CLIMATE RISK ASSESSMENT AND MANAGEMENT REPORT

I. Basic Project Information

Project Title: Proposed Loan and Grant
Kingdom of Bhutan: South Asia Subregional Economic Cooperation (SASEC) Transport, Trade Facilitation and Logistics Project

Project Budget: $23.07 million

Location: Phuentsholing, Bhutan

Sector: Transport

Theme: Inclusive economic growth

Brief Description of the Project

The project will promote road connectivity in the Phuentsholing area, consisting of improvement of the existing section of the Southern East-West Highway (SEWH). The project will complete the last 3.3 km missing section of the Phuentsholing to Samtse highway between Phuentsholing and Chamkuna, and provides the vital intra-country linkage of Samtse Dzongkhag with the rest of the country. The trade facilitation and logistics component is aimed at improving the infrastructures and services at the border crossing points by adding additional equipment to facilitate cross-border traffic and transit of goods and services, trade and commerce nationwide. These interventions are targeted to improve the working conditions and service delivery at the check points so that export and import of goods and services takes place safely and efficiently.

II. Summary of Climate Risk Screening and Assessment

The 3.3 km embankment road to be constructed along the banks of the Amochu river will be exposed to flood flow levels of 5,900 m^3/s with 50 year return period and 7,257 m^3/s at 100 year period. The Amochu river has a large catchment area and with the predicted increase in precipitation, will result to more severe floods. The predicted increase in temperature will accelerate the melting of glacial lakes in its basin which can cause outbursts leading to flashfloods. Increase in severe flooding and potential for flashfloods will result to severe erosion and scouring of the embankment road leading to structural failure.

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 the embankment road	1. Consider future risks of flooding. Design, river discharge and flood level need to be estimated based on projections of future climate scenarios. 2. Increased river discharge will also increase risk of embankment road erosion/scouring. 3. Sediment load of the Amochu and the meandering character may shift the main channel closer to the road embankment and increase the risk of scouring.

B. Climate Risk Screening

Risk topic	*Description of the risk*
Precipitation (mm)	Steady increase in future rainfall will result to larger river discharge and higher flood levels. The ECHAM5 simulations show a steady increase of precipitation/rainfall, from ~ 2000 mm/year (1980) to ~ 2600 mm/year (2069). The HadCM3 simulations also show an increasing trend, from ~1900 mm/year (1980) to ~ 2400 mm/year (2069). The seasonal (monsoonal) trend in monsoonal mean total precipitation between 1980 and 2069 show progressive and steady increase, by ~ 350 mm/year by HadCM3 simulation (~1150 mm/year to ~1500 mm/year) and ~450 mm/year by ECHAM5 simulation (~1300 mm/year to ~1750 mm/year).
Temperature (^oC)	Steady temperature increase in the upper reaches of the Amochu basin will accelerate the melting of glacial lakes and increase dry season flow and outburst causing enormous damaging flashfloods. Downscaled HadCM3 and ECHAM5 climate model outputs of air temperature show a progressive and steady increase in air temperature from 1980 to 2069. The HadCM3 simulations therefore shows a steady increase of temperature, increasing from ~ 13.5^{0}C (1980) to ~ 17.0^{0}C (2069), a temperature increase of ~ 3.5^{0}C. On the other hand, the ECHAM5 simulations shows a steady increase of temperature, increasing from ~ 12.00 C (1980) to ~ 15.5^{0}C (2069), a similar temperature increase of ~ 3.5^{0}C. Same models show a progressive and steady increase in precipitation from 1980 to 2069.

Climate Risk Classification: ***High***
C. Climate risk assessment
1. Reviewed Torsa River Flood Mitigation Project - Detailed Feasibility Study and Engineering Design (August 2007), The design flood once in 50 year return period was adopted as the design standard, estimated at a peak discharge of 5,900 m^3/s, with flood wave duration of 53 hours. 2. Reviewed Amochu Land Reclamation Project (ALRP), DPR 2 by DHI INFRA Bhutan, and confirmed the validity of the August 2007 study. 3. Adjusting these flows to incorporate future climate change, the design "1 in 50 year return period" flood of Amochu determined by the DPR 1 and 2 is 5,900 m^3/s and climate change factor is 1.23, which gives an estimated climate change discharge of 5,900 x 1.23 = 7,257 m^3/s.
III. Climate Risk Management Response within the Project
1. Three sets of erosion and flood control systems were integrated in the Phuentsholing-Chamkuna Road design; first set involves armoring and properly founding the embankment road, second involves river training to maintain safe distance separation of the main Amochu channel from the embankment road, and the third set manages the surface runoff laden with sediment and boulders from the hill side east of the embankment road and providing adequate conveyance structure across the road to allow passage water towards the Amochu river. 2. Of the total estimated Nu.844.5 million ($12.78 million equivalent) civil works cost, the estimated floor and river erosion control components are as follows: i) Nu. 30.6 million for dredging and river channelization, ii) Nu5.26 million embankment slope protection, iii) Nu320 million.1 gabion wall, and Nu.10.1 million spur dike for a total of $5.5 million accounting for 43%.

ALRP = Amochu Land Reclamation Project, DHI INFRA = Druk Holding and Investments, Ltd.-Infrastructure, DPR = Detailed Project Report, ECHAM5 = European Center Hamburg Model Version 5, HadCM3 = Hadley Center Coupled Model Version 3, SEWH = Southern East-West Highway
Note: Amochu River is also known as Torsa River.