PROJECT CLIMATE RISK ASSESSMENT AND MANAGEMENT REPORT

I. Basic Project Information

Project Title:	**Bihar New Ganga Bridge**
Project Budget:	**$715 million**
Location:	**Patna, Bihar**
Sector:	**Road transport (non-urban)**
Theme:	**Inclusive economic growth; environmentally sustainable growth; regional integration**

Brief Description

The proposed project will build a new bridge across the Ganges River, Patna, India, consisting of a six lane road bridge 9.8 kms long with 10 kms approach viaduct and roads, tolling and service facilities, and widening 3 kilometers of connecting national highway. The objective is to improve transport connectivity for Patna, the state capital of Bihar, and the surrounding regions, in particular northern Bihar.

II. Summary of Climate Risk Screening and Assessment

The proposed Ganga Bridge, like other bridge projects are directly exposed during events of high water levels where accessibility could be affected from frequent storms. The immediate project area is prone to riverine flooding the most recent event occurred in 2003 when the HFL surpassed the 1994 record of 50.27m. The project area is classified as having extreme mortality risk from flooding with flood frequency of more than 50 events/100 years. Increase in river discharge also poses risk to the stability of the bridge foundation from scouring.

A. Sensitivity of project component(s) to climate/weather conditions and sea level

Project component	*Sensitivity to climate/weather conditions and sea level*
1. The design of bridges and approaches	1. Consider future risks of flooding. Design river discharge and flood levels needs to be estimated based on projections of future climate scenarios. 2. Increase river discharge will also increase bridge foundation scouring. 3. High sediment load of the ganga river and the erosion prone nature of the banks may result to shifting of the flows across the diara.

B. Climate Risk Screening

Risk topic	*Description of the risk*
Precipitation (mm).	The climate projections were examined over three time slices, viz. near (2020s, i.e.2011– 2040), farther (2050s, i.e. 2041–2070) and transient (2080s, i.e. 2071–2099). The Analysis indicated that monsoon rainfall increases 0.01% at 2020's, 5.5% at 2050's and 7.3% at 2080's. Probability of rainfall extreme over Ganges basin such as maximum 1 day rainfall, count of consecutive rainfall days shows increasing trend, on the other hand number of rainfall event (>20 mm) on monsoon season shows decreasing trend. Results showed that the annual average precipitation, actual evapotranspiration (ET) and net water yields of the whole basin were 1,192 millimeters (mm), 416 mm and 615 mm, respectively. However, there were large variations in both temporal and spatial distribution of these components. Precipitation, ET and water yields were found to be higher in the forested and mountainous upper areas of the upper ganges basin UGB. On an annual average, present-day flows throughout the UGB were about 2-8% lower than in naturalized conditions. The percentage of flow reduction was the highest during the dry months as water was withdrawn for irrigation. Dry and wet season flows under CC scenario A2 are lower than those in present climate conditions at upstream locations, but higher at downstream locations of the UGB. The period/months of minimum daily discharges are highly variable among stations and between different CC scenarios, while the period/months of maximum flow are delayed downstream as a result of the delay in the onset of the monsoon in the lower parts of the basin.

Climate Risk Classification: ***High***

C. Climate risk assessment

1. Reviewed 188 year record of Ganga River meandering particular the existence and formation of the diara and the Fatwa and Mehnar Channels.
2. Assessment of Ganga and Gandak River discharges (55 year record) to determine the maximum river flow at the project site.
3. Assessment of flood level and slopes based on records at the Dighaghat and Mahatma Gandhi Setu records Patna.
4. Estimation of scour depth based on Mahatma Gandhi Setu, Patna Rail cum Road Bridge Munger Rail cum Road Bridge, and Mokama Rail cum Road Bridge records and Indian Railway Standard Bridge Substructure Code.
5. Estimation of foundation level based on IRC 5, Clause 122.2.1 & IRC 78, Clause 705.2.2 on grip length.
6. Compliance to navigational clearance of the Inland Waterways Authority of 10 m from the highest recorded flood level for vertical clearance and 100-m horizontal clearance between two piers of the Bridge.
7. ADB due diligence involved:
   a. Conducted climate change risk assessment based on IPCC A2 scenario and confirmed adequacy of feasibility study design.
   b. Reviewed design flood level and river discharge against projected levels with consideration to increase in rainfall in the upper ganges basin.
   c. Hydrological, sedimentation and erosion risks assessment as part of the EIA to identify preferred bridge design, take-off points, and obliquity with then river flow.
   d. Transect walk and consultations with local residents to establish historical flood levels, river meanderings, overtopping of Diara, and erosion prone areas.
   e. Estimated GHG emission project operation phase.

III. Climate Risk Management Response within the Project

1. Ensured the design discharge is more than 94,127 cumecs based on climate change assessment that will take place in the UGB. The design discharge adopted is 106,839 cumecs.
2. The bridge is sited 12 kilometres downstream of the Mahatma Gandhi Setu bridge with a minimum width of flow due to the formation of the diara, within stable reach, and banks are erosion resistant. The National Highway at the south bank and the state highway in the north bank ensures high floodwater will be contained. This makes the site suitable.
3. A bank to bank bridge with a waterway of 9.760 km is being recommended instead of the alternative of building 2 smaller bridges on the north and south channel with a high embankment six lane expressway connecting them. The recommended bank to bank option will be further investigated by the EPC contractor based on more detailed hydrologic study. Additional adaptation costs for the bank to bridge option is approximately US$200,000.00.
4. Preliminary design for the bridge will be reviewed by the EPC Contractor to include: i)scour depth of 22.5 m was estimated using the Lacey's Method as provided in the Indian Railway Standard Bridge Substructure Code, ii) design flow of 106,839 m3/s, ii) silt factor of 1.0, iii) deep foundation design depth was set at 19.80 m based on Gale's principle, IRC Practice, and Spring Curve, iv) and founding level was estimated at 14.8m based on HFL 50.0m-45.0 scour depth-19.80m Grip length. Detailed soil investigation on each of the pier location will made to provide more applicable information.
5. With respect to the proposed bridge alignment and the flow of the North and South channels, the flow on the North has shown very high obliquity of flow as compared to the smoother flow across the bridge alignment in the South Channel. Bridge should be oriented to maintain perpendicular to the direction of flow. Based on hydraulic modeling to be conducted by the EPC Contractor the orientation of the bridge on across the north and south channels should corrected or provide deeper founding depth and frequent maintenance works to take into account higher scouring.