CLIMATE CHANGE ASSESSMENT

I. BASIC PROJECT INFORMATION

Project Title:	49055-007-PAK: Balakot Hydropower Development Project
Project Cost ($ million):	$755 million
Location:	Khyber Pakhtunkhwa, Pakistan
Sector:	Energy
Theme:	Large Hydropower Generation
Brief Description:	The project will provide financing to construct a 300 megawatt run-of-river hydro power plant located on the Kunhar river in Mansehra District, Khyber Pakhtunkhwa province of Pakistan.

Source: Asian Development Bank.

II. SUMMARY OF CLIMATE CHANGE FINANCE

Project Financing		**Climate Finance**	
Source	**Amount** ($ million)	**Adaptation** ($ million)	**Mitigation** ($ million)
Asian Development Bank			
Ordinary capital resources (regular loan)	$300	$2.79	$297.21
Asian Infrastructure Investment Bank	$280	$2.61	$277.39
Government	$175	$1.63	$173.37

Source: Asian Development Bank.

III. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

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

1. **Generation.** Changes in water availability may affect pattern and level of power generation and the long-term economic performance. Increased sedimentation may require additional operation and maintenance.
2. **Structural components.** Extreme weather events such as flood and landslide may damage structural components.

B. Climate Risk Screening

1. **Flood and landslide.** Project is sited in area with high landslide and flood risk.
2. **Change in rainfall pattern.** Uncertain water availability may affect lifetime and performance of investments, although the long-term forecast is of increased overall resource availability.

Climate Risk Classification: High

C. Climate Risk and Adaptation Assessment

The Kunhar River has a total catchment area of 2,629 km^2 and length of the main reach of about 177 km. Snowmelt from the Kunhar basin contributes about 65% to the total discharge of the Kunhar River and from 20% to 40% of the Jhelum River at Mangla. The Kunhar basin has an average annual precipitation of about 1,550 mm, with two peak periods. The first peak occurs in the upper part of the basin in the month of March associated to the Western Disturbances system in winter and the second in the summer period with the monsoon, affecting mostly the lower part of the basin.

The change of precipitation and temperature are the most important factors for the project area. The volume and timing of water flowing within the Kunhar River has a critical influence on a wide variety of economic and social activities in the region.

Climate change in the Kunhar basin is expected to increase variability of precipitation events and may pose significant problems for hydroelectric generation. The increased variability of precipitation is expected to result in more severe and frequent floods and droughts, seasonal offsets, or changes to timing and

magnitude of precipitation for traditional rainy and dry seasons and peak snowmelt. Climate modelling in the literature shows a maximum rise in the northern areas of Pakistan, central and south Punjab, and lower parts of the Khyber Pakhtunkhwa province. However, mixed trends are projected for precipitation over different regions of Pakistan.

A project climate assessment was undertaken using precipitation, and maximum and minimum surface air temperatures outputs from the Hadley GCM 3 (HadCM3) and NorESM1-M (NORESM) models. Bias correction was applied to the downscaled data. Annual and monthly model types were selected for calibration of 30 years of data representing current climate conditions (1971-2000). Air surface temperature (maximum and minimum) and precipitation were simulated for the period of calibration. RCP8.5 and RCP4.5 scenarios were selected for the NORESM model, and SRES A2 and B2 scenarios for HadCM3. Using the climate model results, the HEC-HMS hydrological model was used to simulate future river flow with the SCS-CN and temperature index methods.

A rise in T_{max} and T_{min} is predicted in the future under all scenarios by both models. The overall results of the downscaled precipitation in the Kunhar river basin show an increase in the annual mean for the future periods under all scenarios of both models.

River flow is expected to increase during summer and autumn months and decline in the winter and spring months. An increase in average flow is expected due to the increase in mean annual precipitation, while an increase in high flow is expected due to the increase in summer precipitation (monsoon season). By the 2080s, river flow is expected to increase by about 40% in summer and about 70% in autumn months while it is expected to decline about 15% in winter and spring months relative to historical levels. The basin may not only face an increase in frequency and magnitude of floods, but also a shift of high flows period from June to July. The sediment load is expected to increase by up to 40% by the 2080s.

The Kunhar river basin is expected to experience an increase of landslide intensity and of erosion and sediment transport in summer and fall seasons. This may be primarily a result of continued declines in the snowpack and projected increases in the frequency and intensity of heavy precipitation events. In winter and spring seasons, these processes are expected to become less important in the future due to diminishing streamflow. Natural climate variability in this region has a strong effect on landslides and sediment processes and will continue to influence these processes in the future.

Potential project vulnerabilities were identified and assessed:

- **Resource availability.** Water availability has a direct impact on power generation output and in upstream water use. The incremental increase in upstream consumptive water use due to climate change is likely to be very low. Annual energy production is expected to increase about 8% for the future, while energy in (daily) peak periods is expected to decrease about 5%. Changes in the pattern and level of precipitation were incorporated into the economic and financial analysis to ensure that the project viability is robust to potential future climate changes.
- **Precipitation and flood events:** The structural components may be damaged by extreme flood events. Under climate change, it is expected that probable maximum flood may increase by up to 35% in the long run relative to historical levels. The dam design is deemed adequately resilient to such flooding, even in the event of overtopping, due to the design incorporating seismic strengthening.
- **Sediments:** Results indicate that there could be a meaningful increase in sediment flow to the river under all scenarios. The projected sediment rate variation in the upstream Kunhar river basin may directly impact the Balakot reservoir and could, therefore be considered a potential project vulnerability.
- **Landslide and avalanches:** The Kunhar river basin region is expected to experience increases in the intensity of landslides and the rate of erosion and sediment transport in summer and fall season primarily as a result of continued decline in the snowpack and projected increases in the frequency and intensity of heavy precipitation events. These are not expected to cause a direct impact on the

magnitude of the landslides in the reservoir, landslides and avalanches are thought to be the key driving factors of sediment peak loads in the Kunhar river.

The most relevant climate related risk for the project is therefore assessed to be the increase in sediment load in the Kunhar river. However, the anticipated impact is significant, leading to an increase in operation and maintenance costs, and to a likely marginal decrease in energy generation due to more frequent flushing operations of the reservoir.

The following adaptation measures are incorporated into the project:

- Integrated cascade operation and management of the hydropower schemes in the Kuhnar river, with a particular view to water use and sediment flushing operations;
- Design of the project structures with safety allowance to withstand increased climate-related risks, as is the case with the dam and the sediment by-pass tunnel. The seismically strengthened design has the co-benefit of improved resilience against flood and landslide-induced waves in the reservoir, as well as upstream dam failure. The sediment bypass tunnel will allow the scheme to cope with increased sedimentation risk without anticipated significant costs;
- Implementation of a climate monitoring and coordination framework, including a meteorological monitoring network upstream of the dam site at suitable locations (including both high and low elevation areas). It is recommended that a permanent organization is constituted for the Kunhar river water users to jointly share, manage and maintain the monitoring network;
- Update of the project climate modelling - uncertainty in current models an adaptive management approach is also necessary for climate change. Since a subset of models participating in CMIP6 will be running experiments at ~25 km or finer horizontal resolution (i.e. current RCM resolution), the results of the updated CMIP6 should be utilized to update risk assessment and re-evaluate impacts using a likely better set of models.

D. Climate Risk Screening Tool and/or Procedure Used

United Nations Environment Program (UNEP) PREVIEW Data Platform

Source: Asian Development Bank.

IV. CLIMATE ADAPTATION PLANS WITHIN THE PROJECT

Adaptation Activity	**Target Climate Risk**	**Estimated Adaptation Costs** ($ million)	**Adaptation Finance Justification**
Disaster-resilient dam design and construction	Increased magnitude of peak floods	4.58	Seismic strengthened design has co-benefit of resilience to flood and landslide impacts. It is not feasible to estimate incremental cost of adaptation, due to lack of baseline scenario. Therefore, a conservative amount of 10% is attributed to adaptation, with the remaining 90% attributed to mitigation finance.
Slope stabilization measures in the reservoir rim	Increased landslide risk	0.25	Infrastructural investment with distributed benefits, including climate change risk mitigation. Incremental cost not feasible to calculate. Therefore, 25% of slope stabilization costs attributed as adaptation.
Climate resilient cascade operation and management of the hydropower schemes	Decrease of water availability during low flow period (peaking); increased sediment inflows and sediment peaks	1.00	Automation, control and communication equipment for integrated operation of the cascade hydropower projects. Capacity building to improve coordinated operation and risk management.
Implementation of a climate monitoring and coordination framework	Increased flood and landslide risk, change in pattern and level of precipitation, increased sediment load (climate variability and scenario uncertainty)	1.00	Capacity building, equipment, and policy dialogue to improve climate risk management in hydropower production. Includes mainstreaming of climate change consideration into dam operating procedures, cascade optimization, sector engagement, disaster risk management and awareness in the community.
Update of the project climate modelling	Increased flood and landslide risks, change in pattern and level of precipitation, increased sediment load (climate variability and scenario uncertainty)	0.20	Technical services to improve information, planning and decision making.
Total		**7.03**	

Source: Asian Development Bank.

V. CLIMATE MITIGATION PLANS WITHIN THE PROJECT

Mitigation Activity	**Estimated GHG Emissions Reduction** (tCO_2e/year)[a]	**Estimated Mitigation Costs** ($ million)	**Mitigation Finance Justification**
Large hydropower generation plant including dam and associated facilities	572,643	$747.97	Construction and commissioning of low carbon grid-connected power generation. Plant is run-of-river and incremental methane emissions are expected to be limited due to negligible due to small capacity and surface area of pondage.
Total	572,643	**$747.97**	

GHG = greenhouse gas, tCO_2e = tons of carbon dioxide equivalent.

[a] Net generation: 1143 GWh per year. Grid emissions factor: 501 tCO_2/GWh (IFI Harmonized Grid Factors).

Source: Asian Development Bank.