CLIMATE CHANGE ASSESSMENT

I. BASIC PROJECT INFORMATION

Project Title: Integrated Urban Flood Management for the Chennai-Kosasthalaiyar Basin Project
Project Cost ($ million): 470.5 (including taxes)
Location: Chennai, India
Sector / Subsector: Water and other urban infrastructure and services
Theme: Urban flood protection and other urban services
Brief Description: The proposed project will increase the resilience of Chennai to extreme weather events by strengthening urban flood management infrastructure consisting of new and rehabilitated drains, pumping stations, augmented canals, and recharge pits. The project aims to reduce surface water flooding in a wide range of heavy rainfall events.[a] It will also improve the capacity of the GCC and communities in urban flood preparedness, as well as the performance of GCC in the sustainable operation of storm water drainage systems. The proposed stormwater drainage systems will be exposed to tropical cyclones, heavy rainfall, and extreme sea levels. The performance of these systems will be affected by the magnitude and frequency of extreme rainfall events and extreme sea levels, which can prevent free drainage from the canals into the sea. The proposed pumping stations could be affected by coastal flooding with high rates of sea level rise. The groundwater recharge structures could also be affected by elevated groundwater levels during the monsoon. The infrastructure is designed for a range of conditions and has been shown to cope with addition rainfall (+16%) and higher sea levels (+21.7cm) due to climate change by 2050. Effective operations and maintenance are needed to maintain high standards of system performance under future climate change scenarios.

GCC = Greater Chennai Corporation

[a] The project is part of a Government of Tamil Nadu and multi-donor strategy to transform flood risk management in Chennai.

II. SUMMARY OF CLIMATE CHANGE FINANCE

Project Financing		Climate Finance	
Source	**Amount ($ million)**	**Adaptation ($ million)**	**Mitigation ($ million)**
ADB Resources			
Sovereign Project (Regular Loan): Ordinary capital resources[a]	251.00	87.00	
Counterpart			
Government	219.50	54.60	
Totals (including taxes)	**470.50**	**141.60**	NA

ADB = Asian Development Bank

[a] Based on a pro-rata split between ADB and cofinancing for Output 1 and attribution of non-structural Climate Action activities in Output 2 and 3 to the ADB loan.

III. SUMMARY OF CLIMATE RISK SCREENING AND ASSESSMENT

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

1. The main climate sensitivities of the project components are as follows:

   (i) **Output 1: Climate-resilient urban flood protection infrastructure improved in the Chennai-Kosasthalaiyar River basin.** Under this output: (a) prolonged and high intensity rainfall in the monsoon season could overwhelm storm drainage systems, leading to surface water flooding in the low-lying areas of the city; (b) extreme sea levels due to a combination of high astronomical tides, sea level rise, and high surge heights reduce free drainage to the sea and reduce the hydraulic capacity of canals leading to fluvial flooding; (c) the recharge pits are sensitive to high groundwater levels which may impede recharge following periods of prolonged rainfall and elevated groundwater levels; and (d) the pumping stations are vulnerable to flooding from heavy rainfall and coastal flooding, particularly in future scenarios with higher rates of sea level rise.

   (ii) **Output 2: Urban flood preparedness of the GCC and project communities enhanced**. The activities under this output are in response to strengthen the management of flood risk in the area and thus by themselves are not sensitive to the impacts of climate and weather conditions.

(iii) **Output 3: Measures for sustaining operation and maintenance of storm water drainage system established in the GCC**. Changes in climate and weather condition can impact the performance of urban infrastructure, thereby requiring capacity of GCC for improved operations and maintenance to deal with extreme weather events.

B. Climate Risk Screening

The climate risk screening was based on climate vulnerability (sensitivity and exposure) of the proposed infrastructure to hazards and the results are as below.

(i) **Flooding (from heavy rainfall):** High. Increases in the North East Monsoon rainfall and daily rainfall intensity, which are likely to cause more frequent and damaging floods.
(ii) **Sea level rise:** Medium. High rates of sea level rise of at least 2 mm per year, which is likely to contribute to coastal flooding, tide-locking drainage outlets, and reduction in the hydraulic capacity of the canals that can contribute to flooding.
(iii) **Extreme heat:** Medium.
(iv) **Drought:** Medium.

Climate Risk Classification: High

C. Climate Risk and Adaptation Assessment

(i) **Methodology:** The climate risk assessment considered project components that had a high vulnerability to extreme weather and future climate change. The assessment was based on desk study using the available baseline data, climate change projections, project documents, detailed project report for the stormwater drainage, and research literature. It included a review of the Tamil Nadu Climate Action Plan and the GCC Disaster Management Plan. Climate scenarios were developed based on NASA statistically downscaled CMIP5 climate change models. Additional data sources included KNMI Climate Explorer datasets and University of Hamburg Integrated Climate Data Center AR5 sea level dataset.
(ii) **Key climate risk:** The key findings of the climate risk assessment were as follows:
  (a) Recent trends in temperature in Chennai are consistent with climate change and temperatures are projected to increase along with heavy rainfall, with large increases projected for the North East monsoon season;
  (b) For the mid-century (2050s) climate change models suggest an increase in average temperature by 1.4 ºC (0.7 ºC to 2.0 ºC) under RCP4.5 and increases of 1.7ºC (1.3 ºC to 2.3 ºC) under RCP8.5;
  (c) For the same time period climate change models suggest an increase in heavy rainfall of 11% (–4% to 24%) under RCP4.5 and 16% (–3% to 32%) under RCP8.5;
  (d) For the late century (2080s) climate change models suggest an increase in average temperature by 1.9 °C (1.2 ºC to 2.6 °C) under RCP4.5 and by 3.0 °C (2.1 ºC to 4.3 ºC) under RCP8.5;
  (e) For the same time period climate change model suggest an increase in heavy rainfall of 15% (4% to 31%) under RCP4.5 and of 28% (–3% to 59%) under RCP8.5;
  (f) Sea level rise is projected to increase by 0.202 m (0.0091 m to 0.241 m) by 2050 and by 0.491 m (0.319 m to 0.764 m) by 2100 under RCP4.5. Under RCP8.5, projected rises of 0.217 m (0.111 m to 0.33 m) by 2050 and 0.675 m (0.379 m to 1.02 m) by 2100. These sea levels are based on the latest IPCC Fifth Assessment Report and more recent IPCC publications indicate greater rises, most likely near the top of the RCP8.5 range; and
  (g) The primary risk is increases in heavy rainfall especially in North East monsoonal rainfall and daily rainfall intensity which are very likely to cause more frequent and damaging floods as heavy rainfall on average is likely to increase by an average of 11% to 16% by the 2050s. This has impacts on the stormwater drainage systems and surplus canals, which need to be adequately sized to cope with higher runoff volumes to reduce flood risk.
(iii) **Adaptation Assessment**. The assessment of adaptation measures primarily focuses on activities under output 1 of the loan and includes:
  (a) New and rehabilitated stormwater drains including in new areas of the city to increase flood capacity. Drainage can safely convey stormwater flow for 1:2-year return period rainfall with provision to cope with 79 mm/hr (16% increase in rainfall intensity) and sea level rise of 21.7 cm under RCP 8.5 scenario to 2050.
  (b) Augmentation and rehabilitation of surplus canals – four canals of length 11 km in total, augmented and desilted by 1–2 m to increase hydraulic capacity for floodwaters, up to a 1 in 5 year event;
  (c) (1) Silt Arrester (Catch) Pits (at 30 m interval); and (2) Silt Arrester (Catch) Pits with Groundwater Recharge Structures (at 60 m interval) along the proposed storm water drain network in addition to kerb inlets with silt grating and PVC chute pipes (at 10 m interval). Existing storm water drain network will be augmented with (1) Silt Arrester (Catch) Pits (at 20 m interval) and (2) Silt Arrester (Catch) Pits with Groundwater Recharge Structures (at 20 m interval). Provision of silt arrester pits with recharge structures at higher intervals along the storm water drain network increases groundwater recharge potential of paved areas in a region that has high risk of water scarcity as well as serving to effectively address problems of saline intrusion, poor groundwater quality, lowered rate of recharge during periods of prolonged rainfall and silting of drains; and

(d) Two pumping stations – located in low-lying areas in the coastal zone of Chennai, with augmented storage designed to handle heavy daily ranfall (246 mm/day) and pumping capacity for anticipated floodwaters in these areas.

In addition, recognizing the importance of strengthening capacity of GCC and wider communities on practicing risk-informed developed, adaptation response are also integral to the actitivties under output 2 and 3 and includes:

(a) Awareness campaigns on green infrastructure and link between flooding and solid waste management to reduce blockages of the drains by encouraging proper waste management;
(b) Guidelines on integrating flood hazard zoning wth spatial plan and development regulations to limit exposures of assets and population to climate and disaster risks; and
(c) Performance-based incentive system to promote the development of green infrastructure by improving performance of GCC in sustainable operation of storm water drain system through improved preventive and routine maintenance of storm water drainage infrastructures, utilization of the operations and maintenance budgets, activities for preventing blockages of drains.

D. Climate Risk Screening Tool and/or Procedure Used

SARD climate risk screening framework and methodology, and a project specific CRA, which used the ThinkHazard tool, CMIP5 downscaled Global Climate Models, local information, and existing climate change studies to review the exposure to hazards and potential risks.

ADB = Asian Development Bank, AR5= Fifth Assessment Report, cm = centimeter, CMIP5 = Coupled Model Intercomparison Project Phase 5, CRA = Community Reinvestment Act, hr = hour, IPCC = Intergovernmental Panel on Climate Change, GCC = Greater Chennai Corporation, km = kilometer, KNMI = Royal Netherlands Meteorological Institute, m = meter, mm = millimeter, NASA = National Aeronautics and Space Administration, PVC = polyvinyl chloride, RCP = representative concentration pathway, SARD = South Asia Department.

IV. CLIMATE ADAPTATION PLANS WITHIN THE PROJECT

Adaptation Activity	**Target Climate Risk**	**Estimated Adaptation Finance** ($ million)	**Adaptation Finance Justification**
Construction of new drainage network for low-lying areas – designed to withstand a 1 in 2 year event with rainfall intensity of 79 mm/hr (16% increase in rainfall intensity) and sea level rise (+21 cm) under RCP 8.5 scenario to 2050 and storm water pump stations	High rainfall and surface water flooding	66.05	Incremental cost of Climate Change Adaptation of SWD network component is estimated by adopting the differential uptake capacity available in the proposed SWD network based on land use category-specific return period recommendations per CPHEEO guidelines.[a] Component cost (100%) of SWD pump stations for low-lying areas is also considered as adaptation finance.The overall impact is a significant reduction in risks from heavy rainfall for a range of events.
Rehabilitation of drains	High rainfall and surface water flooding	Included in above estimate	Existing drains improved to handle larger quantities of flood water from heavy rainfall events.
Rehabilitation and capacity augmentation of surplus canals	High rainfall and surface water flooding	5.89	Incremental cost of increasing the hydraulic capacity of surplus canals is considered as adaptation. Weighted average increase in range of 33% to 43% in the four surplus canals under this project is envisaged and considered as incremental cost of adaptation.
Installation of silt arrester (Catch) pits with grounwater recharge structures (Rainwater Harvesting)	High rainfall and surface water flooding Low rainfall,	11.24	Increased flood retention capacity and permeability of proposed SWD and canals. Greater protection of water sources – addresses risk of water scarcity and drought as well as coastal saline intrusion by increasing groundwater availability. Component

Adaptation Activity	Target Climate Risk	Estimated Adaptation Finance ($ million)	Adaptation Finance Justification
	drought and coastal salinity intrusion		cost (100%) of Silt Arrester (Catch) Pits and Silt Arrester (Catch) Pits with Groundwater Recharge Structures in both existing and proposed storm water drain network is considered as adaptation finance.
Development of guidelines on integrating flood hazard zoning wth spatial plan and development regulations (Project Support Consultant)	Surface water flooding	0.29	Risk-sensitive land use planning and developmet control regulations can help limit exposure of assets and population to climate risk. Thus, proportional cost (5%) of consultancy services is considered as climate adaptation finance.
Development of IEC and awareness campaigns, FRI and FRI Framework, and FCO (Institutional Strenghtening and Reform Consultant)	Surface water flooding	0.09	Increased awareness among population is critical for promoting risk-informed development. FRI and FCO will contribute to increasing resilience and preparedness against the future flood. Thus, proportionate costs (5%) of consultancy services is considered as climate adaptation finance.
Measures to strengthen GCC's operational performance in improving O&M, including preventing waste dumping.	Surface water flooding	3.45	The enhanced operations and maintenance responds to increased frequency of rainfall events to maintain assets and is considered as an important climate adaptation measure. Performance-based incentives are envisaged to be used to develop green infrastructure such as green roofs, rain gardens, vegetated swales, permeable pavements and pathways, tree planting and additional community RWH structures. Proportionate cost (50%) of performance-based incentive that is to be used for green infrastructure development is considered as climate adaptation finance.
Total adaptation finance		**87.00**	

ADB = Asian Development Bank, cm = centimeter, CPHEEO = Central Public Health & Environmental Engineering Organization (Ministry of Urban Development, Government of India), FCO = flood citizen observatory, FRI = flood resilience index, GCC = Greater Chennai Corporation, IEC = Information, Education and Communication, mm/hr = millimeter per hour, O&M = operations and maintenance, RCP = representative concentration pathway, RWH = rainwater harvesting, SWD = storm water drain.

Note: Numbers may not sum precisely because of rounding.

[a] The CPHEEO guidelines (2013) at the time of design stage advise to adopt flood frequencies of: (i) twice a year for peripheral residential areas; (ii) once a year for central and comparatively high priced residential areas; and (iii) 1 in 2 years for commercial and high priced areas. However, considering the high climate change risks in Chennai, the project has adopted a 1 in 2 years return period for designing storm water drainage for the entire project area, irrespective of land use. Estimation of climate adaptation financeis is undertaken by classifying the entire project area into three types of land-use as per the CPHEEO guidelines, and calculating the additional cost incurred for adopting design that follows higher return period compared to the lower return period recommended in the guidelines for categories (i) and (ii) described above.

V. CLIMATE MITIGATION PLANS WITHIN THE PROJECT

Mitigation Activity	**Estimated Greenhouse Gas Emissions Reduction** (tCO_2e/year)	**Estimated Mitigation Finance** ($ million)	**Mitigation Finance Justification**
Total mitigation finance			**NA**

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