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COUNTRY CLIMATE AND DEVELOPMENT REPORT

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Figures and Tables

Acknowledgements

The Bangladesh Country Climate and Development Report (CCDR) is a collaborative effort of the World Bank, International Finance Corporation (IFC), and Multilateral Investment Guarantee Agency (MIGA), produced by a core World Bank Group team led by Gayatri Acharya (Sector Lead, Sustainable Development) and comprised of Persephone Economou (Senior Risk Management Officer), Bernard Haven (Senior Economist), Swarna Kazi (Senior Disaster Risk Management Specialist), Yulia Mironova (Senior Economist), Volker Treichel (Principal Economist), and Ignacio Urrutia (Senior Disaster Risk Management Specialist). Thomas Kerr, Ella Jisun Kim, and Yoko Okura provided cross-cutting inputs.

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Abbreviations

8th FYP	Eighth Five-Year Plan
ADP	Annual Development Programme
AWD	alternate wetting and drying
BAU	business as usual
BC	black carbon
BCCSAP	Bangladesh Climate Change Strategy and Action Plan
BCFF	Bangladesh Climate Fiscal Framework 2020
BDP2100	Bangladesh Delta Plan 2100
CBAM	Carbon Border Adjustment Mechanism
CC	city corporations
CCDR	Country Climate and Development Report
CCE	climate change and environmental education
CH_4	methane
CO_2	carbon dioxide equivalent
CPAT	Carbon Pricing Assessment Tool
CSA	climate-smart agriculture
CSAIP	Climate-Smart Agriculture Investment Plan
CSO	civil society organizations
EV	electric vehicle
FDI	foreign direct investment
GDP	gross domestic product
GHG	greenhouse gas
GoB	Government of Bangladesh
GW	gigawatt
ha	hectare
IPCC	Intergovernmental Panel on Climate Change
IPP	independent power plant
IW	inland waterway
kg	kilogram
km	kilometer
kwh	kilowatt hour
LGED	local government engineering department
LGI	local government institution
m	meter
MCPP	Mujib Climate Prosperity Plan
MFS	mobile financial service
MSME	micro-, small-, and medium-size enterprise
$MtCO_2e$	million metric tons of carbon dioxide equivalent
MW	megawatt
NBS	nature-based solutions
NDC	Nationally Determined Contribution
NGO	nongovernment organization
NMT	nonmotorized transport
O_3	ground level ozone
$PM_{2.5}$	particulate matter 2.5
PPP	public-private partnerships
PPSC	Project/Programme Selection Committee
PV	photovoltaic
RCP	Representative Concentration Pathway
RE	renewable energy
RMG	ready-made garments
RTS	rooftop solar
SLCP	Short-lived Climate Pollutants
SOE	state-owned entities
SREDA	Sustainable and Renewable Energy Development Authority
SSP	Shared Socioeconomic Pathway
SWM	solid waste management
tCO_2e	tons of carbon dioxide equivalent
Tk	Bangladeshi taka
µg/m3	micrograms (one-millionth of a gram) per cubic meter air
ULAB	used lead-acid batteries
TVET	technical and vocational education and training
WSS	water supply and sanitation

1. Growth and Climate Risks in Bangladesh

Bangladesh's vulnerabilities to climate change will put development progress at risk in the coming decades. Building on three decades of growth and poverty reduction, the Government of Bangladesh's (GoB) Vision 2041 aims to achieve country upper-middle income status by 2031 and high-income status by 2041, while eliminating extreme poverty by 2031[1] and absolute poverty by 2041. These goals will require navigating the increasingly severe impacts of climate change. As the world's seventh most climate risk-affected country, with 185 extreme events recorded and 0.38 fatalities per 100,000 inhabitants over the past two decades,[2] Bangladesh must adapt rapidly to climate change while simultaneously accessing cleaner, more efficient technologies that support development, leverage co-benefits (such as in health, air and water quality) and limit emissions.

1.1. Context: Growth, Structural Transition, and the Environment

Bangladesh has been among the fastest growing economies in the world, with annual per capita income growth of 4.0 percent over the past three decades. Over this period, the country has shifted from a predominantly agricultural economy to an industry- and service-led economy (Table 1). Manufacturing has led growth, and Bangladesh has emerged as a leading exporter of ready-made garments (RMG). With increased RMG exports, light manufacturing has created new and more productive jobs. Service-sector growth accelerated with urbanization, expanding by an average of 6.0 percent over the past decade. Agricultural growth declined to an average of 3.3 percent over this period, although it continues to account for about 12 percent of GDP. Labor productivity has grown due to more efficient allocation of labor across sectors as well as productivity gains within sectors, although the labor force remains largely informal.[3] Growth was supported by prudent macroeconomic management. Despite low revenues (9.4 percent of gross domestic product (GDP) in FY21), the GoB has maintained internal and external balance over the past two decades, with inflation under 10 percent over the past eight years and a relatively modest stock of public debt (32.4 percent of GDP in FY21). However, rising global commodity prices and persistent financial sector vulnerabilities have put this strong performance at risk. A surge in imports in FY22 led to a record current account deficit, declining foreign exchange reserves, a sharp exchange rate depreciation, and accelerating inflation. In this context, effective monetary and fiscal policies have taken on new urgency to sustain macroeconomic stability over the medium term.

Table 1: Structure of the Economy (percent of GDP at constant prices)

Sector	FY1990	FY2000	FY2010	FY2020
Agriculture	24.7	21.3	18.4	12.0
share of non-crop agriculture	*35.8*	*41.8*	*41.3*	*52.4*
Industry	18.0	22.9	26.8	34.9
of which manufacturing	*64.6*	*63.9*	*64.2*	*64.1*
Services	57.2	55.8	54.8	52.5

Source: National Accounts Statistics, Bangladesh Bureau of Statistics (BBS), 2021.

Economic growth has been accompanied by large gains in poverty reduction and human development. Poverty declined from 48.9 percent in 2000 to 24.3 percent in 2016 (Figure 1). Agriculture was a powerful driver of poverty reduction, accounting for 69 percent of poverty reduction from 2005–10 and 27 percent from 2010–16. Fertility rates decreased, nearing replacement levels, accompanied by a rise in life expectancy and substantial reductions in infant and child mortality. Child stunting rates fell from 45 percent in 2000 to 31 percent in 2018. Social protection programs now reach 3 out of 10

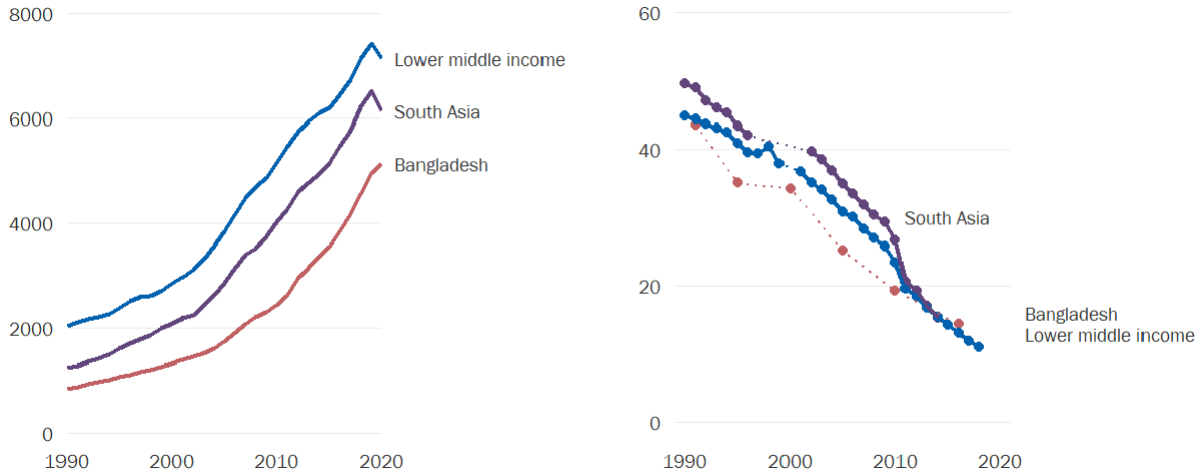
[1] Defined as living below US$1.90 per diem.

[2] Germanwatch. "2021. Global Climate Risk Index 2021." Bonn: Germanwatch. (Link)

[3] In 2017, 85.1 percent of total employed persons (age ≥ 15) were in informal employment.

households, reducing poverty, boosting use of education and health services, and protecting households during shocks. Access to education has risen sharply, with net primary enrollment increasing from 72 percent to 93 percent between 2000 and 2016 and access to tertiary education rising from less than 1 percent to 16 percent.

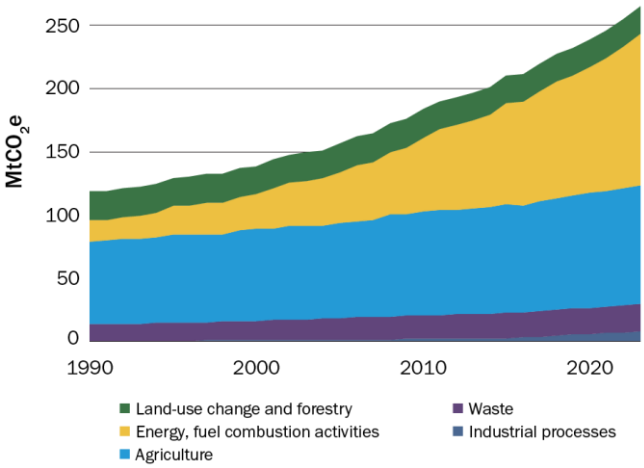
Figure 1: Economic Growth and Poverty



Source: World Development Indicators.
Note: PPP = purchasing power parity.

Urbanization accelerated as the structure of the economy changed. However, returns to agglomeration are declining. The percentage of the population living in urban areas rose from 24 percent in 2000 to 38 percent in 2020. By 2050, an estimated 60 percent of the population will live in urban areas.[4] Based on pre-pandemic urbanization and poverty reduction trends, more than half of poor households are projected to live in urban areas within a decade.[5] Agglomeration has contributed to growth, as the manufacturing and service sectors have benefited from access to labor as well as market and knowledge spillovers. The spatial transformation process has been driven by a robust pace of urbanization, concentrated primarily in the Dhaka region and secondarily the Chattogram region. The institutional capacity of local governments is constrained, and infrastructure and services have not kept pace with population growth. As a result, cities face significant congestion and negative externalities, including air and water pollution, elevated exposure to health risks such as infectious and vector borne diseases,[6] and environmental degradation. Urbanization also has resulted in the loss of

Figure 2: Greenhouse Gas Emissions by Sector



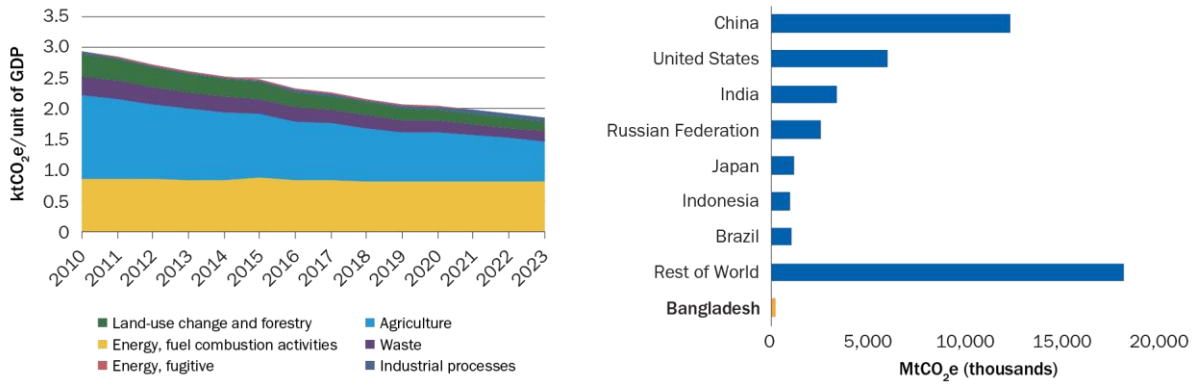
Source: Climate Watch, 2020 and Staff Projections
Note: MtCO2e = million metric tons of carbon dioxide equivalent.

[4] United Nations, Department of Economic and Social Affairs. "World Urbanization Prospects 2018." Database. (Link)
[5] Hill, R. and M.E. Genoni. 2019. *Bangladesh Poverty Assessment: Facing Old and New Frontiers in Poverty Reduction*. Washington, DC: World Bank Group. (Link)
[6] Mahmud, I. et al. 2021. *Climate Afflictions. International Development in Focus*. Washington, DC: World Bank. (Link)

arable land and returns to further agglomeration are declining, including productivity growth and job creation.

Bangladesh is a modest contributor to global greenhouse gas (GHG) emissions, accounting for an estimated 0.4 percent of global emissions in 2018. Rapid economic growth has resulted in higher GHG emissions, which have risen from 115 million metric tons of carbon dioxide equivalent ($MtCO_2e$) in 1990 to 221 $MtCO_2e$ in 2018, including changes from land use.[7] Approximately 70 percent of primary energy consumption is derived from natural gas. Figure 2 presents a forecast of emissions using near-term World Bank macroeconomic projections, with GHG emissions reaching 255 $MtCO_2e$ by 2022 and 276 $MtCO_2e$ by 2024. The growth of GHG over the past three decades was led by the energy sector, consistent with the expansion of the industrial sector and increased electricity access. GHG emissions from energy and fuel combustion activities surpassed GHG emissions from agriculture in 2017. Emission intensity has declined over time with the growth of the nonagricultural economy (Figure 3).

Figure 3: Greenhouse Gas Emission Intensity



Note: Emission data through 2018 from Climate Watch. World Bank staff forecast from 2019 to 2024. Sectoral decomposition based on emission intensity and share of GDP, holding emissions from land use constant, using real GDP in BDT millions.

Sustaining growth, while reversing the degradation of air and water quality, and addressing heightened climate change related risks, is a development challenge. Dhaka is affected by air pollution, water logging, poor waste disposal, and traffic congestion, while Chattogram and Khulna face vulnerabilities linked to their coastal geographic location.[8] Low-income residents are more exposed to these risks and face inadequate water supply and sanitation (WSS), high population density, and poor housing quality. The health costs of air and water pollution have increased. The population-weighted annual average of PM2.5 for the 11 cities covered by air quality monitoring is 81 micrograms (one-millionth of a gram) per cubic meter air ($\mu g/m^3$), or eight times the Air Quality Guidelines of the World Health Organization for annual PM2.5[9] and higher than the population-weighted rural ambient PM2.5 of 57$\mu g/m^3$ and nationwide ambient PM2.5 of 64 $\mu g/m^3$. 81 percent of the population used solid fuels as primary cooking fuels in 2019 (mostly wood and crop resides) and only 23 percent had access to clean cooking fuels and technologies, significantly impacting the health of women and children due to high indoor air pollution.[10] Less than 10 percent of the urban population is connected to a piped sewerage system. Municipal waste collection rates of only 40 percent nationwide result in increased

[7] Bangladesh also emitted an estimated 35–75 $MtCO_2e$ of Black Carbon (BC) and can reduce the emission of Short-lived Climate Pollutants (SLCP)—particularly CH4 and BC which have the highest share of GHGs.

[8] Raza, W. and A. Khan. (Forthcoming). *Water and Health: Impact of Climate Change in Bangladesh*. Washington, DC: World Bank.

[9] Bangladesh's air quality monitoring network consists of 16 fixed Continuous Air Monitoring stations in 13 cities across the eight divisions. The stations are in five cities in Dhaka Division, two cities in Chattogram Division, and one city in each of the other six divisions. Annual average PM2.5 ranges from 48-62 $\mu g/m^3$ at six stations in five cities to 81-103 $\mu g/m^3$ at seven stations in six other cities.

[10] GoB and UNICEF (Government of Bangladesh) and United Nations Children's Fund). 2019. *Progotir Pathey Bangladesh, Multiple Indicator Cluster Survey 2019: Survey Findings Report.* Dhaka, Bangladesh: Bangladesh Bureau of Statistics.

pollution, compromised drainage systems, and a high incidence of vector-borne diseases. Only 10 percent of the 0.8 million tons of annual plastic waste is properly disposed of. Informal recycling of used lead-acid batteries (ULAB) and abandoned recycling sites create lead exposure hotspots.[11] A forthcoming assessment of the health impacts of pollution[12] finds that over 275,000 people died in 2019 from four environmental health risks: (i) ambient and household air pollution (from exposure to PM2.5); (ii) lead exposure; (iii) inadequate drinking water, and (iv) hygiene, and scarce sanitation. Such environmental health hazards further impair the cognitive development of children (i.e., an average of nearly seven IQ points per child over the child's early years of life).

Agricultural productivity has increased, supported by the expansion of irrigation, use of fertilizers, machinery, and high-yielding varieties of rice—but with negative impacts on soil health and water. Fertilizer use increased by 400 percent in the last 30 years, supported by high government subsidies that encouraged inefficient application and overuse. From 2003 to 2016, fertilizer consumption increased from 160 kg to 289 kg per hectare of arable land,[13] leading to an imbalance in nitrogen relative to other nutrients, resource degradation, pollution of surface and ground water bodies, and significant rice yield deficits. Potassium deficiency—the most serious nutrient deficiency in terms of crop productivity—may be responsible for a rice grain production loss of 10–13 million tons per annum, or 27–36 percent of current production, costing Tk 310–379 billion in 2019, equivalent to 1.2–1.5 percent of GDP, or 10–12 percent of agricultural GDP.[14] Crop residue used as household fuel—largely due to scarcity of fuel wood and limited access to clean cooking fuels—is removing large quantities of nutrients from the fields, equivalent to 50–70 percent of the nutrient value of synthetic fertilizers currently used. Correcting the potassium nutrient deficit requires a tripling or quadrupling of synthetic potassium fertilizers, while conservation agriculture, integrated plant nutrition system practices, and access to cleaner fuels could help improve soil health and reduce indoor air pollution.

Forests provide and regulate ecosystem services, including carbon storage and emission offsetting; however, forest cover and biodiversity have declined over this period of growth. Forest areas are concentrated in the northern, southwestern (Sundarbans), and southeastern flanks (Hill Forests), with patches of Sal (deciduous) Forest in the central and northwestern regions. About half of the remaining 1.5 million hectares (ha) of forest land is under natural forest, mostly in the Sundarbans, while the rest is either degraded, deforested, or plantation. Thirty-eight million people depend on forests for their livelihood.[15] Natural forests are under pressure from illicit felling, encroachment, shifting cultivation, and conversion to other land uses. From 2010 to 2015, mangrove forests declined by 2 percent, Sal Forest by 20 percent, Hill Forest by 23 percent, and Bamboo Forest by 83 percent.[16] Nearly 695,000 ha of unclassified state forest in the Chattogram Hill Tracts districts are degraded due to shifting cultivation and nonforest usage conversion. The Forest Department has assessed 2 percent of the country's species to be regionally extinct, 3 percent critically endangered, 11 percent endangered, 9

[11] The Toxic Sites Identification Program, implemented by Pure Earth since 2011 in partnership with the Department of Geology of the University of Dhaka and the Department of Environment of Bangladesh, has assessed 249 contaminated sites. As many as 175 of the sites are ULAB recycling and lead smelting sites (McCartor, A. and E. Nash. 2018. "Project Completion Report: Reducing Lead Poisoning Among Children in Kathgora, Bangladesh." Pure Earth, New York). The total number of ULAB recycling and recharging facilities are, however, substantially larger and are reported in the range of 1,100 (World Bank. 2018. *Enhancing Opportunities for Clean and Resilient Growth in Urban Bangladesh: Country Environmental Analysis 2018*. Washington, DC: World Bank. (Link)) to 12,200 (Ahmad, S. A. et al. 2014. "Blood Lead Levels and Health Problems of Lead Acid Battery Workers in Bangladesh." The Scientific World Journal, Vol. 2014, Article ID 974104: 1–7. (Link)). The latter figure is based on a survey dating back to 2003-04 by the Bangladesh Bureau of Statistics.

[12] World Bank. (Forthcoming). *Building Back a Greener Bangladesh.* Country Environmental Analysis. Washington, DC: World Bank.

[13] South Asia average: 160 kilograms (kg) in 2016 (166 kg for India and 144 kg for Pakistan). See World Bank. 2021. "World Development Indicators." Database. Washington, DC: World Bank. (Link)

[14] World Bank. (Forthcoming). *Building Back a Greener Bangladesh.* Country Environmental Analysis. Washington, DC: World Bank.

[15] Contribution of forest income to total household income ranges from 8.9 percent to 18.6 percent. See Rahman, L. M. 2011. *Status of Coastal Village Forests and Strategies for Sustainable Management in Bangladesh.* Chattogram, Bangladesh: Institute of Forestry and Environmental Sciences, University of Chattogram.

[16] New assessments are planned by the Forest Department in 2022.

percent vulnerable, and 6 percent nearly threatened. Apart from the Sundarbans[17] and a few large water bodies, no biome provides adequate habitat to native species of wildlife. The 2020 Environmental Performance Index[18] ranks Bangladesh 124th out of 180 countries in the biodiversity and habitat category,[19] a slight improvement over the previous year, but low overall.

1.2. Climate risks to growth, poverty reduction, and human development

Even under optimistic global climate scenarios, Bangladesh faces severe risks from climate change and could have 13.3 million internal climate migrants by 2050.[20] Average annual losses from tropical cyclones alone are estimated to be approximately US$1 billion (0.7 percent of GDP),[21] although individual cyclone events could result in larger losses.[22] The coastal population, at 27 percent, is exposed to a 100-year coastal flood event, expected to increase to 35 percent with half a meter of sea level rise. Sea level rise will nearly double asset risk, currently about US$300 million per annum, while threatening agricultural production, water supplies, and coastal ecosystems.[23] One-third of agricultural GDP may be lost due to climate variability and extreme events by 2050 and cropland may shrink by 18 percent in Southern Bangladesh and 6.5 percent nationally by 2040.

Historically, flooding has been the most economically damaging natural hazard in Bangladesh, while cyclones account for the highest number of deaths.[24] A forward-looking perspective of precipitation and temperature trends offers an insight into patterns of floods, landslides, drought, and heat stress under three Representative Concentration Pathway (RCP)/Shared Socioeconomic Pathway (SSP) (SSP1/RCP2.6, SSP2/RCP4.5, and SSP5/RCP8.5) scenarios[25] over the 2041–60 period. With heat stress, river and coastal flooding, and landslides increasing over this period, the effects are devastating, even under low-emission scenarios. Heat stress patterns will increase in severity and extreme rainfall events will increase in magnitude. Under current scenarios, by 2050, rice production could fall by 8 percent, wheat by 32 percent, yield of pulses[26] by 8.8 percent, oilseed-rapeseed by 6.3 percent, vegetables (as a group) by 5.3 percent, and other crops (including jute) by 3.3 percent.

Climate-related hazards pose grave risk to communities and their assets, causing disproportional damage and disrupting lives and livelihoods (Box 1 and Figure 4). Particularly challenging environmental conditions across two aggregations of *upazila*s with high risk are shown in updated overviews of population, built-up assets, and agricultural exposure to and impact of natural hazards, with 2016 poverty rates at the *upazila* level. The western *upazila*s of Mymensingh and eastern *upazila*s of Rangpur have high annual impact of river flooding as well as high exposure to heat stress, agricultural drought, and air pollution. The high rate of poverty in this area calls for the explicit attention of

[17] Total stored blue carbon stock in the Sundarbans is estimated at 91 million tons of carbon dioxide (MtCO2), of which 36 are above ground and 55 below ground. Biodiversity is influenced by seasonal salinity content and the dynamics of waterways which, in turn, are determined by seasonal and annual fluctuations in freshwater flows from the Ganges. With rising sea levels and reduced freshwater flows in recent decades, due to upstream usage of water, salinity intrusion has increased, resulting in a significant loss of fish species. 16 MtCO2 is predicted to be lost from this region by 2115. Together with rising sea levels, this will cause salinity to penetrate further inland. Increased efforts are needed to strengthen regional cooperation between India and Bangladesh and improved water resource management within Bangladesh to manage adequate levels of freshwater flows to this unique ecosystem and provide sustainable livelihood options to dependent communities. Chanda, A. et al. 2016. "Blue Carbon Stock of the Bangladesh Sundarban Mangroves: What Could Be the Scenario after a Century?" Wetlands (36):1033–1045. (Link); Dasgupta et al. 2016. "The Impact of Climate Change and Aquatic Salinization on Fish Species and Poor Communities in the Bangladesh Sundarbans." The Journal of Environment & Development Vol. 20(2): 167–190

[18] Wolf, M. J. et al. 2022. "2022 Environmental Performance Index." New Haven, CT: Yale Center for Environmental Law & Policy. (Link)

[19] This category assesses actions toward retaining natural ecosystems and protecting the full range of biodiversity within country borders.

[20] Rigaud, K. K. et al. 2018. *Groundswell: Preparing for Internal Climate Migration*. Washington, DC: World Bank. (Link)

[21] Ozaki, M. 2016. "Disaster Risk Financing in Bangladesh." ADB South Asia Working Paper Series No. 46. (Link)

[22] The two tropical cyclones that have led to the largest losses on record in Bangladesh are Cyclone Sidr (2007, upper estimate of US$3.8 billion in losses) and Cyclone Gorky (1991, upper estimate of US$3.0 billion in losses). Ozaki, M. 2016.

[23] Kazi, S. et al. 2022. *Bangladesh Enhancing Coastal Resilience in a Changing Climate*. Washington, DC: World Bank.

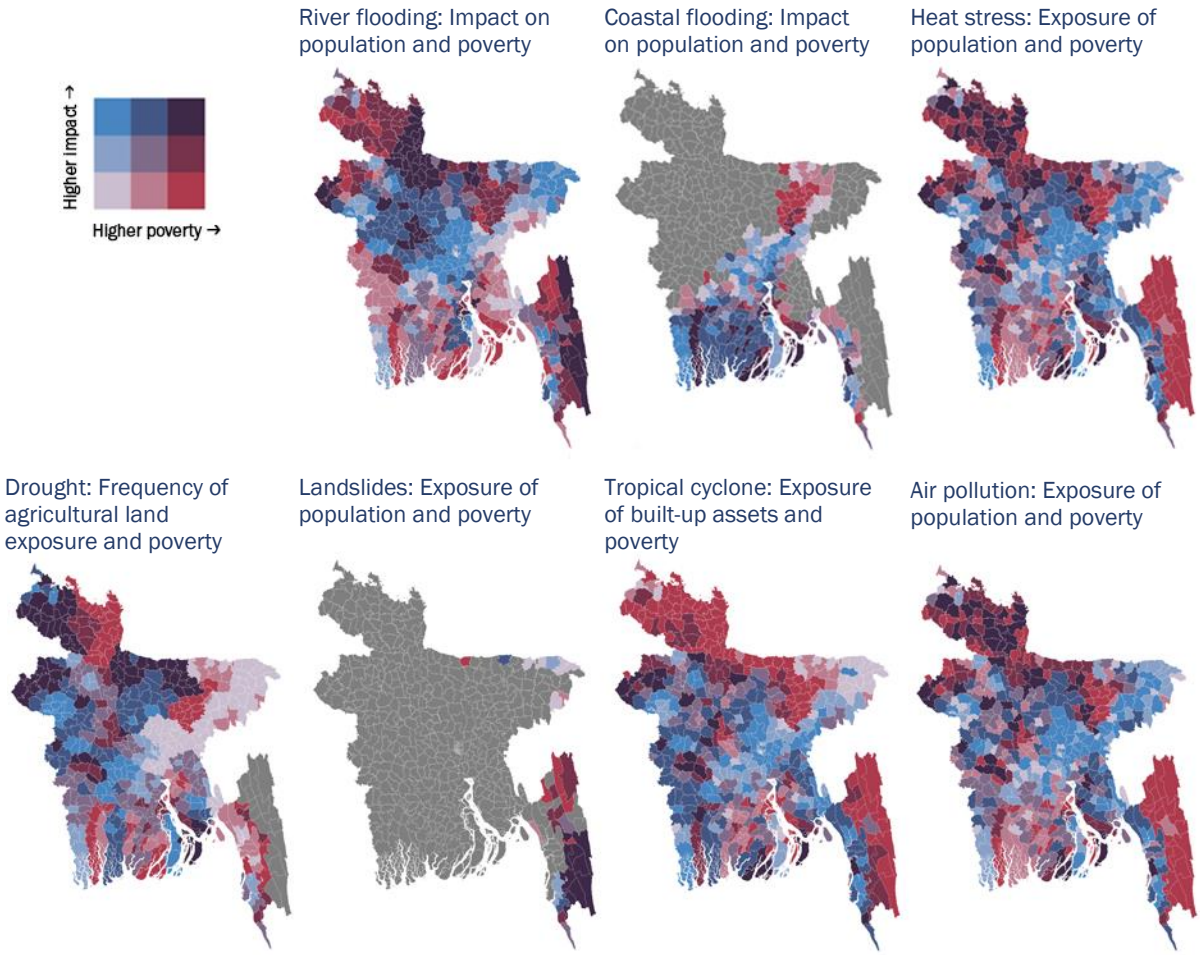
[24] The Intergovernmental Panel on Climate Change (IPCC) defines a natural hazard as the potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. Exposure describes the location of people and assets in an environment where they may be threatened by these natural hazards. People and assets may be exposed, yet not adversely impacted, if they are not vulnerable. Vulnerability summarizes the propensity or predisposition to be adversely affected when exposed, measured by characteristics that favor a negative impact of a hazard if exposed to it. Disaster risk is then the probability of a negative impact in the future, caused by a natural hazard.

[25] See Section 5.1 for further explanation on RCP scenarios.

[26] Pulses include dry peas, lentils, and chickpeas.

policymakers and development partners to safeguard the lives and livelihoods of these population groups from climate-related disasters. Eastern Chattogram faces landslide risk, and the southwest confronts a compounding issue of coastal floods, heat, drought, tropical cyclones, and air pollution, requiring tailored preventative and adaptative interventions. Figure 5 and Figure 6 show the change in poverty headcount rates and their compounding hazard exposure between 2010 and 2016.[27]

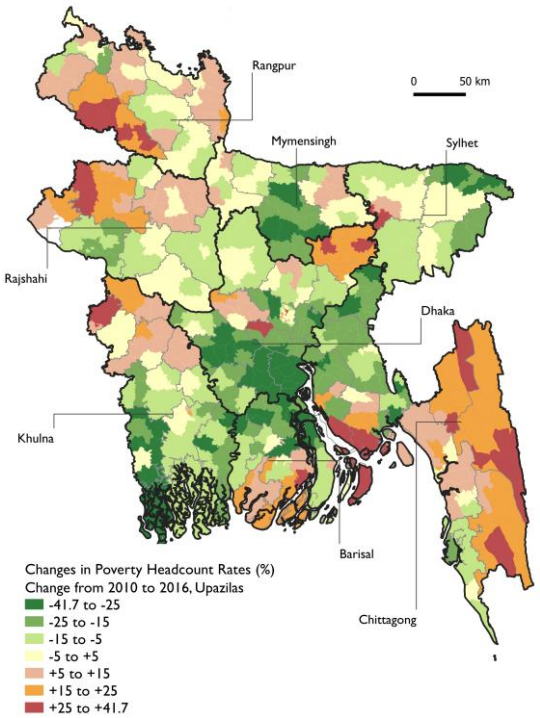
Figure 4: Impacts of natural disasters on poverty



Source: Mapping by World Bank Poverty & Equity Portal, 2020. Aggregate precipitation and temperature projections are provided at a gridded resolution of around 100 kilometers.

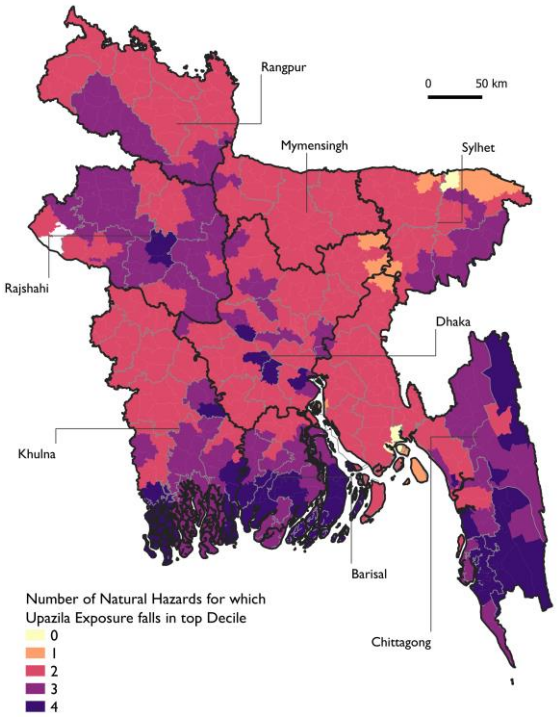
[27] Figure 6 illustrates how many out of the seven hazards (i.e., river floods, coastal floods, heat stress, drought, tropical cyclones, landslides, and air pollution) each *upazila* falls into the highest decile of relative population or built-up area exposure. Individual hazard data sources are flood: Fathom 90m flood model (Fathom. 2020. "Fathom-Global 2.0 Flood Hazard Data." Database. (Link)); landslide: ARUP Landslide Index at 1 kilometer (km) (ARUP. 2022. "Global Landslide Hazard Map." Database. (Link)); heat stress: World Bank-GFDRR Wet Bulb Globe Temperatures at 10 km (World Bank. 2022. "Global Extreme Heat Hazard." (Online Data Catalog). (Link)); drought: FAO Agricultural Stress Index at 1 km (FAO (Food and Agriculture Organization of the United Nations). 2022. "Earth Observation." Database. (Link)); tropical cyclone: NOAA Wind Speeds at 30 km (National Oceanic and Atmosphere Administration. n.d. "Windspeed Unit Converter." Database. (Link)); air pollution: surface PM2.5 concentrations at 1.1 km (Van Donkelaar, A. et al. 2021. "Monthly Global Estimates of Fine Particulate Matter and Their Uncertainty." *Environmental Science & Technology* Vol. 55(22): 15287–15300. (Link)).

Figure 5: Change in Poverty Rates between 2010 and 2016 for Bangladesh's *Upazilas*



Source: Bangladesh Bureau of Statistics, 2010 and 2016; and United Nations Office for Coordination of Humanitarian Affairs, 2020.

Figure 6: Compounding Hazard Exposure for Bangladesh's *Upazilas*



Source: United Nations Office for Coordination of Humanitarian Affairs, 2020.

Box 1: Climate Change and Poverty in Bangladesh

Evidence from the last decade shows that the parts of Bangladesh exposed to multiple overlapping shocks have witnessed relatively slower poverty reduction. In the years ahead, climate change is likely to continue to slow the progress on poverty reduction. The poor and most vulnerable populations are most impacted due to their reliance on agriculture and other climate-sensitive natural resources for income and livelihoods. With higher frequency of climate related shocks and disasters vulnerable populations and the chronically poor will face long lasting and multigenerational effects, resulting in costly coping strategies such as divesting productive assets and curtailing investments in human capital (e.g., nutrition and education). Migration costs are often prohibitive. Strong, adaptive social protection measures to enable poorer households to overcome barriers to internal mobility, are needed. Those households assigned monetary incentives to temporarily out-migrate during the lean season (monga) are likely to do so, suggesting the presence of significant credit constraints.[1]

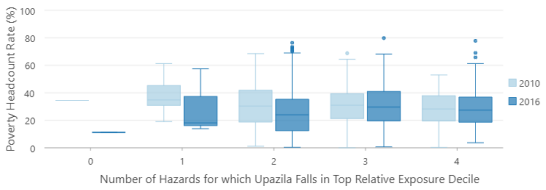
[1] Bryan, G., S. Chowdhury, and A. M. Mobarak. 2014. "Underinvestment in a Profitable Technology: The Case of Seasonal Migration in Bangladesh." *Econometrica, Journal of the Econometric Society* Vol. 82 (5): 1671–1748. (Link).

Poverty trends over time confirm a consistent, diverging pattern for hazard-affected and exposed spatial units with higher risks. Communities exposed to multiple natural hazards show a substantially lower decrease in poverty, or even poverty increases over time. Climate-related hazards could pose a barrier to the lowering of poverty rates, undoing development progress and lowering the resilience of communities (Figure 7 and Figure 8).[28] The findings also point to a possible out-migration of wealthier households, with poorer and more vulnerable households remaining behind in hazard-affected areas.

[28] The figures highlight that *upazilas*, whose population and built-up assets are heavily exposed to three or four compounding natural hazards, show no substantial decline in poverty rates between 2010 and 2016, whereas those with lower compounding exposure (0, 1, or 2 hazards for which they appear in the top-10 percent most exposed *upazilas*) show a mild or even stark decline in poverty rates over this period.

Increasing resilience to natural hazards, therefore, should be a top priority in eastern and southwestern Chattogram, southern Barisal, Rangpur, and Rajshahi Division, where poverty and natural hazards pose a double burden and show a worsening trend over time.

Figure 7: 2010 and 2016 poverty rates and compounding hazards



Sources: World Bank Poverty & Equity Portal, 2020; and World Bank staff calculations.

Figure 8: Change in poverty rates and compounding natural hazards

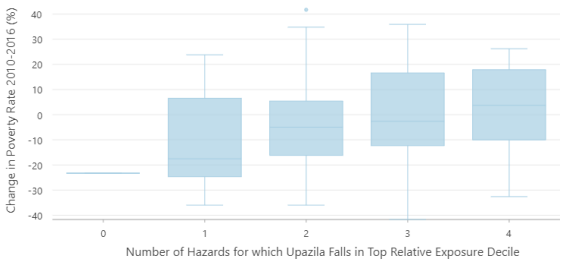
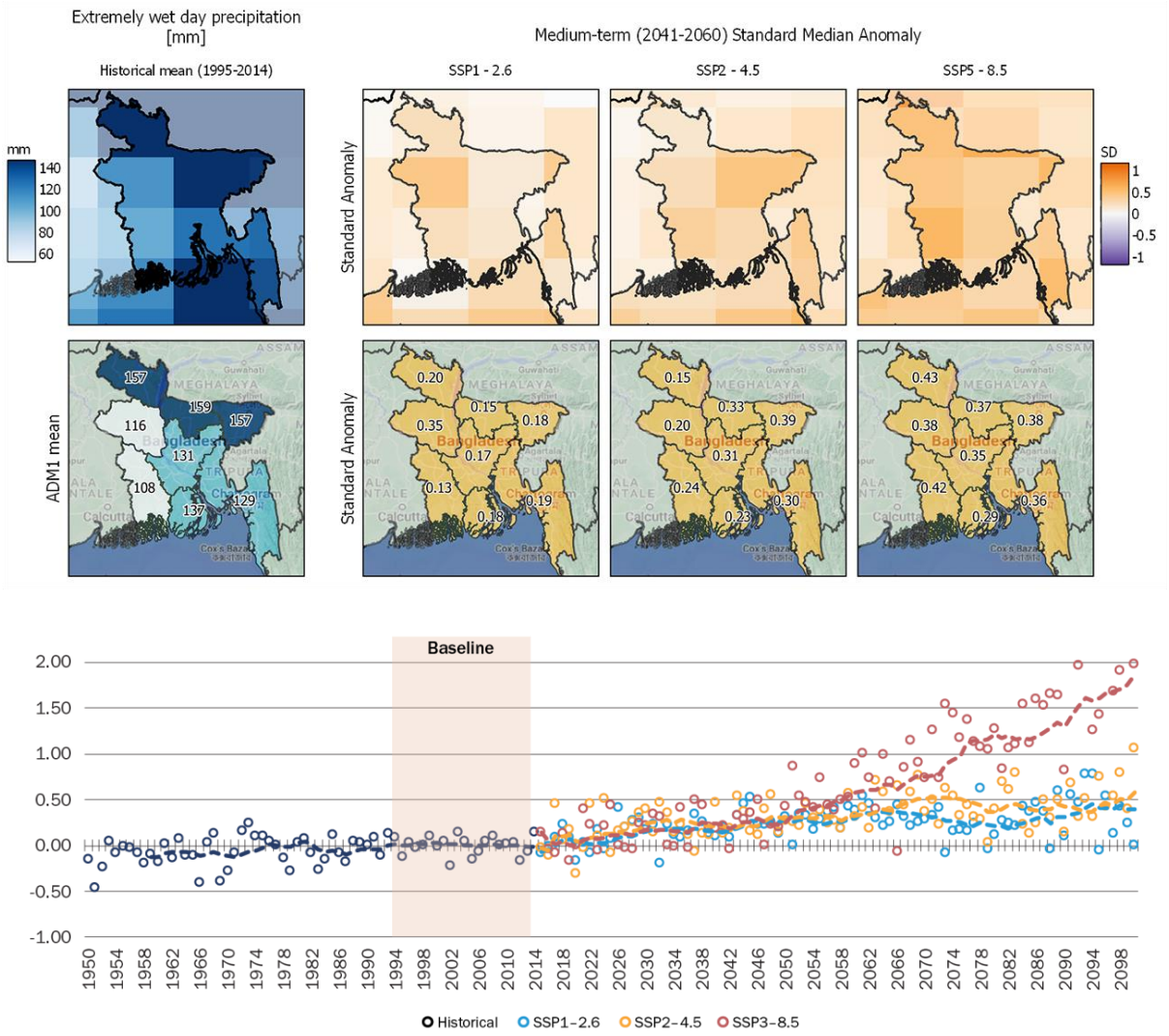


Figure 9: Climate Change Projections: Extremely Wet Day Precipitation (mm) for Bangladesh



Sources: World Bank staff calculations, based on United Nations Intergovernmental Panel on Climate Change; and European Commission's Copernicus Data Store, 2022.

The compounding effect of heat stress, river and coastal flooding, and landslide is significant and disproportionately distributed. Future climate scenarios are shown as mapping ensembles in Figure 9. The gridded historical mean over the baseline period is shown in the top left, with the historical division average over this period at the bottom left. The second, third, and fourth columns represent the projected anomalies for the climate variables under SSP1–2.6, SSP2–4.5, and SSP5–8.5. The top row shows the gridded standardized anomalies for 2041–60, while the bottom row shows the average standardized anomaly for each division.

Current heat stress patterns are set to increase in severity. While the overall precipitation patterns are unlikely to considerably alter, extreme rainfall events are likely to increase in magnitude**.** Precipitation patterns are used to analyze future flooding and landslide scenarios. The historical baseline shows a clear pattern of wet conditions across Bangladesh, particularly in the northern and eastern divisions. Although structural changes in overall precipitation patterns and conditions of wetness are not expected, rainfall volume during extremely wet days and the frequency with which such days occur are set to substantially increase. This is especially the case in the northern divisions, which already faces the most severe precipitation events. Higher GHG emission concentration scenarios will further exacerbate such increases in rainfall. The starkly growing anomalies of sea level rise elevate tremendous concerns for the Khulna Division, which will face the strongest rise in standardized sea level rise anomalies by mid-century of over 40 centimeters in any climate change scenario. The projected increases in extreme rainfall, along with high sea level rise, are alarming as this can lead to more frequent and severe coastal and river flooding, as well as rainfall-induced landslides.

The Standardized Precipitation-Evapotranspiration Index shows little change in the standardized anomaly under all of the SSPs, suggesting that agricultural drought patterns will persist over the 2041–60 period compared to the 1995–2014 baseline. The number of annual consecutive dry days, however, is forecast to increase limitedly and fairly uniform across Bangladesh. Areas with a historical pattern of a large number of consecutive dry days each year—mainly the western divisions—will experience further increases in short-term dry episodes with sharply rising GHG emissions. Agricultural drought concerns will remain valid in the decades ahead. Under all SSPs—and relatively uniformly across Bangladesh—the standardized anomalies of heat are forecast to increase relative to the 1990–2010 base (Figure 10). This increase is stronger under higher-emission scenarios and is particularly significant in historically cooler divisions such as Chattogram. The projected rise in temperature indicates increased heat stress across Bangladesh by the 2041–60 period, raising the urgency of adaptation for urban environments where heat causes significant climate-related health risks.

Current patterns of extreme weather events contribute to climate induced migration, impacting cities and towns and leading to further strains on development. Within South Asia, Bangladesh stands as the most vulnerable to climate migration. About 2.5 percent of the population (4.1 million people) is estimated to have been displaced as a result of climate disasters in 2019. By 2050, 13.3 million internal climate migrants and around 27 percent of all South Asian climate migrants in the future are projected to be from Bangladesh due to climate induced impacts on agricultural production, water scarcity, and rising sea levels, with higher impacts on women.[29,30] Recent evidence links the slow-onset of climatic events (e.g., sea level rise, salinity, and droughts) to migration as a coping mechanism and an adaptation strategy.[31,32] Additional evidence from Bangladesh points to the consequences of

[29] Rigaud, K.K. et al. 2018. *Groundswell: Preparing for Internal Climate Migration.* Washington, DC: World Bank. (Link)

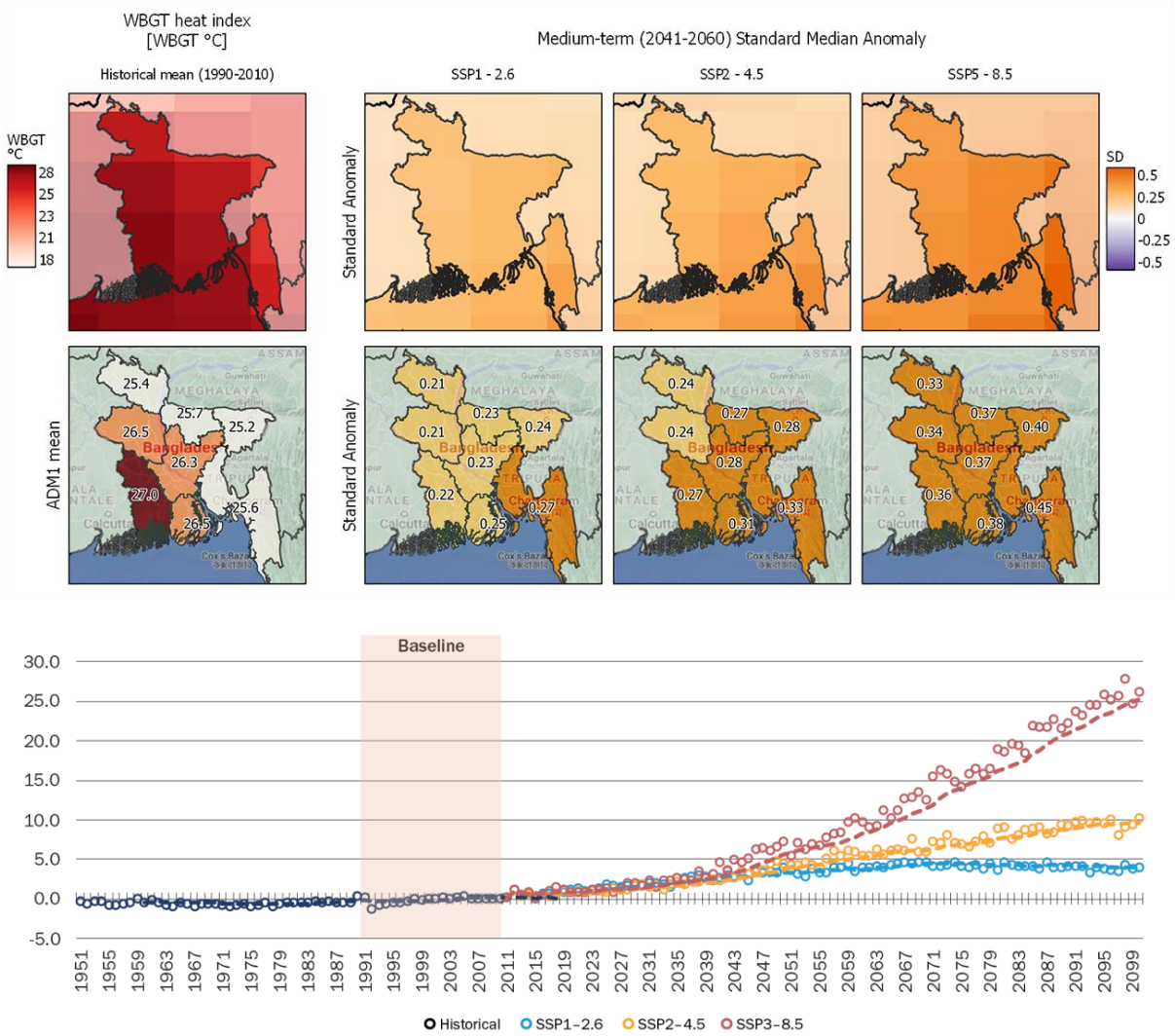
[30] Clement, V. et al. 2021. *Groundswell Part 2: Acting on Internal Climate Migration.* Washington, DC: World Bank. (Link)

[31] Khatun, H., M. H. Kabir, and L. Nahar. 2021. "Out Migration as a Survival Strategy for Char Dwellers." In: Zaman, M., and M. Alam (eds) *Living on the Edge*, pp 307–332. Cham: Springer Geography. (Link)

[32] Nguyen, M. C. and Q. Wodon. 2015. "Temporary and Permanent Migration." In: A. O'Donnell and Q. Wodon (eds) *Climate Change Adaptation and Social Resilience in the Sundarbans*, Chapter 7. London and New York: Earthscan. (Link)

climate-induced migration, especially to cities,[33] including the deepening vulnerabilities for households, further impoverishment, and accelerated poverty.[34] Without targeted policy action, increasing internal climate-induced migration will impact climate-sensitive sectors and further strain infrastructure and social safety net systems in rural and urban areas alike.[35] A multihazard transport infrastructure exposure assessment estimates annual damages to be US$1,500 per kilometer (km), with 30 percent and 40 percent of transport infrastructure affected. The projected mean losses by 2050 are 1.6 percent of GDP in Chattogram, 1.9 percent in Dhaka, and 10 percent in Khulna.[36]

Figure 10: Climate Change Projections: Wet Bulb Globe Temperature Heat Index (°C) for Bangladesh



Sources: World Bank staff calculations, based on United Nations Intergovernmental Panel on Climate Change; and European Commission's Copernicus Data Store, 2022.

[33] Rana, M. M. P. and I. N. Ilina. 2021. "Climate Change and Migration Impacts on Cities: Lessons from Bangladesh." *Environmental Challenges*, Vol. 5. (Link); and Collyer, M. and L. Hammond. 2021. *Migrants on the Margins: Final Report*. London: Royal Geographical Society. (Link)

[34] Vinke, K. et al. 2020. "Migration as Adaptation?" *Migration Studies,* 8(4): 626–634 (Link); Jacobsen, C. et al. 2019. "When is Migration a Maladaptive Response to Climate Change?" *Regional Environmental Change, Vol.* 19: 101–112. (Link)

[35] Rigaud, K. K. et al. 2018. *Groundswell: Preparing for Internal Climate Migration*. Washington, DC: World Bank. (Link)

[36] Hallegatte, S., J. Rentschler, and J. Rozenberg. 2019. *Lifelines: The Resilient Infrastructure Opportunity. Sustainable Infrastructure*. Washington, DC: World Bank. (Link)

The costs of environmental degradation and natural disasters also are expected to rise over time, compounded by higher heat and humidity and impacts on health. Thirty-two percent of all deaths in Bangladesh are linked to environmental degradation, particularly to outdoor and household air pollution; inadequate water, sanitation, and hygiene standards; and lead exposure in adults. These degradations account for a premature death rate of 169 per 100,000 inhabitants. The annual cost of such environmental health effects was estimated to be Tk 4.4 trillion in 2019, equivalent to 17.3 of GDP.[37] Most of the population is exposed to high ambient concentrations of PM2.5, which contains Black Carbon. Higher drinking water salinity from rising sea levels will increase the prevalence of diarrhea and cardiovascular disease as well as affect the usability of groundwater, while more frequent extreme heat events will increase mortality rates among the elderly, children, chronically ill, socially isolated, and at-risk occupational groups. Infectious disease transmission is likely to precipitate infections such as those that are vector borne (e.g., malaria, dengue fever) and waterborne (e.g., diarrhea and cholera). While humidity and mean temperature are negatively correlated to waterborne diseases, they are nevertheless positively correlated to respiratory illnesses. Moreover, mean humidity is positively correlated with mental health issues such as anxiety and depression, and mean temperature is negatively associated with depression.[38]

Bangladesh also faces external risks in the context of new international climate regulations and shifting consumer preferences in key export markets. Rising energy and material costs, resource insecurity and supply unreliability, changing preferences of global buyers, new carbon tax regimes, and national and corporate 'Net-Zero' commitments are also driving more companies to adopt decarbonization as a lever to grow, raise finance and stay competitive in their respective value-chains. A rapid decline in the cost of low-carbon technologies (e.g. solar PV, wind, battery storage) has added to this momentum. The European Union's proposed Carbon Border Adjustment Mechanism (CBAM) is an example of how new carbon pricing initiatives could impact market access. The CBAM places a carbon price on select imported goods in order to reinforce the European Union's Emissions Trading Scheme and to encourage third-country mitigation measures. Canada and Japan are already assessing the feasibility of introducing a form of carbon border adjustment. The impacts on Bangladesh are expected to be low; however, the RMG sector could proactively respond to these signals and improve its energy efficiency, reduce waste, and adopt circular economy models to remain competitive. This is discussed further in Section 5.

1.3. Responding to Climate Risks: Estimating the Cost of Investment

The GoB has outlined priority areas for climate change adaptation and mitigation in national plans with a range of estimated financing requirements, from 0.8 percent to over 5 percent of annual GDP. In 2018, the Bangladesh Delta Plan 2100 (BDP2100) was adopted with the goal of achieving a safe, climate resilient, and prosperous Delta,[39] proposing US$38 billion by 2030 (in 2015 prices) for physical investments and institutional strengthening for implementation and monitoring. Annual BDP2100 expenditure needs, including operations and maintenance and private investment, were estimated to start at 0.8 percent of GDP, increasing to 2.5 percent by 2025. FY22 delta-related expenditure is approximately 1.1 percent of GDP.[40,41] In 2021, the GoB drafted the preliminary Mujib Climate Prosperity Plan (MCPP), offering a multi-sectoral investment plan for climate-resilient infrastructure, clean energy, green value chains, and logistics from 2020 to 2030. The preliminary MCPP estimates investments of US$89.7 billion until 2030 (inclusive of the first phase of the BDP2100 and components of the conditional

[37] World Bank. (Forthcoming). *Building Back a Greener Bangladesh.* Country Environmental Analysis. Washington, DC: World Bank.

[38] Mahmud, I. et al. 2021. *Climate Afflictions: International Development in Focus*. Washington, DC: World Bank. (Link)

[39] GoB (Government of Bangladesh). 2018. *Bangladesh Delta Plan 2100: Bangladesh in the 21st Century—Volume 1: Strategy*. Dhaka: General Economics Division, Bangladesh Planning Commission, Ministry of Planning, GoB.

[40] GoB (Government of Bangladesh). 2018. *Bangladesh Delta Plan 2100: Bangladesh in the 21st Century—Volume 2: Investment Plan*. Dhaka: General Economics Division, Bangladesh Planning Commission, Ministry of Planning, GoB.

[41] The government's Annual Development Programme (ADP) budget allocation for BDP2100 was around US$4.69 billion in FY22.

Nationally Determined Contribution (NDC)), approximately 2.2 percent of GDP on an annual basis. The 2021 NDC Update identifies a requirement of US$32 billion to meet unconditional mitigation objectives, and an additional US$143.8 billion to meet conditional objectives over 2021–30. The BDP2100, NDC, and MCPP include similar investments in some sectors, such as energy and agriculture, with additional climate financing potentially exceeding 5 percent of GDP annually, roughly doubling the GoB's current investment expenditure (Table 2). These plans present a comprehensive set of potential climate investments. However, implementation will likely be constrained by financing availability.

Table 2: Estimates of Climate Finance Requirements

Year	Plan	Proposed investment	US$ billions (Total Plan)	Est. expenditure as % of GDP (Annual Basis)
2018	**BDP2100**	Adaptive water management and multisectoral infrastructure	38.0[a] by 2030	2.50[b]
2021	**NDC Unconditional Mitigation (2021–30)**	Energy	30.8	0.74
		Agriculture, forestry, and other land use	0.8	0.02
		Waste	0.6	0.01
		Total	**32.3**	**0.78**
2021	**NDC Conditional Mitigation (2021–30)**	Energy	137.5	3.31
		Agriculture, forestry, and other land use	2.5	0.06
		Waste	3.8	0.09
		Total	**143.7**	**3.46**
2022	**Preliminary Mujib Climate Prosperity Plan (2022–30)**	Accelerated adaptation	44.1	1.07
		Just transition of labor; technology transfer	11.6	0.28
		Increasing public revenue	3.9	0.10
		Climate and disaster risk financing and management	4.9	0.12
		21st century technologies for wellbeing	4.6	0.11
		Renewable energy, energy efficiency, and power and transportation resilience	20.6	0.50
		Total	**89.7**	**2.18**
	Total estimated range	Lower range: BDP2100 + NDC Conditional Upper range: Combined investments across plans (including for conditional NDC)		**3.28 to 7.00**

Source: World Bank staff calculations. The MCPP financing plan includes components of the investments identified under the BDP2100 and conditional Nationally Determined Contribution (NDC)).

a Measured in 2015 price.

b 0.8 per year, with a gradual scale up to 2.50 by 2025.

Notes: GDP = gross domestic production; BDP2100 = Bangladesh Delta Plan 2100; NDC = Nationally Determined Contributions.

Implementing climate change solutions at scale will require public and private investment. Public resources are constrained by persistently low government revenues, which remained below 10 percent of GDP in FY21. Strengthened cost-benefit analysis to prioritize proposed investment projects will be critical in the context of these financing constraints. Supporting a higher level of publicly-financed investment will require progress on domestic revenue mobilization reforms. The 8th FYP outlines priority tax policy reforms including a rationalization of tax expenditures, adoption of a single standard VAT rate, and modernization of income tax legislation – measures which require stronger administration systems to be fully implemented. Innovative new tax instruments can also create fiscal space for climate investments, including carbon taxes and fees (discussed in Section 5). The MCPP recognizes the urgency of mobilizing additional tax revenues to support public investment, including the operationalization of a carbon tax. Cost recovery also could be an important source of financing, as energy, water, and waste treatment are priced below cost recovery rates. Sectors that require large investments in mitigation and adaptation (e.g., urban infrastructure, transport, electricity transmission and distribution) need broader and competitive private participation, including public-private

partnerships (PPP), foreign direct investment (FDI), and concessional financing. In the MCPP, 47 percent of required investment is targeted from private sector sources, 36 percent from government expenditure, and 16 percent from development partners. The BDP2100 expects 20 percent of the total plan value to come from the private sector. Reaching these ambitious targets is challenging, with substantial reforms required to overcome longstanding domestic and foreign investment constraints. The banking sector's capacity to provide financing and price risks is constrained by weak corporate and regulatory governance, related party lending, and weak credit underwriting capacity, contributing to weak asset quality. The domestic capital market is nascent, with bond issuances at 5 percent of GDP in 2019 (compared to 23 percent of GDP in Indonesia). Access to foreign borrowing is limited by a high level of foreign exchange restrictions. As elaborated in Section 5, financing and institutional capacity constraints will require prioritization of the most impactful and urgent climate investments and policies.

Bangladesh should continue its transition to a green, resilient, and inclusive growth model to reach high middle-income status and address its climate challenges. This model must leverage urbanization as a key driver of productivity, efficiency, and economic growth, and to develop the strengths of Bangladesh's diverse regions. Growth in the mid-1980s had stemmed from rapid improvements in infrastructure, lower political violence, management of financial sector weaknesses, and trade openness as a result of economic reforms to strengthen markets and investment.[42] Post-1990 reforms allowed more private sector participation in trade, finance, and land ownership, which supported growth. Although a long period of macroeconomic stability allowed such reforms to sustain economic growth, new reforms are now needed to boost trade and resolve financial sector vulnerabilities. The current growth model is vulnerable to risks from an undiversified export basket, high levels of spatial concentration, low female labor force participation,[43] insufficient domestic resource mobilization, and weak public institutions. Financial sector vulnerabilities include high levels of non-performing loans and weak capital buffers. These challenges can be addressed with reliable and predictable funding flows and locally led, climate informed, and devolved decision-making. A transition away from high emission industries will have distributional impacts, affecting poor and vulnerable groups, including informal labor. However, there is opportunity for cleaner and more equitable growth through spatial development that leverages agglomeration effects and reduces congestion, makes cities more resilient to heat and reduces environmental pollution. Agricultural resilience to hotter, wetter conditions, safeguarding coastal areas and expanding nature-based solutions will facilitate more equitable development by reducing rural stress and coastal erosion. Accelerating reforms and investments to address these risks will be foundational to sustaining a rapid pace of growth and poverty reduction. Actions relating to these challenges and climate change are discussed in greater detail in subsequent sections.

[42] World Bank Group. 2022. "Bangladesh: Change of Fabric." Country Economic Memorandum. Washington, DC: World Bank Group. (Link)

[43] Female labor force participation is 35 percent compared to that of males, at 81 percent. World Bank. (Forthcoming). "Bangladesh: Country Gender Assessment." Washington, DC: World Bank.

2. Climate Commitments and Capacities: Building an Enabling Environment

Although Bangladesh's primary focus is on adapting to substantial climate risks (Figure 11), the country has made mitigation commitments under the Paris Agreement. The 2015 NDCs cover the power, industry, and transport sectors, while the updated 2021 NDCs include energy, industrial processes and product use, agriculture, forestry and other land use, and waste (Table 3). The updated NDCs commit to reducing emissions across these sectors by 89.5 $MtCO_2e$, or 21.85 percent by 2030, relative to business as usual (BAU) (including 6.73 percent in unconditional reductions and 15.12 percent conditional on international assistance).[44] The energy sector accounts for 96.1 percent of the planned unconditional and conditional reductions, with 2.7 percent of reductions from the waste sector and 1.2 percent from agriculture, forestry, and other land use (see Figure 12 for sectoral emission data). The unconditional targets in the updated NDCs are not ambitious in some sectors, such as the industrial processes and product use sector, which does not have an unconditional target. The NDC Implementation Roadmap and Action Plan is currently being revised.

Table 3: Greenhouse Gas Emission Reduction Targets, Unconditional and Conditional, NDC 2021

UNFCCC Sector	Sub-Sector	Green House Gas Emission Scenario		Green House Gas Reduction by Mitigation (2030)							
		BAU 2030		Unconditional			Conditional			Combined	
		$MtCO_2e$	In %	$MtCO_2e$	In %	$MtCO_2e$	In %	$MtCO_2e$	In %	$MtCO_2e$	In %
Energy	Power	95.14	23.24	87.13	8.01	29.06	51.4	35.73	57.72	43.74	48.9
	Transport	36.28	8.86	32.89	3.39	12.3	26.56	6.33	10.23	9.72	10.86
	Industry (energy)	101.99	24.91	95.33	6.66	24.17	94.31	1.02	1.65	7.68	8.58
	Households	30.41	7.43	28.78	1.63	5.91	24.77	4.01	6.46	5.64	6.3
	Commercial	3.35	0.82	2.94	0.41	1.49	2.51	0.43	0.69	0.84	0.94
	Agriculture	10.16	2.48	9.37	0.79	2.87	10.13	0.03	0.05	0.82	0.92
	Brick kilns	23.98	5.86	20.7	3.28	11.9	12.82	7.88	12.73	11.16	12.47
	Fugitive	8.31	2.03	8.31	2.14		4.03	4.28	6.91	4.28	4.78
	F gases	2.92	0.71	0.78	26.31	7.76	0.03	0.75	1.21	2.89	3.23
Total Energy		**312.54**	**76.34**	**286.23**		**95.46**	**226.56**	**59.71**	**96.46**	**85.98**	**96.1**
IPPU	Cement and fertilizers	10.97	2.68	10.97	0.64	2.32	10.97				
AFOLU	Agriculture and livestock	54.64	13.35	54			53.6	0.4	0.65	1.04	1.16
	Forestry	0.37	0.09	0.37	0.64	2.32	0.37				
Total AFOLU		**55.01**	**13.44**	**54.37**	**0.61**	**2.21**	**53.97**	**0.4**	**0.65**	**1.68**	**1.16**
Waste	Municipal solid waste and wastewater	30.89	7.55	30.28			28.44	1.84	2.97	2.45	2.74
Total Emissions		**409.41**		**381.85**			**319.94**				
Total Reduction					**27.56**	**6.73**		**61.9**	**15.12**	**89.47**	**21.85**

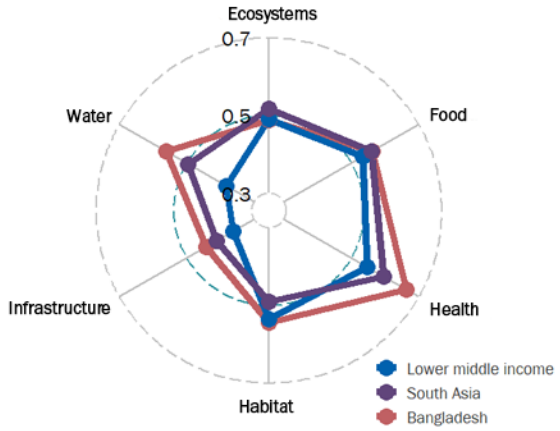
Source: Government of Bangladesh.

Notes: (1) Intended Nationally Determined Contributions (2015) proposed 12 million metric tons of carbon dioxide equivalent (MtCO2e) (5 percent) reduction in unconditional and a further 24 MtCO2e (10 percent) reduction in conditional scenario. Nationally Determined Contributions (2020) proposed 27.56 MtCO2e (6.73 percent) reduction in unconditional and an additional 61.91 MtCO2e (15.12 percent) reduction in conditional scenario. (2) UNFCCC = United Nations Framework Convention on Climate Change; BAU = business as usual; IPPU = industrial processes and product use; AFOLU = agriculture, forestry, and other land use.

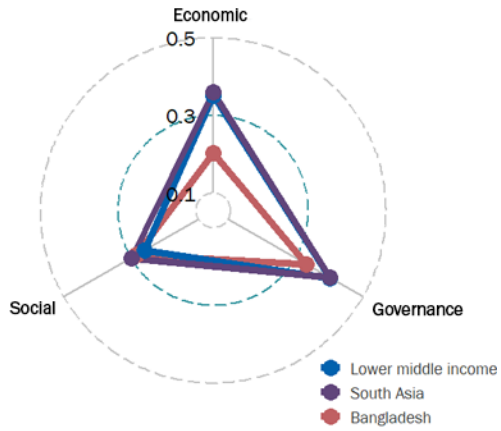
[44] In contrast, initial Nationally Determined Contributions committed only to 10 percent and 5 percent emission cuts with and without international assistance, respectively.

Figure 11: Bangladesh's Climate Vulnerability and Adaptation Readiness

Vulnerability scores (0-1 lower is better), 2019

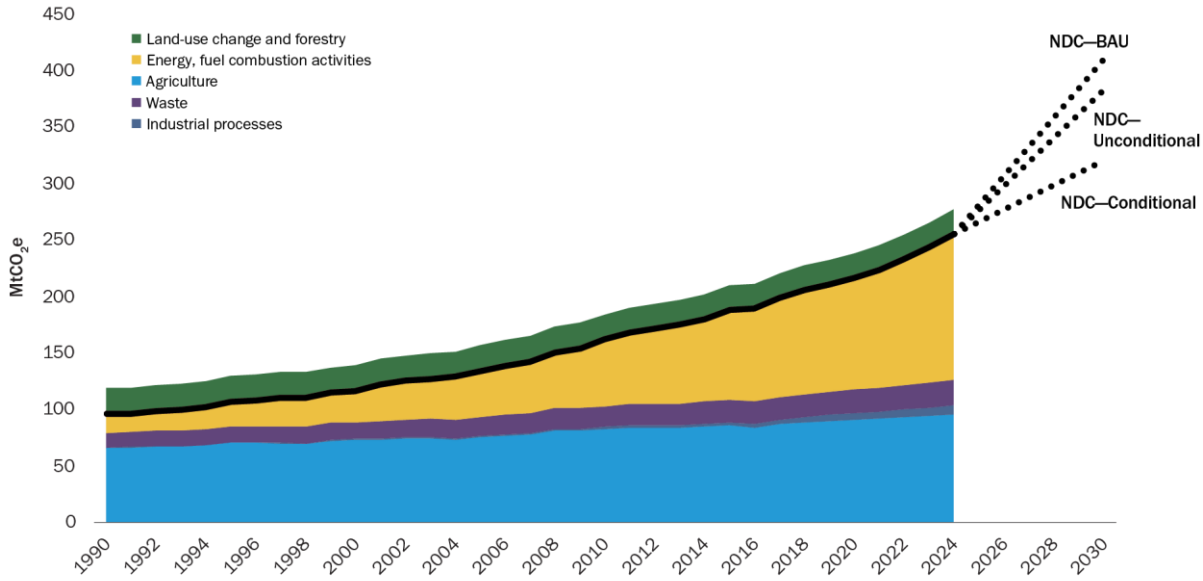


Readiness scores (0-1 higher is better), 2019



Source: The Notre Dame Global Adaptation Index (ND-GAIN) Country Ranking.
Note: Vulnerability measures a country's exposure, sensitivity, and ability to adapt to the negative impact of climate change while Readiness measures a country's ability to leverage investments and convert them to adaptation actions.

Figure 12: Sectoral Emission Data



Sources: Climate Watch Historical Country Greenhouse Gas Emissions Data; and Macro-Fiscal Model (MFMoD) for climate change.
Notes: NDC = Nationally Determined Contributions; BAU = business as usual.

2.1. Policy Framework and Institutional Capacity

Bangladesh has a robust domestic climate policy framework that focuses on resilience. The Bangladesh Climate Change Strategy and Action Plan (BCCSAP), formulated in 2009, presents a vision of pro-poor climate management that centers on reducing disaster risk. The BCCSAP addresses mainstreaming climate change into national development planning through six thematic areas: (i) food security, social protection, and health; (ii) comprehensive disaster management; (iii) infrastructure; (iv) research and knowledge management; (v) mitigation and low-carbon development; and (vi) capacity building and institutional strengthening. In 2005, the GoB launched its National Adaptation Programme of Action and tasked a new Climate Change Unit under the Ministry of Environment and Forests with

mainstreaming climate change into national development planning, along with Climate Change Focal Points in various ministries.[45] The 2018 BDP2100 is a long-term investment plan for climate resilience and economic growth that focuses particularly on multidimensional water investments and water management. The MCPP, currently being finalized, seeks to integrate these plans into an overarching framework for climate resilience and a green energy transition. In the near term, all climate policies must be embedded within the government's 8th Five-Year Plan (8th FYP), followed by proper financing mobilization (particularly budget allocations) for priority investments.

Adopting a Climate Change Act and creating a high-level national coordination committee for climate change are important steps in meeting the NDCs and ensuring local adaptation. A Climate Change Act would support alignment and transparent implementation of government policies and programs, such as the BCCSAP and MCCP, as well as private sector compliance with climate regulations. A high-level national coordination committee would enable stakeholder representation, including civil society organizations (CSO) and academia, for the formulation and monitoring of the implementation of the national climate strategy and the Bangladesh Climate Fiscal Framework (BCFF) 2020.[46] The BCFF provides an important starting point for fiscal planning; however, more systematic costing of climate investment is needed.[47] The BCFF should cost core climate programs like the NDC/BCCSAP, MCCP, BDP2100, and the Country Investment Plan for Environment, Forestry and Climate Change, and prioritized investments should be included in the national budget and the ADP.

The Ministry of Environment, Forest and Climate Change and relevant line ministries must be strengthened to deliver climate programs. Climate policies and national adaptation goals should be integrated into the planning and decision-making process in all core ministries (including energy, power, transport, water, local government, industry, agriculture, disaster management, land, and fisheries), and ministries should merge climate adaptation principles into existing government rules and regulations (e.g., urban storm water regulations, sewerage connection, tariff levies). Adequate staffing, resources, and coordination across government agencies—particularly for managing urban-water services and overall urban planning—are needed.

Effective climate action also will require domestic accountability mechanisms and stronger vertical coordination with local government. The 8th FYP recognizes major challenges in the administrative autonomy and fiscal accountability of local government institutions (LGI). Investing in institutional and fiscal empowerment, as well as the technical capacity of LGIs is necessary due to their critical role in addressing the impacts of climate change. Local agency staff may benefit from training and the application of needs assessment instruments; participatory design, monitoring and evaluation; citizen scorecard usage, transparent service tracking, and service standard protocols to develop a "whole of society" approach that reflects climate action priorities voiced by local stakeholders. The Right to Information Act (2009), parliamentary audits and accounts committees, an active court system, and strong nongovernment organization (NGO) advocacy provide the foundation for Bangladesh to create a sound climate change accountability framework. This framework can be strengthened by introducing a climate change portal, allowing participatory reviews of climate projects and budgets, as well as by establishing a devolved climate finance mechanism for CSO funding.

[45] The formulation of the National Adaptation Programme of Action is being led by the Department of Environment, under MoEFCC, and financed by the Green Climate Fund.

[46] The GoB also may transform the MCPP into a green growth strategy to coordinate investments. In the Republic of Korea, the coordination of Green Deal priorities, investments, and implementation is provided by the high-level Presidential Committee on Green Growth, which comprises of representatives from the private sector/NGOs and national and local government. This is considered a key factor in the success of the Korean Green Deal.

[47] Tk 3.3 billion were allocated across 728 projects from the Bangladesh Climate Change Trust Fund between 2009 and 2021 to implement climate-related projects through respective ministries and divisions.

2.2. Public Financial Management and Financial Sector Capacities

Current public financing for climate adaptation and mitigation falls far short of projected funding needs. Bangladesh's public capital expenditure was estimated at 5.1 percent of GDP in FY21. GoB climate plans call for additional public and private financing of at least 3.3 percent of GDP by 2025 (2021 unconditional NDC and BDP2100). Scaling up public financing will require substantial improvements in revenue collection and public investment management, including rigorous cost-benefit analysis of proposed investments. The GoB currently spends US$1 billion per annum (0.2 percent of GDP) on climate change adaptation. Even without introducing new financing instruments to generate public revenue (e.g., carbon taxes), the public sector can take several actions immediately to improve financing to climate adaptation, not only through public finance management but also by enabling actions for private sector financing. For example, user fees and cost recovery through appropriate tariffs would fund urban investment, services, and maintenance (e.g. water sanitation and integrated waste management), replacing the current system of highly regressive subsidies. This reform would create a more conducive environment for public sector financing to expand services.

Bangladesh spends approximately US$25 billion on public procurement annually—about 37 percent of its annual budget—and can integrate climate goals into public procurement practices. Public procurers should leverage their purchasing power by promoting green procurement through the purchase of energy-efficient, low-carbon-emitting climate/disaster resilient goods, works, and services. The Central Procurement Technical Unit and Implementation Monitoring and Evaluation Division under the Ministry of Planning are in the process of preparing a Sustainable Procurement Policy Note and an implementation road-map to provide strategic direction to integrate sustainable procurement into legal, regulatory, and institutional frameworks.[48] This will enable environmental and socioeconomic considerations with regard to public procurement by promoting green and inclusive practices (e.g., supporting participation of small- and medium-size enterprises and women-led businesses in government procurement). Capacity development for users of the public procurement system to apply sustainable practices will further facilitate progressive implementation.

Given limited fiscal space, the BCFF, as discussed earlier, can enable private investment to address climate change through the judicious use of regulations, taxes and subsidies, financial sector policies, and pricing policies. The BCFF provides a starting point for such policies, such as eliminating fossil fuel subsidies, introducing a carbon tax, implementing the "polluter pays" principle, and applying proper pricing policies for all state-owned entities (SOE), especially public utilities (Box 2). Financial sector policies should mobilize climate financing from the banking sector, domestic and international capital markets, and carbon markets. Establishing well-structured PPPs can help crowd in private capital and increase efficiency in sectors critical for the climate agenda including urban infrastructure, transport, energy, waste, and water. The Bangladesh Water Multi-Stakeholder Partnership[49] has initiated various PPP projects, such as the Gazipur City Corporation Municipal Wastewater Management Project; Narayanganj City Corporation Municipal Wastewater Management Project; and Common Effluent Treatment Plants at the Bangabandhu Sheikh Mujib Shilpa Nagar Economic Zone and the Jamalpur and Srihotto Economic Zones.

Improving the management of land and development rights could provide additional financing options. More efficient land use would require strengthening systems to accurately record land and property, resolve disputes, assess land value. This would support equitable land allocation, improved planning and management, and low property registration costs. Measures to revise restrictive building codes,

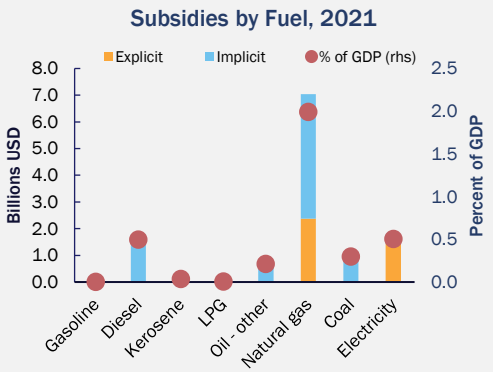
[48] Digitizing Implementation Monitoring and Public Procurement Project.

[49] 2030 Water Resources Group. 2022. "2030 WRG: Collective Action on Water Security for People, Environment, and Economy." Database. Washington, DC: Hosted by the World Bank. (Link)

incentivize timely utilization of land, and curb land speculation could also contribute to efficient and equitable land use.

Box 2: Fossil Fuel Subsidies in Bangladesh

Bangladesh maintains substantial subsidies on fossil fuel use, which create disincentives for decarbonization. These subsidies may be explicit—when retail prices are below a fuel's supply cost—or implicit—when the external costs of fuel use, such as impacts on climate change, are not captured in the selling price. Explicit subsidies vary based on the difference between fixed retail and wholesale prices and import prices. Bangladesh also maintains sizable implicit subsidies on coal, diesel, and other oil consumption. In total, natural gas subsidies amount to an estimated 2.0 percent of gross domestic product (GDP), diesel subsidies to 0.5 percent of GDP, and electricity subsidies to 0.5 percent of GDP.[1] Given the surge in international commodity prices at the time of publication, these subsidies have likely increased.



Subsidized diesel prices perpetuate inefficient diesel-based irrigation systems and motorized transport. These subsidies are regressive and inefficient and could be repurposed and directed to the poor through targeted social protection programs or incentivized transfers.[2] An analysis of the removal of energy subsidies suggests that more efficient resource allocation contributes to GDP growth, with additional growth benefits if a cash transfer program is introduced to support poor households. Subsidy elimination would increase government revenues and contribute to income distribution while helping to reduce the harmful externalities associated with the use of fossil fuels, such as mortality and morbidity associated with PM2.5 air pollution and CO_2 emissions.[3]

[1] IMF (International Monetary Fund). 2022. "Climate Change: Fossil Fuel Subsidies." Washington, DC: IMF (Link)

[2] Arze del Granado, J., D. Coady, and R. Gillingham. 2010. "The Unequal Benefits of Fuel Subsidies: A Review of Evidence for Developing Countries." Working Paper WP/10/202. Washington, DC: Fiscal Affairs Department. International Monetary Fund. (Link)

[3] World Bank. (Forthcoming). "A Computable General Equilibrium Analysis of Green Policies in Bangladesh." Washington, DC: World Bank.

Carbon finance could also provide additional revenue for climate projects. For example, the size of the Clean Development Mechanism market under the Kyoto Protocol was US$33 billion at its peak. Under the Paris Agreement, a new market framework is emerging, offering significant potential for countries to cooperate through compliance and to achieve their NDCs. Voluntary carbon markets are gaining momentum and will become an important source of financing for green private investment. Bangladeshi companies are able to access voluntary carbon markets, as they are open to participants regardless of their geographical location.

Bangladesh nevertheless lags behind other emerging markets and developing economies in green finance due to structural weaknesses in its banking system (Box 3). Scaling up financing will require addressing these persistent structural weaknesses. This includes measures to address growing

financial sector vulnerabilities,[50] including adequate recognition of non-performing loans (NPLs) and the associated capital adequacy of banks. Assessing and mitigating these risks would set appropriate incentives to develop green finance and insurance markets. Bangladesh Bank (BB) joined the Sustainable Banking and Finance Network in 2012 and set the minimum annual target of green finance at 5 percent of total loan disbursement for all financial institutions in 2016. According to the 2021 network assessment, Bangladesh's sustainable finance framework has reached an advanced implementation stage**.** In practice, however, green banking remains limited and green finance products amounted to only 1.6 percent of annual loan disbursement in FY20, compared to an average of 7 percent in emerging markets. The pipeline of green projects is lean, and financial institutions have difficulty identifying green assets and projects due to a lack of clear standards and labels. Banks also rely on short-term deposits for funding, a situation that does not position them well to finance climate projects, most of which are long term. Even if banks were to meet the green finance target, this would amount to financing of US$600 million per annum[51]—a small dent in the financing gap.

Box 3: Managing Climate Risks in the Financial Sector

The regulatory framework for climate risk management in the financial sector is nascent. In 2017, BB introduced its *Guidelines on Environmental & Social Risk Management (ESRM) for Banks and Financial Institutions in Bangladesh* to integrate assessment and mitigation of environmental risk into credit management. Enforcement, however, is weak and climate change considerations are practically absent. BB will need to undertake a comprehensive risk assessment of the impact of environmental and climate change risks on the financial sector (including climate stress testing) and develop risk mitigation plans for specific institutions and the financial system overall. Stronger disclosure requirements and assessment capabilities are needed to manage climate risk. Regulators need to integrate climate considerations in guidelines, develop further guidelines for stress testing regulated financial intermediaries, introduce stress-testing tools for banks, and institute reporting guidelines for listed firms and financial intermediaries on climate risk, in line with the recommendations of the Financial Stability Board's Task Force.

In addition to the impacts of climate change on the financial system through losses from natural disasters, financial institutions are exposed to transitional risks as the global economy moves toward more sustainable and carbon-neutral modes of production. In the short term, this mainly relates to bank exposure to the country's industrial and manufacturing sectors, including the ready-made garments sector, which heavily contributes to the country's poor environmental conditions. Industrial loans represent around 40 percent of bank loan books. Banks have additional exposure to these sectors through trade finance (~30 percent of total loans). As a result of growing domestic and international pressure to reduce pollution, industrial borrowers may face tighter regulations, forcing them to use cleaner production methods and/or shut down production. This will expose banks to stranded assets. Banks also face legal and reputational risks when financing these activities, and there are potential medium-term risks of stranded assets for financial institutions involved in financing highly carbon-intensive industries, including the fossil-based power generation sector.

Capital market instruments for promoting green finance are even less developed than banking products, with total bond issuances at 5 percent of GDP in 2019.[52] Bangladesh currently lags behind India and other emerging markets in developing long-term green finance instruments, with the country's first two corporate green bonds issued in 2022 and no firm plans for sovereign green bonds. Discretionary approval processes for external commercial borrowing limit foreign borrowing and restrict the ability to attract capital from international institutional investors. Local governments could potentially finance infrastructure by issuing climate bonds but are limited by capacity constraints and

[50] In line with the Basel III international regulatory framework for banks. Non-performing loan classification with IFRS 9, including a 90-days past-due rule for definition of default.

[51] In the past five years, net credit to the private sector from banks has averaged around US$12 billion per annum.

[52] Compared to around 23 percent of GDP in Indonesia.

weak creditworthiness. Efforts at private capital mobilization for BDP2100 are underway but need to be accelerated. These efforts include a statutory regulatory order for a green bond to accelerate private capital investment for water quality improvement initiatives and plastic pollution mitigation.

Addressing market and institutional barriers can increase financial sector capacity to support sustainable projects. Priority actions include: (i) setting appropriate macro-prudential incentives (reflecting environmental risks in capital and provisioning requirements); (ii) mandatory certification of environmentally friendly assets in line with best international practices; (iii) knowledge and capacity strengthening of banks to originate and monitor green loans; and (iv) increasing the availability of long-term financing for the climate agenda through green finance instruments (e.g., domestic and international sovereign green bonds, private placements of green bonds by banks, and corporates supported by national regulations aligned with international standards). These measures would diversify liquidity sources, support capital market development, and support lending to longer-term projects. Equally important are policies that will improve the commercial viability of climate-smart projects to increase demand for sustainable finance. The business case for climate-smart investments and demand for green finance is suppressed when externalities are not reflected in prices. Enhancing and enforcing environmental and climate change risk assessment policies would help address this gap. Fiscal measures, such as phasing out fossil fuel subsidies, will help shift capital from brown to green projects by changing risk-return profiles.

2.3. Financing Locally Led Climate Action

Bangladesh has a rich history of locally led climate action and grassroot efforts for adaptation. More than 90 million Bangladeshis (56 percent of the population) are estimated to live in "high climate exposure areas," with 52 million subject to "very high" exposure.[53] With weak local governance systems and poor urban management, climate-driven migration and poverty are likely to drive or amplify underlying social tension, fragility, and conflict.[54] Climate change risks are concentrated in regions which also have higher concentrations of poor and vulnerable groups, including subsistence farmers, microenterprises, landless communities, fishing communities, and the urban poor. Key policies situate locally led action and partnerships with communities and civil society as a central pillar to addressing climate impacts. For example, the draft MCPP envisions a network of locally led action hubs by 2030. Programs and projects are envisioned to support local communities in strengthening adaptive capacity; managing social and climate risks; strengthening transformative adaptation; investing in local and climate resilient livelihoods; integrating climate resilience into local building practices and green energy; and strengthening community-based responses to disasters and extreme weather events. Under the Bangladesh Climate Change Resilience Fund, around US$12.5 million was allocated to NGOs through the Community Climate Change Project to implement community-driven adaptation to climate change. In the project, locally led solutions to climate risk and climate change were prioritized by building on indigenous knowledge and identifying community needs, such as resilient infrastructure, livelihood support, water supply, and homestead raising.[55]

Locally led climate action programs can deliver models of devolved climate finance at scale, leading to cheaper and more effective outcomes, by reducing moral hazard, building on local knowledge, and strengthening accountability. Devolved climate finance and partnerships with local governments and NGO/CSOs can further accelerate locally led climate action. Bangladesh has a multitude of effective localized investments that have strengthened community and household resilience to climate change and which support community adaptation efforts. These efforts, however, have remained largely

[53] USAID (United States Agency for International Aid). 2018. *Fragility and Climate Risks in Bangladesh*. Washington, DC: USAID. (Link)

[54] Hasan, M. and G. MacDonald. 2021. "How Climate Change Deepens Bangladesh's Fragility." *United States Institute of Peace*, September 13. Washington, DC. (Link)

[55] The project was implemented by the Palli Karma-Sahayak Foundation. (Link)

fragmented, with limited opportunity for learning, innovation, and scaling for greater impact. Local governments could play a greater role in partnership with NGOs and community groups to develop locally led solutions for climate action, by integrating participatory climate risk planning and financing into local development planning and delivering on local solutions in local partnerships for climate action. Devolved climate finance can help increase direct funding opportunities for CSOs. Strengthened partnerships with local governments can ensure the catalytic role of such funds by ensuring local planning and financing focus on complementary investments to strengthen resilience.

Complementary investments in institutional coordination, data management, and capacity support can further support transparency and oversight. Global examples of financing locally led climate action demonstrate significant adaptation benefits for individuals, households, and communities, with stronger LGIs and improved responsiveness to local needs.[56] Devolved financing models for adaptation can build on the improved capacity of local governments. Over the past two decades, Bangladesh has implemented reforms to strengthen the capacity of local governments to deliver local services, improve community participation and oversight, institute reliable untied block and performance grants, and develop management information systems. This has resulted in improved performance of local governments in planning and budgeting.[57] Local action can be further supported by introducing devolved climate financing to support investments identified through inclusive and participatory planning processes and by expanding women's engagement in the decision-making process.

Locally led climate action models also offer an opportunity to crowd in financing, including for micro, small-, and medium-size enterprises (MSME). The forthcoming Bangladesh National Adaption Plan recognizes that cottage/MSMEs are disproportionately impacted by climate variability and extreme events (e.g., prolonged floods and waterlogging, heat-stress, devastating cyclones, tidal surges, and salinity intrusion), and identifies the need to support MSMEs as important sources of livelihoods for vulnerable communities, especially women, youth, and ethnic groups.[58] Strengthening community awareness and adaptive capacity, with improved engagement of citizens; locally endorsed plans for resilient investments; and transparent monitoring systems provide a strong foundation for leveraging additional financing. This could be supported by the private and public sectors (especially for "no regrets" climate-resilient investments) as well as international development and climate funds.

Bangladesh's plans to address climate vulnerability would support development, enhance resilience and contribute to decarbonization. However, implementing these plans will require overcoming significant institutional, financing and capacity constraints. Prioritization of investments, institutional realignment to increase planning and implementation efficiency, and a whole-of-economy approach to build on Bangladesh's experience and expertise (e.g., locally led adaption) are needed to deliver effective climate action. Coordinated and realistic costing and budgeting of core climate programs can contribute to establishing priorities and identifying critical timelines to avoid lock-ins to high carbon development pathways. Subsequent sections identify such priorities in key sectors.

[56] World Bank. 2022. "Financing Locally Led Climate Action Program." Kenya. Database. Washington, DC: World Bank. (Link)

[57] World Bank. 2022. "Bangladesh Local Governance Support Project II." Database. Washington, DC: World Bank. (Link); and World Bank. 2022. "Local Governance Support Project – 3." Database. Washington, DC: World Bank. (Link)

[58] GoB (Government of Bangladesh). (Forthcoming). *Draft Bangladesh National Action Plan*. Dhaka: GoB.

3. Key Pathways for Climate Resilience

Investing in adaptation is a priority in the GoB's climate change strategy. The BDP2100 and draft MCPP provide a framework to strengthen climate resilience and sustain growth. If properly implemented, the BDP2100—as a multisector, long-term investment plan—will contribute to poverty reduction, job creation, and sustained growth by promoting sustainable management of water, the environment, and land resources. A review of the key areas of vulnerability in Bangladesh indicates that integrated land and water investments in coastal, river, and urban areas should be prioritized under the BDP2100 and the MCPP. Improved and sustainable agriculture and water resource management can have net social benefits from increased productivity and positive environmental effects, with a larger share of income accruing to poor households, especially in rural areas.[59]

3.1. BDP2100 Implementation and Coastal Resilience

Efficient implementation of the BDP2100 requires a high level of institutional coordination and financing, as well as enabling laws, policies, and regulations. Mechanisms of coordination for investments need to be established, such as the setup of the Delta Wing, Delta units in sectoral ministries, and the Project/Programme Selection Committee[60] (PPSC). Moreover, the enactment of a Delta Act[61] would provide the legal basis to establish mechanisms to govern and fund the BDP2100. Necessary actions include investment prioritization; stable budget allocations; adequate monitoring, evaluation and accountability; and cross-sectoral coordination across the Ministry of Water Resources, Ministry of Local Government, Rural Development and Co-operatives, and related sector departments.

Higher budget allocations, efficient budget execution, and more diverse funding sources are needed to close a significant financing gap. The BDP2100 investment plan through 2030 is estimated to cost US$38 billion. The FY22 ADP has allocated 1.13 percent of GDP to BDP2100 projects. Even if the entire budget of the Ministry of Water Resources was allocated to BDP projects, there would be a shortfall of US$6.6 billion in the 8th FYP. An increased budget allocation, improved budget execution, and additional private financing are required to close this financing gap. Water user fees could improve cost recovery in selected water sector services, based on the "beneficiary pays "principle. Fast-changing climate and socioeconomic conditions also imply that the GoB should regularly reassess investment needs, while avoiding delays that may increase costs and vulnerabilities (Table 4 and Box 4). The majority of the highest priority projects are included in the 8th Five-Year Plan (8th FYP) but only two have been budgeted. Climate change outcomes and and economic conditions could also affect the urgency of investments. Increased climate investments become urgent under RCP8.5 compared to RCP4.5. Investment in areas with high and significantly high levels of climate vulnerability rise from approximately US$6.4 billion under RCP4.5 to US$11.8 billion under RCP8.5. The highest number of priority projects under RCP4.5 or RCP8.5 are in the coastal zones, followed by the Barind and drought-prone areas, rivers, and estuaries; Chattogram Hill Tracts and Haor areas; and cross-cutting and urban areas. The first three projects across RCP4.5 and RCP8.5 are priorities regardless of the climate pathway. The *Jamuna Riverbank Improvement Program* is the highest priority - included in the 8th FYP but as yet without budget allocation. The *Protection of Rivers System around Dhaka City* project is in in

[59] World Bank. (Forthcoming). *A CGE Analysis of Green Policies in Bangladesh*. Washington, DC: World Bank.

[60] The PPSC is outlined in the BDP2100 to facilitate project/program selection for inclusion. It could be established with members, with the General Economics Division (Ministry of Planning's Planning Commission) in the chair, and comprising of representatives of finance, planning, water, environment and forestry, agriculture, land, livestock and fisheries, and shipping. Despite being a part of the BDP2100 document, the PPSC has yet to be established.

[61] In the recent Delta Council meeting of May 2022, the GoB—through its Prime Minister—stated that adaptation to climate change and the implementation of BDP2100 over time should not be dominated nor hampered by short-term incidents (e.g., political change, financial scarcity/cutbacks, and other priorities, among others). The Delta Act is expected to provide a solid legal arrangement of (i) Delta Governance (i.e., the aims, items, and frequent updating of BDP2100), Delta Governance Council, PPSC, Delta Wing, multisectoral coordination, delta decisions, and potentially the water user institutions; (ii) funding of BDP2100 (i.e., an annual 2.5 percent of GDP block provision Delta Fund); and (iii) monitoring and reporting; among others.

a highly climate vulnerable area (under RCP8.5) but is not included in the 8th FYP. The *Development of Chandana-Barasia River Basin System* is also not budgeted.

Box 4: Prioritizing Bangladesh Delta Plan 2100 Investments

The Bangladesh Delta Plan 2100 (BDP100) investment for 2030 identifies 65 physical investment projects and 15 institutional and knowledge-based study projects to be initiated prior to 2030. These projects were selected based on adaptive delta management principles.[1] Due to financing and capacity constraints and low project readiness, prioritization is necessary. To illustrate this, BDP2100 projects were ranked using multicriteria analysis, considering socioeconomic impact and climate vulnerability under climate change scenarios (RCP4.5 and RCP8.5).[2] The climate vulnerability of each project was computed using a risk-level matrix[3] and adaptation capacity of project areas (Table B1).

Table B1: Climate Vulnerability Distribution of the 20 High-Priority Projects

Climate Vulnerability	RCP 4.5	RCP 8.5
	Number of High-Priority Projects[4]	
(0) Negligible	0	0
(1) Mild	0	0
(2) Moderate	8	3
(3) Significant	3	0
(4) High	8	9
(5) Significantly High	1	8

Source: Ahydtech. 2022. "Delta Plan Project Climate Prioritization and Financing Plan." Internal Report for the World Bank. Unpublished.
Note: RCP = Representative Concentration Pathway.

[1] Adaptive Delta Management (ADM) represents a paradigm shift in planning and managing water-related interventions by (i) embodying a structured, iterative decision-making process for water-based development interventions to reduce uncertainty over time, thus minimizing the likelihood of over- or under-investment in the water-related challenges; and (ii) considering the links between demand in space and time.

[2] The multicriteria analysis considers: A. Investment Projects: (i)) water and disaster risk management; (ii) environment and ecosystem; (iii) agriculture and food; (v) project impact; (vi) risks; (vii) economic viability; and (viii) climate vulnerability. B. Study Projects.

[3] Using the Bangladesh Delta Plan 2100 Interactive Atlas risk maps.

[4] High priority defined as the 20 top ranked projects in multicriteria analysis scores.

Table 4: Investment Project Prioritization Summary

Hotspot	Total Projects		High-Priority Projects[1]			
	In BDP2100 Investment Plan 2030	In Budget Documents	RCP4.5	RCP8.5	RCP4.5 or RCP8.5 in Budget Documents[2]	
					8th Five-Year Plan	Budget (ADP)
Major rivers	5	4	3	3	2	0
Drought prone	6	4	3	2	3	0
Urban	11	6	1	1	0	0
Coastal zones	15	12	8	9	8	1
Haor and Wetlands	4	3	2	2	2	0
Cross-cutting	11	6	1	1	1	1
Hill Tracts	4	2	2	2	2	0

Source: Ahydtech. 2022. "Delta Plan Project Climate Prioritization and Financing Plan." Internal Report for the World Bank. Unpublished.
1 High priority is defined as the top 20 projects according to the multicriteria analysis scores, assessed in two climate scenarios (RCP4.5 and RCP8.5).
2 Budget documents refer to: 8th Five-Year Plan/Annual Development Plan 2021-22.
Notes: RCP = Representative Concentration Pathway; BDP2100 = Bangladesh Delta Plan 2100; RCP = representative concentration pathway; ADP = Annual Development Programme/Plan.

The budget execution and implementation capacity of line ministries responsible for BDP2100 projects requires significant improvement. Implementing the BDP2100 effectively could result in GDP rising 20–25 percent by 2050, based on BAU scenario where growth decelerates to 6.8 percent by

2031 and 5.6 percent by 2041. Deviations between the original budget and actual expenditure in the water and sanitation sector were as high as 60 percent in 2018. As budget allocations increase under the BDP2100, implementation capacity and public investment management needs to be strengthened, including project identification, cost-benefit analysis, portfolio management, operations, and asset monitoring. Inadequate project preparedness is impairing timely and efficient implementation. For example, only 16 of the 48 projects in the 8th FYP have development project proposals in place and/or feasibility studies that are ongoing or have been completed. The institutional capacity to prepare bankable projects is relatively low.

The BDP2100 and the multicriteria assessment demonstrate that building coastal resilience can mitigate climate risks. The dynamic nature of the Delta requires constant adaptation to evolving conditions. Since Bangladesh's independence, approximately US$10 billion has been invested in disaster risk management and preparedness. A recent study documents how Bangladesh strengthened coastal resilience by instituting policies and legal frameworks; improving systems, institutions, and hydrometeorological and forecasting capacities (including community-based early warning systems); and by investing in critical infrastructure (e.g., cyclone shelters, coastal embankments, water management infrastructure) in parallel with afforestation initiatives.[62] However, the operation and maintenance of infrastructure, resettlement and land acquisition, and erosion are continuing challenges. River migration rates of 50— 500 meters (m) have been observed within the tidal channels over the last 30 years, threatening the stability of embankments and impacting people and their livelihoods. River migration has a range of causes, including insufficient drainage, lack of adequate maintenance of water infrastructure, and reduced river flow from upstream. Waterlogging can cause long-lasting disruption (e.g., social, physical, and environmental) and can result in income loss and social unrest.

Restoring forests in coastal areas is essential for Bangladesh's coastal stability. Mangroves are a natural barrier to coastal hazards, estimated to protect 1.1 million to 3.5 million people from coastal flooding during cyclones while avoiding an average of US$1.56 billion in annual damages.[63] For example, villages protected by mangroves had only about half the monetary loss associated with cyclone Sidr compared to other villages.[64] Even a 100 m deep coastal shelterbelt can reduce storm surge velocity by up to 92 percent and protect embankments. A double shelterbelt of mangrove and *casuarina* trees (200–300 m in depth) can reduce storm surge height by up to 22 percent and velocity by up to 49 percent.[65] Mangroves may sequester carbon four times faster than mature land-based forests, offsetting 1.5 percent of Bangladesh's fossil fuel carbon emissions in 2014 or 10 percent from 1997.[66]

3.2. Climate-Smart and Planned Urban Development

While rapid urbanization supported economic growth and structural transformation in Bangladesh, it has been accompanied by environmental deterioration and increased climate vulnerability. Climate change impacts will be acutely felt in major cities and towns, which are expected to continue growing as a result of internal migration. Urban areas will need to adapt to emerging climate challenges, including lethal heating and heat island impacts; urban flooding; and a 27 centimeter sea level rise in coastal cities where close to 8.6 million people live. Table 5 summarizes these risks and key adaptation measures. Adaptation deficits under moderate and severe climate scenarios need to be embedded in

[62] Kazi, S. et al. (2022). *Bangladesh Enhancing Coastal Resilience in a Changing Climate.*

[63] Menéndez et al. 2020. "The Global Flood Protection Benefits of Mangroves." *Sci Rep* 10, 4404. (Link)

[64] Akber, Md. Ali et al. 2018. "Storm Protection Service of the Sundarbans Mangrove Forest, Bangladesh." *Natural Hazards* 94: 405–418. (Link)

[65] Dasgupta, S. et al. 2019. "Quantifying the Protective Capacity of Mangroves from Storm Surges in Coastal Bangladesh." *PLoS One* 14(3), e0214079. (Link); and Das, S.C. et al. 2010. "Effects of Coastal Vegetation Species and Ground Slope on Storm Surge Disaster Mitigation," in Proceedings of the Coastal Engineering Conference. (Link)

[66] The global average for oceanic mangroves is estimated at 400 tC/ha, suggesting that mangroves in Bangladesh may be relatively degraded. See Chow, J. 2018. "Mangrove Management for Climate Change Adaptation and Sustainable Development in Coastal Zones." *Journal of Sustainable Forestry* 37(2): 139–156. (Link)

urban planning, including in land use, drainage, and wastewater management, with four overarching interventions for adaptation: improved urban governance and coordination, an increased supply of resilient and affordable housing, more resilient urban-rural connectivity, and investment in nature-based solutions (NBS).

Table 5: Key Climate Impacts in Urban Areas of Bangladesh and Adaptation Strategies

Key Climate Impacts in Cities and Towns	Adaptation Strategies
Lethal heating: Will lead to severe loss of workability and livability, especially in large cities such as Dhaka.	• Cooling plan and measures • Inclusive heat warning systems • Adaptable safety net for migrants and the poor • Reduction of urban heat islands through nature-based solutions, such as green spaces, street trees, among others
Urban flooding: Increasing rainfall precipitation, coupled with vulnerable-built environment will lead to high flood impacts, primarily in large cities such as Dhaka and Chattogram. Regular urban flooding in smaller cities may increase internal migrations to larger cities.	• Inclusive flood warning and emergency preparedness • Integrated urban watershed ad flood risk management • Improved solid waste management, drainage, and sanitation • Nature-based solutions such as floodable parks and wetland management • Retrofit and planning of flood-resilient infrastructure and buildings • Risk-sensitive land use planning and zoning • Flood risk insurance
Sea level rise: In all coastal towns and cities,[1] sea level rise, storm surge, and increasing salinity will affect all aspects of life and economic activities.	• Inclusive storm warning systems and emergency preparedness • Improved drainage, coastal defenses, and salinity barriers • Retrofit and planning of sea level rise-resilient infrastructure and buildings • Risk-sensitive land use planning and zoning • Risk insurance
Climate migration: Internal migration will be a pressing issue in places like Dhaka and Chattogram, where urban services and infrastructure are already overwhelmed.	• Expansion of urban public services in large cities and other climate refuge cities • Support for urban poor through inclusive and adaptable safety nets, including skills development in only the transition context (including ready-made garment industry shifts) • Participatory planning processes with demand-side accountability

Source: Compiled by World Bank staff.

[1] The country's low-lying coastal zone (consisting of 19 districts with an estimated population of 38.1 million, of which 8.6 million is urban), is highly vulnerable to cyclones, storm surge, sea level rise, and salinity intrusion. A 1.5 °C increase in temperature and 4 percent increase in precipitation would potentially result in sea levels in the Bay of Bengal rising by 27 centimeters or more by 2050.

Adaptation planning will need to consider how climate change will impact Bangladesh's future spatial development and growth pattern. Dhaka and Chattogram need support to increase the resilience of infrastructure and services to manage the stress of ongoing internal climate migration. Urban concentration in Dhaka and Chattogram is expected to ease over the medium term, as secondary cities with economic potential and suitable labor markets develop.

Adaptation measures can support urban centers as they deliver critical social and economic functions that protect urban residents from climate impacts. Current forms of urbanization have resulted in inadequate services, environmental degradation and congestion, contributing to lost productivity and increased urban poverty. Urban floods cause property damage, impact transport, and result in the overflow of drains and septic tanks contaminated with untreated wastewater, spreading pathogens and pollutants that increase the risk of disease outbreak.[67] Adaptation measures can help address these challenges by providing inclusive early warning and response systems and scalable social safety nets. Resilience can be strengthened through improved risk management for land use and measures to reduce climate risks in schools, hospitals, and affordable housing.

[67] World Bank. 2021. *Climate Risk Country Profile: Bangladesh*. Washington, DC: World Bank (p.29). (Link)

Improving Urban Governance and Coordination

Conflicting institutional mandates hamper adaptation to urban flooding, heat, and rising sea levels. Urban LGIs have a broad legal mandate to intervene across sectors.[68] However, this mandate overlaps with the responsibilities of deconcentrated line departments, central government agencies, and utilities, resulting in poor accountability. For example, the Bangladesh Water Development Board, city corporations (CC), city development authorities, and water supply and sewerage authorities are all involved in urban flood management services in large metropolitan cities. Separate governance structures exist for *paurashavas* (municipalities), where *paurashava* councils oversee the work of local government engineering departments (LGED) and departments of public health and engineering. Responsibilities of the *upazila parishads* and *union parishads* overlap in key urban management functions, such as planning, budget preparation, and revenue collection, while urban LGIs (including CCs and *paurashavas*) are located within the *upazila* boundaries. All of these administrative units prepare five-year, annual development, and budget plans. *Upazila parishads* oversee the *union parishads*' development programs and budgets and are tasked with preparing plans and budgets for interunion development programs that have no jurisdiction over the urban LGIs. Furthermore, the relevant acts provide no coordination mechanism between the planning and budgetary processes. For urban and rural LGIs to deliver more efficient services, a mechanism to facilitate accountability and joint planning and monitoring is needed (Box 5).

Improving institutional coordination can help address urban adaptation challenges. Interventions should be differentiated between large CCs and other secondary cities. In major CCs, there is a need to better integrate and harmonize the planning and enforcement functions of service mandates, including flooding/drainage, wastewater, and solid waste management (SWM) across the CCs, utilities, and development authorities. Mandating institutional coordination will require the promulgation of an appropriate institutional and regulatory framework from the central ministry to enable CCs and *paurashavas* to support the adoption of broader integrated urban water management while delineating the roles and responsibilities of city agencies responsible for urban planning and WSS services. This distinction is justified since separate governance structures exist for CCs and *paurashavas*. Agencies, such as the City Development Authority, Bangladesh Water Development Board, water supply and sewerage authorities, and CCs, are active in the large metropolitan cities, whereas the *paurashava* council oversees central government departments that include departments of public health and engineering and LGED at the *paurashava* level for water supply, drainage, and wastewater services.

Box 5: Building City and Town Capacity for Climate Resilience in Bangladesh

The Bangladesh Local Government COVID-19 Response and Recovery Project is a US$300 million operation funded by the International Development Association. The project aims to strengthen urban local government institutions (LGI) to better respond to the COVID-19 pandemic and improve preparedness for future climate change impacts and disasters. It will provide bi-annual COVID-19 response grants to LGIs to effectively identify, plan, and implement COVID-19 response and recovery activities following the Build Back Better strategy. The financing can also be used by urban LGIs to undertake climate resilience and flood mitigation work, improve building energy efficiency and urban cooling, with accompanying technical and advisory support.

Building climate resilience also requires skills, technology, and information management capacity in CCs and municipalities. With a clearer mandate, local governments could leverage private investment for the delivery of urban services. For example, there is an estimated investment potential of US$13 billion to expand sewage treatment coverage to 64 percent by 2030. Cost-reflective tariffs and improved land allocation policies will help. As noted in Section 2, an alternative way to generate funding

[68] The UP Act (2009), Local Government (*paurashava*) Act (2009), and Local Government (CC) Act (2009).

for investment in urban services (e.g., water sanitation and integrated waste management services) is to collect user fees and rationalize the tariffs to their costs. Water subsidies are highly regressive, with the top income decile bracket receiving over 30 percent of total benefits.[69]

Embedding preparedness for internal climate migration into urban development planning can support adaptation. Bangladesh has witnessed rapid migration to urban centers, driven in part by impacts of extreme weather events and climate change. Climate change impacts on water availability, crop productivity, and sea level rise will exacerbate migration toward urban centers, especially Dhaka and Chattogram, but smaller cities also can serve as migrant-friendly and climate-resilient centers (Box 6). Planning investment in infrastructure and services and livelihoods, with opportunities for skills and job training with linkages to the local industry, can potentially offer development dividends.

Box 6: Transformative Adaptation in the City of Mongla

Between 2011 and 2021, the city of Mongla made several infrastructure investments to improve climate resilience, including raised embankments, flood control, improved drainage, and water supply systems, resulting in flood reduction. The city's proximity to its seaport and export processing zone made it economically attractive and Mongla's population is estimated to have tripled, from 40,000 to approximately 150,000 inhabitants, fueled in part by new climate migrants from the coastal areas and the Sundarbans. Following recommendations of the International Centre for Climate Change and Development, the city implemented measures to integrate migrants through social and cultural interventions and schools and now offers several lessons relating to investments in resilience, integrated delivery of services, and livelihood opportunities for climate migrants.[1]

[1] Khan, M. R. et al. 2021. "High-Density Population and Displacement in Bangladesh." Science 372 (6548): 1290–1293.

Increasing the Supply of Resilient and Affordable Housing

An increased supply of affordable housing is needed to address current deficits, as well as to house an influx of climate migrants. Bangladesh needs to add or retrofit around 10.5 million urban housing units up to 2030, or 1.1 million units per annum; this includes 6.7 million new housing units and 3.8 million retrofitted units.[70] High-density, green, and climate-resilient buildings are expected to be the primary area of growth. The International Finance Corporation estimates a US$120 billion green building market by 2030, including a US$100 billion residential sector. The unmet housing deficit of around 0.5 million units per annum is likely due to the lack of progress in the affordable housing segment. Climate-related migration from rural to urban areas will increase demand. Overcoming these challenges requires addressing supply- and demand-side constraints as well as strong cooperation between the public and private sectors. On the supply side, formal housing costs can be reduced by improving city planning, building regulations, and access to land; basic infrastructure such as water supply, SWM, and urban transport; strengthening the local construction and building material sectors, especially within the low-cost segment; and strengthening housing market data capabilities (i.e., pricing, supply/demand, exposure to climate risks). If the right construction choices are not made at this time, high-energy urban infrastructure may be locked in for decades. Defining a green building policy and guidelines, certifications and reporting requirements, and incentivizing builders and developers to construct green affordable and resilient housing units is essential. On the demand side, the top priorities are to develop mortgage and housing microfinance markets for low-income households; and provide efficient and well-targeted subsidies for the 47 percent of the urban population currently living in informal housing. Climate change and disaster risk profiles of informal housing can help define

[69] Andres et al. 2019. *Doing More with Less: Smarter Subsidies for Water Supply and Sanitation*. Washington, DC: Water Global Practice, World Bank. (Link)

[70] Assumptions are the urban population will increase from 65 million in 2020 to 85 million in 2030 (United Nations population projections); the average size of a household is for four people; 47 percent of the urban population currently lives in informal housing and at least 50 percent need to be gradually relocated to formal housing, while informal housing units will require a retrofit; and 57 percent of the projected housing demand will be in the affordable segment (IFC (International Finance Corporation). 2020. *Understanding the Housing Market in Bangladesh: Market Study*. Washington, DC: IFC)

technical assistance for housing subsidies. Other measures include upgrading informal settlements to reduce basic service deficits; simplifying property formalization processes; identifying affordable and green retrofitting solutions; and introducing financial instruments, such as microfinance for home improvement loans to low-income households.[71]

A secure supply of disaster-resilient housing can have substantial climate mitigation cobenefits by reducing energy costs. By establishing and enforcing energy efficiency standards and certification (e.g., Building Energy and Environmental Rating System,[72] housing could be made more efficient at a low cost with proper insulation, smart meters, integrated solar, water recycling, and low-carbon materials. An upfront investment of 2 percent in green building design can result in life-cycle savings of 20 percent of total construction cost.[73] Subsidies and regulations also can be designed to shift the supply of new housing away from high-carbon energy sources toward rooftop solar. Integrated land use planning, zoning laws, and other related policies will effectively move development and people out of harm's way (e.g., flood zone) and protect natural systems and open space that provide resilience benefits (Box 7).

Box 7: Climate Sensitive and Inclusive Land Use Planning

Rapid, unplanned expansion has made urban areas highly susceptible to the impacts of climate change. This vulnerability is intensified by development in hazardous areas, densification of settlements, concentration of industries, business, and economic assets, and convergence of connectivity networks, **Integrated land use planning** can support sustainable development with zoning, site plan reviews, and resilient design guidelines (e.g., nature-based solutions).[1] Improved planning capacity and coordination among agencies, with updates to laws and regulations, along with oversight, upgrading technical planning skills for professionals and stronger implementation capacities with data sharing partnerships will enable this transformation. **Participatory landscape and land use planning** protects indigenous, customary, and communal lands from potential land grabbing and can assist communities assert their right to use, own, and manage land. Inclusive and gender-responsive benefit sharing approaches can be scaled up. Social forestry programs and community-led approaches can safeguard landless and land-poor people.[2] Participatory landscape planning should involve local and regional authorities and align community-led activities with spatial and land use planing.[3] Such approaches are of growing importance where there is planned conversion of *khas* land to industrial use e.g., for renewable energy (solar and wind) infrastructure. Integrated approaches can safeguard land access and user rights and co-management approaches can support internal migrants coping with riverbank erosion.

[1] MAPC (Metropolitan Area Planning Council) and MVP (Municipal Vulnerability Preparedness). 2020. "Climate Resilient Landuse: A Primer for Local Governments." Climate Resilient Land Use Workshop Series (Fall 2020). MAPC and MVP. (Link)

[2] Rahman, M. M. et al. 2015. "High Carbon Stocks in Roadside Plantations under Participatory Management in Bangladesh." *Global Ecology and Conservation* (3): 412–423. (Link); GoB. Bangladesh Department of Environment. 2015. *Community Based Ecosystem Conservation and Adaptation in Ecologically Critical Areas of Bangladesh: Responding to Nature and Changing Climate*. Dhaka: Department of Environment, Ministry of Environment and Forests, Government of Bangladesh. (Link); Ferdous, Z. et al. 2016. "Development of Home Garden Model for Year Round Production and Consumption for Improving Resource-Poor Household Food Security in Bangladesh." *NJAS: Wageningen Journal of Life Sciences* 78(1): 103–110. (Link)

[3] In Indonesia and Kenya, integration of locally produced community maps into formal district-level spatial planning procedures have shown benefits such as safeguarding community use rights.

Enhancing the Resilience of Urban-Rural Connectivity

A multimodal resilient rural transport system can support spatial integration and help alleviate stress on large cities. Approximately 62 percent of rural households rely on the rural road transport network and around 25 percent depend on inland water transport. A total of 353,332 km of rural roads and 24,000 km of waterways are highly impacted by flooding, resulting in a 15–40 percent increase in

[71] IFC (International Finance Corporation). 2021. *Creating Markets in Bangladesh: Unleashing the Private Sector to Sustain Development Success. Country Private Sector Diagnostic.* Washington, DC: World Bank Group. (Link)

[72] The Bangladesh Sustainable and Renewable Energy Development Authority (SREDA) has developed a Building Energy and Environment Rating System for green buildings to incentivize the construction sector and material suppliers to become greener by applying more sustainable building practices.

[73] IFC (International Finance Corporation). 2017. *Climate Investment Opportunities in South Asia: An IFC Analysis*. Washington, DC: IFC. (Link)

travel and trade costs. By 2050, an additional 7 percent of roads will be exposed to additional flooding in comparison with 2013. Within the 7 percent, 48 percent represent rural roads, 45 percent feeder roads, and the rest regional or national roads. An estimated 87 percent of these roads will be inundated by up to 0.5 meter and more than 2 percent by over a meter. During each flood, the cost of freight trucks tends to increase by as much as 138 percent in the West, and 142 percent in the East within the BAU scenario. By 2050, more than 600 km of railway track (approximately 20 percent of the current network) are likely to be inundated by up to 0.5 meter. To address this, an estimated USD 2,671 million of climate resilient investment in the land transport infrastructure is essential by 2050.[74] Strategic planning and spatial vulnerability analyses at the network level must identify the most critical and exposed transport assets, and address resilience and redundancy by shifting development away from vulnerable zones and upgrading the network to higher climate-resilient standards. Revised design and construction practices for new construction should incorporate resilient engineering standards that include landscape approaches and water management as well as the use of innovative materials, especially for the unpaved roads at higher risk of damage and the low-volume roads. The adoption of a climate-smart asset management approach for managing the rural road and waterway network (Box 8) is necessary with funding for the maintenance of the most vulnerable assets. Finally, strengthening institutional coordination mechanisms and protocols for emergency repairs during and in the immediate aftermath of climatic events is needed.

Box 8: Asset Management Strategy of the Local Government Engineering Department

In August 2021, the Government of Bangladesh approved the revised road construction and maintenance standards for the Local Government Engineering Department (LGED), taking into consideration climate resilience. In 2021, the LGED approved its first Climate-Smart Asset Management Strategy which prioritizes LGED rural road asset maintenance over new construction. LGED can strengthen this strategy in relation to climate adaptation and resilience. Approval of the new Climate-Smart Asset Management Strategy would enable LGED to optimize the use of constrained resources for the sustainable management of valuable assets (rural road network).

Investing in Nature-Based Solutions

NBS are actions aimed to protect, manage, or restore natural and modified ecosystems in ways that address social challenges[75] and can be effective for urban climate adaptation. Solutions such as green roofs and walls, parks, and street trees can bring down temperatures in urban heat islands; and sustainable drainage systems with wetlands and floodable parks can reduce the risks of urban flooding. NBS offers "no-regret" options, with a relatively low risk of unintended consequences. Although NBS alone will not be sufficient for all adaptation needs, it may be necessary and more cost effective to use a combination of NBS and engineered solutions in many cases. Sectoral development and climate change policymaking appear to prioritize engineered approaches, such as concrete dams and embankments.[76] Most sectoral development policies, with the exception of certain coastal resilience interventions, largely ignore the potential for ecosystem-based approaches—perhaps due to an institutional bias toward hard engineering adaptation options and a lack of awareness of the potential of NBS among policymakers and other stakeholders. NBS can contribute to climate resilience by strengthening and expanding the coverage of submersible embankment systems to protect against wave erosion; creating a sustainable sediment management mechanism to enhance river and wetland

[74] Dasgupta, S. et al. 2010. *Climate Proofing Infrastructure in Bangladesh: The Incremental Cost of Limiting Future Inland Monsoon Flood Damage.* Policy Research Working Paper. Washington, DC: World Bank. (Link)

[75] Cohen-Shacham, E. et al. 2019. "Core Principles for Successfully Implementing and Upscaling Nature-Based Solutions." *Environmental Science and Policy* 98: 20–29. (Link)

[76] Huq, N. et al. 2017. "Mainstreaming Ecosystem Services Based Climate Change Adaptation (EbA) in Bangladesh: Status, Challenges and Opportunities." *Sustainability* 9(6): 926. (Link); and Smith, A. C. et al. 2021. "Nature-based Solutions in Bangladesh: Evidence of Effectiveness for Addressing Climate Change and Other Sustainable Development Goals." *Front. Environ. Sci.* 9:737659. (Link)

systems; afforestation to reduce storm surge impact; ecosystem-based adaptation (e.g., green belts in coastal areas and riversides, protecting and restoring forests to reduce the impact of floods and landslides, building embankments to ensure protection from wave erosion); and harvesting rainwater to reduce water stress (including options such as rooftop tanks).

3.3. Resilient Agriculture: Climate-Smart, Diversified Crop Production

While the agricultural share of GDP is declining, it remains a powerful driver of inclusive growth and poverty reduction. Between 2000 and 2010, agriculture growth contributed 69 percent of rural poverty reduction. While sector growth slowed in the decade that followed, agriculture's contribution to poverty reduction was still 27 percent.[77] Primary agriculture continues to dominate the rural economy in terms of employment, supporting 54 percent of rural employment and 43 percent of national employment.[78] The fisheries sector also provides more than 12 million people with at least 58 percent of their average per capita protein intake. This makes climate change impact on people, livelihood, and nutrition a critical issue. Furthermore, agriculture-growth-led impact on poverty is significant and when growth slows, so do poverty reduction, employment, and food and nutrition security, the latter a key objective of government policies in the sector. For growth and productivity in this sector to be sustainable, it must be adaptive and resilient to climatic change and other shocks. Agriculture is severely threatened by the impacts of climate change on soil and water salinity, water stress, and temperature, as described in Section 1, as well as by unsustainable and inefficient use of inputs. Unsustainable water use, arsenic contamination, and climate-induced changes in precipitation put pressure on groundwater recharge and surface water, affecting irrigation water supply. Yields for crops are projected to decline by 2050, -5.3, 5.5, and 6.4 percent for rice, vegetables and wheat, respectively, compared to a no-climate-change scenario.[79] Fertilizer use has steadily increased over the past three decades, driven by government programs which focus on rice production. The high use of synthetic fertilizers and pesticides acidifies the soil, worsens water quality, and depresses crop yields[80] (Section 1.1) and constitutes 7 percent of agricultural GHG emissions (Section 4).

Diversifying agricultural production would increase resilience to climate change and promote growth while continuing to contribute to poverty reduction. Agricultural policies focused on self-sufficiency in rice production supported the impressive growth cited above. However, these policies have come at a high economic and ecological cost, including elevated GHG emissions from irrigated rice production (Section 4). With urbanization and income growth, dietary patterns are changing and the demand for nutrient-dense foods is growing, creating substantial domestic market opportunities for agricultural diversification. Given its centrality to food security in Bangladesh, there is considerable scope to render rice cultivation more productive and less emissive.

Realizing the growth potential of the agriculture, livestock, and fisheries sector hinges upon increased commercialization and large-scale adoption of climate-smart agriculture (CSA) practices.[81] Significantly higher profit margins in subsectors, such as fruits and vegetables,[82] can provide higher opportunities for women's economic empowerment. Diversified production systems and the adoption

[77] Hill, R. and M. E. Genoni. 2019. *Bangladesh Poverty Assessment: Facing Old and New Frontiers in Poverty Reduction.* Washington, DC: World Bank. (Link)

[78] Hill, R. and M. E. Genoni. 2019; and GoB (Government of Bangladesh). 2017. *Quarterly Labor Force Survey* 2015-16. Dhaka: Bangladesh Bureau of Statistics, GoB. (Link)

[79] CIAT and World Bank. 2017. "Climate-Smart Agriculture in Bangladesh." CSA Country Profiles for Asia Series. Rome: International Center for Tropical Agriculture and Washington, DC: World Bank. (Link) The study uses the IMPACT model to represent climate impacts under assumptions of an SSP2 and RCP4.5, and then to compares them to a BAU scenario.

[80] World Bank. 2019. *Bangladesh Climate-Smart Agriculture Investment Plan: Investment Opportunities in the Agriculture Sector's Transition to a Climate Resilient Growth Path*. Washington, DC: World Bank. (Link)

[81] Adoption of CSA is low. Most observed CSA practices are applied on less than 30 percent of cultivated area. (CIAT and World Bank. 2017. "Climate-Smart Agriculture in Bangladesh." CSA Country Profiles for Asia Series. Rome: International Center for Tropical Agriculture and Washington, DC: World Bank. (Link))

[82] Farmer gross margins per hectare are higher for other crops if inputs (seed, adequate fertilizer, labor) and services (market access, technical knowledge) are available. Mango cultivation could yield a gross margin of US$1,410/ha, gourd US$628/ha; and maize as livestock feed US$412/ha. These are higher returns compared to US$71/ha, US$114, and US$126 US$/ha for *boro*, *aman*, and *aus* rice, respectively. Ahmed, M., J. Saint-Geours, and C. Gitau. 2021. *Promoting Agrifood Sector Transformation in Bangladesh: Policy and Investment Priorities*. International Development in Focus. Washington, DC: World Bank. (Link)

of CSA practices can reduce input use and emissions. Farmers are constantly adapting to challenging climatic conditions, and there is potential to scale up successful practices such as the use of salinity-tolerant, submergence-resistant, short-duration, and/or high yielding varieties for rice cultivation; adaptive cropping patterns and intercropping; innovative local practices such as floating-bed cultivation on water bodies; improved irrigation efficiency and water storage, and revision of water policies. Several resilience-building practices have notable mitigation cobenefits, including fertilizer management practices that promote soil health and reduce GHG emissions; alternate wetting and drying (AWD) in rice; or solar-powered irrigation (Section 4). Scaling these requires addressing constraints such as farm fragmentation, access to finance, and underdeveloped agro-logistics. With an average farm size of less than 0.6 ha and short-term leasing agreements, farmers do not make long term investments in new production technologies and practices,[83] even though it could help increase productivity and profit margins. Around 80 percent of farmers in inland fisheries are unbanked, microfinance is expensive, and agro-insurance is limited.[84] Diversification to other crops is limited by a lack of robust supply chains and limited access to inputs such as quality seeds and to postharvest and storage facilities. Salinity- and water-tolerant rice varieties are available, but seed production is insufficient to meet demand due to inadequate infrastructure (e.g., seed propagation laboratory) and marketing inefficiencies. Box 9 outlines interventions needed to relieve these constraints and increase CSA. The PARTNER[85] performance for results operation under preparation aims to address policy and investment constraints to promote diversification, marketing, and overall food system transformation, aligned with a broad-based policy dialogue on an agriculture transformation program.[86]

A combination of these interventions can help diversify agriculture and promote CSA technologies, with impacts relating to adaptation and mitigation. The Bangladesh Climate-Smart Agriculture Investment Plan (CSAIP)[87] identifies five investment packages at a cost of US$809 million to support pathways to climate resilient, low-carbon growth. This includes among others, strengthening diversification and agricultural innovation systems; and improving rice productivity, fisheries, or livestock upstream investments which, along the agro-food value chain and climate information services, will support famers to monitor and adjust to temperature and conditions made erratic from climate change.[88] Scaling up such approaches can deliver a triple win of higher agricultural productivity, increased resilience to climate change, and lower GHG emissions. The CSAIP's investment packages include, among others, support for diversification in the Northwest, with an investment of US$196 million in institutional and policy strengthening and productive investments in CSA and value chains. This could support 5 million beneficiaries[89] with the doubling of non-rice crop production and an increase in profits by 67 percent. Decreased cultivation of *boro* rice and increased adoption of solar irrigation, buried pipe irrigation, and AWD technologies are expected to reduce water use (projected to decrease by 10 million liters) and GHG emissions (projected to decrease by 8 $MtCO_2e$ per annum by 2040) compared to a BAU scenario. Decreased fuel costs used for irrigation could see profits from rice cultivation rise sixfold. Agricultural innovation systems and collaboration between producer groups and the private sector can accelerate research, development, and dissemination of CSA and new varietals,

[83] The inland fishery subsector faces similar challenges. By increasing the length of land and pond leases, producer organizations and cooperatives, as well as contract farming models, could help address the challenges stemming from land fragmentation.

[84] IFC (International Finance Corporation). 2021. "Ripe for Investment." IFC Insights. Washington, DC: IFC. (Link)

[85] Program on Agricultural and Rural Transformation for Nutrition, Employment and Resilience in Bangladesh (PARTNER).

[86] A joint GoB-development partner effort is ongoing to identify the contours and investments under a proposed Agriculture Transformation Program, aimed at supporting UMIC transition with continued productivity improvements in the sector.

[87] World Bank. 2019. *Bangladesh Climate-Smart Agriculture Investment Plan: Investment Opportunities in the Agriculture Sector's Transition to a Climate Resilient Growth Path*. Washington, DC: World Bank. (Link)

[88] Hossain, R.P. et al. 2021. "Developing Climate Information Services for Aquaculture in Bangladesh: A Decision Framework for Managing Temperature and Rainfall Variability-Induced Risks." *Frontiers in Sustainable Food Systems.* June. (Link)

[89] Investment costs of about US$100 (PPP 2017 US$) per beneficiary, composed of 5 percent project management/planning/ capacity building and policy/regulatory framework; 50 percent for supporting productive investments, including agro-industry and infrastructure; 25 percent for marketing, value chains, and access to finance; and 10 percent for strengthening research and extension services. World Bank. 2019. *Bangladesh Climate-Smart Agriculture Investment Plan: Investment Opportunities in the Agriculture Sector's Transition to a Climate Resilient Growth Path*. Washington, DC: World Bank. (Link)

supported with an investment of US$117 million, benefitting 60 million beneficiaries.[90] Introduction of water-efficient irrigation technologies in the Barind Tract through a drip irrigation system for high-density mango plantations and AWD for rice paddy cultivation also have the potential to attract private capital.

Box 9: Interventions to Diversify Crops and Scale up Climate-Smart Agriculture

Enable private sector participation to increase adoption of CSA technologies and practices:

- Develop interprofessional bodies for public-private dialogue within a value chain—as well as the generation of financial resources to foster economic development.
- Strengthen innovative research-extension linkages and coordination between the government and private sector and improved dissemination of CSA technologies and practices.
- Enhance research on high-quality seeds and share via digital platforms and e-extension services for soil testing, agro-weather information, and market intelligence.
- Build capacity of banks for agro-finance and agro-insurance to finance CSA and risk mitigation.
- Support aggregation models (e.g., producer groups, productive partnerships, contract farming) to facilitate CSA and access to finance, transport, warehousing, and distribution networks.
- Expand market infrastructure and logistic services, clean and efficient cooling solutions with community and private sector partnerships (market hubs, warehouses, cool chains).
- Reconcile CSA practices, which aim for productivity increase, resilience and climate mitigation with Global Good Agricultural Practices (GAP) commodity protocols being developed. Adopt standards for production practices inside agro-processing facilities.

Regulatory and institutional policy changes:

- Repurpose agricultural support policies for green, resilient, and diversified production systems; reform the fertilizer policy to incentivize shifts cropping systems and improve soil health.
- Remove regulatory barriers for production of quality seed; coordination between seed producers, importers, and distributors; market transparency and demand for improved genetic materials
- Formalize land rental markets with longer rental tenures to incentivize long-term investment and support contract framing models, warehouse receipt financing, and digital platforms.
- Remove barriers to the production or import of CSA technologies (e.g., disparate customs duties).

Support women farmers in the uptake of CSA:

- Enable women farmers to access and use climate-adaptive technologies, access capacity building, extension outreach, and agro-finance support for their specific needs; and transition to paid agricultural work and own enterprise development.
- Ensure women can benefit from economic diversification across a wide range of sectors and skill levels (e.g., adaptation approaches that respond to climate change risks on crops and access to green jobs; access to STEM training and education).

Sources: Ahmed, M., J. Saint-Geours, and C. Gitau. 2021. Promoting Agrifood Sector Transformation in Bangladesh: Policy and Investment Priorities. International Development in Focus. Washington, DC: World Bank. (Link); IFC (International Finance Corporation). 2021. Country Private Sector Diagnostic—Creating Markets in Bangladesh: Unleashing the Private Sector to Sustain Development Success. Washington DC: World Bank Group. (Link); and World Bank. 2019. Bangladesh Climate-Smart Agriculture Investment Plan: Investment Opportunities in the Agriculture Sector's Transition to a Climate Resilient Growth Path. Washington, DC: World Bank. (Link)

Enabling women to adopt new agricultural practices will provide additional benefits across all these strategies. Most agriculture workers in Bangladesh today are female—76 percent of women in rural areas are engaged in agricultural work compared to only 44 percent of men.[91] However, women are disproportionately impacted by climate disasters and have unequal control of resources. For example, 65 percent of men aged 15+ own an account at a financial institution or through a mobile money

[90] Fifty-five percent for extension and research; 40 percent for institutions, planning, and capacity building; and 5 percent for project management and planning. World Bank. 2019. *Bangladesh Climate-Smart Agriculture Investment Plan: Investment Opportunities in the Agriculture Sector's Transition to a Climate Resilient Growth Path*. Washington, DC: World Bank. (Link)

[91] Farole T. et al. 2017. *Jobs Diagnostic Bangladesh*. Main Report. Job Series Issue 9. Washington, DC: World Bank. (Link)

provider, compared to 36 percent of women.[92] Enabling access to climate adaptive technologies can have a significant impact on women's economic empowerment, which supports rural households more generally. Access to these technologies can be enabled by adapting crop diversification tools, capacity building, and agricultural finance to meet women's specific needs, and by supporting transitions to paid agricultural work and own-enterprise development.

3.4. Post-Disaster Resilience: Risk Management and Preparedness

Strengthening Shock Responsive Social Protection

Climate shocks have a disproportionate impact on the poor, particularly women. With more frequent disasters, social protection systems must respond quickly to prevent irreversible losses. Faced with climate shocks, the poor can revert to coping strategies that jeopardize human and productive capital and long-term wellbeing, with gender-significant impacts.[93] Costs incurred by rural households in adapting to climate impacts (e.g., for raising floors; protecting agricultural land, livestock, and household materials) amount to as much as 30 per cent of total household expenditure for female-headed households (whose numbers are rising as a result of male out-migration), compared to 15 per cent for male-headed households.[94] The Ministry of Disaster Management and Relief manages 4 of the 10 largest social assistance programs and administers nearly 12 percent of social protection expenditures. The National Plan for Disaster Management (2021–2025) establishes the strategic direction of setting "social protection policies and programs to address poverty and vulnerability and contribute to resilience." With 41 percent of the climate-relevant budget allocation in 2020–20, these programs can strengthen resilience with the following actions:

- **Integrating gender aspects into social welfare programs** to reduce potential for gender-based violence, trafficking, and other vulnerabilities, and ensure access to support services.

- **Transitioning in-kind-based social protection programs to cash-based programs.** Cash transfers provide shock-affected households the choice of options to mitigate the impacts of a shock. In 2021, the Ministry of Disaster Management and Relief approved the first multi-hazard cash-based adaptive social protection scheme, the Employment Generation Programme for the Poorest.

- **Leveraging existing digital payment infrastructure to transfer cash electronically in the event of a shock.** A national government-to-citizen (G2P) platform allows direct transfers from the Treasury to beneficiary accounts (Direct to Citizen transfer, D2C). Some national social assistance programs use mobile financial service agents to improve accessibility of cash-out points to beneficiaries.[95]

- **Streamlining disaster relief data to rapidly identify recipients of income support, before or after natural disasters.** The National Household Database, a social registry of demographic and socioeconomic data, will be a gateway for entry and eligibility assessment for social assistance programs and the pre-identification of vulnerable households. Disaster relief data and information management, however, is fragmented and subject to irregular updates, lack of common operational datasets, fundamental operational datasets, and inconsistent methods of data collection.

[92] World Bank. (Forthcoming). "Bangladesh: Country Gender Assessment." Washington, DC, World Bank; and ILO (International Labour Organization). 2015. *Gender Equality and Green Jobs.* Policy Brief. Geneva: ILO. (Link)

[93] Loss of arable land tends to affect women and vulnerable groups more so due to the fewer opportunities for mobility, migration, or rights to reclaimed land, or having to travel further to collect water.

[94] Eskander, S. et al. 2022. *Still Bearing the Burden: How Poor Rural Women in Bangladesh Are Paying the Most for Climate Risks*. Working Paper. London: International Institute for Environment and Development. (Link)

[95] Currently, 9 million beneficiaries of Department of Social Service allowance programs are paid through a combination of MFS and agent banking services. During the COVID-19 pandemic, the GoB transferred a one-time cash support to the most affected households, using three MFS providers as the last-mile delivery mechanism.

- **Identifying disaster risk financing sources rather than repurposing budgets to increase the speed at which assistance can be deployed.** No disaster risk financing mechanism covers the entire cycle of disaster management (i.e., preparedness, response, recovery, and mitigation). Although some shock response programs receive annual budget allocations, these are de facto repurposed and used for social protection programs in regular times. Budgetary allocations are ad hoc and not risk-informed, resulting in substantial reallocation, delays, and funding gaps post-disasters.

- **Increasing coordination with the Ministry of Social Welfare to improve efficiency across multiple social welfare programs.** Policy directives and interventions for emergency shock response are led by the National Disaster Management Council (NDMC), Inter-Ministerial Disaster Management Coordination Committee, and National Disaster Management Advisory Committee. The Standing Orders on Disasters 2019 elaborates the responsibilities of national and local disaster management committees. To improve efficiency, the Ministry of Social Welfare should be included in the NDMC and the National Disaster Response Coordination Group, responsible for coordinating emergency response, humanitarian assistance, and recovery activities at all levels of government.

Building Macro-financial Resilience to Natural Disasters

The government spends an estimated US$319 million per annum on average on post-disaster interventions. This represents only 1 percent of total government expenditure, based on available historical data. However, total expenditure is likely to be significantly higher, as spending is embedded in other ongoing operations and maintenance budgets. Annual post-disaster response costs are estimated at US$810 million. However, a 1 in 40-year flood (e.g., 1993 flood) case could result in a funding gap[96] greater than US$1.7 billion, while the cost of responding to disasters that have a 1 percent chance of occurring in any given year could exceed US$6.5 billion. The scale of potential costs indicates that better data is needed on historical disaster expenditures.[97]

Disaster resilience and financing has been substantially strengthened but more remains to be done. There is no comprehensive strategy or regulatory framework to meet the costs of natural disasters. Disaster response is financed through ex-post domestic sources of funding and, while there are many different reserve funds, these are largely multipurpose and fragmented. Catastrophe insurance provides little property insurance and no sovereign insurance arrangements. The insurance market neither offers sufficient and sustainable catastrophe risk cover nor access to reinsurance. Less than 1 percent of households have insurance, which results in high expectations of government assistance with recovery. Microfinance is well developed, although it offers limited help to affected households. Further strengthening of the insurance sector, particularly microinsurance regulations and risk analyses, can improve access and affordability of reinsurance as well as provide support to new insurance schemes. Development aid will play a critical role in this area, although it can be delayed and fragmented. A disaster risk financing strategy that follows a risk layering approach could reduce the financial cost of response following a severe disaster event by up to US$410 million while the current disaster risk financing strategy of the government could be made more cost effective through use of additional financial instruments such as contingent credit and/or sovereign insurance [98].

[96] The funding gap is the difference between the financing available and the amount of finance needed.
[97] World Bank.2021. Bangladesh : Crisis and Disaster Risk Financing Diagnostic. Washington, D.C. : World Bank Group.
[98] ibid

4. Key Pathways for Driving Development with Decarbonization

Bangladesh is a modest contributor to global GHG emissions, accounting for an estimated 0.4 percent of global emissions in 2018, although emissions rose from approximately 115 $MtCO_2e$ in 1990 to 221 $MtCO_2e$ in 2018, including changes from land use. GHG emissions are expected to reach 255 $MtCO_2e$ by 2022 and 276 $MtCO_2e$ by 2024. This increase over the past three decades has been led by the energy sector, consistent with an expanding industrial sector and increased access to electricity. While the GoB's primary focus is adaptation, it has made important global commitments to decarbonize its economy, especially in the power sector. This section offers recommendations for increasing energy efficiency; facilitating cross-border renewable energy trade; reforming transport policies for low carbon modes; reducing agricultural emissions; strengthening SWM; reducing deforestation; and expanding ecosystem restoration. Future analyses will need to account for the social impacts of such decarbonization actions and include a package of policy support to facilitate just transitions.

4.1. Improved Efficiency and Decarbonization in the Energy Sector

The power sector is dominated by fossil fuel-based generation. Nearly 70 percent of primary energy consumption in 2021 was derived from natural gas, and only 1.0 percent was derived from renewables. Impressive gains have been made over recent decades to expand energy access, as power generating capacity quadrupled from 4.5 gigawatts (GW) in 2009 to 21 GW in 2020. Electricity access is now nearly universal, a goal that the Perspective Plan of Bangladesh 2010–2021 set to reach by 2021. However, power outages remain common and economic losses from unreliable electricity to households and firms is estimated at US$3.3 billion (1.5 percent of GDP) annually. Bangladesh experiences over 400 storm-induced power outages on average each year.[99] A key priority is to make energy more efficient, affordable and reliable. Resilience enhancement measures that consider future climate conditions should be integrated into asset and system-level planning immediately.[100] Power sector emissions are forecast to grow from 20.98 $MtCO_2e$ in 2012 to 95.14 $MtCO_2e$ by 2030. In 2020, 70 percent of electricity generation was from gas-fired plants, 23 percent from highly polluting and expensive heavy-oil fuel plants, and 6 percent from coal. Although the government cancelled 8.4 GW in planned coal-fired generation in June 2021, seven large coal-fired power plants currently are committed and under construction and are expected to account for up to one-third of the country's energy mix by 2025. Development of renewables has been limited by relatively high costs and the limited availability of physical siting space. Some progress in developing RE capacity is underway. Approximately 770 megawatts (MW) of RE capacity is installed, reducing GHG emissions by 3 $MtCO_2e$, and RE projects of between 1,500 and 2,000 MW are currently in development, concentrated in solar photovoltaics (PV).

Short-term, cost-effective measures can be taken to improve energy efficiency, reduce the energy sector's carbon intensity and improve carbon competitiveness. CH4 and CO2 emissions in the upstream oil and gas sector (production, gathering, processing, refining, transportation, and distribution operations) contributes substantially to Bangladesh's GHG emissions. Most of the country's CO2 emissions stem from oil and gas production and use, which generated close to 84 percent of the country's total emissions (76.6 $MtCO_2e$) in 2020. CH_4 emissions for oil and gas operations were estimated at 408 kilotons in 2020, roughly equivalent to 11.5 $MtCO_2e$, accounting for approximately 70 percent of total energy sector CH_4 emissions. These emissions were predominately from venting (55 percent) and fugitive gases (45.5 percent). Abatement of CO2 and CH4 emissions along the oil and gas value chain is possible with upstream (supply) and downstream (demand) measures to improve

[99] Rentschler, J. et al. 2019. "Candle in the Wind? Energy System Resilience to Natural Shocks." Background Paper, Policy Research Working Paper 8897. Washington, DC: World Bank. (Link) Cyclone Sidr, in 2007, is estimated to have left 75 million people without electricity.

[100] Chattopadhyay, D. E. et al. 2016. "Building Climate Resilience into Power Systems Plans: Reflections on Potential Ways Forward for Bangladesh." *The Electricity Journal* 29(7): 32-41. (Link)

efficiency. Policy and regulatory development for decarbonizing the natural gas value chain hinges on the prioritization of decarbonization opportunities in the sector's upstream and midstream operations—as well as determination of the volume, intensity, and concentration of emissions and an assessment of energy efficiency gaps, power, heat, and combustion processes in operations, and emissions from venting and leakages of CH_4. Addressing emissions downstream needs good monitoring systems (e.g., supervisory control and data acquisition systems for the gas distribution network) and pricing strategies on the demand side. Until all gas consumption in the country is properly metered, it will be difficult to determine, much less control, how and where gas losses and leakages occur in the system. In 2020, Bangladesh adopted a program to begin this process at the residential level. Progress has been positive but needs to be accelerated, with at least 2 million meters needed over the next 2-3 years.

Reforming Power and Energy Sectors through Three Critical Actions

Cost Recovery and Energy Inefficiency

The lack of cost recovery and energy inefficiency are the main issues holding back investment and innovation in the energy value chain. Energy tariffs and gas prices need to adequately reflect cost to incentivize energy efficiency and invite investments in less carbon-intensive generation. Low tariffs are detrimental to utility financial performance and represent a disincentive for investment in more sustainable energy sources or efficiency. Plants with captive generators, with access to cheap gas, can produce their own electricity at less than Tk 2.5 per kilowatt hour (kWh), while industry pays Tk 7.5 per kWh for electricity from the grid. Suboptimal gas allocation practices magnify the problem, with allocation to inefficient public power plants and energy-intensive facilities, such as fertilizer plants. Costly and highly polluting oil-fired rental plants contribute around 8 percent to the electricity mix on energy basis at tariffs which are four to six times higher than domestic gas-based plants that use new technology. Bangladesh has integrated independent power plants (IPP) into its power sector and has registered success through transparent auctioning and competition; however, a fully competitive tendering process for traditional gas-fired or solar PV plants has not been observed in recent years. Implementing the Energy Efficiency and Conservation Master Plan will need improved institutional capacity to strengthen the regulatory framework, finance mechanisms, and to engage private sector service providers and vendors. Demand-side energy efficiency in various end-user segments, such as industry, buildings, and appliances, represent a significant and often low-cost opportunity.

Higher energy efficiency and effective metering can also improve access for the most vulnerable and excluded communities. Gas use in Bangladesh has never been metered for residential consumption. Residential consumers pay a monthly gas bill amounting to Tk 975 for each double burner, irrespective of the gas volume consumed. As a result, there is little incentive for efficient use of this resource, and potential over-billing of the most vulnerable groups. For industrial consumers who benefit from preferential rates, unauthorized connections leading from the meter add to pilferage at advantageous rates for other purposes. While the GoB recently increased gas tariffs, additional work is necessary to align incentives and monitoring capabilities to ensure more efficient use of the resource. Accelerating the rollout of gas meters for residential consumers, piloting smart meters for industrial consumers, and integrating better monitoring systems on the gas distribution network will help while direct cash transfers for lower-income deciles will help address affordability.

Expanding Renewable Energy Capacity and Regional Trade

Renewable energy (RE) potential is likely larger than some past estimates suggested. The investment plan in the World Bank's Scaling Up Renewable Energy Program estimates a total RE technical potential at 3.7 GW. The technical potential for rooftop PV in Dhaka alone, however, is around 7 GW,[101] and the draft SREDA National Solar Energy Road Map 2021–2044 estimates the total PV potential at 40 GW, comprised of 12 GW rooftop and 28 GW utility-scale PV. This potential could increase to 53 GW from

[101] ESMAP (Energy Sector Management Assistance Program). 2022. "Rooftop Solar PV Potential Tool." Database. Washington, DC: World Bank. (Link)

utility-scale solar PV.[102] Access to emerging RE technologies can add to RE use. For example, the Bhola-2 220 megawatt combined cycle power plant can operate on a dual-fuel basis of gas and high-speed diesel, although it is expected to operate primarily on gas[103]. The plant can use hydrogen blended fuel through a gas turbine that allows it to operate on a blended fuel with up to 60 percent of hydrogen concentration. This could result in lower CO2 emissions but will depend upon the availability of blended fuel. With a levelized tariff of approximately US$0.04 per kilowatt/hour, the plant is expected to function as a baseload source of power generation and provide stability to the power grid, thus supporting plans to curtail the expansion of new coal-based power generation for future baseload power needs.

Large-scale development of RE can be facilitated by addressing key constraints, such as access to land. SREDA is working to identify and implement pilots of colocation of solar PV with agriculture, and to assess the potential for floating solar PV. Globally, agrivoltaic pilots have shown positive results, sometimes also with increased crop yields. Options include floating solar, for example, on canals; use of marginal land areas (e.g., degraded lands, riverbanks, karst lands) with improved planning, zoning, land compacting, and flood control measures;[104] and a wholesale roll-out of RE, solar parks, and rooftop PV, incentivized by the GoB's rooftop PV net-metering policy, by the Bangladesh Economic Zones Authority.[105] Uptake of competitive RE auctions, ideally with pre-identified land, can generate projects with lower tariffs. Capacity building within government agencies to prepare tenders and evaluate, award, implement, and monitor IPPs and improvements in the regulatory framework for technical standards and codes, regulated tariff structure, IPPs, and a simplified approval process will facilitate.

The economics of domestic RE projects in the near to medium term are likely to remain less favorable than for RE imports. The indicative tariff for domestic solar projects under development is estimated at 7.5-8 cents per kWh compared to 6.0–6.5 cents per kWh for solar-based electricity imported from India.[106] Expanded access to clean power sources in India, Nepal, and Bhutan will support an increased share of green and least-cost energy in the energy mix; displacement of costlier and dirtier power generation; the phase-out of dilapidated and highly inefficient gas-based steam turbines;[107] and reduce demand on scarce land resources.[108] The region has transitioned from deep skepticism of cross border electricity trade to around 1,500 MW of high-voltage transmission connectivity between Bangladesh and India (1,160 MW) and Nepal and India (300 MW).[109] To unlock the potential for regional power trade, cross-border grid interconnection needs expansion and standardization for technically feasible, reliable, safe, and economical power exchange. The market is dominated by each country's public sector, with a few private developers from India, local (largely public sector) financiers, and international financial institutions. Bangladesh can seek convergence around cross-border transmission connectivity (with fair, open, nondiscriminatory, reciprocal access and congestion management); identify opportunities for sharing generation reserves and backup capacity; and for clear transmission and trade tariff regimes with standardized contractual framework documents for electricity trade.

Improving Transmission and Distribution

Transmission bottlenecks prevent lower-cost electricity, generated by less carbon intensive plants, from reaching the final consumer and could prevent the integration of the needed high volume of RE

[102] Shiraishi, K., R. Shirley, and D. Kammen. 2019. "Geospatial Multi-Criteria Analysis for Identifying High Priority Clean Energy Investment Opportunities: A Case Study on Land Use Conflict in Bangladesh." *Applied Energy* Vol. 235(C): 1457–1467. (Link). Land for PV is a fraction of agricultural land conversion. With a program that reserves maximum land for agriculture and human settlement, there could be more RE capacity than needed to support growth.

[103] The Shahbazpur gas field is not connected to the national gas grid. This gives the plant unlimited access.

[104] The World Bank has launched a study to assess factors to enable better access to land for renewable energy and will include a preliminary assessment of RE potential at five cancelled coal plant sites, and larger ca. 20,000-acre riverbanks and islands karst land area identified by the Power Division.

[105] A World Bank study estimates over 450 MW of RE potential for just a 1,400-acre part of the Bangladesh Economic Zones Authority's planned Bangabandhu Sheikh Mujib Shilpa Nagar (BSMSN) economic zone, indicating a very large potential for the total 30,000-acre BSMSN plan. Another World Bank estimate shows 1.6 GW of industrial rooftop PV potential in Dhaka area (and several GW of other rooftop PV technical potential).

[106] International Finance Corporation assessment, including additional transmission charges and losses.

[107] Repowering these plants to more efficient combined cycle gas turbines should also be considered.

[108] World Bank. 2020. *Toward a South Asian Regional Electricity Market: Assessment of Economic Benefits*. Washington, DC: World Bank.

[109] About 300 MW of Bangladesh's 1,160 MW imports are contracted from a private supplier in India.

generation. Transmission bottlenecks contribute to a low utilization of new generation capacity (43 percent in 2019). Capacity payments for largely idle power capacity in 2019 came to US$1.1 billion, roughly as much as the GoB spent on climate actions. While installed generation capacity has increased four times since 2009, transmission capacity has grown by only 40 percent, and more efficient high-voltage lines account for a significantly small share. For example, 400,000-volt lines account for only 20 percent of total additional capacity (less than 6 percent of total installed capacity). Private participation in transmission sector activities can support improvement of operational and financial performance in distribution.[110] Bangladesh is building part of the power grid system with private investment and has identified several grid lines for implementation on a PPP basis. The Ministry of Power, Energy and Mineral Resources drafted a private sector power transmission policy in July 2019, setting out modalities for implementing transmission projects with private participation, fiscal incentives, incentives for foreign investors, environmental requirements, and service charges. The policy should include a governing law aligned with international precedent; that is, an implementation modality to ensure fair risk sharing between the public and private sectors, bidding and land acquisition processes, and rights of way.[111] These provisions should be included before the policy is finalized.

4.2. Decarbonizing the Industrial Sector

Although the current level of emissions is low compared to other countries, Bangladesh has committed to address emissions across the energy, transport, industry, and agriculture sectors. Industrial sectors are projected as the largest contributor to GHG emissions, generating 30 percent of total emissions in a BAU scenario driven by energy consumption. The NDCs prioritize climate action to reduce industrial energy intensity by 20 percent, promote green industries, and facilitate carbon financing. World Bank analyses indicate that RMG and textile, steel, cement, and fertilizer production are the largest industrial consumers of energy, with significant potential to improve energy efficiencies.[112] The RMG and textiles sector, alone, accounts for around 10 percent of total energy consumption in the country. Other sectors can also contribute to energy efficiency, especially with better technologies becoming more accessible to Bangladesh (Box 10). Manufacturers of GHG-intensive (i.e., hard-to-abate) sectors such as Chemicals (including Plastics and Fertilizers), Construction Materials (Cement, Steel, Glass, Aluminum), and Light Manufacturing who are serious about 'Net-Zero' ambition (and climate performance linked KPIs will need to provide financing to meet these goals and may need help to identify decarbonization options, linked to climate financing and potential investments.

The RMG industry will need to rise to the challenges of competing without preferential trade access and under carbon border adjustment taxes, as well as shift toward more sustainable practices. Buyers are switching to more advanced suppliers who can deliver on sustainability.[113] Suppliers need R&D and innovation to drive product upgrading and diversification in technical materials and to focus on circularity, innovative fibers, and operational improvements. Transition to a climate-neutral industry requires integration of distributed RE and energy storage solutions. Industrial rooftop solar (RTS) may be a viable option for factories that can replace around half of the current consumption of fossil-based generation with solar. Voluntary carbon markets can help improve the viability of distributed energy solutions[114]. SREDA's Energy Efficiency and Conservation Master Plan estimates that energy efficiency solutions will be able to reduce energy consumption in the RMG and textile sector by around 30 percent and increase productivity by 10–15 percent. Solutions include switching to more efficient machinery,

[110] ESMAP (Energy Sector Management Assistance Program). 2015. *Private Sector Participation in Electricity Transmission and Distribution: Experiences from Brazil, Peru, the Philippines, and Turkey*. Working Paper, Knowledge Series 023/15. Washington, DC: World Bank. (Link)

[111] IFC (International Finance Corporation). 2020. *Creating Markets in Bangladesh: Unleashing the Private Sector to Sustain Development Success. Country Private Sector Diagnostic.* Washington, DC: IFC. (Link)

[112] Hossain, I., A. Sarkar, and S. Pargal. 2017. *Demand-Side Energy Efficiency Opportunities in Bangladesh*. Washington, DC: World Bank. (Link)

[113] Berg et al. 2022. "What's Next for Bangladesh's Garment Industry, after a Decade of Growth?" *McKinsey & Company*, March 25. (Link)

[114] Should factories switch to RTS to meet 50 percent of their electricity needs, around 500 MW peak of RTS capacity will be needed. Based on the current international price of carbon, the resulting emission reduction of up to 12 MtCO2e could generate carbon credits to cover around 4 percent of CAPEX. The commercial viability of combined distributed generation and storage in Bangladesh needs to be assessed.

automation, and better management of heat supply. Aside from a reliance on fossil-based sources for their electricity, factories spend two to six times more water than the global average for wet processing of fabric. There is no effective enforcement of industrial wastewater treatment. Anecdotal evidence suggests that although large RMG plants have wastewater treatment equipment installed, proper operational procedures often are not followed, to save on cost. Switching to circular production and distribution models also will contribute to increased efficiency and sustainability. Faster transformation could take place, with a greater awareness of potential resource and energy savings with resource-efficient and cleaner production technologies and processes; access to green technologies and required managerial practices through advisory services and technical support; and access to financial instruments for environmentally friendly and resilient industrial practices. FDI, economic zones and stronger regulatory enforcement of environmental standards can drive a structural shift away from low-margin basic products. Producers will need to increase R&D and innovation for product upgrading and diversification in technical materials, with a focus on resource efficiency, circularity, innovative fibers, and operational improvements. The RMG sector lags behind its Asian peers in terms of FDI.[115] Shared infrastructure in economic zones (e.g., central effluent treatment plants, industrial symbiosis, rooftop- and land-mounted RE installations, and testing labs) will contribute to making domestic industries more efficient and sustainable, together with adequate enforcement of environmental standards.

Box 10: Other Sectors to Promote Energy Efficiency

1. Modernizing the fertilizer industry has massive energy and emission savings potential. Of the 10 largest fertilizer plants, one is privately owned and operates at the international standard benchmark of 24,000 cubic feet of gas/ton of urea. The average of the public sector factories under the Bangladesh Chemical Industries Corporation is 45,000 cubic feet/ton of urea.[1] The Ghorashal-Polash Urea Fertilizer plant, with integrated carbon capture technology is under construction to replace two obsolete plants, each with expected higher efficiency. At a cost of US$1.5 billion, this will be the first "green" fertilizer factory in the country. Public-private partnerships or the import or production of green hydrogen for ammonia also could be explored and developed.

2. The cement industry can adopt emerging technologies; however, increasing energy efficiency requires a policy shift for energy pricing and removal of domestic market protection. Bangladesh imports almost all its raw materials, including the emission-intensive clinker,[2] and the industry is supported by a 21 percent tariff. Globally, cement companies are piloting technologies such as substitution of clinker with less emission-intensive material to reduce emissions; alternative energy sources and waste heat recovery systems to reduce electricity needs; and circularity by recycling construction and demolition waste.[3] Enabling policies such as phasing out energy subsidies; green codes and standards for the construction industry; solid waste management to encourage recycling, and reduced import tariffs will increase efficiency and stimulate competition and innovation.

3. The steel industry is energy intensive, protected by tariffs, and dependent on imported inputs. Steel products are subject to import tariffs of 15 percent or 25 percent, and subsidized energy prices and suboptimal gas allocation practices disincentivize investment in energy efficiency. The sector employs around 1 million people, with an output of US$3.5 billion in 2019[4] and is based on the melting and re-rolling scrap (which is 70–90 percent less energy and carbon intensive compared to the production of steel from iron ore). Energy savings of 10–25 percent can come from switching to more efficient equipment[5] and circular economy solutions could help decarbonize the industry.

[1] Hossain, I., A. Sarkar, and S. Pargal. 2017. *Demand-Side Energy Efficiency Opportunities in Bangladesh.* Washington, DC: World Bank. (Link)

[2] EBL Securities Ltd. 2020. *Bangladesh Cement Industry: Resilient; Better Days Await."* Dhaka: EBL Securities Ltd.

[3] Carbon capture, utilization, and storage currently has limited applicability in Bangladesh.

[4] IDLC Finance. 2020. "Steel and Re-Rolling Industry of Bangladesh: Strengthening Country's Infrastructural Development." *IDLC Monthly* Vol.16(11). Dhaka: IDLC Finance. (Link)

[5] Tetra Tech. 2014. *Bangladesh: Industrial Energy Efficiency Opportunities and Challenges—Final Report.* Technical Assistance Consultant Report undertaken for the Asian Development Bank, Manila. Virginia, United States: Tetra Tech.

[115] FDI-backed companies—from South Korea, Taiwan, Hong Kong, China, and elsewhere—account for around 70 percent of apparel exports in Vietnam which, in 2020, overtook Bangladesh as the second largest RMG exporter. Berg et al. 2022. "What's Next for Bangladesh's Garment Industry, after a Decade of Growth?" *McKinsey & Company*, March 25. (Link)

4.3. Increased efficiency and decarbonization in the Transport Sector

Interventions to decarbonize transport will help transition to higher efficiency while improving air quality, access to jobs and services. The transport sector is responsible for 15 percent of Bangladesh's total emissions, making it the second highest domestic source of energy-related emissions and among the fastest growing in the region. Emissions has increased by 9 percent annually since 1971, reaching 13.5 MtCO2e in 2022 and are expected to triple by 2050. Most of this growth will come from the freight sector, expected to grow by four to five times. A strategy to increase the share of rail and IW transport, with a more efficient trucking sector and fleet could result in reductions of up to 13 MtCO2e by 2050 (Box 11). Freight demand is expected to increase rapidly until 2050 under a BAU scenario and is dominated by road, which carries an estimated 89 percent of total freight. IW transport and railways account for 7 percent and 4 percent, respectively, while heavy commercial vehicles are 24 percent of total vehicle registrations and are responsible for 73 percent of freight activity and 59 percent of CO_2 emissions[116].

Box 11: Three Strategic Shifts Needed for Modal Shift from Road to Rail and Waterways

Correct policy distortions that favor roads. Value added tax rates are 4.5 percent for the transport of petroleum and 10 percent for other goods, except fruit and vegetables which are exempted. For transport via inland waterways (IW), value added tax is 15 percent. This taxation differential, along with diesel subsidies, favors road over IW and rail transport. Insurance markets reinforce this bias.

Create a commercially focused rail freight service. The railway sector budget allocation of US$4.4B from 2016 to 2020, is 23.5 percent of the transport budget. Rail is more competitive than trucking on long distances and for heavy cargo but it focuses on passenger services. Policy changes are needed for Bangladesh railways to deliver efficient freight services. Container services along the Dhaka–Chattogram rail corridor should be a priority, with policies supporting commercialization.

Build on the thriving and rich legacy of IWs. IWs support a significant share of bulk cargo and passenger traffic, much of it on the Dhaka–Chattogram corridor. However, only 12.3 percent of the rural population has access to transport through IWs. Only 3,800 kilometers (km) of the 24,000 km of rivers are functional in the dry season, a decrease from 5,200 km in 1991 due to erosion and sedimentation, leading to wider, shallower rivers and increased seasonal variability in water quantity. Investments in IW could be combined with electric sea transport to further reduce carbon emissions.

The transport sector is also the largest consumer of petroleum products, with a 63 percent share of the total. Fuel subsidies, especially for diesel, account for 0.5 percent of the GDP. There are no explicit diesel subsidies and implicit subsidies are estimated at US$1.8 billion, or 0.5 percent of GDP. As a result, pump price in Bangladesh is below that charged in India, Bhutan, and Nepal. A fuel price elasticity of demand of approximately 0.1 in the short run and 0.3 in the long run, or a 1 percent increase in fuel prices would result in a 3 percent decrease in vehicle per kilometer traveled in the long run. Removing price distortions may reduce inefficiencies in the trucking sector (e.g., empty hauling (35 percent of all trucks are empty hauls)), truck idling, and limited freight consolidation. A National Logistics Development policy is under preparation and several sub-sectoral strategies need to be formulated to reduce freight emissions, modernize the trucking fleet, expand carbon-efficient modes like rail and inland waterways (IW); and decarbonize passenger transport through multimodal public transport (including nonmotorized transport (NMT)). Transport planning, travel demand management to price negative externalities of vehicle use, and innovative technologies such as low-emission vehicles will help. Private sector financing in the transport logistics sector is a priority and SOEs in the sector could move to a landlord model rather than directly compete with private sector players.

[116] Deloitte and World Bank. 2022. *Supporting an Accelerated Pathway for A Development and Decarbonization Transition of the Transport Sector in Bangladesh*. Internal analysis (publishing pending).

A paradigm shift in urban mobility is needed to improve urban livability and productivity. While buses remain the majority passenger transport today (up to 77 percent), the modal share of public transport has been decreasing. Policies that increase the quality of public transport and foster walking and cycling are essential to stem an increase in private cars. The GoB is embarking on an ambitious mass transit program in Dhaka, with the first urban rail line (Line 6) expected to begin operation in 2022. These investments should be supplemented with expansion of NMT infrastructure (30 percent of trips are 5 km or less), modernizing public transport, and implementing travel demand management and Transit Oriented Development (TOD) policies to nudge travel toward sustainable alternatives that increase the efficiency and productivity of urban areas. New metropolitan-level governance mechanisms and investments that foster the use of sustainable modes (i.e., bus, rail, and NMT) which support the development of compact and efficient cities will result in emission reductions of 3.5 $MtCO_2e$ by 2050. The potential to supplement with electrification and low-carbon technologies will also shift the sector toward a low-carbon pathway. The MCPP aims to electrify at least 30 percent of the transportation fleet by 2030 and to mobilize US$5 billion in financing from international investors. While 2030 seems optimistic for large-scale electrification, an enabling ecosystem is possible by establishing a national nodal agency; preparing an EV policy that focuses on vehicles, batteries, and a charging ecosystem that includes grid management; and an implementation roadmap with budgetary commitments and targets.

4.4. Climate Smart Agriculture and Forests as Carbon Sinks

The CSAIP[117] identifies approaches (Section 3.3) to deliver a triple win of higher agricultural productivity, increased resilience, and lower GHG emissions via three vectors: improved livestock management, modifications in rice cultivation and reduced food loss, and waste through food system modernization.

GHG emissions in livestock can be reduced by improving emission intensity per product by increasing the product yield of each animal. Seventy percent of Bangladeshi farmers are engaged in livestock production, accounting for approximately 50 percent of agriculture emissions. Livestock production is essential for smallholder and landless farmer livelihoods; productivity, however, is low. Chronic shortages of feed and fodder and poor nutritive value of available feed have lowered the productive capacity and fertility of livestock, making cattle prone to disease. Heat waves, floods, and cyclones drive up mortality rates, further affecting productivity—and livelihoods. Veterinary services are insufficiently equipped to service a growing number of dairy farm operators. Investments needed include (i) improving feed supplies, whereby links between crop and livestock farmers can improve by aggregating producers, knowledge platforms, or marketplaces; (ii) business models for the uptake of clean and efficient cooling solutions such as solar panel–driven cooling units;[118] (iii) conversion of manure/animal waste into renewable energy; (iv) breeding productive, disease-resilient animals; (v) producer groups, dairy cooperatives, women producers, to overcome risks and facilitate CSA technology adoption, and (vi) training. The Bangladesh Livestock and Dairy Development Project will make investments to build on results that show such investments can generate improvements in greenhouse gas emission intensity between 16 percent (low productivity increase scenario) and 30 percent (high productivity increase scenario), corresponding to reductions of 2.47 MtCO2 and 5.39 MtCO2, respectively.

Modifications in rice production and irrigation practices can reduce water and energy consumption and lower emissions.[119] A conventional and continuously flooded system of rice production contributes to 33 percent of agricultural emissions.[120] Heavily dependent on pumping groundwater for irrigation,

[117] World Bank. 2019. *Bangladesh Climate-Smart Agriculture Investment Plan: Investment Opportunities in the Agriculture Sector's Transition to a Climate Resilient Growth Path.* Washington, DC: World Bank. (Link)

[118] Clean, cold chain infrastructures for the beef and dairy sectors are expensive. Business models can help farmers overcome large capital expenditure to adopt new technologies. In the meat and dairy supply chains for example, customers could pay for cooling on an "as-used basis" while a third party is responsible for the capital, infrastructure, maintenance costs, and selling a service (Energy Sector Management Assistance Program (ESMAP),"Clean and Energy Efficient Cooling for Livestock Supply Chains in Bangladesh" unpublished study for the Livestock and Dairy Development Project).

[119] World Bank. 2022. "Rural Electrification and Renewable Energy Development II (RERED II) Project." Database. Washington, DC: World Bank. (Link)

[120] In flooded rice fields, anaerobic decomposition of organic material produces CH_4.

the current rice production practice generates an estimated 7 $MtCO_2e$ per annum.[121] Of the 1.6 million irrigation pumps in use, 79 percent (1.3 million) are diesel operated and 21 percent (0.32 million) are electric, consuming more than 1.06 million tons of diesel and 1,400 MW of electrical power annually.[122] Diesel subsidies of US$0.3/liter incentivize inefficient groundwater use. Improved production and irrigation practices include groundwater use with incentives for adopting energy efficient irrigation and technologies such as AWD, which could reduce water consumption by 30 percent and emissions, on average, by 37 percent,[123] with lower variable cost compared to traditional, continuous flooding. AWD uptake is constrained by additional labor requirements (weeding) and availability of water to flood the field on demand. Area-based water pricing or subsidized electricity for pumping also does not incentivize the correct use of water.[124] Crop diversification with a shift to less water-intensive crops and a conjunctive use of surface and groundwater could improve productivity and reduce emissions. SREDA intends to install 25,000 solar irrigation pumps with the potential to lower operating costs and reduce GHG emissions by 2025 - these should be installed in locations where water scarcity is not an issue.[125]

Agriculture sector emissions also could be cut by reducing food loss and waste across the food system. An estimated 32 percent of all food production is lost or wasted each year, accounting for 13 percent of GHG emissions.[126] Better integration of supply chains, access to agriculture finance and insurance, and temperature-controlled logistics and cold storage can reduce waste. In milk marketing, solar panel–driven cooling units can store a few dozen gallons, just enough for a semi-commercial farmer to keep milk fresh for two to three days—thereby increasing financial viability for collectors—or to store at village milk collection centers. Enforcement of food safety standards and integration with transport and urban planning can reduce inefficiencies in urban food consumption and distribution.[127]

Additional reductions can be achieved through afforestation and reforestation (Table 6). Emissions from forest lands (due to degradation) stand at 1.17 $MtCO_2e$ per annum, while sequestration is 0.81 MCO_2e per annum, resulting in total positive emissions of 0.37 $MtCO_2e$ per annum. The GoB has committed to increase tree cover from 22.37 percent (2014) to 24 percent by 2025, a relatively low target, while the NDCs[128] aim to reforest 450,000 ha of degraded forest land. If implemented, this will flip the forestry sector from emitter to sink, with 5 million tons of additional carbon sequestration. Of the 90,000 ha of newly accreted tidal mudflats in the estuaries and in coastal Bangladesh, 35,000–40,000 ha could be planted with mangroves, potentially sequestrating 30 $MtCO_2e$ in the next 25 years and providing other ecosystem services. [129,130] The Forest Department plans to develop 44,000 ha of

[121] Islam, M. R., P. C. Sarker and S. K. Ghosh. 2017. "Prospect and Advancement of Solar Irrigation in Bangladesh: A Review." *Renewable and Sustainable Energy Reviews* Vol. 77: 406–422. (Link)

[122] BADC (Bangladesh Agricultural Development Corporation). 2019. *Minor Irrigation Survey Report 2017–18*. Dhaka: BADC. (Link)

[123] Field experiments demonstrate that AWD irrigation reduced, on average, 37 percent of CH_4 emissions across sites, without affecting crop yields compared to continuous flooding. Spatial and seasonal disparities in methane emission reduction require further research. Mofijul Islam, S. M. et al. 2020. "Effects of Water Management on Greenhouse Gas Emissions from Farmers' Rice Fields in Bangladesh." *Science of the Total Environment*. Vol. 734. (Link)

[124] Trang et al. 2021. "Institutional Analysis for Scaling Alternate Wetting and Drying for Low Emissions Rice Production: Evidence from Bangladesh." *Climate and Development*. (Link)

[125] The scheme is dependent on the financing program of the Infrastructure Development Company Ltd (50 percent is a grant, 35 percent is concessional loans, and 15 percent is equity). This is not sustainable; areas advantageous for commercial agriculture could be prioritized with integration of power into the main grid and de-risking of investment through guarantees.

[126] Calculations by the World Bank based on (i) Bala, B. K. et al. 2010. *Post-harvest Loss and Technical Efficiency of Rice, Wheat and Maize Production System: Assessment and Measures for Strengthening Food Security*. Final Report CF 6/08. Dhaka: Bangladesh Agricultural University (Link); (ii) Reza, M. S. et al. 2005. "Studies on the Traditional Drying Activities of Commercially Important Marine Fishes of Bangladesh." *Pakistan Journal of Biological Sciences* Vol. 8: 1303–1310; (iii) FAO (Food and Agriculture Organization of the United Nations). 2011. *Global Food Losses and Food Waste: Extent, Causes and Prevention*. Rome: FAO. (Link); and (iv) Hassan M. K. 2010. *A Guide to Postharvest Handling of Fruits and Vegetables*. Dhaka: Department of Horticulture, Bangladesh Agricultural University. (Link). Achieving reduction in GHG emissions requires an improvement in overall value chains; food loss and waste could be reduced through increased cold storage, although this could result in higher energy use (FAO (Food and Agriculture Organization of the United Nations). 2019. *The State of Food and Agriculture. Moving Forward on Food Loss and Waste Reduction*. Rome: FAO. (Link)

[127] Acharya, G. et al. 2020. *RICH Food, Smart City: How Building Reliable, Inclusive, Competitive, and Healthy Food Systems Is Smart Policy for Urban Asia*. Washington, DC: World Bank. (Link)

[128] GoB (Government of Bangladesh). 2021. *Nationally Determined Contributions (NDCs) 2021 Bangladesh (Updated).* Ministry of Environment, Forest and Climate Change, GoB. (Link)

[129] Bangladesh Space Research and Remote Sensing Organization. Rahman, M. M. et al. "Mapping Tidal Mudflats in the Coastal Regions of Bangladesh using Landsat-8 and Sentinel-2 Satellite Imagery." *Dew-Drop* 6(1): 54-63.

[130] (i) Chanda, A. et al. 2016. "Blue Carbon Stock of the Bangladesh Sundarban Mangroves: What Could Be the Scenario after a Century?" *Wetlands* 36:1033–1045; (ii) Bangladesh Institute of Water Modelling. 2017. "Research on Assessment of Effectiveness of Mangrove Forests for Coastal Protection

coastal plantations[131] with an additional 126,748 ha of land for coastal greenbelts.[132] This afforested land will potentially sequestrate 230 $MtCO_2e$ by 2025. Speeding up the process of afforestation across these forested zones—and increasing the overall target—should therefore be a high priority.

Table 6: Indicative Costs and Carbon Sequestration Benefits of Afforestation/Reforestation Options

Afforestation/Reforestation	Area (hectare)	Investment Cost (US$ million)	Carbon Sequestration Volume in 25 Years (million tons)
Mangroves in newly accreted coastal island	40,000	25	30
Coastal Green Belt	126,000	190	80
Hill Forest in Chattogram	250,000	300	120

Sources: Bangladesh Forest Department and Sustainable Forest and Livelihood Project.

4.5. Improving Integrated Waste Management Systems

Improved waste management has been prioritized in the NDCs and has the potential for reduced emissions. More than 38,000 metric tons of waste is generated each day, expected to reach 47,000 tons per day by 2025.[133] Uncollected waste, particularly plastic, ends up in the drainage system and water bodies. The Ganges-Brahmaputra-Meghna delta is the second highest plastic polluted river worldwide. Localized flooding due to blocked drainage could increase flooding risk between 7.6 per cent and 18.5 percent in several cities.[134] The disproportional impact of poor SWM on informal settlements is high and adds to welfare disparities, while improvements could reduce vulnerability.[135] Bangladesh intends to capture 70 percent of landfill gas to generate energy and to divert 50 percent of waste from landfills to composting facilities by 2030. Models of low-carbon and landfill scenarios show significant emission reduction (–50 percent) from food and yard waste management, reduced landfilling, and improved CH_4 capture. A low carbon scenario also has substantial cobenefits, ranging from renewable energy generation, improved use of resources and sector modernization.

SWM regulation is strong, but implementation remains inadequate. The Solid Waste Rules (December 2021), Hazardous Waste (e-waste) Management Rules (June 2021), and forthcoming Medical Waste Management and Processing Rules should be applied by local implementors. Illegal dumpsites remain, despite the transition to engineered sanitary landfills, and the reduction of emissions from SWM will require improvement of biodegradable waste based on source segregation and smaller/better managed landfills designed to recover CH_4. Regulatory and market-based policy instruments to promote integrated waste management and develop a circular economy from material-based recycling to waste to energy initiatives will help expand investment opportunities and help bring collection levels up from the current 60 percent to 80 percent by 2030. Assuming an average investment of US$75 per capita as part of the low-carbon scenario, SWM projects could raise around US$400 million in carbon finance, around 5 percent of the investment requirement up to 2035. But for projects to be commercially viable and bankable, establishing the right structure of fees (tipping fees for example).is required. An assessment of regulatory policies, tariff system, budgetary allocation, and capacity of local government agencies could identify appropriate regulatory frameworks to enable private sector investment.

against Cyclonic Storm Surge; Bangladesh." Internal Report for World Bank. Unpublished; (iii) Van Zelst, V. et al. 2022. "Mangroves as a Protection from Erosion and Coastal Flooding in Selected West African Coastal Countries." Internal report for the World Bank; (iv) Biswajit, B. et al. 2022. "Significant Reduction of Carbon Stocks and Changes of Ecosystem Service Valuation of Indian Sundarban." *Scientific Reports* 12 (7809). (Link)

[131] Financing from the World Bank's Sustainable Forests and Livelihoods Project (24,000 ha) and the Green Climate Fund (20,000 ha).

[132] GoB (Government of Bangladesh). *Technical Study for Mapping of Potential Greenbelt Zone in the Coastal Regions of Bangladesh, Climate Resilient Participatory Afforestation and Reforestation Project*. Bangladesh Forest Department, Government of Bangladesh.

[133] Waste Concern. 2014. *Bangladesh Waste Database 2014*. Dhaka: Waste Concern. (Link)

[134] Pervin I. A. et al. 2020. "Adapting To Urban Flooding: A Case of Two Cities in South Asia." *Water Policy* 22 (S1): 162–188. (Link)

[135] Uncontrolled recycling of hazardous waste, including of used ULABs, is a public health hazard. There are 148 known ULAB sites, the total number is more than 1,100 and the number of people at risk is nearly 1 million. An analysis of sites in Greater Dhaka suggests that pollution hotspots tend to be in poor areas, particularly the slums in the Southwest, dominated by ULAB recyclers and the leather industry (World Bank. 2018. *Enhancing Opportunities for Clean and Resilient Growth in Urban Bangladesh: Country Environmental Analysis 2018*. Washington, DC: World Bank). (Link)

5. Between Two Waves: Climate and Development Priorities

Bangladesh faces the dual challenge of rapid adaption to climate change while adopting technologies and regulatory standards for adaptation and mitigation. Previous sections have identified priority areas for adaptation that could accelerate development and contribute to lower carbon growth. As discussed in Section 1, the combined adaptation and mitigation expenditures under existing plans could reach 5 percent of GDP—a target that would require a substantial increase in current investment expenditure. Despite this cost, Bangladesh has significant potential to improve development outcomes and accelerate growth.

5.1. Modeling Adaptation and Decarbonization Pathways

The magnitude of climate change will depend in part on the amount of GHG emissions over the coming decades. To account for different possibilities, three climate change scenarios are considered based on the IPCC's Fifth Assessment Report, which reflects an optimistic limited warming outcome, intermediate climate outcomes, and a pessimistic downside scenario. The scenarios are quantified using global and regional data, coupled with atmosphere-ocean general circulation, and Earth system models, to provide insight into the carbon feedback cycle and the climate's sensitivity to a designated radiative forcing by 2100. They are based on RCPs, named for the specified 2100 GHG radiative forcing:

- **RCP2.6:** A scenario with low GHG and CO_2 emissions that represents reductions in GHG emissions in line with the Paris Agreement and average warming of less than 2 ^{0}C by 2100.
- **RCP4.5:** A scenario with intermediate GHG emissions and CO_2 emissions remaining around current levels until the middle of the century before dropping off.
- **RCP8.5:** A very high GHG emission scenario with CO_2 emissions that roughly double from current levels by 2050, leading to an average warming of almost 5 ^{0}C by 2100. RCP8.5 models have been found to align most closely with recent historical emission trends (2005 to the present).[136]

Global average temperature change does not differ considerably across the scenarios in the near term; that is, prior to the 2040s and 2050s. This reflects the relatively long lag in the climate response to cumulative emissions and concentrations. As such, the pessimistic climate scenario case, which is most consistent with recent global emission tracks, appears to be reflective of the climate system's response to cumulative emissions.

5.2. Modeling Damages and Associated Costs

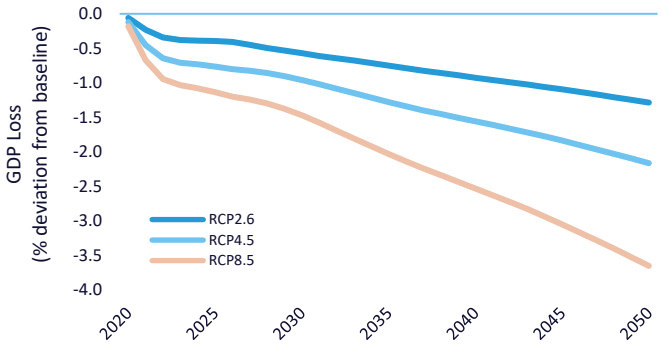
Figure 13 quantifies the impact of damages from riverine flooding and decreased agricultural and worker productivity due to temperature increase. Other damages are not considered due to data limitations.[137] The analysis relies on damage functions that capture how flooding and higher temperatures affect capital stock, working time, labor productivity, and agricultural productivity. Climate change will have deleterious effects on the economy, with the magnitude increasing over time as climate scenarios materialize. The damage of climate change is likely underestimated, as catastrophic outcomes are typically not considered

[136] While long-term GHG emissions in RCP8.5 are considered overly pessimistic, this scenario provides useful (and not implausible) high-warming outcomes, which would be consistent with continued GHG emissions and high climate change sensitivity or positive feedback from the carbon cycle.

[137] Relevant damage also might include extreme heat events, landslides, sea-level rise, and droughts, although droughts are subsumed in the modeled loss of agricultural productivity.

adequately in economic models.[138] Higher and more variable temperature and precipitation patterns will gradually destroy physical, productive, and human assets. Under the RCP4.5 scenario, the costs from riverine flooding damages and decreased agricultural and worker productivity due to temperature increase will rise from about 0.5 percent of GDP in 2023 to 2 percent by 2050. In the more severe RCP8.5 scenario, these costs reach almost 4 percent of GDP in 2050.

Figure 13: Estimated Economic Impacts of Flooding and Higher Temperatures and Precipitation Patterns



Source: Staff calculations, based on Macro-Fiscal Model (MFMod) for climate change.

Notes: Data on riverine flooding is based on data from the United Nations Office for Disaster Risk Reduction relating to agricultural damages, taken from Leclère D. et al. 2014. "Climate Change Induced Transformations of Agricultural Systems: Insights from a Global Model." Environmental Research Letters 9 (12): 124018. (Link); and Havlík, P. et al. 2015. Climate Change Impacts and Mitigation in the Developing World: An Integrated Assessment of the Agriculture and Forestry Sectors. Policy Research Working Papers. Washington, DC: World Bank. (Link). Data for the loss in labor productivity are from UNDP (United Nations Development Programme). 2016. Climate Change and Labour: Impacts of Heat in the Workplace. New York: UNDP; and Ronson, R. and M. Sartori. 2016. "Estimation of Climate Change Damage Functions for 140 Regions in the GTAP 9 Data Base." Policy Research Working Paper 7728. Washington, DC: World Bank. (Link). Agricultural data is sourced from a regional study on the aggregate effect across all crop yield losses. Farmers are assumed to constantly adapt to climate change in their production methods (private adaptation effect), and this optimization behavior is expected to continue under climate change (UNISDR (United Nations Office for Disaster Risk Reduction). 2015. Global Assessment Report on Disaster Risk Reduction—Making Development Sustainable: The Future of Disaster Risk Management. Geneva: UNISDR.

Flooding accounts for the most severe climate-related disasters. The probability of damages and associated costs of riverine flooding are shown in Figure 14. Historical data imply that a 500-year flood[139] will lead to a damage of 12 percent in exposed assets,[140] while for a 1,000-year flood that value increases to 14 percent. The frequency and severity of extreme events are expected to increase with global warming and the realization of adverse climate outcomes. Economic loss from flooding is anticipated to be severe, with annual average damage tripling under the worst-case scenario (RCP8.5) relative to the current trajectory (RCP4.5). Rare events may have a much larger impact on GDP. The bottom chart of Figure 14 (Economic Impact) shows the potential average annual losses from flooding under RCP8.5 (black line) and the uncertainty around those estimates, including the 99th percentile of GDP responses (shaded area). Under severe flooding, GDP falls by 9 percent relative to the baseline.

The potential benefits could be much higher than costs, depending on where investments are made and how much they improve resilience. For example, embankments or delta management investments could help reduce damage from flooding but need regular maintenance to remain effective. Flood

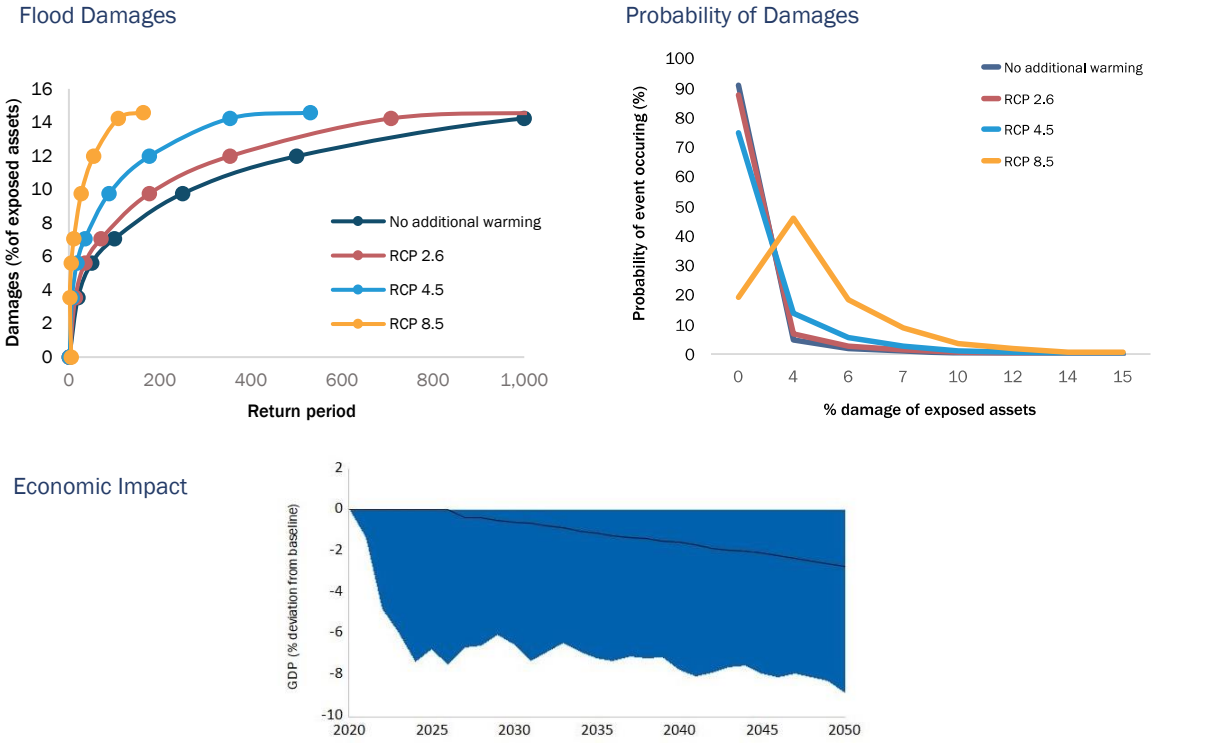
[138] Stern, N. 2013. "The Structure of Economic Modeling of the Potential Impacts of Climate Change: Grafting Gross Underestimation of Risk onto Already Narrow Science Models." *Journal of Economic Literature* 51 (3): 838–59. This is related to the argument of Weitzman that there is a non-negligible risk of apocalyptic catastrophes linked to the possibility that tipping points in the earth system will trigger positive feedback loops of global heating (Weitzman, M. L. 2009. "On Modeling and Interpreting the Economics of Catastrophic Climate Change." *The Review of Economics and Statistics* 91 (1): 1–19. (Link); and Lenton, M. T. et al. 2008. "Tipping Elements in the Earth's Climate System." *Proceedings of the National Academy of Sciences* 105 (6): 1786 LP-1793. (Link)).

[139] The term "500-year flood" means that statistically speaking, a flood of that (or greater) magnitude has a 1 in 500 chance of occurring in any given year. These statistical values are based on observed data.

[140] The exposed assets represent public infrastructure (bridges, roads, among others) and are estimated at 1.3 percent of GDP.

mitigation will be particularly critical in the Dhaka Metropolitan Area (DMA), which accounts for a disproportionate share of built-up area within Bangladesh.[141]

Figure 14: Riverine Flood Damages and Probabilities under Different Climate Scenarios



Source: World Bank staff calculations, based on Macro-Fiscal Model (MFMod) for climate change.

Notes: RCP2.6, RCP4.5, and RCP8.5 represent climate trajectories envisioned by the Intergovernmental Panel on Climate Change, based on projected greenhouse gas emissions. Data on riverine flooding comes from UNISDR (United Nations Office for Disaster Risk Reduction). 2015. Global Assessment Report on Disaster Risk Reduction— Making Development Sustainable: The Future of Disaster Risk Management. Geneva: UNISDR.

Adaptation expenditure comes with tradeoffs under each scenario. To avoid indiscriminate and potential harmful reallocation of public investment funds from productive investments, greater attention to improved public expenditure efficiency is needed. Total expenditure could be increased by raising revenue through the elimination or repurposing of harmful subsidies or by taking on additional public debt. Also, private sector partnerships could be used to mobilize private investment. The magnitude of adaptation also requires consideration since investments could target a range of 20–80 percent of the damage from flooding. These damages could be mitigated with appropriate adaptation investments,[142] with benefits potentially many times higher by improving resilience of built-up areas that enhance the value of investments, increase productivity, and improve the quality of services. Similarly, building the resilience of populations residing in hazard-prone areas, with lower mobility and poorer insurance and adaptative or preventative measures against floods, can improve overall welfare and productivity.

[141] DMA accounts for 0.2 percent of the country and 4.5 percent of built-up area—an intensity 22.5 times greater than the rest of the country.

[142] The model assumes that the product of adaptation investment is adaptation capital which does not have a productive use and, instead, protects the economy from climate-related damage to productive capital. The more adaptation capital an economy accumulates, the less productive capital will be damaged by natural disasters. From a societal point of view, adaptation investment makes sense if the productive capital saved (protected) by the investments exceeds the amount of investment forgone in order to make the adaptation investment. In modeling the effectiveness of adaptation, a key equation is the relationship between adaptation capital and protection. The calibration of the parameters from the functional form is significantly uncertain. Data on these parameters would strengthen the model but is needed for each of the modeled damages separately. IPCC provides some indications on methodology but does not offer data that would be directly useful for calibrating the parameters of the protection function (IPCC (Intergovernmental Panel on Climate Change). 2014. *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge, United Kingdom and New York: Cambridge University Press. (Link). The assumption in the model is that approximately US$1 of investment generates a US$1 reduction in capital destruction.

GDP and public finance outcomes vary depending on the financing strategy. Adaptation investments can be financed by debt, or by deferring other types of public investment. With larger floods, adaptation investments protecting 20 to 40 percent of the expected asset damage are projected to be most efficient,[143] even if financed at the cost of other public investments. The GDP benefits of adaptation are slightly higher when debt-financed, although this could worsen debt sustainability prospects. Investments in decarbonization could help raise additional revenues. While Bangladesh's contribution to global GHG emissions in per capita terms is currently negligible, investments in decarbonization can help limit the extent of lock-in to carbon-intensive investments in the energy sector, reducing the future costs of stranded assets. Adopting a green growth strategy has important cobenefits, for example, for health outcomes and air and water pollution. Lowering GHG emissions also may help maintain competitiveness in global export as well as strengthen Bangladesh's global leadership on climate change. A policy framework that reflects climate risks and mobilizes additional domestic revenue, together with greater international support, will be crucial in financing adaptation investment needs.

5.3. Decarbonization Cobenefits and Spillovers

Cleaner Air

A clean air program for CO2, BC, and CH4 could result in significant cobenefits, reducing GHG emissions while improving health outcomes. Air pollutants and GHGs often come from the same sources (such as coal-fired power plants and diesel-fueled vehicles). Addressing these sources of PM2.5 would address the most toxic air pollution and contribute to mitigation. CH_4 emissions were approximately 42 percent of Bangladesh's total GHG emissions in 2018 and Black Carbon contributed 13 percent (IPCC AR 5). Reducing PM2.5 emissions will have a substantial impact on GHG emissions, ground level ozone (O_3), and CH_4. A clean air program could reduce GHG emissions through:

- **Reducing CO2 emissions:** Interventions in power and heating plants (reduction up to 20 $MtCO_2$ emissions by 2030); industrial combustion (in the 2041 scenario); and industrial processes (in the 2030 scenario as well as the 2041 scenario).

- **Reducing BC emissions:** Interventions in residential combustion (reduction up to 30 kilo tons by 2030); agriculture; heavy duty vehicles (diesel); and industrial combustion.

- **Reducing CH4 emissions:** Interventions in agriculture (reduction up to 768 kilo tons by 2030); waste (reduction up to 122 kilo tons by 2030 and 540 kilo tons by 2040); and residential combustion sector (reductions up to 150 kilo tons by 2030).

Figure 15 compares a baseline to a scenario of BAU emissions and a scenario of clean air interventions.[144] By 2030, the health cobenefits of a clean air program could reduce 50 percent of annual premature deaths,[145] while reduced SLCP emissions, such as BC and CH_4 could improve crop yields across the heavily air polluted Indo-Gangetic Plain.[146] The sectoral pollution costs of a comprehensive clean air scenario that includes abatement of all relevant air pollutants to reach World Health Organization air quality IT standards for $PM_{2.5}$ and O_3 targets for 2030 (IT 1) and 2040/41 (IT IV) are calculated to range from US$10 billion in 2025 to US$17 billion by 2040. While further analyses are needed, the annual cost of air pollution has been estimated as 9 percent of GDP.

[143] World Bank staff calculations, based on the MFMod for climate change.

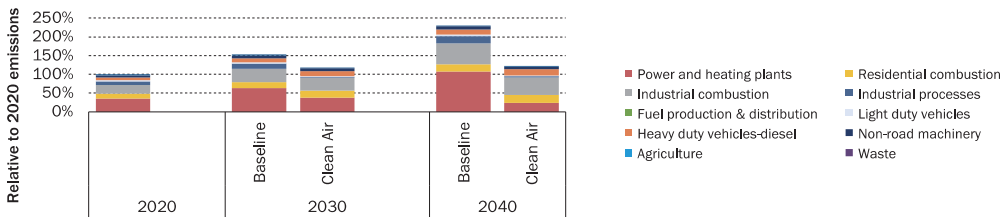
[144] Estimates from current Clean Air Scenarios (CASs) in the South Asia region (UNEP (UN Environment Programme). 2019. *Air Pollution in Asia and the Pacific: Science-Based Solutions (Summary + Full Report)*. Bangkok: UNEP. (Link); and Amann M. et al. 2020. "Reducing Global Air Pollution: the Scope for Further Policy Interventions." *Philosophical Transactions, Royal Society.* A378: 20190331. (Link)). Where possible, additional climate scenarios and optimization of air pollution and climate scenarios can be presented by applying the "GAINS city" model in the South Asia Region, including in Bangladesh.

[145] Based on a 2018 baseline (World Bank. (Forthcoming). *South Asia Region Air Quality Management Flagship Study*.

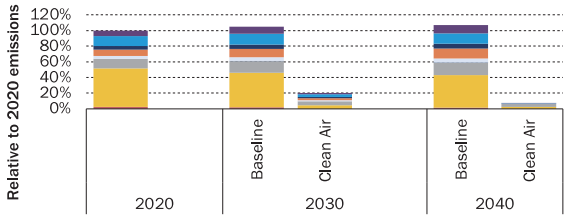
[146] Relative yield losses from high O_3 concentrations are 7–12 percent for wheat, 6–16 percent for soybean, 3–4 percent for rice, and 3–5 percent for maize.

Figure 15: Emissions Reductions by 2025, 2030, and 2040 under a Clean Air Program

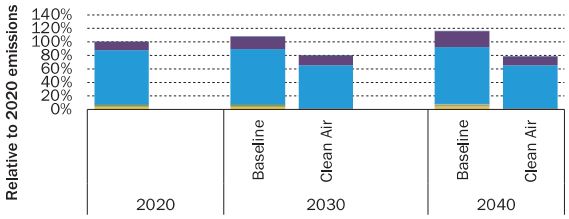
Carbon Dioxide Emissions



Black Carbon Emissions



Methane Emissions



Source: UN Environment Programme, 2019 and Amann M. et al., 2020.

New Skills and Jobs

Investing in skills development can help accelerate the climate transition, with positive economic spillovers. A better trained workforce is needed to help the transition in economic sectors such as manufacturing, urban and building design and construction, energy efficiency and decarbonization, environmental engineering for water, wastewater, and SWM. The production and promotion of efficient appliances, pumping systems (drainage, water supply, and wastewater) and services such as energy auditing and certification are required. Apprenticeship programs for green technology specialists can be supported by government, private enterprises, and NGOs. Skills development requires (i) updating competency standards and curricula to align with climate transition; (ii) needs assessments for low-carbon technologies; (iii) workplace-based upskilling; (iv) skilling for climate migrants. Relevant Industry Skills Councils could develop competency standards. Local (union parishad, district) and national-level public sector can be trained to engage with communities and the private sector, and to improve planning, project management, financing, and monitoring capacity related to climate action. Green guidelines for technical and vocational education and training (TVET) institutions; certification standards for green skills; targets in annual performance agreements with TVET institutions; and revising competency standards are needed. Skills programs should commit to closing gender gaps in training and STEM education. Climate change and environmental (CCE) education in basic education can build awareness and a foundational knowledge of climate change. CCE in curricula can be established as a common core including to build teacher capacity. In addition to universities offering studies in environment and climate change[147], revolving funds for adaptive research and innovation for low-carbon technologies could be introduced. The National Curriculum Policy Framework can include guidelines for CCE; green skills competency standards can be developed under the Bangladesh Qualification Framework in partnership with relevant authorities.

Trade Competitiveness

Greening trade provides opportunities to boost Bangladesh's trade competitiveness. Access to environmental goods and services can play a key role in increasing and diversifying exports in three specific ways. First, access to imports of environmental goods and services can promote the transition to low-carbon production and increase competitiveness. New environmental technologies are expected

[147] Bangladesh Agricultural University, Bangabandhu Sheikh Mujibur Rahman Agricultural University and the Department of Agricultural Extension at the Ministry of Agriculture will establish departments of agrometeorology.

to improve productivity, reduce greenhouse gas intensity, and increase the domestic value addition of exports. Second, such access supports the exports of environmentally preferable products such as jute, textiles, leather, organic seafood, and agricultural products which have a lower impact on the environment. Third, better access can increase Bangladesh's participation in global value chains. Most environmental goods and services are exported by developed countries, but developing countries are able to produce parts and components as part of global value chains. Bangladesh is well positioned to participate in such value chains, thanks to the production of parts and components such as turbines and invertors. The GoB needs to act now to reduce tariffs and behind-the-border barriers affecting trade in environmental goods and services, develop a comprehensive institutional environment, and foster private sector integration in global value chains.[148]

5.4. Financing Adaptation and Decarbonization Development Pathways

Policies and investments to adapt and decarbonize could result in better development outcomes. However, policymakers face difficult tradeoffs between resilience and decarbonization pathways, financial resources are limited, and the capacity to manage substantial change and absorb larger investment flows is constrained. There is a strong case for including the negative externalities associated with the use of fossil fuels in retail energy prices.[149,150] Carbon-intensive fossil fuels are associated with environmental damage and local air pollution, the combustion of fossil fuels contributes to climate change and subsidized road fuel can worsen congestion, road damage, and accidents due to higher driving rates. It would be optimal to internalize these negative externalities in the user prices of fossil fuels. Figure 16 shows the estimated socially optimal prices of different fossil fuels in Bangladesh. The optimal price of each fuel per unit of consumption is composed of supply costs, global climate and local (outdoor) air pollution damages, and a standard value-added/general consumption tax. Current user prices are far below these optimal prices, in some cases not even covering supply costs because of direct subsidies. As a first step (as discussed in box 3, section 2), direct and indirect fuel subsidies should be ended.[151] The removal of fossil fuel subsidies should complement specific sectoral adjustments, discussed in previous sections.

Appropriate carbon pricing can help mobilize resources for adaptation while contributing to decarbonization by correcting for the externality and eliminates any existing fuel subsidies. Current subsidies could be seen as a negative carbon price. The removal of subsidies and a gradual introduction of a carbon tax could provide a strong and credible signal of commitment to a greener economy while raising revenue.[152,153] A carbon tax focused on the energy sector could be implemented progressively.[154] As Bangladesh already has an existing fuel tax system, introducing an additional carbon tax on energy would require only limited administrative capacity with little scope for noncompliance. While more analysis is needed to assess power sector decarbonization impacts with carbon pricing, especially to inform stranded asset risk, current assessment indicates that a carbon tax higher than US$25/$tCO_2e$ would be needed after 2030 to reach an 80 percent reduction of emission in the power sector by 2041. Carbon pricing could also help Bangladesh negotiate better terms for prospective border adjustment mechanisms in trade deals as it approaches least-developed-country

[148] World Bank Group. 2022. "Bangladesh: Change of Fabric." Country Economic Memorandum. Washington, DC: World Bank Group. (Link)

[149] Parry, I., S. Black, and N. Vernon. 2021. "Still Not Getting Energy Prices Right: A Global and Country Update of Fossil Fuel Subsidies." IMF Working Paper 21/236. Washington, DC: Fiscal Affairs Department, International Monetary Fund. (Link).

[150] World Bank. 2022. *Reshaping Norms: A New Way Forward. South Asia Economic Focus, Spring 2022.*Washington, DC: World Bank. (Link)

[151] Mercer-Blackman, V.A., L. Milivojevic, and V. Mylonas. forthcoming. "Are Carbon Taxes Good for South Asia?"

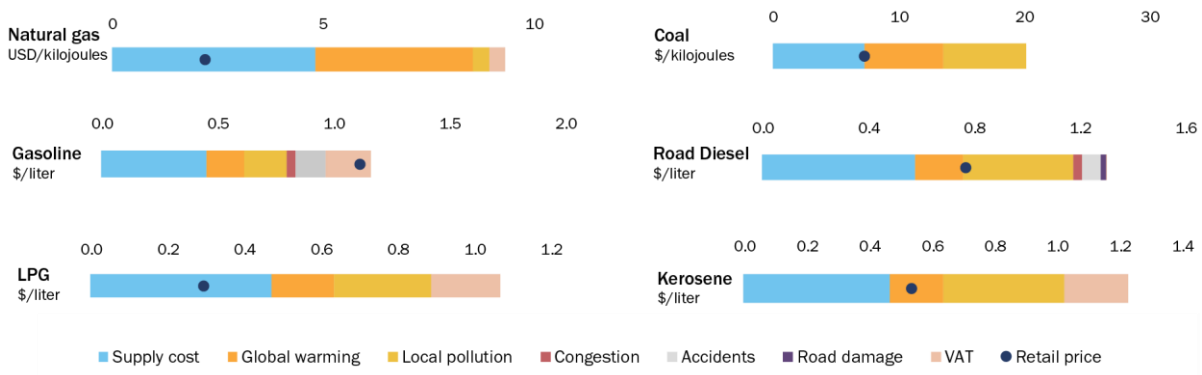
[152] Basu, R. et al. 2022. "Addressing Climate Challenges in Bangladesh: A Smart Carbon Pricing Strategy." IMF Selected Issues Paper 22/72. Washington, DC: International Monetary Fund.

[153] See Parry, I., S. Black, and N. Vernon. 2021. "Still Not Getting Energy Prices Right: A Global and Country Update of Fossil Fuel Subsidies." IMF Working Paper WP/21/236. Washington DC: Fiscal Affairs Department, International Monetary Fund. (Link).

[154] Parry, I. et al. 2021. "Mitigation Policies for the Paris Agreement: An Assessment for G20 Countries." *Journal of the Association of Environmental and Resource Economists* 8(4): 797–823.

graduation[155]. Incentives for higher energy efficiency and transition toward renewable energy can improve energy security and is increasingly important in light of rising fossil-fuel prices in international markets and corresponding pressures on current account balances. Finally, revenue mobilized from a carbon tax could be used to protect economically vulnerable groups, to support firms with decarbonization, and to create jobs through investments in climate projects. Fuel subsidy reform would be required concurrently with a carbon tax to ensure pass-through higher prices. Two illustrative carbon-tax pathways considered below (Table 7) should be viewed as complementary strategies to the sectoral decarbonization pathways from the previous section.[156]

Figure 16: Fossil Fuel Retail Prices and Estimated Optimal Externality-inclusive Levels



Source: World Bank, based on data and methods in World Bank. 2022. Reshaping Norms: A New Way Forward. South Asia Economic Focus, Spring 2022. Washington, DC: World Bank. (Link); and Parry, I., S. Black, and N. Vernon. 2021. "Still Not Getting Energy Prices Right: A Global and Country Update of Fossil Fuel Subsidies." IMF Working Paper WP/21/236. Washington DC: Fiscal Affairs Department, International Monetary Fund. (Link). Notes: Global warming costs consider national damages only. National social price of carbon is used to value CO2 reductions based on Ricke, K. et al. 2018. "Country-level social cost of carbon." Nature Climate Change 8, 895–900.

Table 7: Illustrative Decarbonization Pathways[157]

Illustrative Pathway 1—Achieving NDCs by 2030	Illustrative Pathway 2—International carbon price floor
• Gradual introduction of the carbon price (to US$10 by 2030) and phasing out of fossil-fuel subsidies. Generated revenues are split between public investment (50 percent); current spending on health, education, and social security (25 percent); and cash transfers to households (25 percent) to address inequality and political economy aspects of the reform.	• Gradual introduction of the carbon price (to US$25 by 2030) and phasing out of fossil-fuel subsidies. Generated revenues are split between public investment (50 percent); current spending on health, education, and social security (25 percent); and cash transfers to households (25 percent) to address inequality and political economy aspects of the reform.

In the first pathway, assumed carbon taxes reflect NDC commitments. In its NDC 2021 update, Bangladesh committed to adopt policies that should result in total GHG emission reductions of 89.47 $MtCO_2e$ (21.85 percent), including **unconditional contributions** where GHG emissions would be reduced by 27.56 $MtCO_2e$ (6.73 percent) below the reference pathway in 2030 in the respective sectors; and **conditional contributions** where GHG emissions would be reduced by an additional 61.9 $MtCO_2e$ (15.12 percent). A phased introduction of a carbon tax would forward planning to decarbonize production processes and improve energy efficiency, reduce the probability of stranded assets, lost

[155] The European Union (EU) has proposed the Carbon Border Adjustment Mechanism (CBAM) to avoid carbon leakage and encourage partner countries to establish carbon pricing policies. In its proposed first phase, the CBAM applies to specific imported products in the aluminum, fertilizer, cement, and iron and steel sectors and to imported electricity. In a transition period from 2023 to 2025, importers would report the embedded emissions of certain imported products, and a financial adjustment would begin from 2026. The CBAM does not affect Bangladesh exports during the proposed first phase but it may expand to other products and trading partners in the future. Bangladesh could diversify exports to new, more carbon-intensive products.

[156] The interplay between carbon taxation and complementary sectoral measures is not explicitly modeled and could affect results.

[157] In addition to the pathways discussed here, detailed power sector decarbonization pathways analysis was also conducted; see Annex 5 for a summary of key scenarios. The power sector modeling was also used to inform the macroeconomic model.

competitiveness, or future job losses. A tax that begins at US$3/tCO2e in FY23 and increases to US$10/tCO2e by FY30 would lead to higher emission reductions than the pledged unconditional NDC.

Revenues generated through a carbon tax could contribute to climate financing. A US$10 carbon price is estimated to result in an additional annual revenue of 0.9 percent of GDP in 2030. Additional revenue from the carbon tax could potentially be earmarked to promote domestic equity and transition to a greener economy. Government debt is not particularly high and available resources could be used to dampen the contractionary impact on real variables. In the illustrated simulation, the government channels the generated resources to increase public investments, current spending, and household transfers. This would offset negative effects of carbon tax and lead to neutral or positive GDP outcomes throughout the considered period. In addition, welfare benefits are expected to further offset the potential economic costs. These benefits consist of air pollution cobenefits, including health; transport cobenefits (averted road accidents, reduced road damage, and reduced congestion); as well as national benefits from reduced global warming and associated climate damages.

Under a slightly more ambitious second pathway, the carbon price could be brought to US$25 per tCO2e by 2030. This pathway corresponds to the international carbon price floor for low-income emerging market economies proposed by International Monetary Fund staff.[158,159] Generated budget benefits are higher in this case, resulting in an additional annual revenue of 1.16 percent of GDP. As in the previous case, recycling resources can mitigate negative impacts on the poor but also offset the adverse effects carbon taxation has on economic growth. The multiplier effect through increased public investment and transfers prevails in the medium term, leading to a positive net effect on growth. Carbon taxation would support Bangladesh's NDC commitments and allow for expenditure increase on targeted social protection, infrastructure, and investment in climate adaptation. Additional and predictable fiscal revenue could achieve investment goals (also for adaptation) and pay for just transition costs. The benefits of a well-planned policy package would outweigh the costs of carbon pricing. In both pathways, the net effects on economic growth are positive, and result in a considerable reduction of CO2 emissions of 13.7 percent and 19.3 percent below the 2030 baseline, respectively. Carbon taxation adoption would require a well-coordinated implementation and communications strategy and transparent use of revenues to build public support, as energy prices would gradually rise (Table 8).

Table 8: Impact of Carbon Tax, 2030

Carbon price per ton of CO2	US$ 10	US$ 25
CO2 emission		
Reduction below 2030 baseline	13.7%	19.3%
Economic effects on growth rates		
Cost (percent of GDP growth)	-0.3	-0.4
Net benefit (percent of GDP growth)	0.16	0.18
Revenues		
Relative to 2030 baseline (in percent of GDP)	0.9	1.16
Energy price increase		
Baseline price		
Coal (US$ 8.72 per GJ)	10.8%	27.0%
Natural gas (US$ 4.60 per GJ)	86.7%	105.1%
Electricity (US$ 0.11 per kwh)	25.5%	33.0%
Gasoline (US$ 0.54 per liter)	5.1%	12.8%

Source: World Bank staff calculations.

[158] Parry, I., S. Black, and J. Roaf. 2021. *Proposal for an International Carbon Price Floor among Large Emitters*. IMF Staff Climate Note 2021/001. Washington, DC: International Monetary Fund. (Link)

[159] Chateau, J., F. Jaumotte, and G. Schwerhoff. 2022. "Economic and Environmental Benefits from International Cooperation on Climate Policies." Departmental Papers 2022/007. Washington, DC: Research Department, International Monetary Fund. (Link)

The distributional effects of a carbon tax are estimated to be moderately progressive. Based on the World Bank-IMF Climate Policy Assessment Tool, the impacts of a comprehensive carbon tax that increases gradually from US$5/tCO$_2$ in 2022 to around US$25/tCO$_2$ in 2030 would be disproportionately borne by the rich. The channels through which these taxes bite most are through the consumption of energy, mostly electricity and natural gas, and their indirect effects on goods and services. The regressive indirect and adverse effects on the price of nonenergy goods in the consumption bundle—driven by spending on food—are offset by the progressive direct impact of fuel consumption. Urban households, on average, are likely to be affected more and, within urban areas, too, the richer households would bear most of the brunt. Equal distribution of the modeled revenue gains among the bottom 70 percent of the population could see the net position of households in the poorest decile improve by approximately 5 percent of per capita consumption.[160]

5.5. From Intention to Action

The financing and institutional capacity needs for mitigation and adaptation likely exceed available resources. As outlined in Section 1, current GoB climate investment plans propose public and private investments of between 3.3 percent and 7.0 percent of GDP. Table 9 provides a rough estimate of potential sources of additional climate financing through 2025 of approximately 2.9 percent of GDP. As fuel subsidies in Bangladesh vary based on the difference between floating import prices and fixed domestic prices, they are not presented as a line item in Table 9. Together, these sources of financing would provide approximately 2.9 percent of GDP in climate financing, or US$12.0 billion based on FY21 GDP. While this would be insufficient to fully finance the climate investments outlined in national plans, it remains an ambitious near-term target. Operationalizing this increase in investment will require substantially higher public investment management capacity, as discussed in Section 2.

Reprioritizing the existing public investment envelope and repurposing harmful subsidies is the most accessible form of financing and offers opportunities across multiple sectors as discussed in Sections 3 and 4. In FY21, capital expenditure stood at 5.1 percent of GDP. Prioritizing 20 percent of this budget for climate-related investments would provide approximately 1.0 percent of GDP. The elimination of fuel subsidies may contribute to additional fiscal savings. Over the longer term, a higher level of publicly-financed investment requires domestic revenue mobilization reforms including a rationalization of tax expenditures, adoption of a single standard VAT rate, and modernization of income tax legislation – measures which need stronger administration systems to be fully implemented. Introducing a carbon tax may be a second source of public climate financing with significant potential to finance redistributive programs. A modest US$25 per metric ton carbon tax is estimated to result in annual revenues of approximately 1.2 percent of GDP, which could be allocated for climate finance. Market-based energy pricing and further distributional analysis are required prior to implementation. Mobilizing additional concessional external financing will depend on the allocation of climate finance resources at a global level while scaling up private financing will require overcoming constraints such as the ability to apply tariffs for cost recovery. In FY21, net FDI was only 0.3 percent of GDP. Addressing financial sector and PPP gaps will be critical to access new domestic and external sources of financing.

[160] These findings are consistent with computable general equilibrium analysis that examines the effects of carbon pricing alternatives in economic performance, income distribution, and environment effects. The analysis considers standalone taxes and taxes combined with a cap-and-trade system, using tax proceeds to increase government revenue and redistribution programs. A carbon tax with redistribution to the poor shows the strongest performance in terms of efficiency, environmental effect, and income distribution, even though its net social benefits—if evaluated at market prices—are negative with costs in terms of GDP losses greater than the value of the harmful externalities avoided (World Bank. (Forthcoming). "A CGE Analysis of Green Policies in Bangladesh.")

Table 9: Estimates of Climate Financing Sources by 2025

		Estimated Financing	
Funding Source	Description	Percentage of Gross Domestic Product	US$ Billions
Budget reprioritization	Prioritize 20 percent of the existing capital budget for climate investments	1.02	4.2
Carbon tax	Operationalize a US$25/metric ton carbon tax	1.16	4.9
External financing	External concessional public borrowing	0.50	2.1
Private investment	Guarantees, public-private partnerships, and foreign direct investment	0.20	0.8
Total		2.88	12.0

Source: World Bank staff calculations.

Prioritization

Given financial and institutional constraints, the most impactful and urgent actions to achieve climate resilient development must be prioritized. To do this, the CCDR presents a possible framework and an initial prioritization in the matrix below. This will require further refinement based on deeper consultation and discussion among key stakeholders in Bangladesh. The actions identified are those with the highest impact on development, adaptation, and mitigation with due consideration to trade-offs and distributional effects. They are prioritized based on urgency (adaptation to short-term risks and avoiding lock-in effects); and feasibility (readiness, existing commitments and political economy considerations, access to finance, and ease of implementation). Actions blue are the most urgent to adapt to current and short-term risks, avoid lock-in effects into carbon-intensive patterns, and minimize the accumulation of additional risks. Those in darker blue are at a higher level of readiness and those in lighter blue require additional effort to bring them closer to implementation. Actions in purple/pink are high impact but the risk of delayed implementation is lower. The ones in purple are at a high level of readiness while pink indicates a lower level of readiness.

Overall, given Bangladesh's high climate vulnerability, especially for the poor, adaptation and resilience building actions are clear high priorities. On the mitigation side, over the near-term Bangladesh should prioritize policies and investments that deliver the highest development co-benefits (e.g. increased energy efficiency, better transmission, reduced gas losses, lowering air pollution and congestion and enabling renewable energy and imports to meet future energy needs). Focusing on these actions would enable Bangladesh to meet its NDC commitments through 2030. Options for deeper decarbonization can continue to be analyzed, and decisions can be taken when there is greater clarity on technology development and the availability of concessional international finance.

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Feasibility	Urgency: High Needs immediate action to address major vulnerabilities and prevent additional risks and lock-in effects.	Urgency: Medium Actions with lower lock-in risks.
High Identified in existing plans, with good level of technical and financial readiness.	Actions that should not be postponed and will produce a high impact. Delayed action will increase risk.	Actions with high level of readiness and impact without significant lock-in effects.
Medium Require additional resources/dialog to be ready for implementation.	Urgent actions with risk of delayed implementation that require additional dialog and resources	Actions with lower lock-in effects that need additional resources to be implemented.

= Policies, Strategies, Institutions ***= Investments***

Policy Package 1: People-centric, Climate-smart Spatial Development

Prioritize and allocate financing for Bangladesh Delta Plan 2100 projects.

Projects identified in 2018 were estimated at US$38 billion. Streamlining of institutional arrangements and improving public investment management are critical to accelerate implementation.

Leverage financing mechanisms for locally led climate action.

Increase awareness for local-level climate actions and strengthen systems for adaptation in a transparent and accountable manner. Current capacity levels of local government and communities to address climate vulnerabilities and work together may require further strengthening. Expand access to skills training and jobs for the urban poor and climate migrants.

Realign education and skills training programs to raise climate awareness and meet skill needs for low-carbon transition.

Technical training system to coordinate with industries and local governments to design and implement reskill training programs.

Invest in the transformation of the agri-food sector.

Requires repurposing agriculture support programs (fertilizer, water, energy subsidies); increasing investments in high-productivity, diversified, climate-smart livestock/crop systems; removing barriers for private sector (e.g., in seed production); and strengthening research-extension private sector linkages.

Integrate climate migration into planning and development for select secondary cities and towns.

Proactively plan for climate migration in selected areas. Need to address urban heat island risks and issues of vulnerability and marginalization.

Scale up Nature-Based Solutions for resilience, carbon sequestration, ecosystem services, and livelihoods.

Forest cover is presently carbon positive (0.37 MtCO2e per annum). Restoration and afforestation will contribute to a reverse trend and make forests into carbon sink. Develop a joint regional investment plan (Bangladesh and India) for Resilient Sundarbans.

Expand and improve cash-based shock-responsive social protection programs.

Establish predetermined financing to increase budget predictability of shock response. Enhance efficiency by streamlining beneficiary identification, monitoring, and digital transfers. Leverage targeting and government-to-citizen (G2P) platforms to reach urban poor and climate migrants. Include the Ministry of Social Welfare in the National Disaster Management Council to increase efficiency for disaster response.

Invest in energy-efficient and climate-resilient housing and urban infrastructure.

Provide technical and financial support for new and existing affordable housing, prioritizing low-income communities and informal settlements. Implement urgent investments in water storage and incentives for conservation, and in solid waste management particularly in Greater Dhaka and Greater Chattogram. Leverage public-private partnerships.

Policy Package 2: Delivering development benefits with decarbonization

Implement energy efficiency and circular economy solutions in ready-made garments and textile factories and energy efficiency building standards.

Target reductions of 30 percent with circular economy and energy efficiency measures. Requires regulation, coordination, and financing for private sector action. Will require short-term costs for long-term efficiency gains and competitiveness.

Agriculture and Livestock Climate Smart investments and policies.

To a) improve emission intensity in livestock systems; b) improve rice production and irrigation practices to reduce water and energy consumption and lower emissions and c) reduce food loss and waste across the food system through cooling solutions, improved logistics, storage and processing. Will require private sector and farmer aggregation solutions and adoption of standards for implementing cleaner production practices inside agro-processing facilities.

Gradually eliminate implicit and explicit fossil fuel subsidies, including for gas.

Requires related tariff reforms. Affordability and distributional impact need to be analyzed and targeted support for poor households may be required. Generates air quality co-benefits, incentivizes private-sector emission reductions and helps mitigate emissions in the gas value chain.

Strengthen the power grid to optimize use of generation assets and integrate renewable energy (RE).

Increase efficiency, improve flexibility, improve service, and integrate RE generation. Increase RE generation domestically and RE imports via regional power trade. Requires RE potential assessment, improved land-use planning, and government land allocation. Power trade requires regional cooperation, regulatory and contractual frameworks, and careful consideration of energy security.

Introduce an energy focused carbon tax.

A carbon tax would provide price incentives for mitigation while mobilizing modest additional revenues for climate investments. However, market-based energy pricing and further distributional analysis are required prior to implementation.

Adopt National Logistics Development Policy and decrease road transport with increased transport by rail and waterways.

Requires long-term infrastructure investment and consideration of the environmental impacts of river management. Electric vehicles offer a viable opportunity to reduce carbon emissions. Policies to support electric vehicle adoption may include tax rebates, flexible financing and related infrastructure, such as charging stations. Finalization and implementation of the proposed National Logistics Development policy with a focus on modal shift, resilient and low-carbon multimodal transport logistics and guidelines for private capital mobilization. This includes standardizing VAT rates on fuel transport via roads vs other transport modes.

Policy Package 3: Enabling Environment and Institutional Realignment

Develop and implement clean air programs to reach World Health Organization PM2.5 interim targets.

Benefits to climate and air pollution alike through carbon dioxide, black carbon, and methane emission reductions. Support green tech and green financing uptake and help meet export standards.

Establish a sustainable government procurement policy and implementation roadmap.

Integrate procurement into the legal, regulatory, and institutional public procurement framework to incorporate environmental and socioeconomic considerations and enabling more inclusive and green public procurement.

Establish a climate change portal with publicly disclosed data and engage parliamentary committee on public accounts to assess climate-related public expenditures and reports.

Strong civil society and nongovernment organizational presence, as well as advocacy platforms to provide basis to support accountability on climate action.

Strengthen assessment and disclosure of climate and environmental risks in financial and real sector.

Physical and transitional climate risks in the banking sector require tools for assessment and mitigation, with prudential incentives for green lending. Disclosure requirements can help channel financing for climate investments.

Reduce tariffs and behind-the-border barriers on environmental goods, based on clear classification of such goods. Ensure transparency by publishing the classification and providing advance rulings.

Requires integration in a strategy of broad tariff modernization with low, uniform rates and elimination of para-tariffs.

Enact a climate change act to align policies and programs between line ministries and establish a high-level national coordination committee.

Provides high-level mandate for climate change prioritization and a mechanism for policy implementation, including leadership of the climate fiscal framework.

Develop a risk financing strategy and instruments to mobilize additional resources and cover contingent liabilities.

Adopt innovative strategies for climate finance, including land-based financing and risk insurance. Ministry of Finance to identify government priorities and implement a strategy with a comprehensive risk-layering approach to cover the government's explicit and implicit liabilities. Explore risk financing instruments to crowd in private sector. Green bonds/green *sukuk* can help raise long-term funding. Green bond guidelines needed for sovereign and private issuances, consistent with international standards. Leverage spatial risk assessment data and prioritize programs that target the poor, including property insurance.