CLIMATE RISK COUNTRY PROFILE

BANGLADESH

WORLD BANK GROUP

COPYRIGHT

© 2021 by the World Bank Group
1818 H Street NW, Washington, DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

This work is a product of the staff of the World Bank Group (WBG) and with external contributions. The opinions, findings, interpretations, and conclusions expressed in this work are those of the authors and do not necessarily reflect the views or the official policy or position of the WBG, its Board of Executive Directors, or the governments it represents.

The WBG does not guarantee the accuracy of the data included in this work and do not make any warranty, express or implied, nor assume any liability or responsibility for any consequence of their use. This publication follows the WBG's practice in references to member designations, borders, and maps. The boundaries, colors, denominations, and other information shown on any map in this work, or the use of the term "country" do not imply any judgment on the part of the WBG, its Boards, or the governments it represents, concerning the legal status of any territory or geographic area or the endorsement or acceptance of such boundaries.

The mention of any specific companies or products of manufacturers does not imply that they are endorsed or recommended by the WBG in preference to others of a similar nature that are not mentioned.

RIGHTS AND PERMISSIONS

The material in this work is subject to copyright. Because the WBG encourages dissemination of its knowledge, this work may be reproduced, in whole or in part, for noncommercial purposes as long as full attribution to this work is given.

Please cite the work as follows: Climate Risk Country Profile: Bangladesh (2021): The World Bank Group.

Any queries on rights and licenses, including subsidiary rights, should be addressed to World Bank Publications, The World Bank Group, 1818 H Street NW, Washington, DC 20433, USA; fax: 202-522-2625; e-mail: pubrights@worldbank.org.

Cover Photos: © Scott Wallace/World Bank, "Navigating the river" May 29, 2014 via Flickr, Creative Commons CC BY-NC-ND 2.0. © Scott Wallace/World Bank, "Harvesting crops" May 29, 2014 via Flickr, Creative Commons CC BY-NCND 2.0.

Graphic Design: Circle Graphics, Reisterstown, MD.

ACKNOWLEDGEMENTS

This profile is part of a series of Climate Risk Country Profiles that are developed by the World Bank Group (WBG). These profiles synthesize the most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The profile is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is co-led by Veronique Morin (Senior Climate Change Specialist, WBG) and Ana E. Bucher (Senior Climate Change Specialist, WBG).

This profile was written by Alex Chapman (Consultant, NEF Consulting), William Davies (Consultant, NEF Consulting), Ciaran Downey (Consultant, NEF Consulting) and MacKenzie Dove (Senior Climate Change Consultant, WBG). Technical review of the profiles was undertaken by Robert L. Wilby (Loughborough University). Additional support was provided by Megumi Sato (Junior Professional Officer, WBG), Jason Johnston (Operations Analyst, WBG) and Yunziyi Lang (Climate Change Analyst, WBG). This profile also benefitted from inputs of WBG regional staff and country teams.

Climate and climate-related information is largely drawn from the Climate Change Knowledge Portal (CCKP), a WBG online platform with available global climate data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

CONTENTS

FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group is committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

The World Bank Group is investing in incorporating and systematically managing climate risks in development operations through its individual corporate commitments.

A key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all IDA and IBRD operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

Recognizing the value of consistent, easy-to-use technical resources for client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group has developed this content. Standardizing and pooling expertise facilitates the World Bank Group in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For developing countries, the climate risk profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

It is my hope that these efforts will spur deepening of long-term risk management in developing countries and our engagement in supporting climate change adaptation planning at operational levels.

Bernice Van Bronkhorst
Global Director
Climate Change Group (CCG)
The World Bank Group (WBG)

KEY MESSAGES

- Projected average temperature rises in Bangladesh are broadly in line with the global average. The highest emissions pathway (RCP8.5) projects a rise of 3.6°C by end of the century, above the 1986–2005 baseline, compared to a rise of 1.0°C on the lowest emissions pathway (RCP2.6).
- Rises in minimum and maximum temperatures are considerably higher than the change in average temperature and are concentrated in the period December–March.
- Increased frequency of periods of prolonged high heat are a major threat to human health and living standards in Bangladesh, particularly in urban environments and for outdoor laborers.
- Livelihoods in Bangladesh's coastal zone, which include many of the poorest communities, are under threat from saline intrusion and degrading natural resources linked to climate change.
- Flash, river, and coastal flooding are likely to be exacerbated by intensified extreme rainfall, tropical cyclones and associated storm surges, placing lives, infrastructure, and the economy at risk.
- Without adaptation, the number of people exposed to an extreme river flood is expected to grow by 6–12 million by the 2040s, and the number of people facing coastal inundation could grow by 2–7 million by 2070s.
- Food production and the agricultural sector could face reduced yields driven by temperature rises in the growing season, saline intrusion, increased drought frequency, flooding and waterlogging.
- Climate impacts are not restricted to the coastal zone and hotspots of vulnerability can be found across the country. Global modelling and local evidence all suggest that poor and marginalized groups, and women are likely to suffer disproportionately in a changing climate. Unless rapid global decarbonization can be achieved, inequalities are likely to widen.
- Despite recent progress in disaster risk management, adaptation and disaster risk reduction are still an urgent priority in Bangladesh as the livelihoods and wellbeing of millions of people are threatened.

COUNTRY OVERVIEW

The majority of Bangladesh's land area is a low-lying river delta, formed by the sedimentary deposits of the Ganges, the Brahmaputra, and the Meghna Rivers, which flow from the Himalayas to the Bay of Bengal. The country consists mostly of low-lying and flat land with a network of more than 230 major rivers as well as thousands of tributaries and canals. As of 2020, Bangladesh had a population of approximately 165 million people, with one of the highest population densities in the world (**Table 1**). The largest contributor to Bangladesh's GDP is its services sector, at 54.6%, whilst agriculture contributes 12.6% in 2020.[1] However, agriculture remains the largest employer, occupying 37.7% of the workforce (2020).[2] This mismatch between the source of productivity and the source of employment is one factor linked to high and growing levels of income and wealth inequality.[3]

---

1 World Bank (2021). DataBank – World Development Indicators. [Accessed 25/10/ 2021]. URL: https://databank.worldbank.org/source/world-development-indicators

2 World Bank (2021). Employment in Agriculture – Bangladesh. World Bank Data. URL: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=BD [accessed 04/02.2021].

3 World Bank Group (2020). Bangladesh – Overview. URL: https://www.worldbank.org/en/country/bangladesh/overview

Bangladesh is one of the most vulnerable countries in the world to climate-related hazards such as cyclones and floods. UNISDR estimated the average annual losses to disaster at around $3 billion, or around 1% to 2% of GDP.[4] These losses are focused particularly on the agricultural sector, but increasingly are impacting Bangladesh's rapidly expanding urban areas. Ahmed and Suphachalasai (2014) suggest that by mid-century, climate change is likely to cost Bangladesh a further 2% of GDP on top of its baseline losses to climate hazards, a figure which potentially rises to 9% of GDP by the end of the century if mitigation action is not increased.[5]

The Ministry of Environment, Forest, and Climate Change is the coordinating agency of Bangladesh's Central Government on all matters related to the environment and it sets the climate change strategy for the country. The government developed the Bangladesh Climate Change Strategy and Action Plan (BCCSAP) and the National Adaptation Program of Action (NAPA) in 2009 to respond to climate change-induced development risks. The country's National Plan for Disaster Management (2021–2025) (NPDM) was prepared based on the four key principles of Disaster Risk Management (preparedness, early warning and alert, emergency response, and Rehabilitation, Reconstruction and Recovery) adopted from Sendai Framework for Disaster Risk Reduction (SFDRR) and Standing Order on Disaster (SOD). The country's Standing Orders on Disaster (2019) support Bangladesh's planning and response to disaster risks.[6] These strategies are supported by the Second Perspective Plan of Bangladesh (2021–2041), which was approved by the National Economic Council on February 25, 2020, its 8th Five-Year Plan (2019) for economic growth and development, and the Bangladesh Delta Plan 2100 (2018); approved in December, 2020. Bangladesh ratified the Paris Agreement and its initial Nationally Determined Contribution (NDC) on September 21, 2016, another interim NDC 2020 on December 31, 2020, and its Updated Nationally Determined Contribution on August 26, 2021. Bangladesh's Third National Communication to the UNFCCC (NC3) (2018) identifies the impacts of climate change in key sectors such as agriculture, water resources, coastal erosion, and human health as priority concerns.[7] Bangladesh's NC3 also reflects the country's adaptation and mitigation efforts across key sectors to respond to climate change impacts. Bangladesh's climate change efforts are further supported by the Bangladesh Country Investment Plan for Environment, Forestry and Climate Change 2016–2021.

Bangladesh has assumed the presidency of the 48-nation Climate Vulnerable Forum (CVF) and the Vulnerable Twenty (V20) Group of Finance Ministers. Honorable Prime Minister of Bangladesh H.E. Sheikh Hasina is serving as Chair of the CVF since June 2020. As Chair of the CVF, Honorable Prime Minister has launched a program to develop "Mujib Climate Prosperity Plan" for Bangladesh. The Plan, which will be the first of CVF plans, will be a strategic investment framework to mobilize financing, especially through international cooperation, for implementing renewable energy and climate resilience initiatives.

---

4 UNISDR (2014). Prevention Web: Basic country statistics and indicators. URL: www.preventionweb.net/countries [accessed 14/08/2018].
5 Ahmed, M., Suphachalasai, S. (2014). Assessing the costs of climate change and adaptation in South Asia. Asian Development Bank. URL: https://www.adb.org/publications/assessing-costs-climate-change-and-adaptation-south-asia
6 Bangladesh's NPMD 2021–2025 is currently under review.
7 Ministry of Environment, Forest and Climate Change (2018). Third National Communication of Bangladesh to the UNFCCC. Government of the People's Republic of Bangladesh. URL: https://unfccc.int/sites/default/files/resource/TNC%20Report%20%28Low%20Resolation%29%2003_01_2019.pdf

TABLE 1. Key Indicators

Indicator	Value	Source
Population Undernourished[8]	13.0% (2017–2019)	FAO, 2020
National Poverty Rate[9]	21.8% (2018)	ADB, 2020
Share of Income Held by Bottom 20%[10]	8.6% (2016)	WBG, 2021
Net Annual Migration Rate[11]	–0.23% (2015–2020)	UNDESA, 2019
Infant Mortality Rate (Between Age 0 and 1)[12]	2.7% (2015–2020)	UNDESA, 2019
Average Annual Change in Urban Population[13]	3.2% (2015–2020)	UNDESA, 2018
Dependents per 100 Independent Adults[14]	47 (2020)	UNDESA, 2019
Urban Population as % of Total Population[15]	38.2% (2020)	CIA, 2020
External Debt Ratio to GNI[16]	18.2% (2018)	ADB, 2020b
Government Expenditure Ratio to GDP[17]	10.2% (2018)	ADB, 2020b
Human Capital Index[18]	0.46 (2020)	WBG, 2020

Green, Inclusive and Resilient Recovery

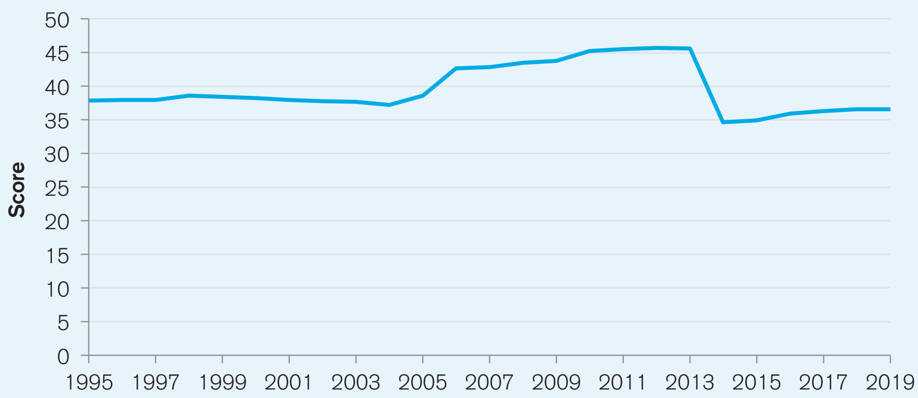
The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies.

8 FAO, IFAD, UNICEF, WFP, WHO (2020) The state of food security and nutrition in the world. Transforming food systems for affordable healthy diets. FAO. Rome. URL: http://www.fao.org/documents/card/en/c/ca9692en/
9 ADB (2020). Basic Statistics 2020. URL: https://www.adb.org/publications/basic-statistics-2020 [accessed 27/01/21]
10 World Bank (2021). Income share held by lowest 20%. URL: https://data.worldbank.org/ [accessed 25/10/21]
11 UNDESA (2019). World Population Prospects 2019: MIGR/1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
12 UNDESA (2019). World Population Prospects 2019: MORT/1-1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
13 UNDESA (2019). World Urbanization Prospects 2018: File 6. URL: https://population.un.org/wup/Download/ [accessed 17/12/20]
14 UNDESA (2019). World Population Prospects 2019: POP/11-A. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
15 CIA (2020). The World Factbook. Central Intelligence Agency. Washington DC. URL: https://www.cia.gov/the-world-factbook/
16 ADB (2020b). Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020
17 ADB (2020b) Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020
18 World Bank Group (2020). The Human Capital Index, 2020 Update – Human Capital in the Time of COVID-19. URL: https://openknowledge.worldbank.org/handle/10986/34432

This document aims to succinctly summarize the climate risks faced by Bangladesh. This includes rapid onset and long- term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods and economies, many of which are already underway. This is a high-level synthesis of existing research and analyses, focusing on the geographic domain of Bangladesh, therefore potentially excluding some international influences and localized impacts. The core data presented is sourced from the database sitting behind the World Bank Group's Climate Change Knowledge Portal (CCKP), incorporating climate projections from the Coupled Model Inter-comparison Project Phase 5 (CMIP5). This document is primarily meant for WBG staff to inform their climate actions. The document also aims to direct the reader to many useful sources of secondary data and research.

Despite significant progress in disaster risk reduction, including the development of early-warning systems, which have dramatically reduced the number of fatalities associated with climate-related disasters, Bangladesh is ranked 163rd out of 182 in the 2020 ND-GAIN Index.[19] The ND-GAIN Index ranks 182 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. The more vulnerable a country is the lower their score, while the more ready a country is to improve its resilience the higher it will be. Norway has the highest score and is ranked 1st. **Figure 1** is a time-series plot of the ND-GAIN Index showing Bangladesh's progress

FIGURE 1. The ND-GAIN Index Score (Out of 100) Summarizes a Country's Vulnerability to Climate Change and Other Global Challenges in Combination with Its Readiness to Improve Resilience. It Aims to Help Businesses and the Public Sector Better Prioritize Investments for a More Efficient Response to the Immediate Global Challenges Ahead.



[19] University of Notre Dame (2020). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

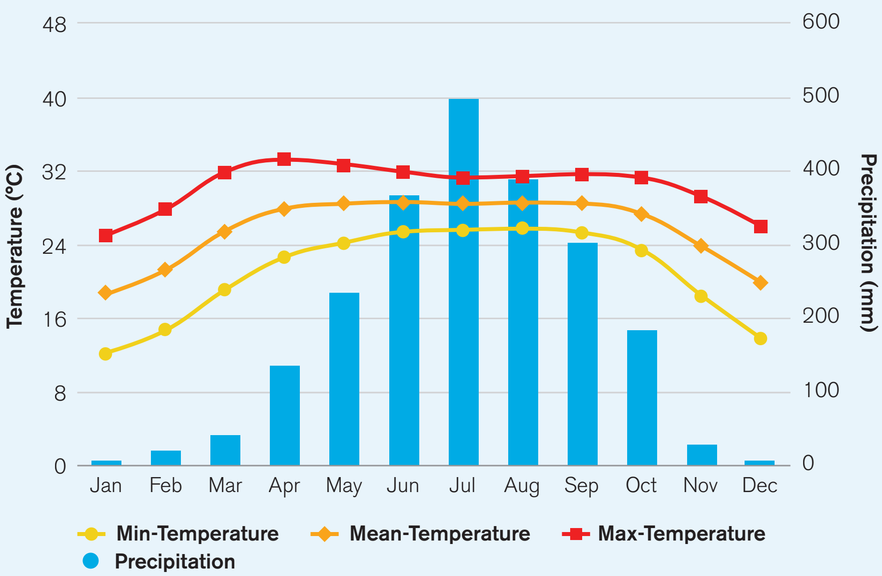
Climate Baseline

Overview

Bangladesh has a humid, warm climate influenced by pre-monsoon, monsoon and post-monsoon circulations and frequently experiences heavy precipitation and tropical cyclones. Bangladesh's historical climate (**Figure 2**) has experienced average temperatures around 26°C, but range between 15°C and 34°C throughout the year. The warmest months coincide with the rainy season (April-September), while the winter season (December-February) is colder and drier. Bangladesh is a very wet country, receiving on average about 2,200 millimeters (mm) of rainfall per year. Most regions receive at least 1,500 mm and others, such as in the northeastern border regions, receive as much as 5,000 mm of rainfall per year. Humidity remains high throughout the year, peaking during the monsoon season (June to October). Rainfall is driven by the Southwest monsoon, which originates over the Indian Ocean and carries warm, moist, and unstable air. Typically, a tropical cyclone (of strength classification Tropical Storm or above) will make landfall in Bangladesh once in every two to three years[20] bringing heavy rainfall, very high wind speeds, and storm surges. **Figure 3** shows observed spatial variation for temperature and precipitation across Bangladesh.

Annual Cycle

FIGURE 2. Average Monthly Mean, Max, and Min Temperatures and Rainfall In Bangladesh (1991–2020)[21]

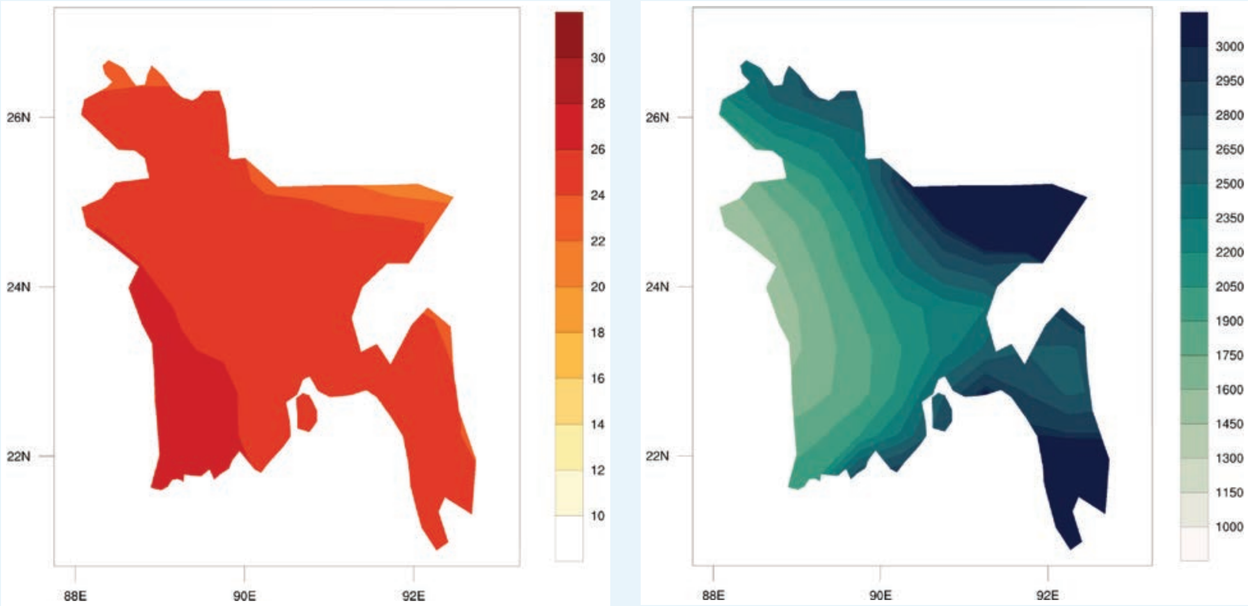


[20] Alam, E., and Dominey-Howes, D. (2015). A new catalogue of tropical cyclones of the northern Bay of Bengal and the distribution and effects of selected landfalling events in Bangladesh. International Journal of Climatology, 35(6), 801–835. URL: https://rmets.onlinelibrary.wiley.com/doi/epdf/10.1002/joc.4035

[21] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. Bangladesh. URL: https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-historical

Spatial Variation

FIGURE 3. Average Annual Temperature (°C) (left); Annual Precipitation (mm) (right) of Bangladesh, 1991–2020[22]



Key Trends

Temperature

Bangladesh's NC3 reports average, daily maximum, and daily minimum temperature rises of 0.16°C, 0.2°C, and 0.12°C per decade respectively over the period 1977–2008.[23] The Berkeley Earth dataset[24] suggests an average temperature rise of 1.03°C in Dhaka over the period 1900–1917 to 2000–2017. Observations indicate that the temperature rise was strongest in the monsoon season (June–August).

Precipitation

Bangladesh's NC3 also reports that no statistically significant changes in historical average annual precipitation have been measured. However, over the period 1975–2003, changes in the seasonality of precipitation were significant, with increases in the post-monsoon season in the range of 5–15%, and decreases in the pre-monsoon season that typically less than 5%.[25]

---

[22] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Historical. Bangladesh URL: https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-historical

[23] Ministry of Environment, Forest and Climate Change (2018). Third National Communication of Bangladesh to the UNFCCC. Government of the People's Republic of Bangladesh. URL: https://unfccc.int/sites/default/files/resource/TNC%20Report%20%28Low%20Resolution%29%2003_01_2019.pdf

[24] Carbon Brief (2018). Mapped: How every part of the world has warmed – and could continue to. Infographics. 26 September 2018]. URL: https://www.carbonbrief.org/mapped-how-every-part-of-the-world-has-warmed-and-could-continue-to-warm

[25] Ministry of Environment, Forest and Climate Change (2018). Third National Communication of Bangladesh to the UNFCCC. Government of the People's Republic of Bangladesh. URL: https://unfccc.int/sites/default/files/resource/TNC%20Report%20%28Low%20Resolution%29%2003_01_2019.pdf

Climate Future

Overview

The main data source for the World Bank Group's Climate Change Knowledge Portal (CCKP) is the Coupled Model Inter-comparison Project Phase 5 (CMIP5) models, which are utilized within the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation. Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. In this analysis RCP2.6 and RCP8.5, the low and high emissions pathways, are the primary focus. RCP2.6 represents a very strong mitigation scenario, whereas RCP8.5 assumes a high-emissions scenario. For more information, please refer to the RCP Database.

A Precautionary Approach

Studies published since the last iteration of the IPCC's report (AR5), such as Gasser et al. (2018), have presented evidence which suggests a greater probability that earth will experience medium and high-end warming scenarios than previously estimated[26]. Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

In Bangladesh, models show a trend of consistent warming that varies by emissions scenario. Projections in rainfall provide a higher degree of uncertainty but a slight increase in average annual rainfall is indicated, with a likelihood of an increase in intensity for extreme rainfall events. **Tables 2** and **3** below, provide information on temperature projections and anomalies for the four RCPs over two distinct time horizons; presented against the reference period of 1986–2005.

TABLE 2. Projected Anomaly (Changes °C) for Maximum, Minimum, and Average Daily Temperatures in Bangladesh for 2040–2059 and 2080–2099, from the Reference Period of 1986–2005 for All RCPs. The Table is Showing the Median of the CCKP Model Ensemble and the 10–90th Percentiles in Brackets.[27]

	Average Daily Maximum Temperature		Average Daily Temperature		Average Daily Minimum Temperature	
Scenario	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**
RCP2.6	1.1 (–1.3, 3.7)	1.2 (–1.3, 3.8)	1.2 (–0.8, 2.9)	1.3 (–0.8, 3.0)	1.1 (–0.5, 2.7)	1.2 (–0.5, 2.8)
RCP4.5	1.5 (–0.9, 3.9)	2.2 (–0.3, 4.9)	1.6 (–0.5, 3.2)	2.1 (0.1, 4.1)	1.4 (–0.2, 3.2)	2.1 (0.3, 4.0)
RCP6.0	1.2 (–1.6, 3.7)	2.6 (–0.1, 5.6)	1.2 (–0.9, 3.1)	2.5 (0.4, 4.6)	1.2 (–0.3, 2.9)	2.6 (0.7, 4.4)
RCP8.5	1.9 (–0.5, 4.4)	3.9 (1.4, 6.7)	1.9 (0.0, 3.8)	3.9 (2.0, 6.2)	2.0 (0.4, 3.8)	4.2 (2.3, 6.3)

[26] Gasser, T., Kechiar, M., Ciais, P., Burke, E. J., Kleinen, T., Zhu, D., . . . Obersteiner, M. (2018). Path-dependent reductions in CO_2 emission budgets caused by permafrost carbon release. Nature Geoscience, 11, 830–835. URL: https://www.nature.com/articles/s41561-018-0227-0?WT.feed_name=subjects_carbon-cycle

[27] WBG Climate Change Knowledge Portal (CCKP, 2021). Climate Data: Projection. Bangladesh. URL: https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-projections

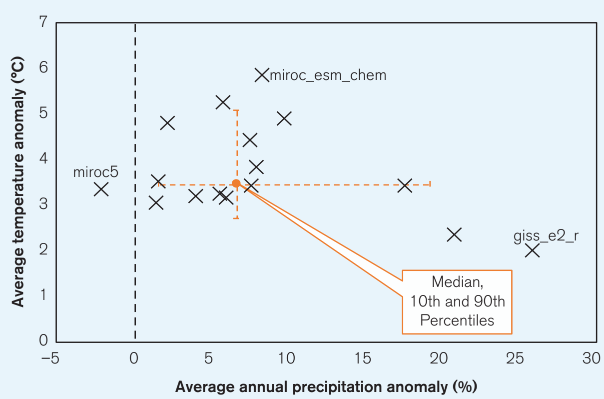
TABLE 3. Projections of Average Temperature Anomaly (°C) in Bangladesh for Different Seasons (3-Monthly Time Slices) Over Different Time Horizons and Emissions Pathways, Showing the Median Estimates of the Full CCKP Model Ensemble and the 10th and 90th Percentiles in Brackets[27]

	2040–2059		2080–2099	
Scenario	**Jun–Aug**	**Dec–Feb**	**Jun–Aug**	**Dec–Feb**
RCP2.6	0.6 (–1.1, 2.9)	1.5 (–0.7, 2.8)	0.6 (–0.9, 3.2)	1.7 (0.7, 2.9)
RCP4.5	1.0 (–0.6, 3.3)	1.6 (–0.4, 2.9)	1.6 (–0.1, 4.2)	2.3 (0.3, 4.0)
RCP6.0	0.7 (1.1, 3.4)	1.5 (–0.7, 2.8)	1.8 (0.1, 4.8)	2.9 (0.8, 4.5)
RCP8.5	1.6 (0.0, 4.0)	2.2 (0.0, 3.8)	3.4 (1.7, 5.9)	4.5 (2.4, 6.2)

Model Ensemble

Climate projections presented in this document are derived from datasets available through the CCKP, unless otherwise stated. These datasets are processed outputs of simulations performed by multiple General Circulation Models (GCM) (for further information see Flato et al., 2013).[28] Collectively, these different GCM simulations are referred to as the 'model ensemble'. Due to the differences in the way GCMs represent the key physical processes and interactions within the climate system, projections of future climate conditions can vary widely between different GCMs, this is particularly the case for rainfall related variables and at national and local scales. To present the range of projections **Figure 4** shows a selection of 16 GCMs representing annual average temperature change and annual precipitation change in Bangladesh under RCP8.5. Spatial representation of future projections of annual temperature and precipitation for mid and late century under RCP8.5 are presented in **Figure 5**.

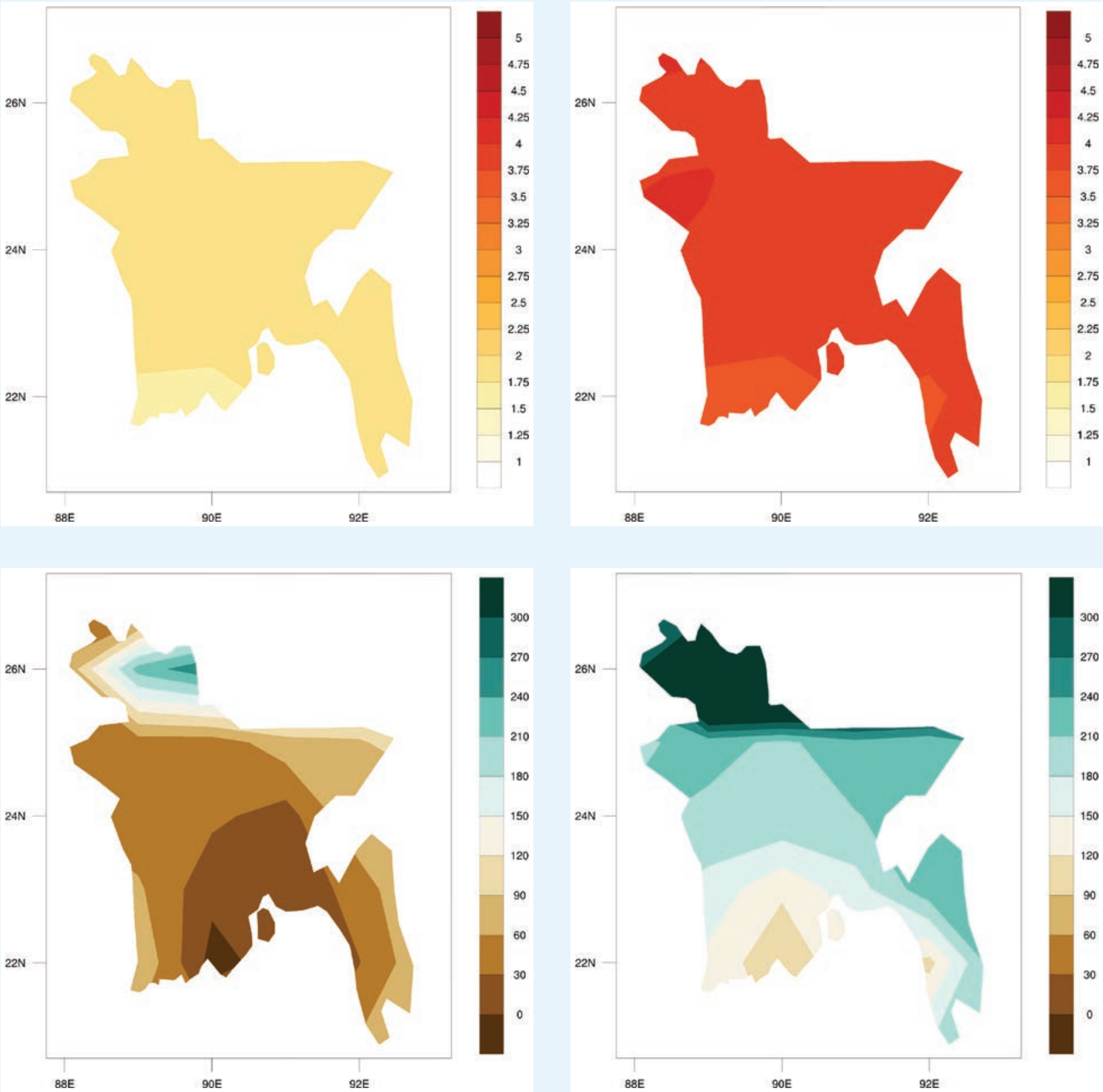
FIGURE 4. 'Projected Average Temperature Anomaly' and 'Projected Annual Rainfall Anomaly' in Bangladesh. Outputs of 16 Models Within the Ensemble Simulating RCP8.5 Over the Period 2080–2099. Models Shown Represent the Subset of Models Within the Ensemble Which Provide Projections Across All RCPs and Therefore are Most Robust for Comparison.[27] Three Outlier Models are Labelled.



[28] Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W., . . . Rummukainen, M. (2013). Evaluation of Climate Models. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 741–866. URL: http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

Spatial Variation

FIGURE 5. CMIP5 Ensemble Projected Change (32 GCMs) in Annual Temperature (top) and Precipitation (bottom) by 2040–2059 (left) and by 2080–2090 (right) Relative to 1986–2005 Baseline Under RCP8.5[29]



[29] WBG Climate Change Knowledge Portal (CCKP 2021). Bangladesh. Climate Data. Projections. URL: https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data-projections

Temperature

Projections of future temperature change are presented in three primary formats. Shown in **Table 2** are the changes (anomalies) in daily maximum and daily minimum temperatures over the given time period, as well as changes in the average temperature. **Figures 6** and **7** display the annual and monthly temperature projections. While similar, these three indicators provide slightly different information. Monthly and annual average temperatures are most commonly used for general estimation of climate change, but the daily maximum and minimum can explain more about how daily life might change in a region, affecting key variables such as the viability of ecosystems, health impacts, productivity of labor, and the yield of crops, which are often disproportionately influenced by temperature extremes.

FIGURE 6. Projected Average Annual Temperature in Bangladesh Under RCP2.6 (Blue) and RCP8.5 (Red) Estimated by the Model Ensemble. Shading Represents the 10th and 90th Percentile of the Multi-Model Range.[30]

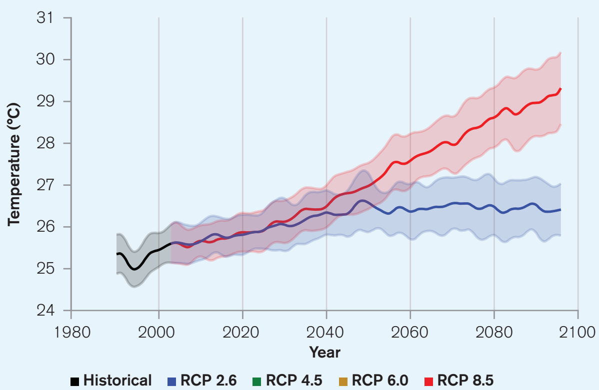
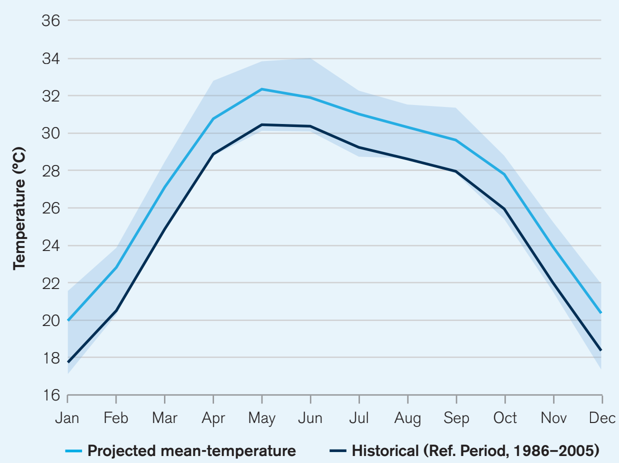


FIGURE 7. Projected Monthly Mean Temperature, in Relation to the Historical Reference Period, 1986–2005, for Bangladesh for the Period 2040–2099 under RCP8.5. The Value Shown Represents the Median of the Model Ensemble with the Shaded Areas Showing the 10th–90th Percentiles.[30]



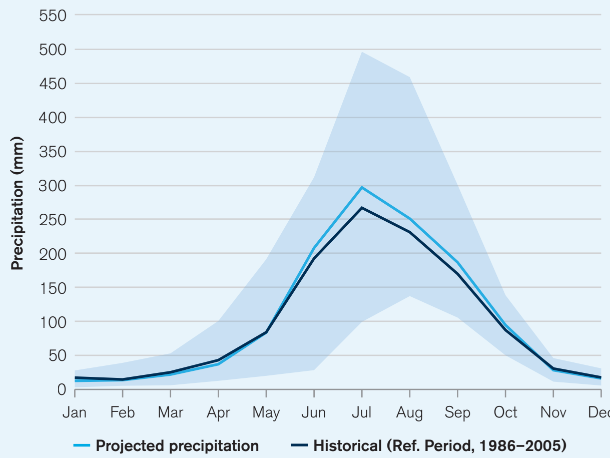
Average temperature increases in Bangladesh are broadly in line with the IPCC's global projections. When factoring in warming prior to the baseline period of 1986–2005 (i.e. when calculating temperatures against pre-industrial levels) the warming experienced in Bangladesh will breach the 2°C threshold by the end of the century under all RCPs except RCP2.6. This highlights the importance of achieving lower global emissions pathways. Warming in Bangladesh has two distinctive features. First, warming in both daily maximum and minimum temperatures considerably outstrips average warming, typically rising around 10%–20% higher. Second, warming is much stronger in the winter season (December-February) than the summer (June-August), typically 10%–30% higher. These features have the potential to amplify the impacts of temperature rises on human health and livelihoods, as is discussed in the sections that follow.

[30] WBG Climate Change Knowledge Portal (2021). Climate by Sector: Interactive Climate Indicator Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/energy/oil-gas-and-coal-mining?country=BGD&period=2080-2099.

Precipitation

Trends in future precipitation in Bangladesh are highly uncertain. As shown in **Figures 4** and **8,** the model ensemble's most common estimate is of a slight increase in average precipitation. However, the response of precipitation to higher emissions pathways appears not to be a simple linear relationship with temperature change. Future changes will likely depend both on climate change influences on monsoon rainfall patterns and on tropical cyclone activity. These are currently uncertain. Work by Jayasankar et al. (2015) aimed to identify the best performing sub-group of models for simulation of future monsoon rainfall changes.[31] Their favored models point towards a slight reduction in the frequency of future light precipitation events which is offset by an increase in the frequency of high and extreme precipitation events. In fact, there is agreement among the available studies that higher temperatures will increase evaporation and atmospheric moisture, leading to increases in the intensity of extreme precipitation events in the South Asian Monsoon.[32] This finding is in keeping with global-climate modelling. The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia.[33]

FIGURE 8. Seasonal Cycle Showing the Projected Average Monthly Precipitation for Bangladesh for the Period, 2040–2059, in Relation to the Historical Reference Period, 1986–2005, RCP8.5[30]



CLIMATE CHANGE AND NATURAL HAZARD RISK

Bangladesh faces some of the highest disaster risk levels in the world, ranked 22nd out of 191 countries by the 2019 Inform Risk Index[34] (**Table 4**). Bangladesh has extremely high exposure to flooding (ranked 1st in the world), including, riverine, flash, and coastal, as well as high exposure to tropical cyclones and their associated hazards (ranked 19th) and drought (ranked 47th). Disaster risk in Bangladesh is also driven by its social vulnerability. Bangladesh's vulnerability ranking (37th) is driven by its high levels of socioeconomic deprivation.

[31] Jayasankar, C., Surendran, S., Rajendran, K. (2015). Robust signal of future projections of Indian Summer Monsoon rainfall by IPCC AR5 climate models: Role of seasonal cycle and interannual variability. Geophysical Research Letters: 42: 3513–3520. URL: https://agupubs.onlinelibrary.wiley.com/doi/pdf/10.1002/2015GL063659

[32] Lee, D., Min, S.-K., Fischer, E., Shiogama, H., Bethke, I., Lierhammer, L., and Scinocca, J. F. (2018). Impacts of half a degree additional warming on the Asian summer monsoon rainfall characteristics. Environmental Research Letters, 13(4), 44033. URL: https://www.osti.gov/pages/servlets/purl/1523641

[33] Westra, H. J. Fowler, J. P. Evans, L. V. Alexander, P. Berg, F. Johnson, E. J. Kendon, G. Lenderink, N. M. R. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555. URL: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014RG000464

[34] European Commission (2019). INFORM Index for Risk Management. Bangladesh Country Profile. URL: https://drmkc.jrc.ec.europa.eu/inform-index/Countries/Country-Profile-Map

TABLE 4. Selected Indicators from the INFORM 2019 Index for Risk Management for Bangladesh. For the Sub-Categories of Risk (e.g. "Flood") Higher Scores Represent Greater Risks. Conversely the Most at-Risk Country is Ranked 1st. The Average Score Across All Countries is Shown in Brackets.

Flood (0–10)	Tropical Cyclone (0–10)	Drought (0–10)	Vulnerability (0–10)	Lack of Coping Capacity (0–10)	Overall Inform Risk Level (0–10)	Rank (1–191)
9.9 [4.5]	6.9 [1.7]	5.0 [3.2]	5.7 [3.6]	5.1 [4.5]	6.0 [3.8]	22

Bangladesh scores somewhat better in terms of its coping capacity. The section which follows analyses climate change influences on the exposure component of risk in Bangladesh. As seen in **Figure 1**, the ND-GAIN Index presents an overall picture of a country's vulnerability and capacity to improve its resilience. In contrast, the Inform Risk Index identifies specific risks across a country to support decisions on prevention, preparedness, response and a country's overall risk management. Bangladesh has also developed its own Multi-Hazard and Vulnerability Assessment Modeling and Mapping products,[35] and disaster related disaggregated information at district and upazila levels;[36] managed under the Department of Disaster Management.

Heat Waves

Bangladesh regularly experiences some of the highest maximum temperatures in Asia, with an average monthly maximum of around 30°C and an average April maximum of 33°C. The current probability of a heat wave (defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 2%–3%.[30,37] However, currently, the median number of days per year during which Bangladesh experiences a Heat Index of greater than 35°C is around 70 days, reflecting a highly-frequent, heat stressed environment. The Heat Index represents a measure of combined temperature and humidity which captures the relative heat stress experienced by humans, plants and animals.

The projected rise in long-term temperatures, particularly under higher emissions pathways, might be regarded as a move towards an almost permanent state of heat wave, as temperatures will regularly breach levels associated with health risks.[38] Based on the 1986–2005 baseline, the CCKP model ensemble suggest Bangladesh faces a very significant increase in the annual exposure to extreme heat. As shown below in **Figure 9**, Bangladesh will experience emerging hot and humid seasons, in which the Heat Index surpasses 35 °C. The country has already begun to experience increased number of days surpassing this threshold, with signficnat increased seen in the spring and fall seasons, likely indicating the expansion of the hot and humid summer seasons.

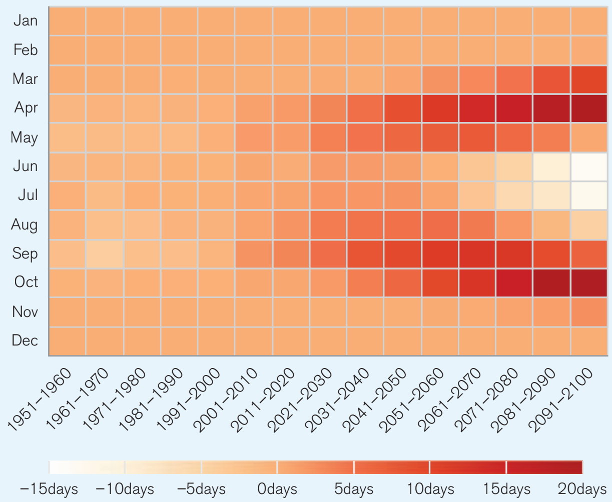
[35] Department of Disaster Management (2018). Multi-Hazard and Vulnerability Assessment Modeling and Mapping products. Bangladesh National Portal. URL: http://www.ddm.gov.bd/site/page/c2d881ae-fcfd-45bd-9f03-81b33d080aab/Multi-Hazard-Risk-and-Vulnerability-Assessment-Modeling-and-Mapping—

[36] Department of Disaster Management (2021). GeoDASH. URL: https://geodash.gov.bd/groups/group/DDM/?limit=100&offset=0

[37] Nissan, H., Burkart, K., de Perez, E. C., Van Aalst, M., and Mason, S. (2017). Defining and predicting heat waves in Bangladesh. Journal of Applied Meteorology and Climatology, 56(10), 2653–2670. URL: https://research.utwente.nl/en/publications/defining-and-predicting-heat-waves-in-bangladesh

[38] Im, E. S., Pal, J. S., and Eltahir, E. A. B. (2017). Deadly heat waves projected in the densely populated agricultural regions of South Asia. Science Advances, 3(8), 1–8. URL: https://advances.sciencemag.org/content/3/8/e1603322

FIGURE 9. Projected Heatplot Demonstrating the Anomaly (Change) of the Number of Days with Heat Index >35°C. Heat Index is a Combined Measure of Both Temperature and Humidity Which Helps to Understand the Effective Temperature Experienced by Humans, Plants, and Animals.[27]



Drought

Two primary types of drought may affect Bangladesh, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). Agricultural drought may follow on from these phenomena, but is also influenced by other factors such as crop and land management choices. At present, Bangladesh faces an annual probability of severe meteorological drought of around 4%, as defined by a Standardized Precipitation Evaporation Index (SPEI) of less than –2 occurring over at least a daily time interval (**Figure 10**). Less severe droughts occur on a more regular basis (see Rahman and Lateh, 2016).[39] Factors affecting hydrological drought in Bangladesh are complex, particularly in the context of water sharing agreements with India. Issues include the health of groundwater resources, many of which have experienced salinization, and poor management practices. One study suggested that between 2001–2013, approximately 1% of Bangladesh's population was exposed to drought (in this case drought was categorized as a Normalized Difference Drought Index of >0.6).[40]

Naumann et al. (2018) provide a global overview of future changes in meteorological drought conditions under different warming scenarios. The research suggests that in South Asia, there could be an increase in the frequency of drought events, with what is currently a 1 in 100-year event returning approximately every 40–50 years under 1.5°C–2°C of warming, and every 20 years under 3°C of warming.[41]

---

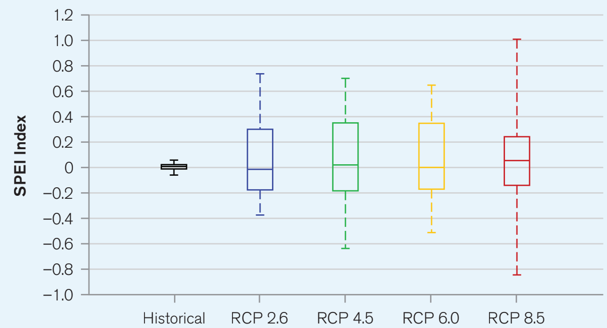
[39] Rahman, M. R., and Lateh, H. (2016). Meteorological drought in Bangladesh: assessing, analyzing and hazard mapping using SPI, GIS and monthly rainfall data. Environmental Earth Sciences, 75(12). URL: https://pubag.nal.usda.gov/catalog/5234128

[40] Amarnath, G.; Alahacoon, N.; Smakhtin, V.; Aggarwal, P. (2017). Mapping multiple climate-related hazards in South Asia. Colombo, Sri Lanka: International Water Management Institute (IWMI). 41p. (IWMI Research Report 170). URL: http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/pub170/rr170.pdf

[41] Naumann, G., Alfieri, L., Wyser, K., Mentaschi, L., Betts, R. A., Carrao, H., . . . Feyen, L. (2018). Global Changes in Drought Conditions Under Different Levels of Warming. Geophysical Research Letters, 45(7), 3285–3296. URL: https://agupubs.onlinelibrary.wiley.com/doi/10.1002/2017GL076521

The picture presented by the CCKP data is less clear. Although the median annual probability projected by the model ensemble increases under all emissions pathways, the degree of certainty suggested by the interquartile range is low. By the 2090s, the model ensemble projects a larger median increase in annual drought probability under RCP4.5 and RCP6.0 than under RCP8.5. Further research is required, including downscaled modelling, to understand finer scale changes, global model refinement to constrain the range of estimates of future drought probability, and systems modelling to better understand the potential for hydrological and agricultural drought. Larger-scale climate phenomena, such as El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) have complex relationships with drought in Bangladesh. Emerging evidence suggests a potential relationship between ENSO and hydrological drought in Bangladesh as a result of reduced precipitation over the Ganges Basin,[42] and a potential relationship between IOD and meteorological drought.[43] However, such phenomena are currently poorly simulated by global climate models.[44]

FIGURE 10. Boxplots Showing the SPEI Index for Annual Drought Probability in Bangladesh in 2080–2099, Across RCPs[30]



Flood

The World Resources Institute's AQUEDUCT Global Flood Analyzer can be used to establish a very approximate baseline level of river flood exposure (**Figure 11**). As of 2010, assuming protection for up to a 1 in 25-year event, the population annually affected by river flooding in Bangladesh is estimated at 1.6 million people and the expected annual impact on GDP is estimated at $2.6 billion. Development and climate change are both likely to increase these figures. The climate change component can be isolated and by the 2030s is expected to increase the annually affected population by 5.3 million people, and the impact on GDP by $25 billion under the RCP8.5 emissions pathway (AQUEDUCT Scenario B).[45]

[42] Pervez, M. S., and Henebry, G. M. (2015). Spatial and seasonal responses of precipitation in the Ganges and Brahmaputra river basins to ENSO and Indian Ocean dipole modes: implications for flooding and drought. Natural Hazards and Earth System Sciences, 2, 147–162. URL: https://www.nat-hazards-earth-syst-sci.net/15/147/2015/nhess-15-147-2015.pdf

[43] Ahmed, M. K., Alam, M. S., Yousuf, A. H. M., and Islam, M. M. (2017). A long-term trend in precipitation of different spatial regions of Bangladesh and its teleconnections with El Niño/Southern Oscillation and Indian Ocean Dipole. Theoretical and Applied Climatology, 129(1), 473–486. URL: https://pubag.nal.usda.gov/catalog/5750193

[44] Chen, C., Cane, M. A., Wittenberg, A. T., and Chen, D. (2017). ENSO in the CMIP5 Simulations: Life Cycles, Diversity, and Responses to Climate Change. Journal of Climate, 30(2), 775–801. URL: https://journals.ametsoc.org/doi/pdf/10.1175/JCLI-D-15-0901.1

[45] These are approximate figures derived from flood simulation on Bangladesh from Winsemius, H. C. *et al.* (2013). A framework for global river flood risk assessments. *Hydrology and Earth System Sciences*, 17(5), pp. 1871–1892. URL: https://hess.copernicus.org/articles/17/1871/2013/hess-17-1871-2013.pdf

Work by Paltan et al. (2018) demonstrates that even under lower emissions pathways coherent with the Paris Climate Agreement, nearly all Asian countries face an increase in the frequency of extreme river flows.[47] What would historically have been a 1 in 100-year flow, could become approximately a 1 in 50-year or 1 in 25-year event in most of South, Southeast, and East Asia. There is good agreement among models on this trend.

Table 5 shows estimates from Mohammed et al. (2018) of the increase in the magnitude of a 1 in 100-year flow in Bangladesh's three major rivers.[48] There are multiple factors leading to these changes, including climate change-driven melting of Himalayan glaciers and increased extreme precipitation intensities in the upstream basins. However, projected changes could also be subject to future development trajectories, and in the case of Bangladesh future inter-governmental water sharing agreements. Increases in extreme river flows are likely to place pressure on Bangladesh's flood defense system that without adaptation action are expected to increase the risk of disaster-level fluvial flood events.

FIGURE 11. Modelled Inundation Depth of a Once-in-Ten Years Riverine Flood Event in Bangladesh in the Year 2030[46]

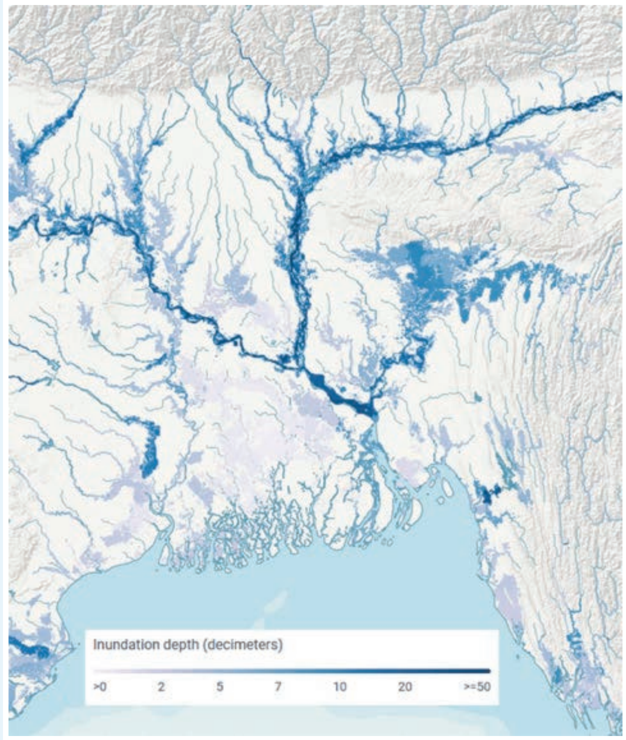


TABLE 5. Projected Increase in the Magnitude of a 1 in 100-Year Flow in Bangladesh's Three Major Rivers Based on a Subset of Models from the CMIP5 Ensemble. Changes Against a 1986–2005 Baseline.[48]

Estimate	Ganges	Brahmaputra	Meghna
1.5°C	27%	8%	15%
2°C	29%	24%	38%
4°C	54%	63%	81%

[46] WRI (2021) Aqueduct. World Resources Institute. Available at: www.aqueduct.wri.org [accessed 19/02/2021]

[47] Paltan, H., Allen, M., Haustein, K., Fuldauer, L., and Dadson, S. (2018). Global implications of 1.5°C and 2°C warmer worlds on extreme river flows Global implications of 1.5°C and 2°C warmer worlds on extreme river flows. Environmental Research Letters, 13. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aad985/pdf

[48] Mohammed, K., Islam, A. K. M. S., Islam, G. M. T., Alfieri, L., Khan, M. J. U., Bala, S. K., and Das, M. K. (2018). Future Floods in Bangladesh under 1.5°C, 2°C, and 4°C Global Warming Scenarios. Journal of Hydrologic Engineering, 23(12), 04018050. URL: https://ascelibrary.org/doi/abs/10.1061/%28ASCE%29HE.1943-5584.0001705

Willner et al. (2018) suggest a potential increase in the population affected by extreme floods in the region of 6–12 million people by 2035–2044 (**Table 6**).[49] Another study conducted by the World Bank Group put the proportional increase in the population exposed to river flood by the mid-century at 40%.[50] Bangladesh's rapidly growing urban population faces intense and diverse flood risks, both from fluvial and surface water flooding. The World Bank Group estimates that a flood of the level experienced in 2004 in Dhaka, if repeated with levels of climate change expected by the 2050s, could increase damages by around $23 million (assuming present day infrastructure and economic values).[51] Further, and more significant, increases are also highly likely as a result of the increased future value of infrastructure in flood exposed areas, and the ongoing migration to such areas. The population exposed to flood risk in Bangladesh's metropolitan areas often live in poorly planned and informal developments and are also among the poorest and most vulnerable groups in society. See Dasgupta et al. (2015) for detailed assessment of future flood risks in Dhaka.[51]

TABLE 6. Estimated Number of People in Bangladesh Affected by an Extreme River Flood (Defined Here as the 90th Percentile of Numbers of People Affected) in the Historic Period 1971–2004 and the Future Period 2035–2044. Figures Represent an Average of All Four RCPs and Assume Present Day Population Distributions.[49]

Estimate	Population Exposed to Extreme Flood (1971–2004)	Population Exposed to Extreme Flood (2035–2044)	Increase in Affected Population
16.7 Percentile	1,385,548	7,884,141	6,498,593
Median	2,872,942	13,507,271	10,634,329
83.3 Percentile	4,580,038	16,637,013	12,056,975

Coastal Zone

Sea-level rise threatens significant physical changes to coastal zones around the world. Global mean sea-level rise was estimated in the range of 0.44–0.74 meters (m) by the end of the 21st century by the IPCC's Fifth Assessment Report,[52] but some studies published more recently have highlighted the potential for more significant rises, shown in **Table 7**. An estimated 6,170 km^2 of the Ganges Delta sits at less than 2 m above sea-level. Human development processes, such as groundwater extraction, sand mining, and aquaculture have contributed to accelerating the sinking of the land, and the blocking of sediment which would otherwise deposit on the floodplain with dykes and dams acts to accelerate the relative rate of sea-level rise. Recent research suggests that once all contributing factors are aggregated, relative sea-level rise in the Ganges Delta is likely to be around 5–10 mm/year.[53]

49 Willner, S., Levermann, A., Zhao, F., Frieler, K. (2018). Adaptation required to preserve future high-end river flood risk at present levels. Science Advances: 4:1. URL: https://advances.sciencemag.org/content/4/1/eaao1914

50 Winsemius, H. C.; Jongman, B.; Veldkamp, T. I.E.; Hallegatte, S.; Bangalore, M.; Ward, P. J. (2015). Disaster risk, climate change, and poverty: assessing the global exposure of poor people to floods and droughts (English). Policy Research working paper; no. WPS 7480. Washington, D.C. World Bank Group. URL: http://documents.worldbank.org/curated/en/965831468189531165/pdf/WPS7480.pdf

51 Dasgupta, S., Zaman, A., Roy, S., Huq, M., Jahan, S., Nishat, A. (2015). Urban flooding of greater Dhaka in a changing climate: Building local resilience to disaster risk. World Bank Group. URL: http://documents.worldbank.org/curated/en/683381468001782892/pdf/100228-PUB-REVISED-Box393232B-PUBLIC-PUBDATE-10-26-15-DOI-10-15969781464807107-EPI-1464807108.pdf

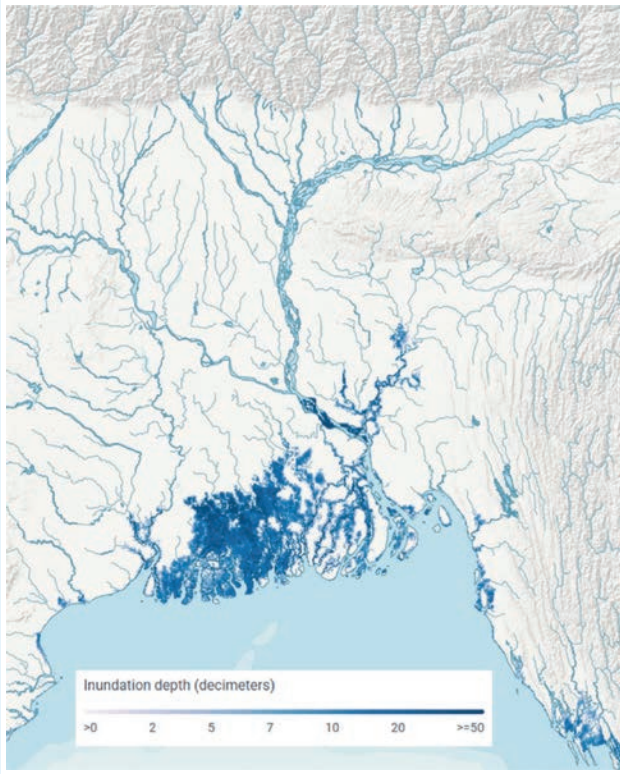
52 Church, J. a., Clark, P. U., Cazenave, A., Gregory, J. M., Jevrejeva, S., Levermann, A., . . . Unnikrishnan, A. S. (2013). Sea level change. In Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 1137–1216). Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press. URL: http://www.climatechange2013.org/images/report/WG1AR5_Chapter13_FINAL.pdf

53 Nicholls, R. J. *et al.* (2021). A global analysis of subsidence, relative sea-level change and coastal flood exposure. *Nature Climate Change*. Springer US. URL: https://www.nature.com/articles/s41558-021-00993-z

The impacts of sea-level rise along Bangladesh's coastal zone are mitigated by the extensive network of polders which encircle the land. Vulnerability to sea-level rise is highest in the areas outside of these polders, which are often inhabited and farmed by the poorest groups in society. Davis et al. (2018) suggest around 900,000 people could be forced to migrate out of coastal areas due to permanent inundation by mid-century under RCP8.5.[54] While the majority of Bangladesh's coastal zone sits inside polders, which (when maintained properly) protect against monsoon and storm surge flooding, some the poorest communities are found pursuing livelihoods outside of poldered areas. Dasgupta et al. (2014b) emphasize the challenges facing Bangladeshi communities living in the coastal zone under climate change.[55] Low elevation, and higher salinity levels are already strongly correlated with lower incomes but these issues are also driving a 'hollowing out' of the population, with working-age adults forced to migrate away to seek a living wage. The population left behind in the exposed lands are often dominated by women, the elderly and disabled, representing impoverished dependent communities with limited resilience to climate-hazards.

Climate change threatens to significantly increase coastal flood risk in Bangladesh, from an already high baseline. **Figure 12** shows modelled flood inundation depth in a once-in-ten-year coastal flood event in 2030. Work by the UK Met Office suggests that without adaptation, 2.5 million to 7.2 million people (depending on the emissions pathway) may be affected by coastal flooding in Bangladesh in the 2070s to 2100s.[56] **Table 8** shows the average number of people in the coastal zone experiencing flooding per year.

FIGURE 12. Modelled Inundation Depth of a Once-in-Ten Years Coastal Flood Event in Bangladesh in the Year 2030[57]. Note, this Figure Assumes that No Embankment is Present.



[54] Davis, K. F., Bhattachan, A., D'Odorico, P., and Suweis, S. (2018). A universal model for predicting human migration under climate change: examining future sea level rise in Bangladesh. Environmental Research Letters, 13(6), 64030. URL: https://pdfs.semanticscholar.org/2162/ff3e8b5c2e06c77bd3ad629924a61bc20a7f.pdf

[55] Dasgupta, S., Hossain, M. M., Huq, M., and Wheeler, D. (2014b). Facing the hungry tide: Climate change, livelihood threats, and household responses in coastal Bangladesh. World Bank Group. URL: http://documents.worldbank.org/curated/en/558921468006267567/pdf/WPS7148.pdf

[56] UK Met Office (2014). Human dynamics of climate change: Technical Report. Met Office, UK Government. URL: https://www.metoffice.gov.uk/binaries/content/assets/metofficegovuk/pdf/weather/learn-about/climate/human-dynamics-of-climate-change/hdcc_alternative_version.compressed.pdf

[57] WRI (2021) Aqueduct. World Resources Institute. Available at: www.aqueduct.wri.org [accessed 19/02/2021]

Significant risk is also presented by the potential for climate change to increase storm surge heights during tropical cyclones, and the associated potential for dyke breaches. Disaster events involving inundation and intense erosion may cause 'rapid-onset' loss of habitable land in the coastal zone. Sea-level rise is also expected to increase soil salt concentrations and saline intrusion distances. This process is already damaging crop yields and changing fish species distributions and aquaculture potential.[58] The net impact of climate change on ecosystems and communities in the coastal zone will ultimately be heavily affected by planned adaptation activities in the region, including potential polder construction and enhancement, habitat restoration initiatives and a potential coastal greenbelt, as outlined in the coastal hotspot activities set out in the Bangladesh Delta Plan 2100.[59] Communities with greater access to natural resources (ecosystem services) may have greater capacity to bounce back from disaster as these can provide rapid income generation sources and heightened regenerative capabilities for natural systems,[60] however, climate change may represent a threat to those resources, such as through damage to fisheries or other mangrove resources.[61]

TABLE 7. Estimates of Global Mean Sea-Level Rise by Rate and Total Rise Compared to 1986–2005 Including Likely Range Shown in Brackets, Data from Chapter 13 of the IPCC's Fifth Assessment Report with Upper-End Estimates Based on Higher Levels of Antarctic Ice-Sheet Loss from Le Bars et al[62]

Scenario	Rate of Global Mean Sea-Level Rise in 2100	Global Mean Sea-Level Rise in 2100 Compared to 1986–2005
RCP2.6	4.4 mm/yr (2.0–6.8)	0.44 m (0.28–0.61)
RCP4.5	6.1 mm/yr (3.5–8.8)	0.53 m (0.36–0.71)
RCP6.0	7.4 mm/yr (4.7–10.3)	0.55 m (0.38–0.73)
RCP8.5	11.2 mm/yr (7.5–15.7)	0.74 m (0.52–0.98)
Estimate Inclusive of High-End Antarctic Ice-Sheet Loss		1.84 m (0.98–2.47)

TABLE 8. The Average Number of People Experiencing Flooding per Year in the Coastal Zone in the Period 2070–2100 Under Different Emissions Pathways (Assumed Medium Ice-Melt Scenario) and Adaptation Scenarios for Bangladesh[56]

Scenario	Without Adaptation	With Adaptation
RCP2.6	2,598,420	14,060
RCP8.5	7,226,640	21,550

[58] Rabbani, G., Rahman, A., and Mainuddin, K. (2013). Salinity-induced loss and damage to farming households in coastal Bangladesh. International Journal of Global Warming, 5(4), 400–415. URL: http://www.climatechange.gov.bd/sites/default/files/LossDamageDueSalinitySatkhiraBangladesh.pdf

[59] Ministry of Environment, Forest and Climate Change (2018). Third National Communication of Bangladesh to the UNFCCC. Government of the People's Republic of Bangladesh. URL: https://unfccc.int/sites/default/files/resource/TNC%20Report%20%28Low%20Resolution%29%2003_01_2019.pdf

[60] Akter, S., and Mallick, B. (2013). The poverty–vulnerability–resilience nexus: Evidence from Bangladesh. Ecological Economics, 96, 114–124. URL: https://www.ufz.de/export/data/2/80332_Akter_and_Mallick_2013_webversion.pdf

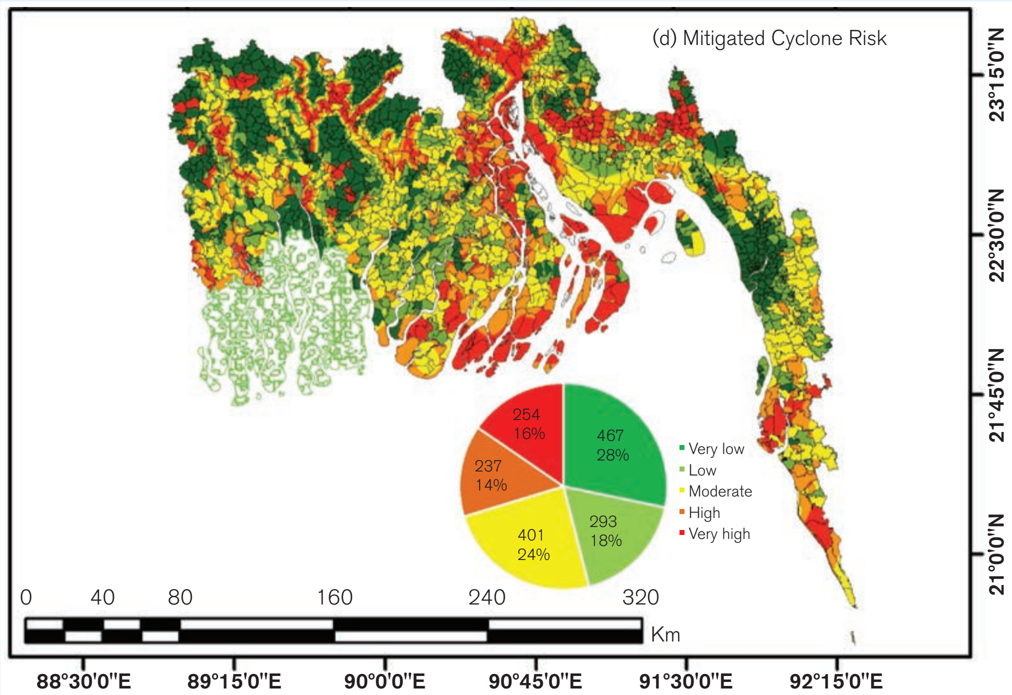
[61] Dasgupta, S., Huq, M., Mustafa, M., Sobhan, M., and Wheeler, D. (2016). Impact of Climate Change and Aquatic Salinization on Fish Habitats and Poor Communities in Southwest Coastal Bangladesh and Bangladesh Sundarbans. World Bank Group. URL: http://documents.worldbank.org/curated/en/199851468000266963/pdf/WPS7593.pdf

[62] Le Bars, D., Drijhout, S., de Vries, H. (2017). A high-end sea level rise probabilistic projection including rapid Antarctic ice sheet mass loss. Environmental Research Letters: 12:4. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aa6512/pdf

Cyclones and Storm Surge

Cyclones and associated storm surges are significant drivers of disaster risk in Bangladesh. A wide variety of factors influence this risk, relating to the nature of the cyclone hazard itself, particularly the wind speed and landfall location, but also exposure of the population (factoring in disaster risk reduction measures), the social vulnerability of the population, and the coping capacity of the population. Analysis of the category 1, tropical cyclone, Mora, in 2017, showed that a population of around 10 million people were exposed to wind speeds of 120 kilometers per hour (km/h) or above.[63] Similarly an estimated 9 million people were exposed to cyclone Sidr, in 2007.[64] **Figure 13** shows the relative risk levels to tropical cyclone impacts by region in Bangladesh's coastal zone.

FIGURE 13. Mitigated Risk Index (MRI) by Union in the Bangladesh Coastal Zone. MRI was Calculated by Multiplying Hazard, Exposure, and Vulnerability (Subtracting Coping Capacity).[65]



Climate change is expected to interact with cyclone hazard in complex ways which are currently poorly understood. Known risks include the action of sea-level rise to enhance the damage caused by cyclone-induced storm surges, and the possibility of increased wind speed and precipitation intensity. Modelling of climate change impacts on cyclone intensity and frequency conducted across the globe points to a general trend of reduced cyclone frequency

[63] UNOSAT (2017). Bangladesh – Tropical Cyclone Mora – 17. Population exposure analysis – Update 1. UNITAR-UNOSAT. URL: http://unosat-maps.web.cern.ch/unosat-maps/BD/TC20170529BGD/UNOSAT_PoP_Exposure_Analysis_Bangladesh_update1.pdf

[64] GoB (2008). Cyclone Sidr in Bangladesh: Damage, loss, and needs assessment for disaster recovery and reconstruction. Government of Bangladesh. URL: https://reliefweb.int/sites/reliefweb.int/files/resources/F2FDFF067EF49C8DC12574DC00455142-Full_Report.pdf

[65] Quader, M. A., Khan, A. U., and Kervyn, M. (2017). Assessing Risks from Cyclones for Human Lives and Livelihoods in the Coastal Region of Bangladesh. International Journal of Environmental Research and Public Health, 14(8). p. 16, d. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5580535/pdf/ijerph-14-00831.pdf

and increased intensity and frequency of the most extreme events.[66] Research assessing historical cyclone activity in the Bay of Bengal is broadly in line with this expectation. Balaguru et al. (2014) report increased intensity of tropical cyclone activity in the Bay of Bengal over the period 1981–2010,[67] a finding supported by a longer-term assessment made by the World Bank Group.[68] Bangladesh established its Emergency Cyclone Recovery and Restoration Project after the devastation incurred from Cyclone Sidr in 2007. This assists in emergency response, temporary disaster shelters and has strengthened the country's disaster risk reduction and management efforts and has also established a monitoring and evaluation processes to support agencies' preparedness for future disasters.[69] Further research is required to better understand potential changes in cyclone seasonality and pathways, as well as the possibility that cyclone hazards might be experienced in unprecedented locations.

The effect of sea-level rise to enhance the impact of storm surge in Bangladesh is of concern to low-lying coastal regions. Past events, notably cyclone Sidr, have shown the potential damage storm surges can cause both in unprotected lands (outside of polders) and when dykes fail. Jisan et al. (2018) suggest that under sea-level rise of 0.54 m (expected to be met or exceeded by 2100 under RCP4.5, RCP6.0 and RCP8.5) the area inundated by the storm surge associated with cyclone Sidr would increase by around 53% to almost 3,000 km^2.[70]

CLIMATE CHANGE IMPACTS

Natural Resources

Water

During the monsoons, Bangladesh receives high amounts of rainfall and very significant flows from the Padma, Brahmaputra, and Meghna Rivers. In spite of the high-water availability, a multitude of water resource challenges primarily linked to the nation's rapid development present major challenges. A lack of adequate infrastructure and particularly asset maintenance, as well as challenges in the planning of flood control, drainage, and irrigation, is thought to have led to worsened flooding, poor drainage of wetlands, water quality issues, and increased water logging and salinization.[71] Waterlogging is known to have become a major issue in the agricultural areas of neighboring Khulna

---

[66] Walsh, K., McBride, J., Klotzbach, P., Balachandran, S., Camargo, S., Holland, G., Knutson, T., Kossin, J., Lee, T., Sobel, A., Sugi, M. (2015). Tropical cyclones and climate change. WIREs Climate Change: 7: 65–89. URL: https://onlinelibrary.wiley.com/doi/epdf/10.1002/wcc.371

[67] Balaguru, K., Taraphdar, S., Leung, L. R., and Foltz, G. R. (2014). Increase in the intensity of post-monsoon Bay of Bengal tropical cyclones. Geophysical Research Letters, 41(10), 3594–3601. URL: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1002/2014GL060197

[68] Bandyopadhyay, S., Dasgupta, S., Khan, Z., Wheeler, D. (2018). Cyclone storm landfalls in Bangladesh, West Bengal and Odisha, 1877–2016. World Bank Group. URL: http://documents.worldbank.org/curated/en/904751516818659880/pdf/WPS8316.pdf

[69] World Bank (2009). Emergency 2007 Cyclone Recovery and Restoration Project. URL: https://projects.worldbank.org/en/projects-operations/project-detail/P111272

[70] Jisan, M. A., Bao, S., and Pietrafesa, L. J. (2018). Ensemble projection of the sea level rise impact on storm surge and inundation at the coast of Bangladesh. Natural Hazards and Earth System Sciences, 18(1), 351–364. URL: https://www.nat-hazards-earth-syst-sci.net/18/351/2018/

[71] Tuong, T.P., Humphreys, E., Khan, Z.H., Nelson, A., Mondal, M., Buisson, M-C., George, P. (2014). Messages from the Ganges Basin Development Challenge: Unlocking the Production Potential of the Polders of the Coastal Zone of Bangladesh through Water Management Investment and Reform. CPWF Research for Development Series, paper 9. Dhaka, Bangladesh: CPWF. URL: https://assets.publishing.service.gov.uk/media/57a089de40f0b649740002d8/CPWF-Ganges-basin-messages-final.pdf

and Satkhira and is also seen in Dhaka city. Many of these changes are exacerbated by land-use conflicts, such as between rice and aquaculture in the coastal zone, but also by climate change. The projected changes to the intensity of both hydrological extremes is likely to increase the pressure on Bangladesh's water resources.[72] The likely need for widespread land use and livelihood changes due to crop range shifts, and saline intrusion may increase water conflicts.[73]

Bangladesh is already experiencing pressure as a result of the increased occurrence of saline intrusion into its groundwater as well as surface water resources, especially along the coast, in part due to increases in sea-level, as a direct impact of climate change.[74] Conflict and competition between various water using sectors may also lead to water scarcity during the dry seasons, which are likely to be worsened by the increased frequency of projected drought periods. Bangladesh struggles with water-borne diseases and water quality issues, both of which have been associated with flood and drought. Notably, arsenic contamination of groundwater has presented a major health risk over recent years.[75] Past research has, for instance, indicated a potential link between variables such as sea-surface temperature and precipitation, and cholera incidence.[76] Further research is needed to understand the potential climate change impacts in these areas.

Ecosystems, Biodiversity, and the Sundarbans

In its efforts to protect the Sundarbans, Bangladesh is preserving the world's largest remaining mangrove forest and thus a precious natural ecosystem. Nearly 1,000 species of plants and animals inhabit the Sundarbans, however, serious concerns have been raised for their future as rapid development unfolds in their vicinity, and climate change threatens the environmental services upon which they rely. Over the late 20th and early 21st centuries in Bangladesh, human development pressures both local (i.e. aquaculture cultivation) and upstream, (i.e. damming and water abstraction), have disrupted the balance of the ecosystem and resulted in local extinction of many rare species.[77] Concerns have been raised regarding the impact of sea-level rise on the spatial extent of the Sundarbans, and hence the viable range of iconic species such as the Bengal tiger population which has uniquely adapted to the Sundarbans mangrove environment.[78] However, more recent studies have underlined that human development processes, such as agricultural encroachment and changes to sediment regime, remain the dominant threat to the spatial extent of the Sundarbans ecosystem.[79] Nonetheless, the increasing salinization of the Sundarbans, to which

72 Gain, A. K., Apel, H., Renaud, F. G., and Giupponi, C. (2013). Thresholds of hydrologic flow regime of a river and investigation of climate change impact—-the case of the Lower Brahmaputra river Basin. Climatic Change, 120(1), 463–475. URL: https://ideas.repec.org/a/spr/climat/v120y2013i1p463-475.html

73 Ayeb-Karlsson, S., van der Geest, K., Ahmed, I., Huq, S., and Warner, K. (2016). A people-centered perspective on climate change, environmental stress, and livelihood resilience in Bangladesh. Sustainability Science, 11(4), 679–694. URL: https://link.springer.com/article/10.1007/s11625-016-0379-z

74 Khan, A.E., Ireson, A., Kovats, S., Mojumder, S.K., Khusru, A., Rahman, A. and Vineis, P. (2011). Drinking water salinity and maternal health in coastal Bangladesh: implications of climate change. Environmental health perspectives, 119(9), p. 1328. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3230389/

75 Abedin, M.A. and Shaw, R. (2013). Safe water adaptability for salinity, arsenic and drought risks in southwest of Bangladesh. Risk, Hazards and Crisis in Public Policy, 4(2), pp. 62-82. URL: https://onlinelibrary.wiley.com/doi/pdf/10.1002/rhc3.12033

76 Cash, B. A., Rodó, X., and Kinter, J. L. (2008). Links between Tropical Pacific SST and Cholera Incidence in Bangladesh: Role of the Eastern and Central Tropical Pacific. Journal of Climate, 21(18), 4647–4663. URL: https://journals.ametsoc.org/doi/pdf/10.1175/2008JCLI2177.1

77 Gopal, B., and Chauhan, M. (2006). Biodiversity and its conservation in the Sundarban Mangrove Ecosystem. Aquatic Sciences, 68(3), 338–354. URL: https://link.springer.com/content/pdf/10.1007%2Fs00027-006-0868-8.pdf

78 Loucks, C., Barber-Meyer, S., Hossain, M. A. A., Barlow, A., and Chowdhury, R. M. (2009). Sea level rise and tigers: predicted impacts to Bangladesh's Sundarbans mangroves. Climatic Change, 98(1), 291. URL: https://link.springer.com/content/pdf/10.1007%2Fs10584-009-9761-5.pdf

79 Payo, A., Mukhopadhyay, A., Hazra, S., Ghosh, T., Ghosh, S., Brown, S., . . . Haque, A. (2016). Projected changes in area of the Sundarban mangrove forest in Bangladesh due to SLR by 2100. Climatic Change, 139(2), 279–291. URL: https://link.springer.com/content/pdf/10.1007%2Fs10584-016-1769-z.pdf

sea-level rise contributes, has already begun a restructuring of the ecosystem to favor more salt-tolerant species. This shift comes to the cost of both rare plant and animal species[80] and humans who rely upon the natural resources the Sundarbans provides.[81] Bangladesh's inland freshwater ecosystems, which are important for aquaculture and as a key source of livelihoods are also at risk. In Bangladesh, freshwater aquiculture, primarily includes pond farming (carp, cichlids and catfish), which accounts for more than 80% of total aquiculture production. While climate variability varies across Bangladesh's regions, inland freshwater ecosystems are typically thought to be less exposed. However, flooding and intense precipitation periods may disrupt and or damage local infrastructure. Impacts are thought to be most acute for the central and northeast regions, which typically are impacted by frequent floods, flash flooding and riverbank erosion.[82]

Economic Sectors

Agriculture and Fisheries

Climate change is expected to influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation and temperatures. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to the submergence of coastal lands and desertification. On an international level, these impacts are expected to damage key staple crop yields, even on lower emissions pathways. Tebaldi and Lobell (2018) estimate 5% and 6% declines in global wheat and maize yields respectively even if the Paris Climate Agreement is met and warming is limited to 1.5°C.[83] Shifts in the optimal and viable spatial ranges of certain crops are also inevitable, though the extent and speed of those shifts remains dependent on the emissions pathway.

The yields of the key staple crops in Bangladesh, Aman rice, Boro rice, and wheat have all been shown to suffer significantly from increases in maximum temperatures.[84] The increase in the number of very hot days (Tmax >35°C) in Bangladesh under all emissions pathways (**Figure 13**) is therefore likely to have significant production costs, especially when combined with increased frequencies of heat wave and drought. For some crops, such as Boro rice, it has been suggested that the benefits of increased atmospheric CO_2 emissions may offset yield losses, for others, such as wheat, significant declines are expected.[85] When other drivers are factored in there is strong evidence that net rice production is likely to decline significantly as a result of climate change. Work by the World Bank Group reports that nine Upazilas (administrative region at sub-district level) are likely to cross the 4 deciSiemens per meter (dS/m)

---

80 Banerjee, K., Gatti, R. C., and Mitra, A. (2017). Climate change-induced salinity variation impacts on a stenoecious mangrove species in the Indian Sundarbans. Ambio, 46(4), 492–499. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5385663/

81 Uddin, S., Aminur, M., Shah, R., Khanom, S., and Nesha, M. K. (2013). Climate change impacts on the Sundarbans mangrove ecosystem services and dependent livelihoods in Bangladesh. Asian Journal of Conservation Biology, 2(2), 152–156. URL: https://pdfs.semanticscholar.org/8466/e243ecbb447a4426ce173df735d70ed30b3b.pdf

82 Islam, M., Barman, A., Kundu, G., Kabir, M. and Paul, B. (2019). Vulnerability of inland and coastal aquaculture to climate change: Evidence from a developing country. *Aquaculture and Fisheries.* 4(5), 183–189. DOI: https://doi.org/10.1016/j.aaf.2019.02.007

83 Tebaldi, C., and Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48/pdf

84 Ruhul Amin, M., Zhang, J., and Yang, M. (2015). Effects of climate change on the yield and cropping area of major food crops: A case of Bangladesh. Sustainability (Switzerland), 7(1), 898–915. URL: https://www.mdpi.com/2071-1050/7/1/898

85 Thomas, T., Mainuddin, K., Chiang, C., Rahman, A., Haque, A., Islam, N., Quasem, S., Yan, S. (2013). Agriculture and adaptation in Bangladesh: Current and projected impacts of climate change. International Food Policy Research Institute. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2310087

salinity threshold by the 2050s as a result of sea-level rise, and that this could result in a 15.6% reduction in rice output.[86] The number of Upazilas passing this threshold is likely to increase considerably beyond mid-century and without adaptation action there is also a possibility of land loss through permanent inundation. Across the country, farmers have and will seek to modify their livelihood and crop choices to optimize their economic productivity[87] but poorer and marginalized groups may face challenges and barriers to in-situ (autonomous) adaptation. Land-use conflicts are arising,[88] trade-offs will be necessary, and ultimately many different adaptation 'pathways' are possible.[89]

Fisheries and aquaculture an important part of Bangladesh's agriculture sector. They provide livelihoods to over 17 million people; Fisheries contribute 3.69% of the GDP and 22.6% of the agricultural GDP (2017). Fish is an important compliment to the national diet and a key source of protein for many households. Inland aquaculture contributes more than 55% of total production and provides more than 2% of Bangladesh's export value. The country has one of the largest and most active deltas, fed by the Padma, Meghna and Jamuna rivers. The Bay of Bengal is endowed with rich coastline and a wide range of marine biodiversity, which contribute to the vibrant fisheries sector.[90] A primary impact from climate variability and change to the sector will be frequent cyclonic events (marine) as well as inland and coastal flooding, low flows of water and droughts, salinity intrusion, changes of the river bed level due to sedimentation and changes in morphological processes. Consequently, minimum acceptable surface water levels in many rivers and streams are likely to be compromised which threatens the existing aquatic ecosystem and fisheries[91]. Erratic and irregular rainfall patterns and temperature change will affect the readiness, maturity and gonad development of fishes in breeding season. Increasing temperatures may also increase disease outbreak in aquaculture, with impacts to livelihoods and food security.[92]

Whether the long-term future involves widespread land loss and displacement depends both on the emissions pathway and on Bangladesh's planned adaptation efforts. The Bangladesh Delta Plan 2100, approved in 2018, sets out a large program of infrastructure interventions, many of which aim to protect agricultural lands from rising sea-levels, flooding, saline intrusion, and water logging. An investment of $37 billion is expected by 2030. Proposed projects include both reinforcement and expansion of the polder network in the coastal zone.

A further, and perhaps lesser appreciated influence of climate change on agricultural production is through its impact on the health and productivity of the labor force. Dunne et al. (2013) suggest that global labor productivity during peak months has already dropped by 10% as a result of warming, and that a decline of up to 20% might be expected by the 2050s under the highest emissions pathway (RCP8.5).[93] In combination, it is highly likely

---

[86] Dasgupta, S., Hossain, M. M., Huq, M., and Wheeler, D. (2014a). Climate Change, Soil Salinity, and the Economics of High-Yield Rice Production in Coastal Bangladesh. World Bank Group. URL: http://documents.worldbank.org/curated/en/131161468004833954/pdf/WPS7140.pdf

[87] Moniruzzaman, S. (2015). Crop choice as climate change adaptation: Evidence from Bangladesh. Ecological Economics, 118, 90–98. URL: https://econpapers.repec.org/article/eeeecolec/v_3a118_3ay_3a2015_3ai_3ac_3ap_3a90-98.htm

[88] Paul, A. K., and Røskaft, E. (2013). Environmental degradation and loss of traditional agriculture as two causes of conflicts in shrimp farming in the southwestern coastal Bangladesh: Present status and probable solutions. Ocean and Coastal Management, 85, 19–28. URL: https://pdfs.semanticscholar.org/e656/a3eee93167bba5593317bfcf2bac242fb27c.pdf

[89] Hossain, P. R., Ludwig, F., and Leemans, R. (2018). Adaptation pathways to cope with salinization in south-west coastal region of Bangladesh. Ecology and Society, 23(3). URL: https://www.ecologyandsociety.org/vol23/iss3/art27/

[90] Shamsuzzaman, M., Islam, M., Tania, N., Mamun, A., Barman, P., and Xu. X (2017). Fisheries resources of Bangladesh: Present status and future direction. *Aquaculture and Fisheries*. 2(4), 145–156. DOI: https://doi.org/10.1016/j.aaf.2017.03.006

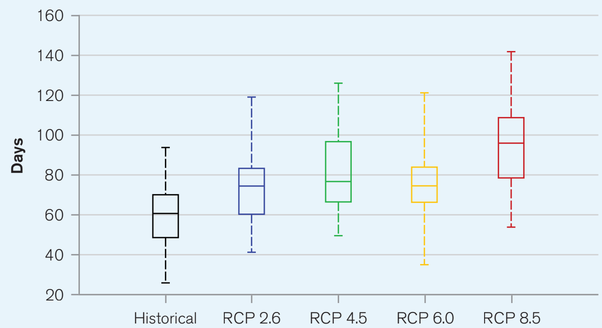
[91] Islam, M., Islam, N., Habib, A., and Mozimder, M. (2020). Climate Change Impacts on a Tropical Fishery Ecosystem: Implications and Societal Responses. *Sustainability*. 12. DOI: 10.3390/su12197970

[92] ICUN (2012). Climate Change and Fisheries and Livestock in Bangladesh. URL: https://www.iucn.org/sites/dev/files/import/downloads/frsheries.pdf

[93] Dunne, J. P., Stouffer, R. J., and John, J. G. (2013). Reductions in labor capacity from heat stress under climate warming. Nature Climate Change, 3(6), 563–566. URL: https://ui.adsabs.harvard.edu/abs/2013NatCC...3..563D/abstract

that the above processes will have a considerable impact on Bangladesh's food consumption patterns both through direct impacts on internal agricultural operations, and through impacts on the global supply chain. **Figure 14** shows the estimated number of very hot days (Tmax >35°C) by mid-century.

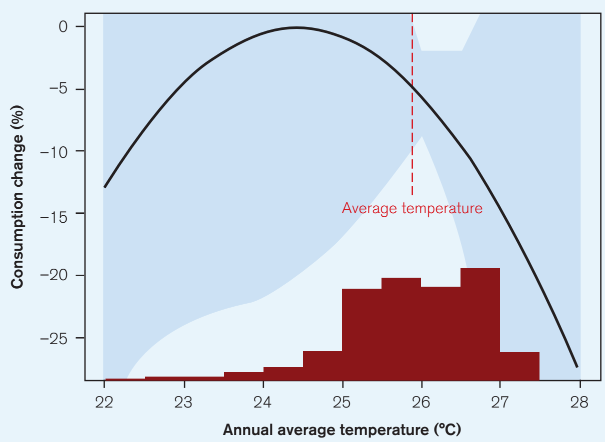
FIGURE 14. Boxplots Showing the Model Ensemble Estimate of the Annual Number of Very Hot (Tmax >35°C) Days in 2040–2059 Under Four Emissions Pathways in Bangladesh[30]



Urban

Research has established a reasonably well-constrained relationship between heat stress and labor productivity, household consumption patterns, and (by proxy) household living standards.[94] In general terms, the impact of an increase in temperature on these indicators depends on whether the temperature rise moves the ambient temperature closer to, or further away from, the optimum temperature range. The optimum range can vary depending on local conditions and adaptations. Mani et al. (2018) suggest that Bangladesh's average annual temperature (around 25.9°C) is already higher than the optimal level (around 24.5°C) for maximum consumption (**Figure 15**) and that further increases, through their impact on the productivity of labor (particularly linked to health issues), will reduce living standards.

FIGURE 15. The Relationship Between Temperature and Consumption in Bangladesh, Shaded Areas Represent 90% Confidence Intervals. Black Line Shows the Relationship Between Temperature and Consumption and the Optimum Temperature (Around 24.5°C) at Which No Consumption is Lost[95]



The effects of temperature rise and heat stress in urban areas are increasingly compounded by the phenomenon of the Urban Heat Island (UHI) effect. Dark surfaces, residential and industrial sources of heat, an absence of vegetation, and air pollution can push temperatures higher than those of the rural surroundings, commonly anywhere in the range of 0.1°C–3°C in global mega-cities.[96] UHI in Dhaka City has been estimated at between 2°C–8°C, with the highest UHI typically recorded during the

---

[94] Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A., Mosier, T. (2018). South Asia's Hotspots: The Impact of Temperature and Precipitation changes on living standards. South Asian Development Matters. World Bank, Washington DC. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/28723/9781464811555.pdf?sequence=5&isAllowed=y

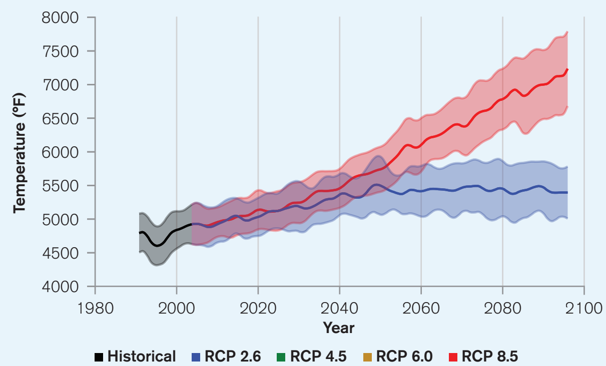
[95] Mani, M., Bandyopadhyay, S., Chonabayashi, S., Markandya, A., and Mosier, T. (2018). South Asia's Hotspots: The Impact of Temperature and Precipitation changes on living standards. South Asian Development Matters. World Bank, Washington DC. p. 5, b. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/28723/9781464811555.pdf?sequence=5&isAllowed=y

[96] Burkart, K., Schneider, A., Breitner, S., Khan, M. H., Krämer, A., and Endlicher, W. (2011). The effect of atmospheric thermal conditions and urban thermal pollution on all-cause and cardiovascular mortality in Bangladesh. Environmental Pollution, 159(8), 2035–2043. URL: https://www.sciencedirect.com/science/article/pii/S0269749111000790?via%3Dihub

night time.[97] As well as impacting on human health (see Communities) the temperature peaks that will result from combined UHI and climate change, as well as future urban expansion, are likely to damage the productivity of the service sector economy, both through direct impacts on labor productivity, but also through the additional costs of adaptation. In their assessment of climate change and living standard in Bangladesh, Mani et al. (2018) identify multiple urban districts facing significant declines in living standards driven by temperature rises and increased potential for disease outbreaks. Notably districts of Chittagong and Dhaka face declines of up to 20% by the 2050s on higher emissions pathways.

The above risks highlight the need for adaptation of the urban environment. **Figure 16** shows the considerable increase in cooling requirement projected in Bangladesh, particularly under higher emissions pathways. Research suggests that on average, a one degree increase in ambient temperature can result in a 0.5%–8.5% increase in electricity demand.[98] This increase in demand places strain on energy generation systems which is compounded by the heat stress on the energy generation system itself, commonly due to its own cooling requirements, which can reduce its efficiency.[99] Increased strain on energy systems during extreme temperatures is identified of just one amongst many urban vulnerabilities to climate change in Bangladesh.[100] Others include the capacity of urban sewerage systems to cope with extreme rainfall and flood events. The Government of Bangladesh adopted a Roadmap and Action Plan for in support of its energy, transport and industry sectors meet increasing demands while also meeting its adaptation and mitigation commitments, as defined in Bangladesh's NDC.[101]

FIGURE 16. Projected Annual Cooling Degree Days in Bangladesh (Cumulative Degrees Above 65°F) Under RCP2.6 (Blue) and RCP8.5 (Red). The Values Shown Represent the Median of the Multi-Model Ensemble with the Shaded Areas Showing the 10–90th Percentiles[30]



[97] Tashnim, J., and Anwar, A. (2016). Reasons and Remedies of Heat Island Phenomena for Dhaka City: A Review. In 3rd International Conference on Civil Engineering for Sustainable Development (pp. 228–234). URL: http://iccesd.com/proc_2016/Papers/ICCESD-2016-471.pdf

[98] Santamouris, M., Cartalis, C., Synnefa, A., and Kolokotsa, D. (2015). On the impact of urban heat island and global warming on the power demand and electricity consumption of buildings—A review. Energy and Buildings, 98, 119–124. URL: https://pdfs.semanticscholar.org/17f8/6e9c161542a7a5acd0ad500f5da9f45a2871.pdf

[99] ADB (2017). Climate Change Profile of Pakistan. Asian Development Bank. URL: https://www.adb.org/sites/default/files/publication/357876/climate-change-profile-pakistan.pdf

[100] Shahid, S., Wang, X. J., Harun, S. Bin, Shamsudin, S. B., Ismail, T., and Minhans, A. (2016). Climate variability and changes in the major cities of Bangladesh: observations, possible impacts and adaptation. Regional Environmental Change, 16(2), 459–471. URL: http://eprints.utm.my/id/eprint/71643/

[101] Ministry of Environment, Forest and Climate Change (2018). Roadmap and Action Plan for Implementing Bangladesh NDC, Transport, Power and Industry Sectors. URL: https://moef.portal.gov.bd/sites/default/files/files/moef.portal.gov.bd/page/ac0ce881_4b1d_4844_a426_1b6ee36d2453/NDC%20Roadmap%20and%20Sectoral%20Action%20%20Plan.pdf

Communities

Poverty and Inequality

Bangladesh experienced a steady proportional transfer of national income from the poorest 80% of earners to the richest 20% over the period 1973–2010.[102] This trend has been driven by the proportionately faster GDP growth in sectors such as services and industry versus agriculture, which remains a major employer but low earner. Climate change is expected to exacerbate this trend. Research conducted across multiple countries has suggested that households in the bottom 40% by income, typically experience income losses as a result of climate change that are 1.7 times greater than the average income loss.[103]

Many of the climate changes trends are likely to disproportionately affect the poorest groups in society. For instance, heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress.[104] The health of Bangladesh's agricultural laborers, also among the lowest paid in the country, should already be considered an issue of deep concern.[38] In addition, poorer farmers and communities are least able to afford local water storage, irrigation infrastructure, and technologies for adaptation.

Vulnerability

Bangladesh's regions are divided into 'hotspots' in the Bangladesh Delta Plan 2100, which characterize the different risks faced and different social and demographic traits which drive vulnerability. Key areas of particular vulnerability include the Chittagong Hill Tracts, Char regions, the drought prone regions of the northwest, and the country's Coastal Zone. However, cross-cutting regional vulnerabilities are the vulnerabilities of women and minority groups, who have been shown to experience proportionally greater hardship from climate-linked disasters.[105] Drivers of vulnerability in these groups are often shared by poorest groups, e.g. lack of ownership of land and assets, exposure to corruption, and barriers to successful adaptation and resilience.[106]

While Bangladesh faces significant disaster risk, particularly due to fluvial flooding and cyclone impacts, the country has made rapid progress in reducing the death-toll of extreme climate events. Developments such as early warning systems and storm shelters, alongside reductions in the national poverty rate and improved education have helped to build the resilience of exposed populations. However, extreme climate events can still have very significant

[102] Matin, K. (2015). Income inequality in Bangladesh. Bangladesh Journal of Political Economy Vol. 31, No. 2, December 2015, pp. 173–188. URL: https://bea-bd.org/site/images/pdf/063.pdf

[103] Hallegatte, S., and Rozenberg, J. (2017). Climate change through a poverty lens. Nature Climate Change, 7, 250. URL: https://doi.org/10.1038/nclimate3253.

[104] Kjellstrom, T., Briggs, D., Freyberg, C., Lemke, B., Otto, M., and Hyatt, O. (2016). Heat, human performance, and occupational health: A key issue for the assessment of global climate change impacts. Annual Review of Public Health: 37: 97–112. URL: https://www.annualreviews.org/doi/pdf/10.1146/annurev-publhealth-032315-021740

[105] Rahman, S. (2013). Climate Change, Disaster and Gender Vulnerability: A Study on Two Divisions of Bangladesh. American Journal of Human Ecology, 2(2), 72–82. URL: http://worldscholars.org/index.php/ajhe/article/view/315/0

[106] CCC (2009). Climate change, gender, and vulnerable groups in Bangladesh. Climate Change Cell, DoE, MoEF, Component 4b, CDMP, MoFDM. Dhaka. URL: https://core.ac.uk/download/pdf/48024281.pdf

long-term impacts on human health and livelihoods, and these impacts are felt most often by poor and marginalized communities who are the most exposed.[107] These risks are reflected in Bangladesh's ranking on the INFORM 2019 Risk Index (**Table 4**).

Disaster risk is faced across Bangladesh, and studies have shown that some of the greatest vulnerability is found in the northeastern region where flash flooding and river flooding are frequent.[108] Additional factors that drive up the region's vulnerability include poor access to health services and food insecurity. Toufique and Islam (2014) also link vulnerability to daily maximum temperatures and precipitation variability, factors likely to be compounded by climate change.[108]

Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.[109]

Human Health

Nutrition

Undernourishment remains prevalent in Bangladesh, and progress in its alleviation has been relatively slow. The FAO suggests that between 2004–2016 the national undernourishment rate for the country fell from 16.6% to 15.5%.[110] The World Food Program estimates that without adaptation, the risk of hunger and child malnutrition on a global scale could increase by 20% respectively by the 2050s.[111] Work by Springmann et al. (2016) assessed the potential for excess, climate-related deaths associated with malnutrition.[112] The study identified two key risk factors that are expected to be the primary drivers: a lack of fruit and vegetables in diets, and health complications caused by increasing prevalence of people underweight. Projections suggest there could be approximately 67 climate-related deaths per million population each year linked to lack of food availability in Bangladesh by mid-century under RCP8.5.

---

[107] Brouwer, R., Akter, S., Brander, L., and Haque, E. (2007). Socioeconomic Vulnerability and Adaptation to Environmental Risk: A Case Study of Climate Change and Flooding in Bangladesh. Risk Analysis, 27(2), 313–326. URL: https://www.ncbi.nlm.nih.gov/pubmed/17511700

[108] Toufique, K. A., and Islam, A. (2014). Assessing risks from climate variability and change for disaster-prone zones in Bangladesh. International Journal of Disaster Risk Reduction, 10(PA), 236–249. URL: https://iks.ukzn.ac.za/sites/default/files/167.pdf

[109] World Bank Group (2016). Gender Equality, Poverty Reduction, and Inclusive Growth. URL: http://documents1.worldbank.org/curated/en/820851467992505410/pdf/102114-REVISED-PUBLIC-WBG-Gender-Strategy.pdf

[110] FAO, IFAD, UNICEF, WFP, WHO (2017). The state of food security and nutrition in the world. Building Resilience for peace and food security. FAO. Rome. URL: http://www.fao.org/3/a-i7695e.pdf

[111] WFP (2015). Two minutes on climate change and hunger: A zero hunger world needs climate resilience. The World Food Program. URL: https://docs.wfp.org/api/documents/WFP-0000009143/download/

[112] Springmann, M., Mason-D'Croz, D., Robinson, S., Garnett, T., Godfray, H. C. J., Gollin, D., . . . Scarborough, P. (2016). Global and regional health effects of future food production under climate change: a modelling study. The Lancet: 387: 1937–1946. URL: https://www.sciencedirect.com/science/article/pii/S0140673615011563?via%3Dihub

Heat-Related Mortality

Research has placed a threshold of 35°C (wet bulb ambient air temperature) on the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death.[38] Temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health. Climate change is expected to push global temperatures closer to this temperature 'danger zone' both through slow-onset warming and intensified heat waves. **Figure 14** showed the annual occurrence of days over 35°C, this is projected to more than double in Bangladesh by the 2090s, under RCP8.5.

Honda et al. (2014), which used the A1B emissions scenario from CMIP3 (most comparable to RCP6.0) to estimate that without adaptation, annual heat-related deaths in the South Asian region, could increase 149% by the 2030s and 276% by the 2050s.[113] Dhaka is identified as facing some of the highest heat-related health risks in the world with future conditions moving towards what would currently be considered a state of permanent heat wave.[114] The potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is very significant, as demonstrated by Mitchell et al. (2018).[115]

Disease

Climate change pressures, such as increased incidence of drought, extreme rainfall and flood, as well as higher temperatures, are environmental drivers of vector and water-borne diseases. In Bangladesh, the population that is expected to be at risk of Malaria is projected to rise by 2041–2070 regardless of whether or not the most ambitious emission targets are met. However, the World Health Organization (2015) estimates that 30 million more people will be at risk of contracting the disease under a high emissions scenario (RCP8.5) than under a low emissions scenario (RCP2.6), due to an extension in malaria transmission viable range.[116] Other studies have also shown that the incidence of Dengue fever may increase considerably under a high emissions scenario.[117] In the case of water-borne diseases, highest transmission rates are often seen during flood events. The limitations of urban sewerage systems in Bangladesh's urban areas, and their vulnerability during extreme precipitation and flood events are likely to increase risks of disease outbreaks.[100]

Diarrheal disease is a significant health risk to children in Bangladesh. UNICEF estimates that around 7,000 children under five years of age died as a result of diarrheal disease in 2016.[118] This represents around 7% of all under five deaths in Bangladesh. While overall deaths due to diarrheal disease are projected to decline significantly, modelling by WHO estimates the change in the number of deaths in under fifteen-year-olds attributable to climate change under the A1B scenario in the South Asia region. Climate change is projected to increase the number of deaths in the 2030s by around 5%–15% and by around 10–20% in the 2050s.[119]

---

113 Honda, Y., Kondo, M., McGregor, G., Kim, H., Guo, Y-L, Hijioka, Y., Yoshikawa, M., Oka, K., Takano, S., Hales, S., and Sari Kovats, R. (2014). Heat-related mortality risk model for climate change impact projection. Environmental Health and Preventive Medicine 19: 56–63. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/pmid/23928946/

114 Matthews, T. K. R., Wilby, R. L., and Murphy, C. (2017). Communicating the deadly consequences of global warming for human heat stress. Proceedings of the National Academy of Sciences, 114(15), 3861–3866. URL: https://www.ncbi.nlm.nih.gov/pubmed/28348220

115 Mitchell, D., Heaviside, C., Schaller, N., Allen, M., Ebi, K. L., Fischer, E. M., . . . Vardoulakis, S. (2018). Extreme heat-related mortality avoided under Paris Agreement goals. Nature Climate Change, 8(7), 551–553. URL: https://www.ncbi.nlm.nih.gov/pubmed/30319715

116 WHO (2015). Climate and Health Country Profile: Bangladesh. World Health Organization. Geneva. URL: https://apps.who.int/iris/bitstream/handle/10665/208856/WHO_FWC_PHE_EPE_15.02_eng.pdf?sequence=1&isAllowed=y

117 Banu, S., Hu, W., Guo, Y., Hurst, C., and Tong, S. (2014). Projecting the impact of climate change on dengue transmission in Dhaka, Bangladesh. Environment International, 63, 137–142. URL: https://www.ncbi.nlm.nih.gov/pubmed/24291765

118 UNICEF (2019). Data: Diarrhoeal Disease. URL: https://data.unicef.org/topic/child-health/diarrhoeal-disease/ [accessed 29/01/2019].

119 WHO (2014). Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. World Health Organization. URL: https://apps.who.int/iris/handle/10665/134014

Water Quality

Surface water quality and management issues have left many regions of Bangladesh heavily dependent on groundwater for household consumption. This dependence can grow when hydrological and meteorological droughts further deplete surface supplies. The projected increase in drought incidence attributed to all climate change scenarios may further deplete surface water quality and availability, increasing pressure on groundwater resources. In many regions of Bangladesh, groundwater levels are falling over time at rates up to 10 centimeter (cm) per year.[120] A major and persistent health risk has been the contamination of groundwater with arsenic. While approximately 97% of households in Bangladesh have access to basic water supply, an estimated 12.5% of household water sources are contaminated with arsenic.[121] Arsenic exposure has led to a wide variety of primary and secondary health impacts, and ultimately has contributed to elevated mortality rates over the early 21st century.[122]

Migration

Work by the World Bank Group suggests that South Asia could experience an estimated 17 million to 36 million internal climate migrants by 2050 as a result of slow-onset climate changes.[123] Around a third of this migrating population is expected to be in Bangladesh. The range reflects different future development pathways with various levels of emissions reduction and inequality in development outcomes. Under all scenarios, the poorest and most climate-vulnerable communities are likely to be the hardest hit. Poorer residents and businesses are least able to afford air conditioning, an increasing need given the projected increase in cooling days and in the context of rapid urban expansion, slum growth, and intensification of urban heat islands. Poorer residents and businesses are also located in the most flood exposed areas and the physical infrastructure upon which they rely is most at-risk of damage during extreme events. Without significant mitigation action, the climate-induced migration rate is likely to accelerate considerably from the mid to latter half of this century. It is expected that 'hotspots' of in and out-migration are likely to form. Rigaud et al (2018) suggest the northern and eastern regions of Bangladesh, as well as the metropolitan area around Dhaka City, are likely to become hotspots of out-migration.[123] As shown in **Figure 17** the majority of climate migrants are expected to come from communities dependent on rain-fed croplands for their livelihoods.

Migration is tightly bound to development dynamics and distilling the climate contribution to migration remains a challenging and uncertain research area. The Bangladesh Delta Plan 2100 projects future migration from and to different hotspots in Bangladesh, estimating that without the projects proposed in the plan, there could be a net migration of around 18 million people away from the coastal, river system, and estuarine hotspots by the 2040s. With the plan implemented, the net number of migrants leaving these regions is projected to halve. This reflects both the plan's impact on livelihood opportunities as well its contribution to climate change adaptation.

---

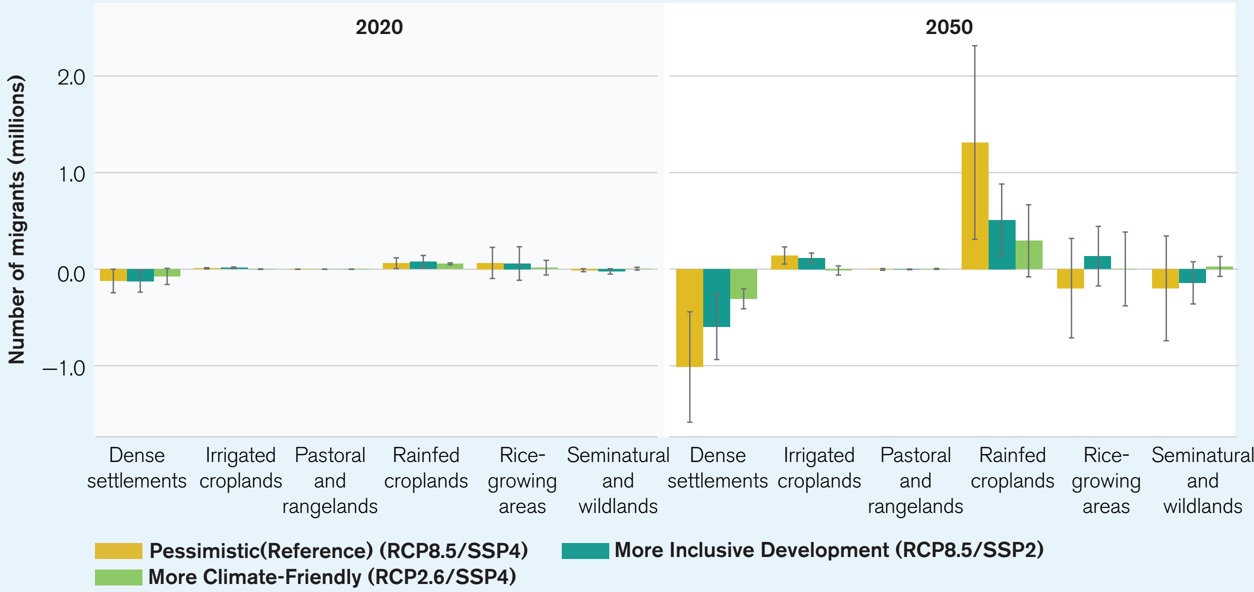
[120] MacDonald, A., Bonsor, H., Taylor, R., Shamsudduha, M., Burgess, W., Ahmed, K. . . . (2015). Groundwater resources in the Indo-Gangetic Basin: resilience to climate change and abstraction. British Geological Survey Open Report. URL: http://nora.nerc.ac.uk/id/eprint/511898/

[121] WaterAid (2018). The Water Gap: State of the World's Water 2018. URL: https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/The%20Water%20Gap%20State%20of%20Water%20report%20lr%20pages.pdf

[122] Ahmad, S. A., Khan, M. H., and Haque, M. (2018). Arsenic contamination in groundwater in Bangladesh: implications and challenges for healthcare policy. Risk Management and Healthcare Policy, 11, 251–261. URL: https://www.ncbi.nlm.nih.gov/pubmed/30584381

[123] Rigaud, K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McClusker, B., Heuser, S., Midgley, A. (2018). Groundswell: Preparing for internal climate migration. World Bank Group, Washington DC. URL: http://documents.worldbank.org/curated/en/846391522306665751/pdf/124719-v2-PUB-PUBLIC-docdate-3-18-18WB-ClimateChange-Final.pdf

FIGURE 17. Projected Net Climate Migration In and Out of Livelihood Zones in Bangladesh Under Three Scenarios (2020 and 2050) from Rigaud et al. (2018)[124]



Note: Whiskers show 95th percent confidence intervals for climate migrants.

Rigaud et al (2018) also establish migration as an effective adaptation strategy, if well planned and supported by upskilling and job creation and conducted with sensitivity to the impacts on the communities already living in receiving areas.[123] Climate-induced migration remains a poorly understood area, and investment is needed to understand push and pull factors, where hotspots may form, and how communities might be supported in different local contexts. Research can support governance which embeds migration across sectoral planning.

POLICIES AND PROGRAMS

National Adaptation Policies and Strategies

- National Communications to the UNFCCC (2018)
- Bangladesh Delta Plan 2100 (2018)
- National Plan for Disaster Management 2016–2020 (2017)
- Nationally Determined Contribution to Paris Climate Agreement (2016)
- Technology Needs Assessment (TNA) and Technology Action Plans for Climate Change Adaptation (2012)
- National Adaptation Program of Action (NAPA) (2009)

[124] Rigaud, K., de Sherbinin, A., Jones, B., Bergmann, J., Clement, V., Ober, K., Schewe, J., Adamo, S., McClusker, B., Heuser, S., Midgley, A. (2018). Groundswell: Preparing for internal climate migration. World Bank Group, Washington DC. p. 154. URL: http://documents.worldbank.org/curated/en/846391522306665751/pdf/124719-v2-PUB-PUBLIC-docdate-3-18-18WB-ClimateChange-Final.pdf

Climate Change Priorities of the WBG

WBG Country Partnership Framework

Climate change and environmental management form one of the key focus areas of the WBG's most recent Bangladesh Country Partnership Framework (CPF)[125] (FY2016–FY2020); which has been extended to FY22. The next CPF is expected for FY23–FY27. In order to manage the complex Bangladesh delta, the Government is preparing an integrated and holistic long-term plan, Delta Plan 2100, to promote safe living through greater resilience and sustainable economic development. This Plan is based on an adaptive delta management (ADM) approach, which ensures that all sectoral investments take into account the long-term uncertainties related to climate change and growth. WBG support will be aligned with the ADM principle. At the time of writing, a Systematic Country Diagnostic (SCD) for Bangladesh is under development. The latest Program Learning Review (2020) reaffirmed the contribution to climate resilience by incremental progress through ongoing projects and meeting these commitments, while raising the level of ambition where possible. The ongoing SCD is incorporating climate change analytics, and this will inform the upcoming CPF.

The WBG is also developing its Climate Change Action Plan (CCAP) for the South Asia Region, which is expected to be released in 2021. In addition to CCAP, the WBG is rolling out a new country-level analysis for climate change and development (CCDR), which will begin in selected countries mid-2021. Bangladesh will undertake CCDR development, which is intended to:

- Inform World Bank country engagement (SCDs and CPFs) by providing insights on the interplay between development (poverty reduction, growth, inequality), climate change and climate policies;
- Highlight opportunities and challenges in both climate resilience and mitigation tailored to the country situation; and
- Draw upon existing analytics and climate data, while providing a framework on prioritization for policy action, investments, and future analytical work.

Activities of the WBG's current CPF with Bangladesh (**Table 9**) will focus on boosting Bangladesh's resilience to climate change and natural disasters, improving the management of water infrastructure and promoting agricultural productivity with climate- smart farm practices and technology, diversification and accelerating the move up the value chain.

[125] WBG (2016). Country Partnership Framework for Bangladesh for the period FY16–FY20. URL: https://documents1.worldbank.org/curated/en/362231468185032193/pdf/103723-REVISED-PUBLIC-IDA-R2016-0041.pdf

TABLE 9. Objectives and Related Interventions Identified Within Bangladesh's CPF Focus Area on Climate Change and Environmental Management

Objective	Interventions
Increased Resilience of Population to Natural Disasters In Urban and Coastal Areas	WBG's large portfolio in climate change and disaster risk management provide a strong basis to support the Delta Plan 2100. Interventions address the three strands of infrastructure enhancements, systems improvements and capacity-building. Three lending operations are supporting government efforts to invest in critical coastal housing/shelter and embankment infrastructure to protect against flooding and in long-term preparedness and response, particularly with respect to tropical cyclones. An urban resilience project will bolster the capacity of local agencies to respond to emergencies in Dhaka and Sylhet and to strengthen systems to reduce the vulnerability of future building constructions to disasters. The portfolio also includes community-level interventions to support afforestation and reforestation as well as capacity- building for communities to increase their resilience to climate change. To complement these investments, WBG will support the Government's capacity to deliver reliable weather forecasting and services to better prepare for natural disasters and improve access to services in weather-dependent sectors such as agriculture. This focus on building a robust national system in Bangladesh as well as neighboring countries is relevant to the Bank's broader effort to promote regional cross-border cooperation and information-sharing in hydro-meteorological activities. Ongoing technical assistance on agriculture, livestock and fishery sector insurance, as well as a planned insurance sector support project will also contribute to WBG efforts in promoting disaster resilience. In addition, the International Finance Corporation (IFC) will look for opportunities to enhance the climate resilience of its investment projects, particularly in infrastructure, through climate change adaptation interventions.
Improved Water Resource Infrastructure for Climate Resilience	WBG's support for water resources management is based on a multi-pronged strategy to address the sector's underlying weaknesses—by building and rehabilitating infrastructure to improve resilience; enhancing institutional capacity of key water institutions; improving data monitoring; and developing asset management systems for long-term operations and maintenance (O&M). IDA will seek to enhance the resilience of coastal communities by rehabilitating polders, improving institutional capacity in environmental compliance and O&M, supporting the improvement of monitoring systems to ensure the sustainability of embankment works, rehabilitating damaged water infrastructure along the Jamuna River and improving capacity in asset management and long-term planning. Advisory work supported by the South Asia Water Initiative (SAWI) will supplement these projects by supporting basin modeling for the Ganges and Brahmaputra rivers to promote efficient use of existing water resources and better understanding of the combined impacts of climate change and upstream activities on Bangladesh's water resources as well as investment planning related to the Delta Plan 2100 and the provision of TA for improved groundwater management. Analytical work will be pursued to address long-term security of drinking water supplies (both urban and rural) as well as groundwater for sustainable irrigation. In the private sector space, IFC will support the efficient use of water in the RMG sector through a cleaner production program aimed at reducing environmental and social impacts resulting from prevailing practices such as excessive ground water extraction and surface water pollution.
Increased Adoption of Sustainable Agricultural Practices	The WBG will seek to scale up generation and adoption of climate smart technologies to enhance productivity and diversification, building on lessons from previous interventions. In particular, WBG will seek to contribute to increased agricultural productivity of smallholder farms and improve their access to markets, with special emphasis on women farmers. A key lesson to date is the need to focus beyond productivity increases to facilitating market linkages to ensure sustainability of farmer groups and in particular of producer organizations. IDA will seek to deliver to farming households improved extension services, stronger linkages with research, on-farm demonstrations of new technologies, training and skills development, as well as co-funding productive assets. In its remaining year of implementation, a joint IDA-GAFSP operation will leverage technology and training to enhance agricultural production in the northern and southern districts affected by flash floods, drought and tidal surge areas affected by saline. The Bank's interventions in agriculture will be guided by Dynamics of Rural Growth, a report jointly coordinated with the National Planning Commission. IFC is working with partners and farmers in the seeds sector, supporting climate smart agriculture, and is training farmers in farm management to improve their productivity and competitiveness. In addition, IFC is assisting farmers to mitigate weather related risks by supporting global index insurance products.

The WBG is also committed to supporting Bangladesh's adaptation efforts and increasing resilience to climate change and disasters throughout its projects. This includes, but is not limited to:

I. implementing community awareness programs focused on the growing health risks posed by climate change, such as (a) heat stress, (b) water- and vector-borne diseases, (c) decreased nutrition and food security, (d) reduced access to health services, (e) reduced access to potable water;
II. investing in improved public hygiene, water, and sanitation efforts, particularly in the case of sudden-onset or protracted natural disasters;
III. improve the management and use of datasets on disease incidences and vectors, meteorological and/or environmental conditions for water- and vector-borne diseases;
IV. increase the construction of flood protection barriers, levees, dykes and improve soil and water conservation efforts;
V. upgrade local industrial parks, special economic zones, industrial estates and similar facilities with drainage facilities to drain out heave rainfall and stormwater, including all weather access infrastructure above flood level;
VI. cultivate nutritional crops and trees to address climate change-related drought and food scarcity; and
VII. incorporate energy efficiency measures in design and construction of community infrastructure making provisions for solar power and energy efficiency improvement in lighting, appliances, and equipment.[126]

[126] WBG (2016). Country Partnership Framework for Bangladesh for the period FY16–FY20. URL: https://documents1.worldbank.org/curated/en/362231468185032193/pdf/103723-REVISED-PUBLIC-IDA-R2016-0041.pdf

CLIMATE RISK COUNTRY PROFILE

BANGLADESH

WORLD BANK GROUP