APPENDIX K CLIMATE CHANGE ASSESSMENT

K CLIMATE CHANGE ASSESSMENT METHODOLOGY

The key objective of this assessment is to understand the potential high-level physical risks to the Project from climate change. The methodology constituted of three (3) major steps as given below:

1. Step 1: Desktop Review of the baseline natural hazards

For the first step, a desktop-based review of prominent natural hazards was undertaken at the Project locations offshore as well as onshore. The natural hazards are then evaluated and categorized based on potential to cause damage to the natural environment due to intensity / severity and frequency.

2. Step 2: Evaluation of climate change projections

This second step involved evaluation projections for various climate variables such as temperature, sea level and precipitation. The climate change projections data involved multi-model mean climate change projections published under Coupled Model Intercomparison Project 6 (CMIP-6)[71], which is a recognized standard by the Intergovernmental Panel on Climate Change (IPCC). The climate change scenarios for which the data was evaluated involved RCP 8.5 over timelines of 2030 and 2050.

3. Step 3: Qualitative estimation of future hazards and physical risks

The third step involved use of the future projections on natural hazards to evaluate the potential risks in future. Qualitative estimation of future natural hazards was also conducted based on changes in indicator climate variables which are likely to affect a particular natural hazard, and baseline natural hazards in cases where future hazard level was not readily available. Hazard level in combination with exposure and vulnerability levels are used to estimate the physical risk to the Project.

It should be noted that this is a high-level review of publicly available information, and no detailed site-specific analysis or modelling has been undertaken. Hence, further investigation may be warranted to quantify the risks in more detail for consideration of adaptation measures.

Further, the qualitative evaluation of the impacts of climate change on natural hazards is an exercise of educated speculation and professional judgement. The likely changes in natural hazards presented here are based on the possible relation between the natural hazards and climatic parameters.

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[71] Under the World Climate Research Programme (WCRP) the Working Group on Coupled Modelling (WGCM) established the Coupled Model Intercomparison Project (CMIP) as a standard experimental protocol for studying the output of coupled atmosphere-ocean general circulation models (AOGCMs). CMIP provides a community-based infrastructure in support of climate model diagnosis, validation, intercomparison, documentation and data access. This framework enables a diverse community of scientists to analyze GCMs in a systematic fashion, a process which serves to facilitate model improvement. CMIP6 is the latest phase of the project, and it involves a large number of modeling groups from around the world. It involves more modeling groups, uses advanced emissions scenarios considering socioeconomics, and features more sophisticated climate models. CMIP6 offers a wider range of experiments for a deeper look at climate change.

What are the Representative Concentration Pathways (RCP)?

RCPs usually refer to the portion of the concentration pathway extending up to the year 2100, for which Integrated Assessment Models produced corresponding emission scenarios. Each RCP provides only one of many possible scenarios that would lead to the specific radiative forcing characteristics. The term “pathway” emphasizes that not only the long-term concentration levels are of interest, but also the trajectory taken over time to reach that outcome.

Four (4) RCPs produced from Integrated Assessment Models were selected from the published literature and are used in the Fifth Intergovernmental Panel on Climate Change (IPCC) Assessment as a basis for the climate predictions and projections are as follows:

RCP2.6 One pathway where radiative forcing peaks at approximately 3 W m^{-2} before 2100 and then declines (the corresponding ECP assuming constant emissions after 2100);

RCP4.5 and RCP6.0 Two intermediate stabilization pathways in which radiative forcing is stabilized at approximately 4.5 W m^{-2} and 6.0 W m^{-2} after 2100 (the corresponding ECPs assuming constant concentrations after 2150);

RCP8.5 One high pathway for which radiative forcing reaches greater than 8.5 W m^{-2} by 2100 and continues to rise for some amount of time (the corresponding ECP assuming constant emissions after 2100 and constant concentrations after 2250).

K.1 HAZARD CATEGORIZATION

Hazard is defined by the IPCC AR6[72] as:

The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Open access databases have been reviewed to assess the hazard level at the Project site. As different sources present different classifications, ERM has reorganized those into three levels: low, medium, and high.

The table below presents the classification of the hazard level used in this report.

TABLE K-1 CATEGORIZATION OF NATURAL HAZARDS

Hazard (Criteria for Categorization)	**Report Categorization**
Water Availability	
Water Stress Source: WRI-Aqueduct Water Risk Atlas 4.0 *Based on the ratio of total water demand to available renewable water resources (surface and groundwater)*	Low: <20%
	Medium: 20-40%
	High: >40%
Inter Annual Variability Source: WRI-Aqueduct Water Risk Atlas *(Based on coefficient of variability (CV) as ratio of standard deviation of the available water and the mean available water during the period of 1979-2019 on monthly and annual basis)*	Low: <0.25
	Medium: 0.25-0.5
	High: >0.5
Seasonal Variability Source: WRI-Aqueduct Water Risk Atlas *(Based on coefficient of variability (CV) as ratio of standard deviation of the annual available water and the annual mean available water during the period of 1979-2019)*	Low: <0.33
	Medium: 0.33-0.66
	High: >0.66

[72] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.

Hazard (Criteria for Categorization)	Report Categorization
Water Depletion Source: WRI-Aqueduct Water Risk Atlas *(Based on ratio of total water consumption to available renewable water resources (surface and groundwater))*	Low: <5%-25%
	Medium: 25-50%
	High: >50%
Floods Inland and Coastal	
Riverine Flood Risk Source: WRI-Aqueduct Water Risk Atlas *(Based on population exposed to floods per 1,000 people)*	Low: 0-2/ 1,000
	Medium: 2-6/ 1,000
	High: > 6/ 1,000
Coastal Flood Risk Source: WRI-Aqueduct Water Risk Atlas *(Based on population exposed to floods per 1,000,000 people)*	Low: 0-9/ 1,000,000
	Medium: 9-300/ 1,000,000
	High: >300/ 1,000,000
Flood Hazard Map Source: WRI-Aqueduct Flood Tool *(Based on depth of inundation in meters)*	Low: ≤0.5m
	Medium: 0.5-1.5m
	High: > 1.5m
Flood Hazard Map Source: FM Global *(Based on probability of flood occurring each year for a given flood return period)*	Medium
	High
Landslides	
Landslides Susceptibility Source: Think Hazard[73] *(The classify hazards based on probabilistic data in Think Hazard)*	Low
	Medium
	High
Landslides Hazard	Low

[73] GIS processing International Centre for Geohazards /NGI. Preprocessing for ThinkHazard! conducted by GFDRR

Hazard (Criteria for Categorization)	Report Categorization
Source: Think Hazard[74] *(The classify hazards based on probabilistic data in Think Hazard)*	Medium High
Extreme Heat Source: Think Hazard *(Based on widely accepted heat stress indicator, the Wet Bulb Globe Temperature (°C))*	Low: under 28°C Medium: between 28 and 32°C High: above 32°C
Cyclone and Hurricane Intensity Source: UNEP global Risk Data Platform *(Cyclone categories based on damage potential as classified by Saffir-Simpson Scale)*	Low: 119-153 km/h Medium: 154-177 km/h High: above 178 km/h
Wind Speed Source: Global Wind Atlas *(Based on damage potential of wind speed (m/s) with reference to the Beaufort's scale)*	Low: ≤ 11 m/s Medium: 11-21 m/s High: ≥ 21 m/s
Sea Level Rise	Low: 1-50cm

74 GIS processing International Centre for Geohazards /NGI. Preprocessing for ThinkHazard! conducted by GFDRR

Hazard (Criteria for Categorization)	Report Categorization
Source: CLIMsystems, Sea Level Rise for Cities *(Combined processes of local (absolute) sea level rise and local vertical land movement expressed in centimetres)*	Medium: 51-150cm
	High: 151-200cm
Lightning Source: Lighting Imaging Sensor (LIS) on TRMM Science Data *(Lightning Density average between 1998 and 2013 expressed as Flashes per km^2)*	Low:1-20
	Medium: 21-60
	High: >61

K.1.1 EXPOSURE AND VULNERABILITY CATEGORIZATION

Exposure and vulnerability of the Project are necessary to determine the risk level.

Vulnerability is defined by the IPCC AR6[75] as:

The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements, including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Exposure is defined as:

The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected.

Details of the Project location, design of components, buildings and infrastructures, activities of Project personnel are used to determine the exposure of the Project to the hazards. Vulnerability can then be assessed in more detail, drawing on Project design information and standards together with any other factors which may provide resilience, e.g., pre-existing flood prevention measures.

The combination of exposure and vulnerability is categorized in three levels: low, medium, high.

K.1.2 RISK CATEGORIZATION

Risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Such interaction is complex and subject to uncertainty, therefore, ERM has performed a qualitative evaluation based on professional judgement.

The relation between hazard, vulnerability and exposure is presented in the table below.

TABLE K-2 CLIMATE CHANGE RISK LEVEL

		Hazard		
Exposure x Vulnerability		**Low**	**Medium**	**High**
	Low	**Low**	**Low**	**Low**
	Medium	**Low**	**Medium**	**Medium**
	High	**Medium**	**High**	**High**

[75] IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., doi:10.1017/9781009325844.