CLIMATE CHANGE ASSESSMENT

I. BASIC PROJECT INFORMATION

Project Title:	Outer Island Maritime Infrastructure Project
Project Cost ($ million)**:**	20
Location:	Nui, Tuvalu
Sector:	Transport
Theme:	Water Transport [Nonurban]
Brief Description:	The Climate Risk and Vulnerability Assessment (CRVA) for the proposed Nui Boat Harbour found that components of the project are vulnerable to climate change hazards. The blockwork quay wall is also exposed to overtopping from sea-level rise, storm surge, and wave climate. All three proposed options for the landside infrastructure (coastal protection, sportsfield area, and land reclamation) face exposure to impacts of sea-level rise, wave climate, and wind climate. The effects of these climate impacts on the project may render the Harbour unusable in extreme events due to damage or changed operations.

Source: Asian Development Bank.

II. SUMMARY OF CLIMATE CHANGE FINANCE

Project Financing		Climate Finance	
Source	**Amount** ($ million)	**Adaptation** ($ million)	**Mitigation** ($ million)
Asian Development Bank	**20.0**	**3.1**	**0.0**
Special Funds resources (ADF grant)	20.0	3.1	0.0

ADF = Asian Development Fund.
Source: Asian Development Bank.

III. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

A. Sensitivity of Project Component(s) to Climate or Weather Conditions and the Sea Level

1. **Blockwork quay wall.** Sea-level rise plus storm surge and/or wave climate could potentially overtop the quay wall if it not sufficiently high.
2. **Turning basin.** There are no significant vulnerabilities to the turning basin under either of the two design options.
3. **Landside Infrastructure Option A (Coastal Protection).** This option is exposed to impacts of sea-level rise, wave climate, and wind climate as it is not located inland (as is Option B).
4. **Landside Infrastructure Option B (Sportsfield Area).** This option is the least exposed to impacts of sea-level rise, wave climate, and wind climate as it is located inland. However, consequences on the Harbour from extreme events may still damage the landside infrastructure.
5. **Landside Infrastructure Option C (Land Reclamation).** This option is the most exposed to direct impacts of sea-level rise, wave climate, and wind climate as it is not located inland (like Option B) and it lacks a revetment that could shield it from waves hitting the island from the south/southwest.

B. Climate Risk Screening (2020-2075)

1. **Sea-level rise.** Regular inundation due to SLR may render the Harbour unusable.
2. **Wave climate.** SLR plus wave heights result in regular wave overtopping of the Harbour and landside infrastructure, impacting operating procedures.
3. **Storm surge.** SLR plus increased storm surge heights result in regular wave overtopping of the Harbour and landside infrastructure, impacting operating procedures.
4. **Wind climate.** Changes in mean wind direction, seasonal peak wind gusts, and winds during cyclones impact the operating procedures of the Harbour.

5. **Ocean acidification.** Ocean acidification slightly diminishes structural integrity of pH-sensitive components of the Harbour.
6. **Sea surface temperature.** Increased sea surface temperature may slightly diminish structural integrity of temperature-sensitive components of the Harbour.
7. **Air temperature.** Extreme heat may slightly diminish structural integrity of temperature-sensitive components of the Harbour.
8. **Rainfall.** There is little to no projected change of significance in rainfall.

Climate Risk Classification: {*low*} {*medium*} ***{high}***

C. Climate Risk and Adaptation Assessment

Methodology

To describe current and future conditions in Nui, the CRVA used the Australian Bureau of Meteorology (BoM) and Commonwealth Scientific and Industrial Research Organization (CSIRO) 2015 and 2014 country reports on Tuvalu, completed under the Australian-supported Pacific Climate Change Science Program (PCCSP) (BoM and CSIRO 2015). The PCCSP information is supplemented by a literature review of more recent publications.

The team assembled best available observed and projected data for each climate driver. These model outputs assessed individual climate change drivers under different assumptions regarding base year and timeframes. To accommodate these variations, the CRVA takes a conservative approach by using values that represent outer-bound risk during the service life of the harbour. For example, if a climate change scenario is provided for both 2070 and 2100, then the scenario for 2100 was selected.

The CRVA summarizes current climate conditions and future climate change scenarios for the Nui Boat Harbour by 2075 (assuming a project design life of 50 years from the end of the construction date of 2025) under a range of future greenhouse gas emissions levels. These future climate change scenarios include analyses of primary and secondary climate drivers, and the degree of change from baseline levels of each driver.

Summary of climate change scenarios by 2075

Climate Driver	**Projection Value by 2075**
Primary Drivers (under RCP 8.5)	
Mean sea level	+0.65 m above mean sea level +0.75 m including interannual variation
Extreme storm surge wave level	+2 m above mean sea level
Wave climate	Seasonal variation: December to March • -0.15 to -0.1 m change in mean wave height • No change in mean wave direction June to September • +0.05 to 0.1 m change in mean wave height • No change in mean wave direction
Wind climate	Change to current wind speeds: • Annual: +3.6% • Dec–Feb: -1.8% • Mar–May: +0.8% • Jun–Aug: +7.9% • Sep–Nov: +7.1% Anticipated lower number of cyclones with increased intensity
Secondary Drivers (under RCP 8.5)	
Ocean acidification	2.1 – 2.8 Ωar
Sea surface temperature	+2.5°C
Air temperature	+3.1°C
Rainfall	No projected change of significance

The CRVA applied the values derived for the climate scenario primary drivers to determine the likelihood of an asset facing exposure to climate change risks and the magnitude of consequences if the asset is exposed. These likelihood and consequence scores are multiplied together to create an overall risk score. The risk levels of secondary climate drivers are not scored, but rather considered qualitatively within the overall decision-making framework.

Results

Sea-level rise and wave climate. While the risk ratings (a combination of the likelihood and consequence of a climate impact) assigned to sea-level rise alone were assessed to be broadly similar, the three design options have markedly different levels of exposure to sea-level rise plus wave impacts. Without risk management measures built into the design, Options A and C are more exposed to the direct impacts of sea-level rise and wave climate than Option B, which has key infrastructure placed inland away from the immediate coastal zone. However, given the dominant wave direction from the south and southwest, Option A is less exposed than Option C due to the presence of a rock revetment, which serves as coastal protection.

Wind exposure. There are overall minor differences in wind exposure between the three options. Option B is slightly less exposed to wind climate due to being located inland.

Secondary drivers. For the majority of the secondary climate change drivers, the climate change risk assessment was not significantly different for the three options, given the similar levels of exposure. The ratings for air temperature were modified slightly to reflect the very minor differences in temperature between infrastructure located on the lagoon versus on the atoll. In addition, the risk ratings for ocean acidification were assessed to be slightly different due to the extremely small variations in exposure to ocean spray of the landside infrastructure.

Recommendations

The Project Team considered a broad suite of recommended actions to the array of climate change risks outlined in the previous section to extend the life and increase the resilience of Nui Boat Harbour. The table below outlines the climate risk management measures recommended for incorporation into the harbour expansion.

Summary of recommended climate risk management measures

Design Element	Recommended Risk Management Response
Quay wall	Incorporate flexibility into the quay design to allow for future reinforcement, such as allowing additional blocks to be placed on the wall to accommodate future sea-level rise of up to 0.65m. Ensure that foundations are sufficient to allow for extra blocks and that toppling factors have been included in the design.
Boat ramp	Use flexmat material to accommodate changes in the beach profile from changed sediment transport regimes due to climate change.
Landside infrastructure	Ensure that there is an option to increase the height of the landside infrastructure foundation to accommodate future sea-level rise of up to 0.65m. Build coastal protection structures that shield landside infrastructure from impacts of sea-level rise, storm surge, and wave run-up. Ensure that these coastal protection structures can readily incorporate future adaptation needs without significant cost or effort, such as the ability to add additional height to accommodate future sea-level rise.
Turning basin	There are no significant vulnerabilities that require mitigation actions under either of the two design options.

D. Climate Risk Screening Tool and/or Procedure Used

The CRVA used a custom climate vulnerability assessment method. Risk is evaluated based on the degree of **likelihood** of risk occurrence and the level of anticipated **consequence** of a given event. These two factors are combined to form a risk matrix, which rates events based on both the likelihood and consequence.

Levels of risk likelihood assuming risk is not mitigated

Level	Description	Likelihood of Occurrence
L1	Rare	<10%
L2	Unlikely	10-50%
L3	Possible	50-70%
L4	Likely	70-99%
L5	Almost Certain	Over 99%

Levels of risk consequence assuming risk is not mitigated

Level	Description	Consequence
C1	Negligible	Insignificant impact
C2	Minor	Low impact, localized
C3	Moderate	Medium impact, potentially reversible
C4	Major	Significant long-term impact, potentially irreversible
C5	Extreme	Major, irreversible impact

Risk assessment matrix

		Consequence				
		C1	**C2**	**C3**	**C4**	**C5**
Likelihood	**L1**	**Low**	**Low**	**Low**	**Moderate**	**Moderate**
	L2	**Low**	**Low**	**Moderate**	**Moderate**	**High**
	L3	**Low**	**Low**	**Moderate**	**High**	**Extreme**
	L4	**Low**	**Moderate**	**Moderate**	**High**	**Extreme**
	L5	**Low**	**Moderate**	**High**	**Extreme**	**Extreme**

Source: Asian Development Bank.

IV. CLIMATE ADAPTATION PLANS WITHIN THE PROJECT

Adaptation Activity	Target Climate Risk	Estimated Adaptation Costs ($ million)	Adaptation Finance Justification
Quay wall	Sea-level rise	$0.5	Incorporate flexibility into the quay design to allow for future reinforcement, such as allowing additional blocks to be placed on the wall to accommodate future sea-level rise of up to 0.65m.
	Sea-level rise	$0.5	Ensure that foundations are sufficient to allow for extra blocks and that toppling factors have been included in the design.
Boat ramp	Sea-level rise	$0.1	Use flexmat material to accommodate changes in the beach profile from changed sediment transport regimes due to climate change.
Landside infrastructure	Sea-level rise, increase cyclones	$0.8	Ensure that building up the height of the landside infrastructure foundation to accommodate future sea-level rise of up to 0.65m.
	Sea-level rise, increase cyclones	$1.2	Build coastal protection structures that shield landside infrastructure from impacts of sea-level rise, storm surge, and wave run-up. Ensure that these coastal protection structures can readily incorporate future adaptation needs without significant cost or effort, such as the ability to add additional height to accommodate for future sea-level rise and increased cyclones.
Total		**$3.1**	

Source: Asian Development Bank.

The harbor has a critical function in disaster risk reduction (DRR). The DRR measures included in this project are landside infrastructure improvements to reduce the impact of extreme weather events, mainly cyclones, that frequently occur in Nui. Specific DRR measures include raising the height of the landside infrastructure foundation and building coastal protection structures. . The combined costs of these interventions is $2.0 million.

V. ASSESSMENT OF RESIDUAL RISKS AFTER THE PROJECT

Type of Activity	Identified Impact	Residual Risk	Justification Not to Be Included Within the Project
Adaptation	Blockwork quay wall.	Sea-level rise plus storm surge and/or wave climate could potentially overtop the quay wall if it not sufficiently high – beyond the economic assessment period of the project	If the quay wall is raised to a level that will accommodate high sea-level rise projections to the end of the century, then the usability of the wharf in the near-term decades of the project lifetime (50 years) will be impacted. Transfer of goods and people will be much more difficult as the wharf will be too high for current tidal conditions. Importantly, the quay will be constructed using techniques that will enable rapid and cost-effective raising in the future without the need for complete reconstruction or strengthening of foundations.