitivity provides a measure of the potential impact of the climate threat to the toad infrastructure. A simple matrix system is used to rate it from very low to very high. The impacts can be assessed as either direct, such as a landslide blocking a road, or indirect such as roadside debris blocking cross drains and resulting in the road being flooded.

D. Adaptive Capacity to Deal with the Climate Threat

The adaptive capacity of the road asset to prepare for and respond to the climate change impacts is assessed through considering

- the policies, regulations and institutional capacity to address the threats from climate change,
- technical and financial resources available within the organizations directly responsible for the asset's management.
- manpower and machinery availability for regular maintenance of the road asset

E. Vulnerability Assessment

The final vulnerability assessment is determined by considering together the impact and adaptation capacity using a simple vulnerability scoring matrix to rank the assets from very low to very high. The scoring matrices used are presented in Annex D.

F. Threats and Impacts on Road Infrastructure

Table F4.1 summarizes the key climate change threats and their impacts on the five selected project roads taken from the vulnerability assessments presented in Annex C. These threat and impacts could be considered fairly representative for the other four project roads within Region IX that were not studied due to security issues.

Table FIV.1: Key Climate Change Threats and Associated Impacts on Roads

CLIMATE THREAT	PROJECT ROAD				
	PR 04	PR 08	PR 09	PR 10	PR 11
Increased Temperature Rise	The present mean temperature experienced throughout Region IX is 27^{O}C The mean average seasonal temperature by 2050 is projected to rise by a further 2^{O}C. This is not anticipated to have any significant adverse effects on any of the existing project road pavements or those to be upgraded as concreting of the road surfaces is proposed. Steel bridges could experience some small additional thermal expansion. However those existing steel bridges present along the proposed project roads have insufficient loading capacity and it is proposed will be replaced with concrete bridge structures. These will incorporate suitable expansion joints and support bearings to allow for thermal movement. It is not anticipated that the projected increased temperatures will have significant adverse impacts on the project roads and only a medium vulnerability has been recorded for all roads				
Increased Precipitation and Associated Flooding	Project roads in Region IX are classified as experiencing both Type III and IV climates. The significance being that Type III has a more pronounced dry period between November to April and occurs in the more westerly sections of the peninsular. Based on 30 years of data to 2000 the average rainfall throughout the Region is some 1872mm. Projected increases in mean seasonal rainfall by 2050 are 5%, 10%, and 22% for the provinces of Zamboanga Del Norte, Del Sur and Sibugay respectively For all project roads this increase in precipitation will put further stress on road longitudinal and cross drainage infrastructure and increase flood volumes passing under road bridges More significantly the projected increase by 2050 of rainfall events greater than 300mm will increase the occurrence and magnitude of flash floods causing damage to road embankments, culvert and bridge structures and potential inundation of road surfaces. Some Municipalities along the road alignments of PR04 and 11 have already reported instances of flooding. Projected increases in precipitation and flooding will have adverse impacts on the project roads and a high vulnerability score has been recorded for all roads.				
Landslide Risk	Information from the DRRMP plans for Tabina, Pitogo, Dimataling and Margosatubig indicate there are already some landslide prone areas in these Municipalities.	The road alignment is though hilly terrain requiring steep cut faces to the roadsides. Increased intensity rainfall events are	Some cut faces to road side slopes have been observed to be unstable along sections of this road. Road alignment is through rolling terrain and	There are already critical landslide prone areas at Barangays Pangi and Picanan. A bypass is proposed around the Vitali and	This road alignment is along the flat coastal plain so no threat from landslides. This road has a low vulnerability score

CLIMATE THREAT	PROJECT ROAD PR 04	PR 08	PR 09	PR 10	PR 11
	Increased intensity rainfall events are going to exacerbate these areas. This road has a medium vulnerability score.	going to increase the potential for soil erosion and landslide events. This road has a high vulnerability score	increased intensity of rainfall events will increase potential for soil erosion and landslide events. This road has a medium vulnerability score.	Tagasilay prone areas. The hillsides in these areas are unstable. This road has a high vulnerability score	
Sea Level Rise	There is a projected rise in sea level around the coasts of the Philippines of 82cm by 2100. Its alignment is along the hillsides above the shoreline. Only in a very few places does it actually run parallel to the shore line but even then still well above high tide level. This road has a medium vulnerability score	This road alignment is through the hills and nowhere near the shore line. This road has a low vulnerability score	At the Guicam sea channel crossing site projected increased sea level rises will impact on the road alignments at the ferry terminals This road has a high vulnerability score	The majority of this road alignment away from the coast and through hilly terrain. Only in a very few places does it drop down to the just above the shore line but even then still well above high tide level This road has a medium vulnerability score	Some sections are very close to the foreshore where the alignment is very vulnerable. The four bridges carrying the road over tidal rivers will require adequate freeboard to allow for sea level rises. This road has a high vulnerability score
Increased Wind	Increased wind associated with tropical depressions could induce storm surges though to date none have been recorded along this coast. This road has a medium vulnerability score	Increased wind associated with tropical depressions or storms could impact in exposed locations on road safety. This road has a medium vulnerability score	The Guicam channel crossing is very vulnerable to sea level rise and storm surges which impacts on the operation of the ferry terminals. This road has a medium vulnerability score	Increased wind associated with tropical depressions or storms could impact in exposed locations on road safety. This road has a medium vulnerability score	A storm surge in 2006 passed over the existing coastal road to a height of 0.3m at Tukuran. Allowances are to be made for additional storm surges associated with higher tides. This road has a high vulnerability score

It can be concluded from the vulnerability assessment exercise that the most critical road alignments of those studied to potential climate change impacts are the Lutiman to Olutanga Road (PR 09) and the Tukuran to Pagadian Coastal Road (PR 11). They both had a high vulnerability scores for four of the climate threats with the impacts from sea level rise and increased flooding risks being of particular significance.

V. ADAPTATION ASSESSMENT

A. Potential Climate Proofing Options

For each road screened its degree of vulnerability to the significant climate change threats was assessed. The conclusions in general were:

- Increased precipitation and the number of larger rainfall events will have a high impact on road drainage facilities and bridge integrity
- There is a high vulnerability for those roads in the hilly areas to suffer from landslide risks
- Rises in the sea level coupled with increasing wind velocities associated with more severe storms creating tidal surges will have a high impact on coastal roads with alignments close to the foreshore

Table F5.1 summarizes the most important structural and non-structural adaptation measures that need to be considered to make the project roads in general more resilient to climate change impacts.

Table FV.1: Key Climate Change Impacts and Proposed Adaptation Measures Associated with the Road Improvement Works

Climate Threat	Road Aspect Affected	Adaptation Measures Associated with Road Improvements	
		Structural Measure	Non-Structural Measure
Increased Precipitation	Road Pavement	• Improve road surface and subsurface drainage systems • Raising pavement levels • Seal cracked and distressed areas	• Increase maintenance budgets
	Road Drainage	• Increase size of side drains • Consider alternative drain section • Increasing water retention capacity of drains • Use of water capture and storage retention ponds	• Regular O&M of road side drains • Allow slow infiltration through natural or bioengineered systems
	Culverts and Cross Drainage Pipes	• Increase capacity of hydraulic structures • Increase the number of cross drains • Use apron rather than catch pit at pipe entrance to avoid clogging by debris • Downstream protection at outlets to reduce scouring	• Regular O&M to clear out debris and blockages • Develop and check new standards for pipe and culvert designs
	Bridges	• Review design storm return periods • Raise bridge if inadequate freeboard • Reinforce bridge piers and abutments at risk from scouring • Provide retention dams upstream to reduce flood flows • Install automatic gauging station	• Clean out debris in river bed • Work with DENR to improve land use and upstream watershed management • Keep records of flood events
Increased Storm Intensities	Road Pavement	• Realign road away from potential landslide areas • Cut back steep slopes to a safer angle	• Coco netting interplanted with vetiver grass to reduce erosion from steep slopes

Climate Threat	Road Aspect Affected	Adaptation Measures Associated with Road Improvements	
		Structural Measure	Non-Structural Measure
and Landslide Risk		• Provide gabion basket walling to support slopes • Bioengineer slope protection to provide vegetative reinforcement	• Plant trees or introduce sloping agricultural land technology above road alignment to reduce storm water runoff
	Drainage	• Increase road drainage capacity • Drainage outfalls to be well protected against downstream scouring and well away from potential landslip areas • Lower water tables through construction of French drains combined with catch drains across the top of steep sloping road sections	• Install brush layers and live stacking placed across the potential landslide zone with a catch drain dug above • Analyze maximum storm intensities and undertake risk assessment • Increase maintenance budgets
Rising Sea Level and Storm Surge Risk	Road Pavement	• Raise the road embankment level • Construct sea wall • Realign the road away from the coast	• Plant mangroves and sea grass along the shoreline • Encourage the development of sea weed farming to dissipate wave actions
	Drainage	• Construct additional longitudinal and transverse drainage systems • Flap gates at drain outfalls to prevent sea water entering at high tide	• Undertake risk assessment and increase O&M budgets
	Bridges	• Where affected by tidal conditions ensure adequate freeboard maintained to bridge deck soffit • Raise bridge deck levels and approach embankments	• Keep records of maximum tide levels and storm surge events

B. Prioritize Options

To prioritise the proposed adaptation measures consideration was made to manage climate risk to an acceptable level combining any mitigation and positive opportunities that could arise. The adaptation measures proposed were categorized as short, medium and long-term measures based on a:

- short term phasing referring to works to be carried out over the next 1 to 3 years,
- medium term over years 3 to 6
- long term for anything beyond the next 6 years

C. Adaptation Planning

Table F5.2 gives a proposed adaptation plan and the phasing proposed for the project road improvement works taking into account the impacts from climate change.

Table FV.2: Adaptation Plan and Phasing Proposed for the Road Improvements

Priority Phasing	Adaptation Measure	Technical Feasibility	Required Resources	Financial Viability	Effectiveness
Short Term	Increase budgets for maintenance of road pavement and side drains	Feasible	Budget approval	Funds required from Regional office	Repairs can be undertaken as and when needed
	Regularly clear out debris from cross drainage pipes, culverts and river beds under bridges	Feasible as part of general O&M activities	Human resources required from DPWH district offices with small powered machinery	Funds required from Regional office	Very effective if regularly undertaken during periods of heavy rain
	Cut back steep roadside cuttings and provide vegetative reinforcement to stabilize slopes	Technical support required to decide slope angle and confirm stability	Backhoe, dump truck and labour forces with hand tools. Vegetative materials sourced from nurseries.	Funds required from Regional office	Effective to control road side slope erosion and minimize landslide hazards
	Lower water tables in areas of steep roadside cuttings	Technical support to undertake geotechnical investigations and design remedial works	French drains installed in sloping surfaces with catch drains across the top of the slopes	Funds required from Regional office	Effective in areas prone to landslide hazards
	Establish mangrove and sea grasses and encourage sea weed farming along coastlines to reduce storm surge impacts	Collaboration with DENR under their Mangrove and Beach Forest Development and Management Programme.	Vegetative materials sourced from approved nurseries. Women to plant and maintain with support from Municipal Offices	Requires support from DENR and Municipal Offices	Effective when fully established in reducing coastal wave action and storm surge impacts
	Where bridges cross main rivers install automatic gauging station	Requires a river rating curve	New gauging station equipment	Modest cost outlay	Effective in reviewing flood return periods and determining long term flooding risks
Medium Term	Improvement to road embankment subsurface drainage systems	Site investigations required and designs prepared before installation	Machinery and drainage materials for improvements to road subgrade preparation	Funds from roads improvement project	Effective in controlling water table rises due to increased precipitation
	Increase size of side drains and other road drainage hydraulic structures	Computation of hydraulic parameters and design of upgraded structures	Machinery and labour to break out old structures and install new	Funds from roads improvement project	Effective in removing runoff and flood waters due to increased precipitation
	Raise bridge levels if inadequate freeboard	Requires computation of return period events and maximum flood levels	Replace existing bridge if steel or raise soffit of other bridge structures	Funds from roads improvement project	Very effective in allowing increased flood flows to pass

Priority Phasing	Adaptation Measure	Technical Feasibility	Required Resources	Financial Viability	Effectiveness
	Provide erosion protection at pipe and culvert outlets and around bridge piers and abutments	Requires computation of flood flows and design of appropriate flexible aprons	Equipment, labour, stones and gabion baskets	Funds from roads improvement project	Effective in controlling damage from larger flash floods
	Provide retaining walls to stabilize steep slopes prone to landslides	Geotechnical investigations and structural design required	Gabion baskets or stone masonry revetments	Funds from roads improvement project	Gabions effective as a flexible alternative to trapping materials falling down from steep cut slopes
	Raise embankments where road passes close to the shoreline	Consider 82cm sea level rise coupled with a projected maximum storm surge height and 30cm freeboard	Provision of suitable sub base materials, machinery and labour	Funds from roads improvement project	Effective to ensure coastal road unaffected by storm surges
Long Term	Construct upstream water capture and side road retention ponds	Hydraulic computations to determine size and location	Acquisition of Suitable land space	Funds from roads improvement project	Reduces volume of flood waters to be disposed off from road drainage and allows scope for water reuse
	Realign road away from steep terrain with landslide hazards or exposed coastal locations including to a higher elevation	Detailed topographic land survey and road pavement and drainage design	Land acquisition	Funds from roads improvement project	The optimum solution where impacts from landslides or coastal erosion and storm surges are acute
	Construct sea wall alongside coastal road	Consider 82cm sea level rise coupled with a projected maximum storm surge height and 30cm freeboard	Reinforced concrete wall to be designed	Funds from roads improvement project	Only where coastal road passes though urban areas and space for the alignment is limited

VI. RECOMMENDATIONS

The impacts from climate change on the coastal roads improvements proposed in Region IX contain many uncertainties. Will greenhouse gas pollution continue at the same rate? Will mitigation measures to reduce emissions become more effective? Will the results from the general circulation models quoted in IPCC's recent fifth assessment report be revised further in the future? Will there be new data on climate projections for Region IX coming out of PAGASA's ongoing downscaling exercises? Will extreme weather events become more frequent or severe as projected? All these have to be factored into the risks to be taken into account when considering a management plan to increase resilience to climate change.

That is why all the short term measures proposed in the adaptation plan are part of a dynamic process to address the current hazards, manage the current risks and uncertainties and help build on the capacity to adapt to climate change impacts in the future. These can be considered as "low regret" actions as most should form part of the annual road operation and maintenance activities. At the same time they are providing resilience against future climate change impacts. Some proposed adaptation measures, such as watershed and sea shore protection works, however require liaison and cooperation with other agencies.

The medium term measures are more specific to address major impacts to the road infrastructure from climate change. They would be included in the improvement works proposed for the project. The road drainage and bridge designs would adopt the design criteria already set out in the DPWH memorandum dated 21 June 2011 which details the upgrades in hydraulic parameters to be used to take account of climate change impacts. See Annex E

Additional erosion protection works, stabilization of steep slopes against landslides, raising of embankments along shorelines and improvement to embankment subsurface drainage systems would be factored into the standard road designs at critical locations as deemed necessary.

The long term measures are more radical affecting only a few critical sections of the road improvement works. Whilst climate change impacts will need considering there may be other factors that dictate the inclusion of these works in the project. To give some idea on costs to take account of climate change the following criteria has been adopted:

- A factor of 4% to be included in the annual district O&M budgets to take account of short term adaptation measures, as the majority of the works proposed can be related to regular O&M activities
- Medium and long term adaptation measures to be at a cost per length of road as presented in Table F6.1 below

Table FVI.1: Example Medium and Long Term Adaptation Measure Costs

ADAPTATION MEASURE	UNIT	Php	$
Improved subsurface drainage to 5m wide road embankments	Km	8.0M	0.17M
Raise coastal road embankments by 1.0m against storm surges	Km	32.0M	0.68M
Realign 6m wide national concrete road around landslide areas	Km	50.0M	1.07M
Reinforced concrete wave wall 2m high along coastal roads	Lin.m	25,000	535
Gabion retaining wall to stabilize steep slopes against landslides	Lin.m	15,000	321
Side road drains & retention pond for storm water management	Lin.m	10,000	214

ANNEX A CHECKLISTS FOR PRELIMINARY CLIMATE RISK SCREENING

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR01a: OPENING/UPGRADING, GUTALAC TO BALIGUIAN ROAD

Division/Department: DPWH 2nd DEO ZDN

Screening Questions		Score	Remarks[12]
Location and Design of project	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	Parallel to the coast line but alignment generally in the low hills above the immediate coast
	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	The road crosses many rivers and drainage paths passing down to the coast
Materials and Maintenance	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)?	1	Slope protection required on exposed roadside cut faces and measures provided to ensure cross drains not blocked with debris
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance programmes required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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: The road alignment is through hilly terrain parallel to the coast and susceptible to potential impacts from increased drainage runoff and cut slope erosion and landslips from projected increased rainfall intensities due to climate change. Bridges and road culverts will have to allow for potentially larger flash flood events.

Prepared by: A R Key (PPTA Climate Change Specialist) 14th May 2015

[12] 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.

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR01b: OPENING/UPGRADING, SIRAWAI TO SIBUCO ROAD

Division/Department: DPWH 2nd DEO ZDN

Screening Questions		Score	Remarks[13]
Location and Design of project	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	Parallel to the coast line but alignment through the hilly terrain above the immediate coast
	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	The road crosses rivers and drainage paths passing down to the coast
Materials and Maintenance	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)?	1	Slope protection required on exposed roadside cut faces and measures provided to ensure cross drains not blocked with debris
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance programmes required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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: The road alignment is through hilly terrain parallel to the coast and susceptible to potential impacts from increased drainage runoff and cut slope erosion and landslips from projected increased rainfall intensities due to climate change. Bridges and road culverts will have to allow for potentially larger flash flood events.

Prepared by: A R Key (PPTA Climate Change Specialist) 14th May 2015

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

[13] 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.

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR04: OPENING/IMPROVEMENT, ZAMBOANGA DEL SUR COASTAL ROAD

Division/Department: DPWH 2nd DEO ZDS

Screening Questions		Score	Remarks[14]
Location and Design of project	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	Parallel with coast line but alignment generally in the low hills above the immediate coast
	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.)?	2	Bridges and cross drainage culverts carry the road over rivers and streams passing down to the coast
Materials and Maintenance	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)?	1	Slope protection required on exposed roadside cut faces and provisions made for ensuring drains are not blocked with debris
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance programmes need to be applied
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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): HIGH

Other Comments: The road alignment is through low hills parallel to the coast and susceptible to potential impacts from increased drainage runoff and cut slope erosion and landslips. Bridges crossing rivers and streams have to allow for potentially larger flash flood events.

Prepared by: A R Key (PPTA Climate Change Specialist) 13th May 2015

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

[14] 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.

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR06: OPENING/UPGRADING, ALICIA TO MALANGAS ROAD

Division/Department: DPWH 1st DEO ZS

Screening Questions		Score	Remarks[15]
Location and Design of project	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	Road passes over flat to rolling terrain
	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	Bridges and cross drainage culverts to be improved and allow for increased flood flows
Materials and Maintenance	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	Standard DPWH design criteria should be used and will be adequate for bridge and drainage structures
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance of bridge and drainage infrastructure required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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: The road alignment is through flat to rolling terrain and the existing DPWH designs for upgrading this road and its associated infrastructure should be adequate to cope with any climate change impacts.

Prepared by: A R Key (PPTA Climate Change Specialist) 14th May 2015

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

[15] 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.

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR07: UPGRADING, TAMPILISAN TO SANDAYONG ROAD

Division/Department: DPWH 2nd DEO ZDN

Screening Questions		Score	Remarks[16]
Location and Design of project	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	Road passes over rolling to hilly terrain in the centre pf the peninsular
	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	Bridges and cross drainage culverts to be improved and allow for increased flood flows
Materials and Maintenance	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)?	1	On exposed roadside cut faces slope protection necessary and provision made to ensure road drains are not blocked with debris
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance programmes for road infrastructure required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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: The road alignment is through rolling to hilly terrain and susceptible to impacts from increased road drainage runoff and cut slope erosion. The existing DPWH designs for upgrading this road and its associated infrastructure should be adequate to cope with any climate change impacts.

Prepared by: A R Key (PPTA Climate Change Specialist) 14th May 2015

[16] 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.

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR08: UPGRADING, R T LIM - SIOCON ROAD

Division/Department: DPWH 2nd DEO ZS AND 2nd DEO ZDN

Screening Questions		Score	Remarks[17]
Location and Design of project	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?	2	Road passes through flat terrain with central section across the centre of the peninsular very hilly and vulnerable to landslides
	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	Bridges and cross drainage culverts to be improved and allow for increased flood flows
Materials and Maintenance	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)?	1	On exposed roadside cut faces slope protection necessary and provision made to ensure road drains are not blocked with debris
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance programmes for road infrastructure required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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): HIGH

Other Comments: Upgrading the road from gravel to concrete and where road geometry is to be improved to meet DPWH standards, climate change impacts could instigate landslides where the road traverses steep unstable hillsides. Bridge and spillweir designs will have to be checked to cater for larger floods.

[17] 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.

Prepared by: A R Key (PPTA Climate Change Specialist) 14th May 2015

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR09: UPGRADING, LUTIMAN – GUICAM - OLUTANGA ROAD

Division/Department: DPWH 1st DEO ZS

Screening Questions		Score	Remarks[18]
Location and Design of project	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?	2	Road passes through flat to rolling terrain. The ferry terminals at the Guicam channel crossing exposed to sea level rises and storm surges
	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	Bridges and cross drainage culverts to be improved and allow for increased flood flows
Materials and Maintenance	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)?	1	Salt laden air could impact on bridge structures if not adequately protected
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance of bridge and drainage infrastructure required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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): HIGH

Other Comments: Upgrading the road from gravel to concrete through flat to rolling terrain where climate change impacts will affect mostly on the road drainage provisions. However there is a much higher

[18] 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.

risk at the Guicam channel ferry terminals where sea level rises and storm surges need to be taken into account for.

Prepared by: A R Key (PPTA Climate Change Specialist) 25th October 2015

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR10: VITALI – TAGASILAY BYPASS

Division/Department: DPWH 1st DEO ZAMBOANGA DEL SUR

Screening Questions		Score	Remarks[19]
Location and Design of project	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?	2	Some sections where the road traverses steep hillsides are vulnerable to landslides
	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	Allowances need to be made for increased flows and flash floods at river crossing sites
Materials and Maintenance	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)?	1	Slope protection required on exposed roadside cut faces and measures provided to ensure cross drains not blocked with debris
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance programmes required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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): **HIGH**

Other Comments: The road alignment is through both flat, rolling and hilly terrains and susceptible to impacts from increased road drainage and cut slope erosion. Increased rainfall

[19] 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.

intensities could instigate landslides. Bridges designs and culverts will have to be checked to cater for larger flood flows.

Prepared by: A R Key (PPTA Climate Change Specialist) 25th October 2015

Country/Project Title: PPTA 8574 PHI: IMPROVING NATIONAL ROADS IN MINDANAO

Sector: PROVINCIAL/LOCAL ROAD CONVERSION TO NATIONAL/SECONDARY ROAD

Subsector: PR11: IMPROVEMENT/CONCRETING, PAGADIAN -TUKURAN COASTAL ROAD

Division/Department: DPWH 1st DEO ZDS

Screening Questions		Score	Remarks[20]
Location and Design of project	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?	2	Very close to shoreline in places so sea level rise combined with storm surges will affect road
	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.)?	2	Bridges across tidal rivers need adequate freeboard to cater for bigger floods & rising sea levels
Materials and Maintenance	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)?	1	Salt laden air could impact on bridge components if not adequately protected
	Would weather, current and likely future climate conditions, and related extreme events likely affect the maintenance (scheduling and cost) of project output(s)?	1	Regular maintenance of bridge and drainage infrastructure required
Performance of project outputs	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 newly designed infrastructure will take into account long term performance outputs

Options for answers and corresponding score are provided below:

Response	Score
Not Likely	0
Likely	1
Very Likely	2

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): HIGH

Other Comments: The close proximity of the road alignment to the sea shore in places exposes the road to the impacts of potential future sea level rises which could be exacerbated by increased

[20] 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.

severity of storm surges. Bridges crossing streams entering the shore line could also be affected. Further climate risk screening required..

Prepared by: A R Key (PPTA Climate Change Specialist) 13th August 2015

ANNEX B AWARE PROGRAMME CLIMATE RISK SCREENINGS

aware
Aware for Projects

01 Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

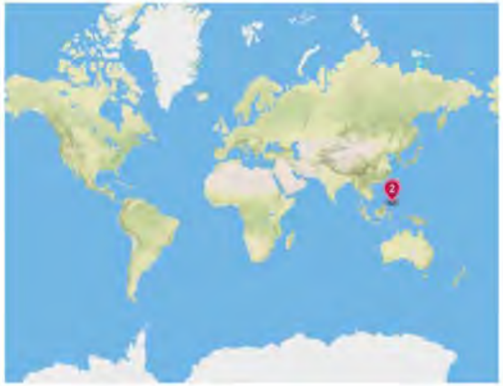
The screening is based on the Aware™ geographic data set, compiled from the latest scientific information on current climate and related hazards together with projected changes for the future where available. These data are combined with the project's sensitivities to climate variables, returning information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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Gutalac to Baliguian Road
REFERENCE:	PR01A
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Opening and upgrading of an alternative route to N967 over 28km

02 Chosen Locations

1) Philippines
2) Philippines



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03 Project Risk Ratings

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

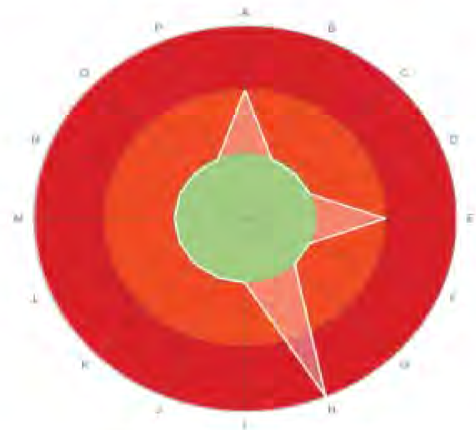
The radar chart provides an overview of which individual risks are most significant. This should be use conjunction with the final rating to determine whether the project as a whole, or its individual compone should be assessed in further detail. The red band (outer circle) suggests a higher level of risk in relation 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 exist and possible future climate conditions and associated hazards. A number of questions are provided to h stimulate a conversation with project designers in order to determine how they would manage current future climate change risks at the design stage. Links are provided to recent case studies, relevant data por and other technical resources for further research.

Final project risk ratings

Medium Risk

Breakdown of 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

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.
• Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section.

Projected higher intensity storms occurring where there are steep cut faces along certain sections of the road alignment could instigate landslide events

05

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?

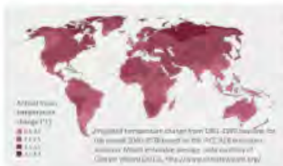
• There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

• 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?



• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

The road surfacing is to be concrete which will not be impacted by the projected small increase in temperature. Similarly the bridges will be concrete incorporating suitable expansion joints to take account of thermal expansion

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06
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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

DPWH road drainage designs already cater for increased runoff from projected increase in precipitation due to climate change

07

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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

Decreasing precipitation will not have an impact on the road performance

08

The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

HELP AND GLOSSARY:

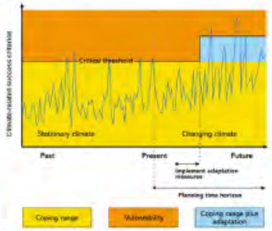
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].**

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Climate model projections do not agree": defined as 14 or fewer out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Significant proportion": defined as at least 25% of locations when multiple locations are selected.
"Large proportion": defined as at least 75% of locations when multiple locations are selected.

The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

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01 Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

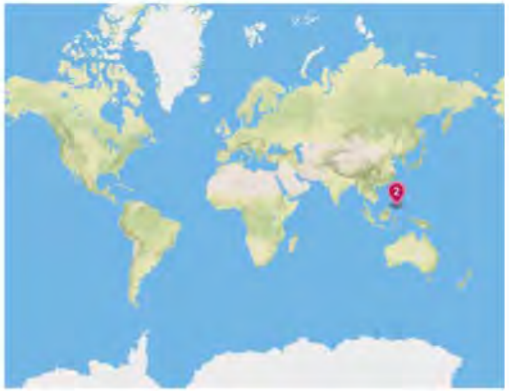
The screening is based on the Aware^{TM} geographic data set, compiled from the latest scientific information on current climate and related hazards together with projected changes for the future where available. These data are combined with the project's sensitivities to climate variables, returning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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Gutalac to Baliguian Road
REFERENCE:	PR01A
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Opening and upgrading of an alternative route to N967 over 28km

02 Chosen Locations

1) Philippines
2) Philippines



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03 Project Risk Ratings

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

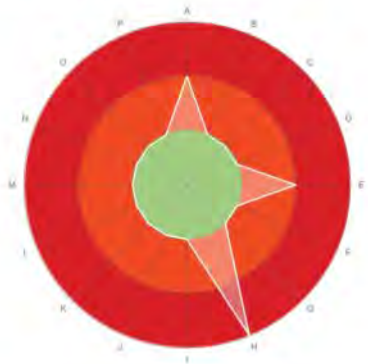
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

Medium Risk

Breakdown of 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

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.
• Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section

Projected higher intensity storms occurring where there are steep cut faces along certain sections of the road alignment could instigate landslide events

05

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?

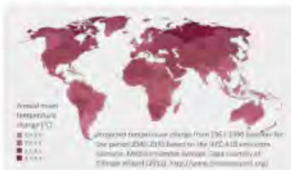
• There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

• 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?



• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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

The road surfacing is to be concrete which will not be impacted by the projected small increase in temperature. Similarly the bridges will be concrete incorporating suitable expansion joints to take account of thermal expansion

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06 PRECIPITATION INCREASE

MEDIUM RISK

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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

☑ I have acknowledged the risks highlighted in this section

DPWH road drainage designs already cater for increased runoff from projected increase in precipitation due to climate change

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07

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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

Decreasing precipitation will not have an impact on the road performance

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08

The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

HELP AND GLOSSARY:

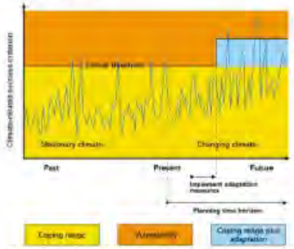
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities.

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Climate model projections do not agree": defined as 14 or fewer out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Significant proportion": defined as at least 25% of locations when multiple locations are selected.
"Large proportion": defined as at least 75% of locations when multiple locations are selected.

The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

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Section 10 of 10

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The Content does not provide any form of advice (investment, tax, legal) amounting to investment advice, or make any recommendations regarding particular financial instruments, investments or products. Acclimatise will not be liable for any loss or damage caused by a reader's reliance on information obtained in our Content. Users are solely responsible for their own investment decisions. Acclimatise's opinions and analyses are based on sources believed to be reliable and are written in good faith, but no representation or warranty, expressed or implied, is made as to their accuracy or completeness. Acclimatise is not authorised for the conduct of investment business (as defined in the UK's Financial Services and Markets Act 2000) and the Content provided in our services and products are not intended as, and shall not constitute, investment advice.

01

Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Zamboanga del Sur Coastal Road
REFERENCE:	PR04
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Upgrading and opening of new road sections over a total length of 114km

02

Chosen Locations

1) Philippines
2) Philippines
3) Philippines
4) Philippines
5) Offshore

03

Project Risk Ratings

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

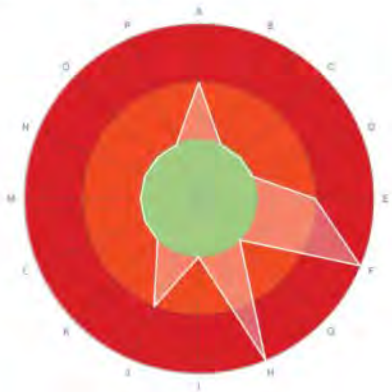
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

Medium Risk

Breakdown of 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 2010 there have been more than 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
- Urban drainage infrastructure
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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 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.
- If flooding 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of floods?

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 floods and climate change.

☑ I have acknowledged the risks highlighted in this section

With the upgrading and opening of new roads the design criteria of DPWH for the road infrastructure takes into account the higher return period flood events that are projected to occur as a result of climate change

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.
- Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section

The projected increase in single storm events of greater than 300mm saturating and loosening them soil on steep cut sections of the road alignment could result in more occurrences of landslide events

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?

• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

As the proposed road pavements are to be of concrete the small projected increase in temperature will not unduly impact on the road performance. Concrete road bridges are proposed with suitable expansion joints to take account of thermal expansion

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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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

I have acknowledged the risks highlighted in this section

DPWH road drainage designs already cater for climate change impacts from increased rainfall

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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?

• 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.

I have acknowledged the risks highlighted in this section

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09 PRECIPITATION DECREASE

LOW RISK

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 current heavy 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 seasonal 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).
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4. What next?

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2. Click here or here for the latest news and information relating to water and climate change.

☑ I have acknowledged the risks highlighted in this section

Reducing water availability will not impact on the road performance

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10

The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

Decreasing precipitation will not have any impact on the road performance

HELP AND GLOSSARY:

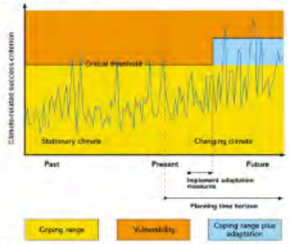
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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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 above, 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.

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:

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• Flood
• Permafrost
• Landslides

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Climate model projections do not agree": defined as 14 or fewer out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Significant proportion": defined as at least 25% of locations when multiple locations are selected.
"Large proportion": defined as at least 75% of locations when multiple locations are selected.

The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

DISCLAIMER:

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01 Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Alicia to Malangas Road
REFERENCE:	PR06
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Road Opening and upgrading over 24km

02 Chosen Locations

1) Philippines
2) Philippines
3) Philippines

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03 Project Risk Ratings

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

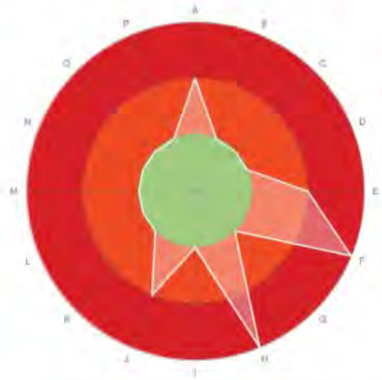
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

Medium Risk

Breakdown of 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

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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 2010 there have been more than 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
- Urban drainage infrastructure
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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 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.
- If flooding 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of floods?

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 floods and climate change.

☑ I have acknowledged the risks highlighted in this section.

DPWH design criteria takes into account higher return period flood events and flows through road drainage pipes and culverts

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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.
- Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section.

Projected higher intensity storms occurring where there are steep cut faces along certain sections of the road alignment could instigate landslide events

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?

• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

The road surfacing is to be concrete which will not be impacted by the projected small increase in temperature. Similarly the bridges will be concrete incorporating suitable expansion joints to take account of thermal expansion

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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

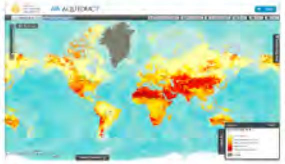
DPWH road drainage designs already cater for increased runoff from projected increase in precipitation due to climate change

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?

• 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.

Any reduction in water availability will not be an issue

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Section 9 of 12

09

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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

☑ I have acknowledged the risks highlighted in this section

Decreasing precipitation will not have an impact on the road performance

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Section 10 of 12

10

The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

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Section 11 of 12

HELP AND GLOSSARY:

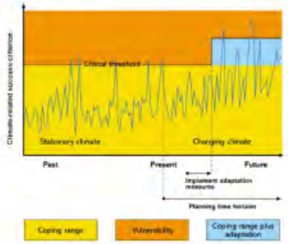
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities.

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
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The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

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01

Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Tampilisan to Sandayong Road
REFERENCE:	PR07
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Opening and upgrading of existing road to National Standard over 17km

02

Chosen Locations

1) Philippines
2) Philippines

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03

Project Risk Ratings

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

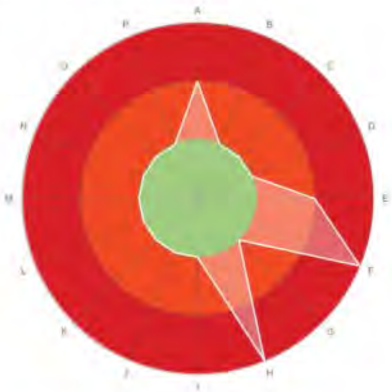
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

Medium Risk

Breakdown of 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

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04 FLOOD

HIGH RISK

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 2010 there have been more than 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
- Urban drainage infrastructure
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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 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.
- If flooding 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of floods?

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 floods and climate change.

☑ I have acknowledged the risks highlighted in this section

DPWH design criteria takes into account higher return period flood events and flows through road drainage pipes and culverts

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05 LANDSLIDE

HIGH RISK

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.
- Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section

Projected higher intensity storms occurring where there are steep cut faces along certain sections of the road alignment could instigate landslide events

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?

• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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

The road surfacing is to be concrete which will not be impacted by the projected small increase in temperature. Similarly the bridges will be concrete incorporating suitable expansion joints to take account of thermal expansion

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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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

☑ I have acknowledged the risks highlighted in this section.

DPWH road drainage designs already cater for increased runoff from projected increase in precipitation due to climate change

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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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

☑ I have acknowledged the risks highlighted in this section.

Decreasing precipitation will not have an impact on the road performance

09 The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

HELP AND GLOSSARY:

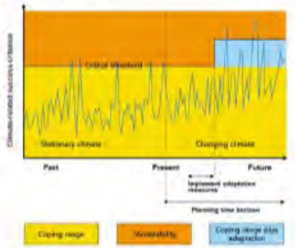
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities.

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Climate model projections do not agree": defined as 14 or fewer out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Significant proportion": defined as at least 25% of locations when multiple locations are selected.
"Large proportion": defined as at least 75% of locations when multiple locations are selected.

The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

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01 Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	R T Lim to Siocon Road
REFERENCE:	PR08
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	

02 Chosen Locations

1) Philippines

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03 Project Risk Ratings

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

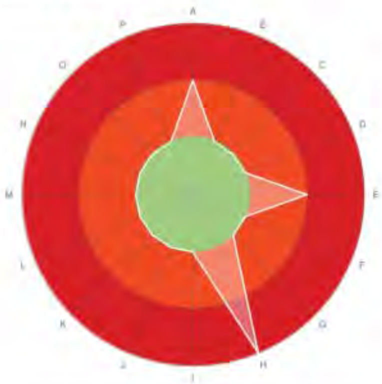
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

Medium Risk

Breakdown of 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

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.
• Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section

Increase in the number of higher intensity storm events will increase erosion on steep cut faces along the roadsides and could instigate landslides

05

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?

• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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

As the proposed road pavements are to be concrete the small projected increase in temperature will not unduly impact on the road performance. Concrete road bridges are proposed with suitable expansion joints to take account of thermal expansion.

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06
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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

DPWH road drainage designs already take into account increase in runoff from additional projected precipitation amounts resulting from climate change

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07 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 current heavy 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.

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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.
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Decreasing precipitation will not have an affect on road performance

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08

The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

HELP AND GLOSSARY:

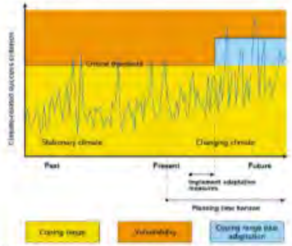
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions, Challenges and Opportunities.

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
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The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

DISCLAIMER:

01 Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Lutiman to Olutanga Road
REFERENCE:	PR09
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Upgrading of existing road over 37km

02 Chosen Locations

1) Philippines
2) Philippines
3) Philippines
4) Philippines

03 Project Risk Ratings

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

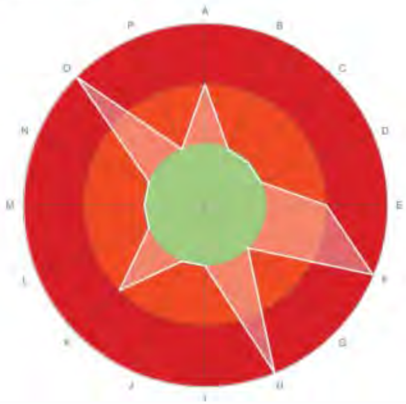
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

High Risk

Breakdown of 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 2010 there have been more than 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
- Urban drainage infrastructure
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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 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.
- If flooding 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of floods?

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 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.
- Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section

Projected higher intensity storms occurring where there are steep cut faces along certain sections of the road alignment could instigate landslide events

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06
HIGH RISK

SEA LEVEL RISE

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 inundation from the sea as well as potential future changes.

2. How could sea level rise affect the project even without future climate change?

• Low lying coastal regions are particularly prone to local tropical cyclones, mid-latitude storms and associated storm surges.
• Erosion of the coastline can exacerbate 'coastal squeeze', putting pressure on natural sea defences, such as salt marshes and mangroves as well as man-made structures.
• Up to date information on coastal storm and flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

3. What does the science say could happen by 2100?

• Some recent research suggests that global sea levels could be 0.75 to 1.9m higher by the end of the century.
• Local changes in ocean density/dynamics and land movements can also add to, or lessen, the effects of sea level rise at a given location.
• Sea level rise has the potential to accelerate the rate of coastal erosion. Changes in erosion regimes also impact the rate of sedimentation in other areas, particularly in estuarine and other tidal settings. This could provide problems with access to existing ports and jetties.
• In tropical regions, increasing ocean acidification and temperatures can lead to coral reef bleaching and destruction. Such reefs can provide a natural barrier to coastal inundation and erosion.
• In addition, sea level rise could cause saline intrusion into aquifers, further depleting useable water resources.
• Local sea level rise in combination with storm surge and wave height poses a hazard to offshore fixed assets, such as oil and gas platforms.

If you want to know more about projected changes for the project location across a range of sea level rise scenarios, please refer to: The University of Arizona's Sea Level Rise Map.

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 sea level and climate change.

☑ I have acknowledged the risks highlighted in this section

Sea level rise of 82cm expected by 2100. The ferry terminals at either end of the Guicam sea channel have to take account of this projected sea level rise together with the increased likelihood of storm surges raising the sea level.

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07
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?

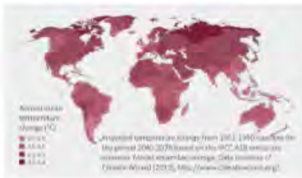
• There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

• 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?



• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

The road is to be concrete which will not be severely impacted by the small projected temperature rise.

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08
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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

☑ I have acknowledged the risks highlighted in this section.

DPWH road drainage designs already take into account the climate change impacts from the projected increasing precipitation amounts.

F-71

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09

MEDIUM RISK

WIND SPEED INCREASE

Would an increase in average and maximum wind speed 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 wind speed.

ACCLIMATISE COMMENTARY

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

• The project is considered to have high sensitivity to wind and 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 increasing wind speed as well as potential future changes.

2. How could stronger winds affect the project even without future climate change?

• The design and operation of certain infrastructure (e.g. wind turbines) is determined by the prevailing climatic wind conditions.
• Given the energy in the wind is the cube of wind speed, a small change in the wind climate can have substantial consequences for the wind energy available.
• Similarly, small changes could have dramatic consequences for wind related hazards e.g. wind storm damage.
• If our data suggests that there is an existing risk of tropical storms in the region, it will be highlighted elsewhere in the report.

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

• Climate change could alter the geographic distribution and/or the seasonal variability of wind resource.
• Climate model projections remain uncertain and it appears unlikely that mean wind speeds will change by more than the current inter-annual variability.
• Changes in extreme wind speeds associated with extra-tropical and tropical storm are similarly uncertain. However, there have been studies that suggest fewer but more intense events. Stronger storms bring with them an increases risk of coastal storm surge, coastal erosion, wind damage and flooding.
• Given future uncertainty it is advisable to carefully assess past wind speed 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 wind 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.

☑ I have acknowledged the risks highlighted in this section.

Increased wind speeds associated with tropical storms and depressions could create larger coastal storm surges.

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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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

4. What next?

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2. Click here or here for the latest news and information relating to water and climate change.

☑ I have acknowledged the risks highlighted in this section.

Decreasing precipitation not an issue

11 The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

HELP AND GLOSSARY:

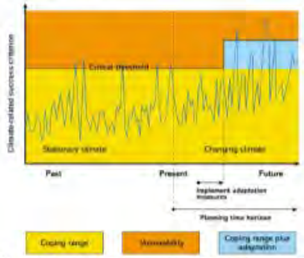
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities.

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- Permafrost
- Landslides

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DISCLAIMER:

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01

Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

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

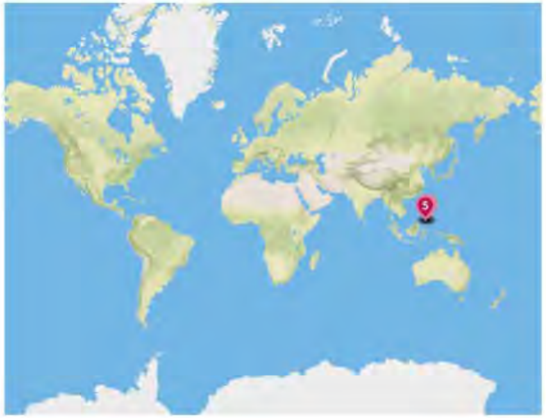
Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Resiliency of Lanao Pagadian Zamboanga Ciy Road
REFERENCE:	PR10
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Resiliency to ensure safety, security and uninterrupted use over 282km of existing roadway.

02

Chosen Locations

1) Philippines
2) Philippines
3) Philippines
4) Philippines
5) Philippines
6) Philippines



03 Project Risk Ratings

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

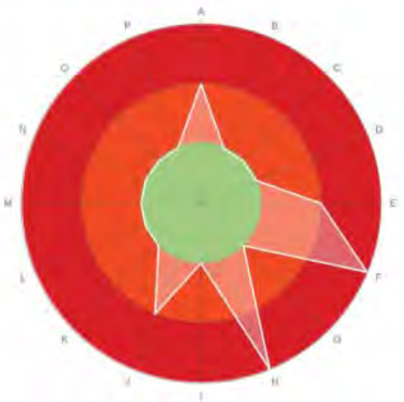
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

Medium Risk

Breakdown of 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 FLOOD

HIGH RISK

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 2010 there have been more than 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
- Urban drainage infrastructure
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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 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.
- If flooding 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of floods?

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 floods and climate change.

I have acknowledged the risks highlighted in this section

DPWH design criteria takes into account higher return period flood events and flows through road drainage pipes and culverts

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.
• Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section

Projected higher intensity storms occurring where there are steep cut faces along certain sections of the road alignment could instigate landslide events

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?

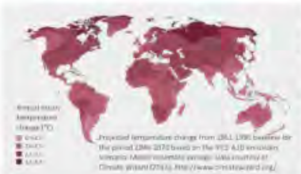
• There is a potential for an increase in incidences where current design standards will not be sufficient. See "Critical thresholds" in the "Help and glossary" section for further details on how a changing climate can impact on critical thresholds and design standards.

• 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?



• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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

The road surfacing is to be concrete which will not be impacted by the projected small increase in temperature. Similarly the bridges will be concrete incorporating suitable expansion joints to take account of thermal expansion

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Aware for Projects

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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

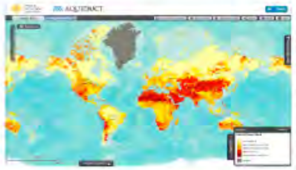
I have acknowledged the risks highlighted in this section

DPWH road drainage designs already cater for increased runoff from projected increase in precipitation due to climate change

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?

• 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.

☑ I have acknowledged the risks highlighted in this section

Any reduction in water availability will not be an issue

09
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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

☑ I have acknowledged the risks highlighted in this section

Decreasing precipitation will not have an impact on the road performance

Aware for Projects

Section 10 of 12

10

The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

Section 11 of 12

HELP AND GLOSSARY:

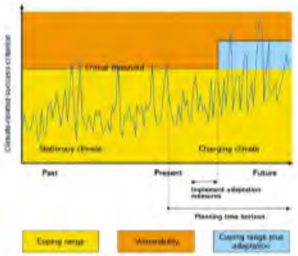
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities.

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Climate model projections do not agree": defined as 14 or fewer out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Significant proportion": defined as at least 25% of locations when multiple locations are selected.
"Large proportion": defined as at least 75% of locations when multiple locations are selected.

The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

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01 Introduction

This report summarises results from a climate risk screening exercise. The project information and location(s) are detailed in Section 02 of this report.

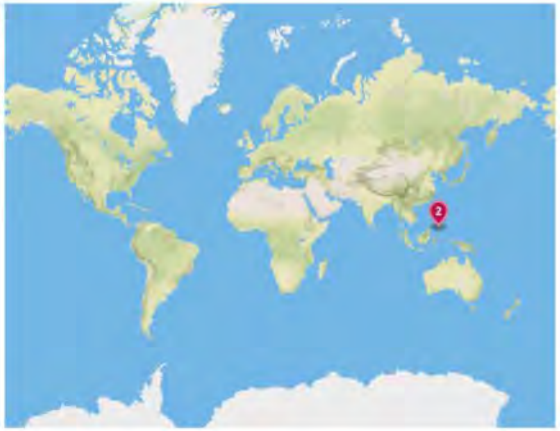
The screening is based on the Aware™ geographic data set, compiled from the latest scientific information on current climate and related hazards together with projected changes for the future where available. These data are combined with the project's sensitivities to climate variables, returning information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

Project Information

PROJECT NAME:	Improving National Roads in Mindanao
SUB PROJECT:	Pagadian City to Tukuran Coastal Road
REFERENCE:	PR11
SECTOR:	Rural transport infrastructure
SUB SECTOR:	Road/ highway/ runway surface
DESCRIPTION:	Construction of new road parallel to the coast with bridges crossing over rivers entering the foreshore

02 Chosen Locations

1) Philippines
2) Philippines



03

Project Risk Ratings

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

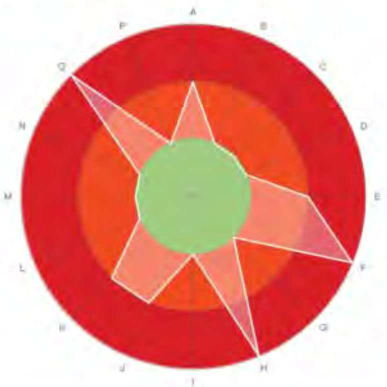
The radar chart provides an overview of which individual risks are most significant. This should be used in conjunction with the final rating to determine whether the project as a whole, or its individual components, should be assessed in further detail. The red band (outer circle) suggests a higher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

High Risk

Breakdown of 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 2010 there have been more than 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
- Urban drainage infrastructure
- Up to date information on flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

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 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.
- If flooding 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of floods?

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 floods and climate change.

☑ I have acknowledged the risks highlighted in this section

DPWH design criteria takes into account higher return period flood events resulting from climate change passing under bridges and through road pipe drainage culverts

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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.
• Risk is locally influenced by other factors, for example local slope and vegetation conditions as well as long term precipitation trends. 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 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.

2. 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 Will the project include continuity plans which make provision for continued successful operation in the event of landslides?

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 landslides and climate change.

☑ I have acknowledged the risks highlighted in this section.

As the road is along the flat coastal plain there is no threat from landslides

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06

HIGH RISK

SEA LEVEL RISE

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 inundation from the sea as well as potential future changes.

2. How could sea level rise affect the project even without future climate change?

• Low lying coastal regions are particularly prone to local tropical cyclones, mid-latitude storms and associated storm surges.
• Erosion of the coastline can exacerbate 'coastal squeeze', putting pressure on natural sea defences, such as salt marshes and mangroves as well as man-made structures.
• Up to date information on coastal storm and flood risk worldwide is available online, for example UNEP / UNISDR's Global Risk Data Platform.

3. What does the science say could happen by 2100?

• Some recent research suggests that global sea levels could be 0.75 to 1.9m higher by the end of the century.
• Local changes in ocean density/dynamics and land movements can also add to, or lessen, the effects of sea level rise at a given location.
• Sea level rise has the potential to accelerate the rate of coastal erosion. Changes in erosion regimes also impact the rate of sedimentation in other areas, particularly in estuarine and other tidal settings. This could provide problems with access to existing ports and jetties.
• In tropical regions, increasing ocean acidification and temperatures can lead to coral reef bleaching and destruction. Such reefs can provide a natural barrier to coastal inundation and erosion.
• In addition, sea level rise could cause saline intrusion into aquifers, further depleting useable water resources.
• Local sea level rise in combination with storm surge and wave height poses a hazard to offshore fixed assets, such as oil and gas platforms.

If you want to know more about projected changes for the project location across a range of sea level rise scenarios, please refer to: The University of Arizona's Sea Level Rise Map.

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 sea level and climate change.

☑ I have acknowledged the risks highlighted in this section.

Sea level rise of 82cm expected by 2100 and already this section of coast has experienced storm surges where waves passed over the foreshore. Area has also suffered from an historic tsunami event.

07

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?

• Climate model projections do not agree that seasonal temperature will increase beyond 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

The road is to be concrete which will not be impacted by the small temperature increase projected. Similarly the bridges will be concrete incorporating suitable expansion joints to take account of thermal expansion.

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08 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 do not agree that seasonal precipitation will increase 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 decrease (see elsewhere in the report for more details of projections related to precipitation decrease).
• If you want to know more about projected changes in the project location across a range of GCMs and emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

DPWH road drainage designs already cater for climate change impacts from increased rainfall

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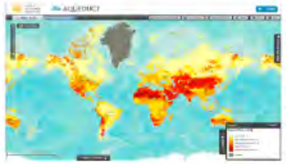
09 MEDIUM RISK

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.

Reducing water availability is not an issue

10

MEDIUM RISK

WIND SPEED INCREASE

Would an increase in average and maximum wind speed 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 wind speed.

ACCLIMATISE COMMENTARY

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

• The project is considered to have high sensitivity to wind and 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 increasing wind speed as well as potential future changes.

2. How could stronger winds affect the project even without future climate change?

• The design and operation of certain infrastructure (e.g. wind turbines) is determined by the prevailing climatic wind conditions.
• Given the energy in the wind is the cube of wind speed, a small change in the wind climate can have substantial consequences for the wind energy available.
• Similarly, small changes could have dramatic consequences for wind related hazards e.g. wind storm damage.
• If our data suggests that there is an existing risk of tropical storms in the region, it will be highlighted elsewhere in the report.

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

• Climate change could alter the geographic distribution and/or the seasonal variability of wind resource.
• Climate model projections remain uncertain and it appears unlikely that mean wind speeds will change by more than the current inter-annual variability.
• Changes in extreme wind speeds associated with extra-tropical and tropical storm are similarly uncertain. However, there have been studies that suggest fewer but more intense events. Stronger storms bring with them an increases risk of coastal storm surge, coastal erosion, wind damage and flooding.
• Given future uncertainty it is advisable to carefully assess past wind speed 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 wind 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 or here for the latest news and information relating to wind and climate change.

I have acknowledged the risks highlighted in this section

Increased wind speeds associated with tropical storms and depressions could create larger coastal storm surges

11

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 current heavy 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 seasonal 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 emissions scenarios please refer to The Nature Conservancy's Climate Wizard for detailed maps and Environment Canada's Canadian Climate Change Scenarios Network for scatter plots of expected changes.

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.

I have acknowledged the risks highlighted in this section

Decreasing precipitation not an issue

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12 The sections above detail all High and Medium risks from Aware™. Selected Low risks are also 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.

HELP AND GLOSSARY:

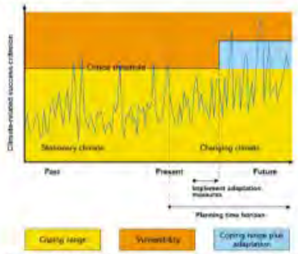
Model agreement and uncertainty:

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 are described as having potentially higher degree of uncertainty when less than 14 out of 16 GCMs agree on the direction and / or a pre-defined magnitude 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:



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].

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 above, 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.

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:

	Report detailing changes in global climate: The Global Climate 2001 - 2010 (PDF)
	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: Working Group II Report "Impacts, Adaptation and Vulnerability"
	IFC report on climate-related risks material to financial institutions: Climate Risk and Financial Institutions. Challenges and Opportunities.

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 (CMIP3) multi-model dataset (Meehl et al., 2007), were downscaled to a 0.5 degree grid.

[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

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": defined as more than 14 out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Climate model projections do not agree": defined as 14 or fewer out of 16 GCMs agreeing on the magnitude (e.g. temperature warming of 2 °C) and / or direction of change (e.g. seasonal precipitation).
"Significant proportion": defined as at least 25% of locations when multiple locations are selected.
"Large proportion": defined as at least 75% of locations when multiple locations are selected.

The above thresholds are used as a means of providing a project-wide risk score where a project may be spread across multiple locations. This requires more than one individual location to be at risk to begin signifying whether there is a risk at the overall project level. However, it is always recommended that individual locations are analysed separately for more accurate, site-specific risk screening. The overall risk score for the project (high, medium or low) is based on a count of high risk topic scores. A project scores overall high risk if greater than or equal to 3 individual risk topics score high. A project scores overall medium risk if between 1 and 2 individual risk topics score high. A project scores overall low risk if none of the individual risk topics score high.

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ANNEX C VULNERABILITY ASSESSMENTS

PR 04 Zamboanga Del Sur Coastal Road

Asset – Road opening and upgrading over 113.90kms. Major elements are:

- **Existing pavements150mm thick, 2 lanes standard for provincial road**
- **Majority of the road sections are gravel**
- **Some sections just mud tracks**
- **22km now being upgraded to provincial road standards**
- **All road sections to be finally upgraded to provincial road standard**
- **13 new bridges to be upgraded and improvements to culverts and cross drains**

Climate Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increased Flooding	Floods already experienced in Municipalities of Dinas, Sagun, Dimataling and Margosatubig	H [21]	H [22]	H	• Damage to road embankments • Scouring of bridge abutments • Floods crossing roads	M	H
Landslides	Reports of past landslides in Municipalities of Tabina, Pitogo, Sagun and Margosatubig	M [23]	H [24]	M	• Blocks and damages road • Debris enters road drainage channels	M	M
Sea Level Rise	Projected sea level rise of 82cm by 2100	M [25]	L	M	• Little impact on road infrastructure • Road alignment well above sea level	H	M

[21] The number of storms >300mm/day are projected to increase to 4 in a year by 2050
[22] Some existing road bridges have inadequate capacity to pass large floods
[23] Basalt flow on top of Coralline limestone
[24] Existing slope protection works alongside the road are inadequate
[25] Road alignment very rarely passes along the coast at sea level

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Temperature Rise	Deterioration of pavement integrity Expansion of steel bridge structures	M [26]	L [27]	M	• Not anticipated to affect traffic movements • Design life of roads not materially affected	H	M
Increased precipitation	Road drainage systems need to be adequately sized	H [28]	H [29]	H	• Road side ditches overtopped • Surcharging of cross drainage pipes • Flood volumes passing under bridges increases	M	H
Increasing Wind Speed	Associated with tropical storms or depressions passing over the area	L [30]	M	M	▪ Coastal storm surges increase in size ▪ Road traffic movements interrupted	M	M

Linkages with other sectors

- DENR for watershed management protection
- NAMRIA for tide level projections
- Provincial and Municipal Government officials for information on local conditions

Conclusion from Vulnerability Assessment

PR04 is most vulnerable to increased precipitation and intensity of rainfall events impacting on road side drainage and road bridge infrastructure

[26] 2^{O}C rise in seasonal temperature projected by 2050
[27] Existing concrete road pavements and gravel roads not impacted by the small temperature rise
[28] Average seasonal rainfall projected to increase by 2050 by some 10% during june/july/august period
[29] Provision for adequate road drainage facilities not always satisfactory
[30] Typhoons are not projected to cross the area but storm surges have been recorded

PR 08 R T Lim to Siocon Road

Asset – Road upgrading over 55.25kms. Major elements are:

- **Short sections of existing pavements 150mm thick with width 4-5m**
- **Majority of the existing road sections are gravel**
- **Ongoing road concreting at Siocon**
- **All road sections to be finally upgraded to national secondary road standard**
- **8 existing steel bridges to be replaced and replacement of 120m spillway**

Climate Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increased Flooding	Particularly at the large river crossing where there is an existing 120m spillway	H [31]	H [32]	H	• Damage to road pavement • Scouring of embankments • Floods closing the road	M	H
Landslides	Road alignment through hilly terrain requiring steep roadside cut faces	H [33]	H [34]	H	• Blocks and damages road • Debris enters road drainage channels	M	H
Sea Level Rise	Projected sea level rise of 82cm by 2100	L [35]	L	L	• Little impact on road infrastructure • Road alignment in the hills	H	L

[31] The number of storms >300mm/day are projected to increase to 2 in a year by 2050
[32] Some existing road bridges have inadequate capacity to pass large floods and spillway susceptible to damage
[33] Steep cut road embankment faces susceptible to erosion
[34] Existing slope protection works alongside the road are inadequate
[35] Road alignment does not pass along the coast at sea level

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Temperature Rise	Deterioration of pavement integrity Expansion of steel bridge structures	M [36]	L [37]	M	• Not anticipated to affect traffic movements • Design life of roads not materially affected	H	M
Increased precipitation	Road drainage systems need to be adequately sized	H [38]	H [39]	H	• Road side ditches overtopped • Surcharging of cross drainage pipes • Flood volumes passing under bridges increases	M	H
Increasing Wind Speed	Associated with tropical storms or depressions passing over the area	L [40]	M	M	▪ Damage to road infrastructure ▪ Road traffic movements interrupted	M	M

Linkages with other sectors

- DENR for watershed management protection
- NAMRIA for tide level projections
- Provincial and Municipal Government officials for information on local conditions

Conclusion from Vulnerability Assessment

PR08 is most vulnerable to increased precipitation and intensity of rainfall events impacting on road side drainage and road bridge infrastructure. As its alignment is through hilly areas there is also vulnerability from landslide events

[36] 2^{O}C rise in seasonal temperature projected during june/july/august period
[37] Concrete road pavements and bridges proposed not impacted by the small temperature rise
[38] Average seasonal rainfall projected to increase by 2050 by some 5% in the September to November period
[39] Provision for adequate road drainage facilities not always satisfactory
[40] Typhoons are not projected to cross the area

PR 09 Lutiman to Guicam to Olutanga Road

Asset – Road upgrading gravel to concrete over 37.49kms. Major elements are:

- **Some existing concrete pavements to provincial road standard**
- **Majority of the road sections are gravel**
- **Existing road geometry elements not meeting DPWH standards**
- **1 existing concrete bridge to be upgraded**

Climate Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increased Flooding	No records of serious flooding issues in the past	H [41]	H	H	• Damage to road embankments • Scouring of bridge abutments • Floods crossing roads	M	H
Landslides	Road alignment across rolling terrain but some roadside drains cut into steep side slopes	M [42]	H [43]	M	• Blocks and damages road • Debris enters road drainage channels	M	M
Sea Level Rise	Projected sea level rise of 82cm by 2100	H [44]	M	H	• Ferry terminals at either end of the Guicam channel inundated at high tides	M	H

[41] The number of storms >300mm/day are projected to increase to 4 in a year by 2050
[42] Basalt flow on top of Coralline limestone
[43] Existing slope protection works alongside the road are inadequate
[44] Road at the Guicam channel ferry terminals to be raised

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Temperature Rise	Deterioration of pavement integrity Thermal expansion of bridge components	M [45]	M [46]	M	• Concrete road pavements not affected • Suitable designs need to be considered for thermal expansion of bridge components	H	M
Increased precipitation	Road drainage systems need to be adequately sized	H [47]	H [48]	H	• Road side ditches overtopped • Surcharging of cross drainage pipes • Flood volumes passing under bridges increases	M	H
Increasing Wind Speed	Associated with tropical storms or depressions passing over the area	L [49]	H [50]	M	▪ Coastal storm surges increase in size ▪ Road traffic movements across the Guicam bridge could be interrupted	M	M

Linkages with other sectors

- DENR for watershed management protection
- NAMRIA for tide level projections
- Provincial and Municipal Government officials for information on local conditions

Conclusion from Vulnerability Assessment

PR09 is most vulnerable to increased precipitation and in relation to the Guicam channel crossing the roads at the ferry terminals are vulnerable to projected sea level rises and storm surges.

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[45] $2^{O}C$ rise in seasonal temperature projected by 2050
[46] Due to the length of the bridge thermal expansion is a consideration to be taken account for
[47] Average seasonal rainfall projected to increase by 2050 by some 22% during june/july/august period
[48] Provision for adequate road drainage facilities not always satisfactory
[49] Typhoons are not projected to cross the area but storm surges have been recorded
[50] The Guicam channel bridge will be exposed to storm surges from tropical depressions which also raises the tide levels

PR 10 Lanao to Pagadian to Ipil to Zamboanga City Road

Asset – Concreting of 2 lane hard shoulders over 80kms of National High. Major elements are:

- **Existing 2 lane concrete pavement with 1.5m shoulders and 90 bridges**
- **Majority of the existing bridges and culverts are concrete**
- **Ongoing road widening between Pagadian and Dumalinao**
- **Slope stability issues in some places**
- **Upgrading/rehabilitation of 13.29km Vitali – Tagasilay bypass section**

Climate Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increased Flooding	Some large river crossings liable to flooding	H [51]	H [52]	H	• Damage to road pavement • Scouring of embankments • Floods closing the road	M	H
Landslides	Critical existing landslide areas between Pangi and Picanan, and Vitali – Tagasilay bypass	H [53]	H [54]	H	• Blocks and damages road • Debris enters road drainage channels	M	H
Sea Level Rise	Projected sea level rise of 82cm by 2100	M [55]	L	M	• Little impact on road infrastructure • Road alignment in the hills	H	M

[51] The number of storms >300mm/day are projected to increase to 2 in a year by 2050
[52] Some existing road bridges and culverts have inadequate capacity to pass large floods
[53] Regular landslide events within these areas
[54] Existing slope protection works alongside the road are inadequate. May need to realign the road
[55] Road alignment very rarely passes along the coast at sea level

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Temperature Rise	Deterioration of pavement integrity Expansion of steel bridge structures	M [56]	L [57]	M	• Not anticipated to affect traffic movements • Design life of concrete roads not materially affected	H	M
Increased precipitation	Road drainage systems need to be adequately sized	H [58]	H [59]	H	• Road side ditches overtopped • Surcharging of cross drainage pipes • Flood volumes passing under bridges increases	M	H
Increasing Wind Speed	Associated with tropical storms or depressions passing over the area	L [60]	M	M	▪ Damage to road infrastructure ▪ Road traffic movements interrupted	M	M

Linkages with other sectors

- DENR for watershed management protection
- NAMRIA for tide level projections
- Provincial and Municipal Government officials for information on local conditions

Conclusion from Vulnerability Assessment

PR10 is most vulnerable to increased precipitation and intensity of rainfall events impacting on road side drainage and road bridge infrastructure. As part of its alignment is through two critical hilly areas there is also vulnerability from landslide events

[56] 2.2^{O}C rise in seasonal temperature projected during june/july/august period
[57] Concrete road pavements and bridges proposed not impacted by the small temperature rise
[58] Average seasonal rainfall projected to increase by 10%
[59] Provision for adequate road drainage facilities not always satisfactory
[60] Typhoons are not projected to cross the area

PR 11 Pagadian to Tukuran Coastal Road

Asset – Road opening and upgrading over 18.67kms. Major elements are:

- **Existing 2 lane road in Pagadian**
- **Existing gravel road sections and new alignment sections to be included**
- **Some sections just mud tracks**
- **2 existing bridges and 3 new bridges required**
- **New alignment next to the coast but to avoid mangrove areas**

Climate Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Increased Flooding	Floods already experienced in Municipalities of Tukuran and Labangan	H [61]	H [62]	H	• Damage to road embankments • Scouring of bridge abutments • Floods crossing roads	M	H
Landslides	Flat coastal road not passing through any landslide areas	L [63]	L	L	• Little impact on road infrastructure • Debris enters road drainage channels	H	L
Sea Level Rise	v	H [64]	H	H	• Road alignment and elevation needs to take account of sea level rises • Road bridge freeboard needs adjusting	M	H

[61] The number of storms >300mm/day are projected to increase to 4 in a year by 2050
[62] Some existing road bridges have inadequate capacity to pass large floods
[63] Area along road alignment not prone to landslides
[64] Road alignment very close to sea shore

Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Temperature Rise	Deterioration of pavement integrity Expansion of steel bridge structures	M [65]	L [66]	M	• Not anticipated to affect traffic movements • Design life of roads not materially affected	H	M
Increased precipitation	Road drainage systems need to be adequately sized	H [67]	H [68]	H	• Road side ditches overtopped • Surcharging of cross drainage pipes • Flood volumes passing under bridges increases	M	H
Increasing Wind Speed	Associated with tropical storms or depressions passing over the area	H [69]	H	H	▪ Coastal storm surges increase in size ▪ Road traffic movements interrupted	M	H

Linkages with other sectors

- DENR for watershed management protection
- NAMRIA for tide level projections
- Provincial and Municipal Government officials for information on local conditions

Conclusion from Vulnerability Assessment

Where the PR11 road alignment is very close to the shore line it is most vulnerable to sea level rises and storm surges associated with tropical depressions. Increased precipitation and rainfall intensity will impact on road drainage requirements and road bridge infrastructure

[65] 2^{O}C rise in seasonal temperature projected by 2050
[66] Existing concrete road pavements and gravel roads not impacted by the small temperature rise
[67] Average seasonal rainfall projected to increase by 2050 by some 10% during june/july/august period
[68] Provision for adequate road drainage facilities not always satisfactory
[69] Typhoons are not projected to cross the area but a storm surge in 2006 passed over the existing coastal road to a height of 0.3m at Tukuran

ANNEX D VULNERABILITY ASSESSMENT SCORING MATRICES

Sensitivity of system to climate threat	Exposure of system to climate threat: Very Low	Low	Medium	High	Very High
Very High	Medium	Medium	High	Very High	Very High
High	Low	Medium	Medium	High	Very High
Medium	Low	Medium	Medium	High	Very High
Low	Low	Low	Medium	Medium	High
Very Low	Very Low	Low	Low	Medium	High

Adaptive Capacity	Impact: Very Low Inconvenience (days)	Low Short disruption to system function (weeks)	Medium Medium term disruption to system function (months)	High Long term damage to system property or function (years)	Very High Loss of life, livelihood or system integrity
Very Low Very limited institutional capacity and no access to technical or financial resources	Medium	Medium	High	Very High	Very High
Low Limited institutional capacity and limited access to technical and financial resources	Low	Medium	Medium	High	Very High
Medium Growing institutional capacity and access to technical or financial resources	Low	Medium	Medium	High	Very High
High Sound institutional capacity and good access to technical and financial resources	Low	Low	Medium	Medium	High
Very High Exceptional institutional capacity and abundant access to technical and financial resources	Very Low	Low	Low	Medium	High

ANNEX E DPWH MEMORANDUM ON UPGRADING DESIGN STANDARDS FOR ADAPTATION TO CLIMATE CHANGE

Republic of the Philippines
DEPARTMENT OF PUBLIC WORKS AND HIGHWAYS
OFFICE OF THE SECRETARY
Manila

[illegible]

MEMORANDUM

FOR: Undersecretaries
Assistant Secretaries
Bureau Directors
Regional Directors
Service Directors
Project Directors/Managers
District Engineers

SUBJECT: Upgrades on Flood Control and Road Drainage Standards

In line with the Department's continuing effort to upgrade the design standards for adaptation to climate change to minimize flooding, all concerned offices shall adopt the following guidelines in the design of flood control and road drainage facilities/structures:

1. The minimum flood return periods to be used for the design of flood control and road drainage facilities shall be as follows:

   a. Drainage pipes — 15-year flood with sufficient freeboard to contain the 25-year flood

   b. Culverts
      i. Box — 25-year flood with sufficient freeboard to contain the 50-year flood
      ii. Pipe — 15-year flood with sufficient freeboard to contain the 25-year flood

   c. Esteros/creeks — 15-year flood with sufficient freeboard to contain the 25-year flood

   d. Rivers — For principal and major rivers: (40 sq. km drainage area and above) 50-year flood with sufficient freeboard to contain the 100-year flood

      For small rivers: (Below 40 sq. km drainage area) 25-year flood with sufficient freeboard to contain the 50-year flood

2. The minimum spacing of drainage manholes/inlets shall be 20 meters.

3. The minimum size of drainage pipes shall be 910 millimeters in diameter.

4. The provision of underground detention tanks as part of storm water management system, particularly in flood prone urban areas to temporarily store flood water shall be a consideration in the design of the drainage system.

The Bureau of Design shall integrate the above-mentioned guidelines in the updating of the DPWH Design Guidelines, Criteria and Standards.

For strict compliance.

ROGELIO L. SINGSON
Secretary

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