Netherlands Commission for Environmental Assessment
Dutch Sustainability Unit

Climate Change Profile: BANGLADESH

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Advisory Report by the Dutch Sustainability Unit

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Climate Change Profile: Bangladesh

Bangladesh is often cited as one of the most vulnerable countries to climate change. It ranked sixth on German Watch's Global Climate Risk Index 2016[1]. This vulnerability is caused by a combination of biophysical factors (being a flat, low, delta country, exposed to flooding and cyclones)[2] and socio-economic factors (such as high dependence on agriculture, population density, and poverty)[3]. Hotspots of climate change vulnerability, where both biophysical and socio-economic vulnerability are high, are in the central and western coastal area, the north-western highlands, and along the main rivers.

This profile gives an overview of factors that contribute to climate change vulnerability, and of what is being done to address these. Its thematic focus is on factors related to food security and water. The profile aims to give practitioners the information needed to address climate change in these two sectors.

Overall ranking

Bangladesh ranks 140 out of 180 countries in the ND-GAIN index[4] (2014), which is slightly better than in 2013 (rank 143). Bangladesh is the 43rd most vulnerable country and the 37th least ready country- meaning that it is vulnerable to, yet unready to combat climate change effects. *Vulnerability* measures the exposure, sensitivity, and ability to cope with climate related hazards by accounting for the overall status of food, water, environment, health, and infrastructure within a country. *Readiness* targets those portions of the economy, governance and society that affect the speed and efficiency of adaptation.

Biophysical vulnerability

Current climate. Bangladesh has a unique geography, situated on the Bay of Bengal and forming one of the largest deltas in the world with a dense network of tributaries of the Ganges, Brahmaputra and Meghna (GBM) Rivers. Most of the country is less than 10 m above sea level (and 10% is less than 1 m).

Bangladesh has a monsoon-type climate. It has three seasons:

- hot, humid summers (March-June) with average maximum temperatures of 37 °C;
- cooler monsoon seasons (June-September);
- dry, cooler winters (October-March) with average maximum temperatures of 28 °C[5].

[1] Kreft, S. et al (2015). Global Climate Risk Index 2016. Who suffers most from extreme weather events? Weather-related loss events in 2014 and 1995 to 2014. Germanwatch website: https://germanwatch.org/en/download/13503.pdf

[2] Ayers, J.; Huq, S.; Wright, H.; Faisal, A.M.; Hussain, S.T. (2014): Mainstreaming climate change adaptation into development in Bangladesh. *Climate and Development* 6(4): 293-305. http://dx.doi.org/10.1080/17565529.2014.977761

[3] Thomas, T.S.; Mainuddin, K.; Chiang, C.; Rahman, A.; Haque, A.; Islam, N.; Quasem, S.; Sun, Y. (2013): *Agriculture and Adaptation in Bangladesh: Current and Projected Impacts of Climate Change*. IFPRI Discussion Paper 01281. http://www.ifpri.org/sites/default/files/publications/ifpridp01281.pdf

[4] GAIN index summarizes a country's vulnerability to climate change and other global challenges in combination with readiness to improve resilience. http://index.gain.org/country/bangladesh

[5] Karmalkar, A.; McSweeney, C.; New, M.; Lizcano, G. (2012): *UNDP Climate Change Country Profiles: Bangladesh*. Available via http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/UNDP_reports/Bangladesh/Bangladesh.hires.report.pdf

The highest **temperatures** are in the southwest, the lowest in the northeast of the country[6] (see Map 1).
Rainfall in Bangladesh also differs per season and per location. The central west receives the least, less than 1,400 mm per year, while the northeast and southeast receive over 3,000 mm per year[7] (see Map 2). About 80% of all precipitation falls during the monsoon season, in heavy, torrential rains[8].

Due to its topography and climate, Bangladesh is subject to devastating **cyclones**, mostly in April–May and September–November[9]. UNDP has ranked Bangladesh first of all countries in the world in terms of vulnerability to tropical cyclones. The country is hit by a severe cyclone on average every three years[10].

Bangladesh is also vulnerable to **flooding**, with 80% of its surface forming a giant floodplain[11]. Floods originate from precipitation in the whole of the GBM Basin, not just the 7% that lies within Bangladesh, and can therefore be of great magnitude[12]. Most of the floods occur in July and August, almost every year[13]. In an average year, about 25% of the country is inundated. During severe floods, occurring every 4–5 years, over 60% of the country is covered. These floods have devastating effects. Riverbank **erosion** results in the loss of thousands of hectares of agricultural lands[14] and affects the population for decades[15]. Moreover, floods contribute to further **salinization** of coastal lands, causing not only loss of harvests but also of productive agricultural land[16]. Out of 2.85 million hectares of coastal and offshore areas, about 1.2 million hectares of arable land are already affected by varying degrees of soilsalinity[17].

[6] World Bank (2011): *Vulnerability, Risk Reduction, and Adaptation to Climate Change: Bangladesh*. World Bank Climate Risk and Adaptation Country Profile. http://sdwebx.worldbank.org/climateportalb/doc/GFDRRCountryProfiles/wb_gfdrr_climate_change_country_profile_for_BGD.pdf

[7] Thomas et al. (2013)

[8] Karmalkar et al. (2012)

[9] Karmalkar et al. (2012)

[10] MoEF (2009): *Bangladesh Climate Change Strategy and Action Plan*. Ministry of Environment and Forests, Government of the People's Republic of Bangladesh. http://cmsdata.iucn.org/downloads/bangladesh_climate_change_strategy_and_action_plan_2009.pdf

[11] Ayers et al. (2014)

[12] World Bank (2010a): *Economics of Adaptation to Climate Change: Bangladesh*. https://openknowledge.worldbank.org/bitstream/handle/10986/12837/702660v10ESW0P0IC000EACC0Bangladesh.pdf?sequence=1

[13] Sharmin, Z.; Islam, M.S. (2013): *Consequences of Climate Change and Gender Vulnerability: Bangladesh Perspective*. http://www.bangladeshstudies.org/files/WPS_no16.pdf

[14] MoEF (2009)

[15] Sharmin and Islam (2013)

[16] Thomas et al. (2013)

[17] World Bank (2011)

While many parts of Bangladesh suffer from widespread and common floods, other parts experience seasonal **droughts**[18]. These occur especially in the northwest of the country, and mostly in the months leading up to the November-December rice harvest[19]. See Map 3 for an overview of the different types of extreme climatic events and their distribution over the country.

Current trends. Changes have been observed in the climate of Bangladesh. Overall, weather patterns have been erratic and less predictable than before[20]. Total annual **rainfall** for the country as a whole has not changed significantly between 1960 and 2003, although there has been a significant increase in some parts, most notably the west and northwest (see Map 4). There has also been a significant increase in certain seasons, including a 3.4% increase in country-wide rainfall during the pre-monsoon summer season and a 1.7% decrease in monsoon rainfall[21]. See Map set 5 for a differentiation per season for different regions. The rainy season has become shorter, and heavy rainfall occurs within a shorter period. The cool, dry season has also decreased in length[22]. Average **temperature** shows an increasing trend, especially during the monsoon season (June-August) at 0.07°C per decade and during early winter (September-November) at 0.12°C per decade[23]. According to IPCC figures (2007), higher temperatures and erratic rainfall have in some areas contributed to wetlands drying up and ecosystems degrading[24].

Under the current climatic trends, the incidence of **extreme events** is also changing. A significant increase has been observed in cyclone frequency during the 'cyclone seasons' in November and May[25]. Some regions of Bangladesh are increasingly prone to drought; a small increase in dry months has been measured in the far northwest of the country (see Map 6). A relatively new phenomenon in Bangladesh is landslides which have in recent years occurred more frequently, caused by heavy rain events[26].

Significant **sea level rise** has been measured in Bangladesh, with 4 mm per year at Hiron Point in the west, 6 mm per year at Char Changa in the centre of the country, and even 8 mm per year at Cox's Bazar in the southeast[27]. Sea level rise has been one of the factors that led to an increase in soil salinity in Bangladesh, from 1.5 million hectares under mild salinity in 1973 to 3 million in 2007[28].

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[18] Xenarios, S.; Sarker, G.W.; Biswas, J.C.; Maniruzzaman, M.; Nemes, A.; Nagothu, U.S. (2014a): *Agricultural interventions and investment options for climate change in drought and saline-flood prone regions of Bangladesh*. Bioforsk. http://www.riceclima.com/wp-content/uploads/2014/05/BIOFORSK-RAPPORT_AgricInterventions.pdf

[19] MoEF (2009)

[20] World Bank (2011)

[21] Karmalkar et al. (2012)

[22] Thomas et al. (2013)

[23] Karmalkar et al. (2012)

[24] Al Mamun, A.; Al Pavel, M.A. (2014): Climate Change Adaptation Strategies through Indigenous Knowledge System: Aspect on Agro-Crop Production in the Flood Prone Areas of Bangladesh. *Asian Journal of Agriculture and Rural Development* 4(1): 42-58. http://ageconsearch.umn.edu/bitstream/198381/2/6-383-AJARD-4%281%292014-42-58.pdf

[25] World Bank (2011)

[26] Sharmin and Islam (2013)

[27] Sharmin and Islam (2013)

[28] Khatun, F.; Nazrul Islam, A.K.M. (2010): *Policy agenda for addressing climate change in Bangladesh: Copenhagen and beyond*. CPD Occasional Paper 88. http://www.cpd.org.bd/pub_attach/op88.pdf

Lastly, **glacial melt** in the Himalayas – accelerated by increasing temperatures – is having effects on many of the great river basins downstream, including the GBM Basin. Himalayan glaciers have reduced by 21% (in area) since the 1980s[29] and have lost about 174 gigatonnes of water between 2003 and 2009, which contributed to catastrophic floods in these basins[30].

Climate change. Future climate change projected for Bangladesh is less ambiguous than for many other countries: there is agreement among most models that both temperatures and rainfall will increase significantly. Mean annual **temperatures** are projected to increase by ca. 1.8°C by the 2060s and 2.7°C by the 2090s (compared to 2010), although some project increases up to 4.1°C for the 90s (compared to the 1970–2000 mean)[31]. The largest increase is projected for the dry winter season[32], where a temperature increase of 4.1°C may occur by the 2070s[33]. Southern regions are likely to have a somewhat smaller increase than northern regions: the latter may, in the most extreme scenarios, experience an increase of 5.3°C by the 2090s, relative to the 1970–2000 mean climate (see Map set 7).

Bangladesh is expected to be 4% wetter by the 2050s[34]. By the 2090s, mean annual **rainfall** is projected to increase by on average 7% compared to the 1970–2000 mean climate (although some models project increases up to 24%). Regionally, this increase is expected to be higher in the north and northwest, and lower in the south of the country (see Map set 8). The highest increases will take place in the monsoon season (on average 14% by the 2090s)[35] and the post-monsoon season (September–November; 17% by the 2070s[36]). For the dry winter season, projections are mixed – with some models projecting rainfall decreases[37] and others projecting increases of about 10% by the 2070s[38]. Large increases are expected in 5-day rainfall maxima, especially during the wet season, and an increasing portion of total rainfall will fall during 'heavy rainfall events' (see Map set 9) – indicating a rainfall pattern with more extremes[39].

Extreme events in Bangladesh, such as cyclones and floods, will be both heavier and more frequent[40]. Floods will not only be more frequent and cover a larger area of land, but inundation depth will also increase significantly in most of the country (see Map set 10). In some parts of the northwest seasonal droughts may become heavier due to erratic rainfall and delayed monsoons[41].

[29] World Water Assessment Programme (2009): *Water in a Changing World*. UN World Water Development Report 3. http://unesdoc.unesco.org/images/0018/001819/181993e.pdf

[30] Laghari, J. (2013): Climate change: Melting glaciers bring energy uncertainty. *Nature* 502(7473): 617–618. http://www.nature.com/news/climate-change-melting-glaciers-bring-energy-uncertainty-1.14031

[31] Karmalkar et al. (2012)

[32] Khatun and Nazrul Islam (2010)

[33] Roy, K.; Rahaman, M.; Kumar, U. (2009): Future Climate Change and Moisture Stress: Impact on Crop Agriculture in South-Western Bangladesh. *Climate Change and Development Perspective* 1(1). http://www.unnayan.org/documents/Climatechange/futureclimatechange.pdf

[34] World Bank (2010a)

[35] Karmalkar et al. (2012)

[36] Roy et al. (2009)

[37] Khatun and Nazrul Islam (2010)

[38] Roy et al. (2009)

[39] Karmalkar et al. (2012)

[40] Thomas et al. (2013)

[41] Xenarios et al. (2014a)

The **sea level** will also rise further. The IPCC projected increases of 14 cm by 2030, 32 cm by 2050, and 88 cm by 2100 (compared to 2000)[42]. Relative sea level rise in Bangladesh is greater than in many other countries, due to the simultaneous submergence of low coastal areas. This will affect a large number of people: by 2050, about 27 million will be at risk due to the effects of sea level rise. A 1-meter sea level rise would inundate 18% of the country's land[43]. Moreover, sea level rise and cyclones have combined effects: cyclone-induced storm surges are projected to inundate an additional 15% of the coastal area[44].

For **glacial melt** in the Himalayas, the future is highly uncertain; projections of the rate and effects of melting are lacking. However, the already reported rate of current melting combined with findings that the rate of glacial retreat is accelerating over time[45] give reason to expect major effects in the future.

The effects of climate change will differ per region:

- the northwest will suffer most from temperature increase and drought;
- the centre and northeast of the country will suffer from increased frequency and intensity of floods;
- the coastal area and islands will experience effects of sea level rise and salinity intrusion (see Map 11 and Map set 12), as well as increased cyclone frequency and intensity, while urban coastal areas will suffer from drainage congestion[46].

Climatic changes will influence both **food security** and **water availability**[47]. Anticipated effects include:

- increased temperatures, especially if combined with standing water, lead to an increase in diseases, pests, insect attacks, etcetera (including those that affect livestock);
- changing seasons (with the length of the crop growing periods decreasing between 2000 and 2030, see Map set 13), and erratic rainfall will lead to lower crop productivity or harvest failures;
- higher temperatures will lead to higher rates of evaporation, which may increase by 10-20% already by 2030[48] - leading to higher irrigation requirements;
- glacial melt in the Himalayas, combined with increased monsoon rainfall in the whole of the Ganges-Brahmaputra-Meghna (GBM) Basin (up to +20%[49]) will lead to higher quantities of river discharge. An increase in glacial melt, which already contributes to up to half of the current river flow in the basin[50], will increase runoff especially during early spring, when

[42] Khatun and Nazrul Islam (2010)

[43] World Bank (2010b): *Implications of Climate Change for Fresh Groundwater Resources in Coastal Aquifers in Bangladesh*. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2010/09/13/000334955_20100913054039/Rendered/PDF/565560WP0P1059980Box353728B01PUBLIC1.pdf

[44] World Bank (2010a)

[45] Yao, T.; Thompson, L.; Yang, W.; Yu, W.; Gao, Y.; Guo, X.; Yang, X.; Duan, K.; Zhao, H.; Xu, B.; Pu, J.; Lu, A.; Xiang, Y.; Kattel, D.B.; Joswiak, D. (2012): Different glacier status with atmospheric circulations in Tibetan Plateau and surroundings. *Nature Climate Change* 2: 663-667. http://www.nature.com/nclimate/journal/v2/n9/full/nclimate1580.html

[46] Thomas et al. (2013)

[47] Compilation of: Thomas et al. (2013); World Bank (2011); MoEF (2009)

[48] Mahmood, S.A.I. (2012): Impact of Climate Change in Bangladesh: The Role of Public Administration and the Government's Integrity. *Journal of Ecology and the Natural Environment* 4(8): 223-240. http://www.bdresearch.org/home/attachments/article/nArt/14_impact_of_cc_role_of_pubadmin.pdf

[49] World Bank (2010a)

[50] Laghari (2013)

irrigation water demand is still low[51]. Median summer discharges of the three rivers will increase by 6-18% by 2050[52] and up to 50% by the 2070s[53]. This increases risks of flooding and requirements for drainage capacity;

- floods lead to harvest failures, destruction of infrastructure that is vital for agricultural production, and increased sedimentation in riverbeds which causes drainage congestion and waterlogging;
- river and soil erosion and landslides lead to loss of agricultural land and production;
- sea level rise leads to salinity and saltwater intrusion, which negatively affects conditions for crop cultivation and decreases availability of freshwater resources for consumption and production. Pumping of fresh groundwater in coastal aquifers, to adapt to salinization, further accelerates saltwater intrusion and degradation of water quality, thus creating a vicious circle[54]. Recent studies indicate that increased salinity in rivers is likely to affect the districts Bagerhat, Barguna, Barisal, Bhola, Khulna, Jhalokati, Pirojpur and Satkira most severely. Increased soil salinity is expected to affect many areas of Barisal, Chittagong and Khulna. Increase of soil salinity is expected to vary from 26% up to 55% in most affected areas, by 2050[55];
- more droughts in some areas will reduce crop/livestock productivity and increase irrigation demand;
- Cyclones and storm surges destroy vital infrastructure and lead to harvest failures.

Specific effects on food security are discussed further below, since they are related to socio-economic factors such as the cultivation of specific crops and the use of certain farming methods.

Socio-economic vulnerability

Vulnerability to climate change is related not only to biophysical factors, but also to social, cultural, and economic ones. Socio-economic aspects that affect climate change vulnerability in Bangladesh include the country's dependence on agriculture (most notably rice cultivation) and other resource-dependent sectors, its economic growth and poverty (which forms a vicious cycle with climate change effects), health, gender, population density and migration. See Map set 14 for hotspots where social and biophysical factors combined represent a significant vulnerability to climate change.

Key facts:

GDP (PPP) per capita (2015)[56]:	USD 3,332.8
Population (May 2016)[57]:	162,750,067
Projected population (2050)[58]:	202,209,000
Population density per km^2 (2015)[59]:	1,236,8

[51] World Water Assessment Programme (2009)
[52] World Bank (2010a)
[53] Mahmood (2012)
[54] World Bank (2010b)
[55] http://www.worldbank.org/en/news/feature/2015/02/17/salinity-intrusion-in-changing-climate-scenario-will-hit-coastal-bangladesh-hard
[56] World Bank Data - GDP per capita, PPP. http://data.worldbank.org/indicator/NY.GDP.PCAP.PP.CD
[57] World Population Review - Bangladesh. http://worldpopulationreview.com/countries/bangladesh-population/#popClock
[58] UNDESA (2015): *World Population Prospects: The 2015 Revision.* http://esa.un.org/wpp/
[59] World Bank Data - Population density. http://esa.un.org/unpd/wpp/Download/Standard/Population

Human Development Index (2014)[60]:	142 out of 188 countries
Corruption Perception Index (2015)[61]:	139 out of 168 countries
Gender Inequality Index (2015)[62]:	111 out of 188 countries
Adult literacy (2015)[63]:	61,5% (male 64,6%; female 58.5%)

Part of Bangladesh's vulnerability to the effects of climate change stems from its dependence on agriculture. Although the agricultural sector contributes only 16% to the country's GDP, almost half (47%) of the Bangladeshis are employed in the agricultural sector, with rice as most important product[64]. Within the agricultural sector, the largest sub-sector is crop cultivation (8.73% of GDP), followed by fisheries (3.29%), livestock (2.07%) and forestry (1.42%)[65].

Climate change effects are already being noticed by farmers in Bangladesh. One study found that 80% of farmers reported that they had noted changes in climate, with the most cited changes being unseasonable rain, a more intense dry season, and less rain. More than half of the respondents reported that their agricultural land had been affected by natural hazards in the last five years, of which the most common were floods, droughts and cyclones. Farmers reported having lost on average 12% of their harvests to some kind of shock, half of which were attributable to flooding and related issues (including water logging and river erosion)[66].

These effects are likely to increase as climate change continues. It has been estimated that increased droughts may in the future cause 40% reductions in crop productivity in some areas in the northwest by 2050, while erratic rainfall can cause a 30% reduction[67].

Climate change has different impacts on different crops. In Bangladesh, **rice** is by far the most important crop. Rice cultivation occupies 77% of all cropland, employ 65% of the country's labour force and provide 95% of all food grain consumption[68] (as well as 63% of the caloric intake for urban consumers and 71% for rural consumers[69]). The three main crops in order of area harvested are rain fed aman rice (monsoon-winter), irrigated boro rice (winter), and aus rice (summer). They are followed by jute, wheat, potato, maize, and sugarcane. In terms of volumes produced, rice is followed by potato, sugarcane and maize[70].

For rice cultivation in Bangladesh, the effects of climate change are relatively well documented. The following effects are reported[71]:

[60] UNDP (2015). http://hdr.undp.org/en/content/table-1-human-development-index-and-its-components
[61] https://www.transparency.org/cpi2015/#results-table
[62] http://hdr.undp.org/en/composite/GII
[63] World Factbook (2015). https://www.cia.gov/library/publications/the-world-factbook/fields/2103.html
[64] Bangladesh Bureau of Statistics, http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/GDP/GDP_2014-15_Final.pdf; World Factbook, accessed May 2016: https://www.cia.gov/library/publications/the-world-fact-book/geos/bg.html
[65] Thomas et al. (2013)
[66] Thomas et al. (2013)
[67] Thomas et al. (2013); Khatun and Nazrul Islam (2010)
[68] Xenarios et al. (2014a)
[69] Wright, H.; Kristjanson, P.; Bhatta, G. (2012): *Understanding Adaptive Capacity: Sustainable Livelihoods and Food Security in Coastal Bangladesh*. CCAFS Working Paper No. 32. http://www.seachangecop.org/sites/default/files/documents/2012%2011%20CCAFS%20-%20Understanding%20Adaptive%20Capacity_Bangladesh.pdf
[70] Thomas et al. (2013)
[71] Compilation of: Khatun and Nazrul Islam (2010); MoEF (2009); World Bank (2010a);

- current temperatures are already approaching critical levels during the susceptible stages of rice plants in March–June;
- aman rice production will be affected by more frequent and intense floods, while boro rice will suffer from (seasonal) limited availability of surface water and depletion of groundwater levels;
- about 60% of the land used for rice production will be affected by seasonal drought by 2030 (alternating with increased rainfall and flooding in other seasons), leading to a similar percentage of Bangladesh's rice yields being affected by drought in some way;
- about 55,000 hectares of paddy land and 121,000 tonnes of paddy rice will be lost due to inundation by 2030;
- soil salinity will eventually cover about 20% of the total paddy cultivation area, leading to a potential loss of another 395,000 tonnes of rice;
- by 2050, Bangladesh's total rice production will be decreased by about 8% (compared to 1990) according to some sources; according to others, climate change will lead to a cumulative loss of 80 million tonnes of rice between 2005 and 2050 – equal to two years' worth of rice production lost over a period of 45 years.

Effects on rice production differ for different regions of the country. The south is most vulnerable: for Khulna region, for instance, losses of 10% for aus and aman rice and 18% for boro rice are expected for the 2050s – in large part due to sea level rise. The northwest is also vulnerable, since for this area the estimated lost volume of rice is a large fraction of existing household consumption[72].

For cultivation of some other important crops, effects of climate change have been described as follows:

- **Wheat:** by 2050, up to 32% of Bangladesh's total wheat production may be lost[73], primarily due to heat stress. Even if optimum planting dates, varieties and fertilizer application are used, still 15% of yields is expected to be lost[74]. Import of wheat from other South Asian countries will be difficult and prices will be high, because up to 50% of the region's total wheat yields may be lost[75].
- **Potato:** potato yields are expected to suffer increasingly from moisture stress due to untimely rainfall (currently 64% of yields is lost due to moisture stress; this will increase to 76% by 2030). Up to 22% more irrigation would be required to cope with this[76].
- **Maize:** for rain fed maize, a productivity reduction of 10–20% is projected (2000–2050) if current planting dates and varieties are used. If newly optimised dates and varieties are used, however, maize yields may increase. Since maize prices are projected to increase more than prices of any other food commodity (209% by 2050), some have suggested that a switch from rice to maize production could be advantageous for farmers in Bangladesh[77].

Wright, H. (2014): *What does the IPCC say about Bangladesh?* ICCCAD Briefing October 2014. http://www.icccad.net/wp-content/uploads/2015/01/IPCC-Briefing-for-Bangladesh.pdf

[72] World Bank (2010a)

[73] Khatun and Nazrul Islam (2010); MoEF (2009)

[74] Thomas et al. (2013)

[75] Wright (2014)

[76] Roy et al. (2009)

[77] Thomas et al. (2013)

- **Sugarcane, soybeans and sorghum:** Productivity of each of these (rain fed) crops is expected to decline by 7.5–10% between 2000 and 2050, regardless of any change in farming practices[78].

Apart from the effects of climate change on national production, Bangladesh will also experience effects of increasing international food prices. For all cereals (including rice, maize, wheat, etc.), Bangladesh does not export, but imports over USD 500 million worth of food per year (in 2011) from India and Pakistan. In the future, imports may increase vastly if climate change affects yields all over South Asia[79].

Not only crop cultivation, but also livestock will be affected by climate change. Livestock are an important source of income and food for the rural poor of Bangladesh. Drought, salinity intrusion, heat waves, cyclones and floods are all expected to affect the livestock sector negatively[80]. In many cases there is an indirect effect, because lower crop yields make it difficult for people to provide food for their cattle[81].

Fisheries are also affected by climate change effects such as floods, riverbank erosion, cyclones, and storm surges. Aquaculture infrastructure can be lost and fishers may have to stay at home during longer periods of cyclones[82]. Saline water intrusion has caused fisheries to end their practices in certain areas, although it has also been reported that this created new opportunities for shrimp farming[83].

Forest resources, important for the livelihoods of the poor especially in the Sundarbans area, are severely affected by salinity intrusion, floods, and cyclones. Sea level rise is likely to affect forest coverage and biodiversity in coastal areas severely. In other areas, prolonged droughts prevent the growth of trees[84].

Through its effects on agriculture and other resource-dependent sectors, climate change affects the national economy of Bangladesh. Climate change is expected to decrease agricultural GDP by 3.1% each year, equal to a cumulative loss in added value of USD 36 billion between 2005 and 2050. This increases to a cumulative USD 129 billion if also indirect impacts on complementary industries are included[85].

These economic effects of climate change also contribute to a potential increase in poverty in Bangladesh. Some of the most serious effects of climate change will be concentrated in areas that also have the highest concentrations of poor people. Among these are the low-lying Haor depression in the northeast; the drought-prone higher area in the northwest; several districts

[78] Thomas et al. (2013)

[79] Jha, R.K.; Singh, N.K. (2013): *Climate Change, Food Security and Trade Linkages in South Asia*. http://www.cuts-citee.org/pdf/Briefing_Paper13-Climate_Change_Food_Security_and_Trade_Linkages_in_South_Asia.pdf

[80] Thomas et al. (2013)

[81] World Bank (2010c): *The Social Dimensions of Adaptation to Climate Change in Bangladesh*. World Bank Discussion Paper Number 12. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2011/01/11/000333037_20110111020245/Rendered/PDF/588990NWP0Bang10Box353823B01public1.pdf

[82] Thomas et al. (2013)

[83] World Bank (2010c)

[84] Thomas et al. (2013); World Bank (2010c)

[85] World Bank (2010a)

among the major rivers, particularly the Jamuna; and several south-eastern districts, including the Chittagong Hill Tract[86] (see Map set 14). Climate change thus affects the poor disproportionately. Moreover, many poor households depend on climate-sensitive sectors such as agriculture and fisheries for their livelihoods. Destruction of their livelihoods and assets leaves them with a limited capacity to recover[87]. Among poor populations, the most vulnerable to climate change are the urban poor and the rural poor with insecure land tenure, particularly of the lower Adivasi castes[88].

Levels of food insecurity in Bangladesh are already high, with 56% of households reporting periods with food shortages during each year (of which one third even faces food deficits for over half the year)[89]. Climate change is likely to increase these figures: it has been reported that climate change may cause a net increase in poverty of up to 15% between 2000 and 2030 (in a low productivity scenario)[90]. At the same time, both poverty and food insecurity limit people's resilience and capacity to adapt to climate change – leaving the more vulnerable to its effects.

The same two-way relationship exists between climate change and health. Climate change is likely to affect people's health negatively because it creates favourable conditions for outbreaks of infectious diseases such as cholera (which requires high temperatures) or vector diseases such as malaria (mosquitoes prefer both high temperatures and standing water). There are reports that such effects are already being felt in Bangladesh[91].

Among the most vulnerable populations to climate change are women and girls, due to their limited access to resources and decision-making processes. In times of climate-related disasters (which are likely to happen more often in the future), women are hit harder than men: in the past, cyclones and floods have been associated with death rates for women five times higher than for men. Women are often unable to access information which is distributed in public spaces, may not be allowed to leave their homes without a male relative, and cannot swim.

Women are considered more vulnerable than men to slower and less abrupt effects of climate change, such as changing rainfall patterns or increasing temperatures. Women's household responsibilities are often strongly resource-dependent: fetching fresh water for consumption and production, for example, becomes increasingly difficult under salinization and drought[92]. It has also been found that Bangladeshi women's agricultural resources (such as livestock) are sold off first in times of scarcity while men's resources are preserved; this further increases their vulnerability because it limits their assets[93]. Women often have very limited access to land and land ownership, which means that they have no collateral for insurances against climate risks and simultaneously makes them less inclined to make long-term investments in land

[86] World Bank (2010c)
[87] World Bank (2010a)
[88] Ayers et al. (2014)
[89] Wright et al. (2012)
[90] Wright (2014)
[91] Mahmood (2012)
[92] Sharmin and Islam (2013)
[93] Aberman, N.; Birner, R.; Ali, S. (2011): *A Stakeholder Map for Climate Change Adaptation in Bangladesh's Agricultural Sector*. IFPRI. http://womenandclimate.ifpri.info/files/2012/03/Bangladesh_Net-Map_final.pdf

conservation measures[94]. Especially in the most climate-vulnerable areas, women are often left alone to take care of their households because men migrated elsewhere to find alternative livelihoods[95].

Unless existing coastal polders are strengthened and new ones built, millions of people will become 'climate migrants' due to sea level rise. Estimates are for 6-8 million people from Bangladesh's coastal zones to be displaced by 2050[96], with 20 million environmental refugees due to climate change in general by 2100. Migration will increase pressures on land and resources in other parts of Bangladesh, which will exacerbate existing problems in this country that is already extremely densely populated[97].

Socio-economic vulnerability to climate change in Bangladesh differs per region. One study compares different districts in saline flood prone Barisal (south Bangladesh) and in drought-prone Rajshahi (north Bangladesh), assessing their adaptive capacity to climate change by combining different socio-demographic, agro-economic and infrastructural indicators. They found the saline flood prone districts to be on average more vulnerable to climate change than the drought-prone districts[98]. Another study suggests the coast of Bangladesh to be most vulnerable to climate change effects, due to the multiple hazards that it faces (including cyclones, flooding, sea level rise, and soil salinity) combined with the vulnerability of activities in the area (fisheries, shrimp farms, but also ports, airports, and tourism)[99].

National government strategies and policies

Bangladesh has ratified the UN Convention on Biological Diversity (CBD) for which it elaborated a National Biodiversity Strategy and Action Plan in 2004, the Convention to Combat Desertification (CCD), the Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. It has prepared two National Communications for the UNFCCC and a National Action Plan for Adaptation (NAPA). The NAPA was developed between 2003 and 2005 with support from GEF, and has been updated in 2009. The 2009 update identified 38 adaptation measures[100]. Although the NAPA was generally well regarded, only one of its projects, focusing on coastal afforestation, was funded (by GEF) and implemented[101].

In 2008, adaptation priorities from the NAPA were updated and embedded in a new Bangladesh Climate Change Strategy and Action Plan (BCCSAP)[102]. The BCCSAP describes 44 immediate, short, medium and long-term programmes, based on six pillars:

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[94] Ayers et al. (2014)

[95] Wright (2014)

[96] MoEF (2009)

[97] Mahmood (2012)

[98] Xenarios, S.; Nemes, A.; Nagothu, U.S.; Sarker, G.W.; Biswas, J.C.; Maniruzzaman, M. (2014b): *Climate Change and Vulnerability in Bangladesh*. Bioforsk TEMA No. 11. http://www.researchgate.net/profile/Stefanos_Xenarios2/publication/261099543_Climate_Change_and_Vulnerability_in_Bangladesh/links/02e7e5333524d8617e000000.pdf?disableCoverPage=true

[99] World Bank (2010b)

[100] Nakhooda, S.; Norman, M.; Barnard, S.; Watson, C.; Greenhill, R.; Caravani, A.; Canales Trujillo, N.; Hedger, M.; Whitley, S. (2014): *Climate finance: is it making a difference?* ODI. http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9359.pdf and http://www.climatechangecell.org.bd/Documents/NAPA%20october%202009.pdf

[101] Ayers et al. (2014)

[102] Nakhooda et al. (2014); BCCAP http://www.bcct.gov.bd/images/law/Bangladesh%20Climate%20Change%20Strategy%20and%20Action%20Plan%202009.pdf

- food security, social protection and health;
- comprehensive disaster management;
- infrastructure;
- research and knowledge management;
- mitigation and low carbon development;
- capacity building and institutional strengthening[103].

The BCCSAP was revised in 2009, allowing more involvement of relevant stakeholders (among others the Bangladesh Agricultural Research Council and the Water Resources Planning Organization)[104]. The 7th five-year plan mentioned that the BCCSAP needs to be updated.

The framework for enactment of the BCCSAP is Bangladesh's Vision 2021 (and its concretisation in the 7th Five Year Plan)[105]. These documents also contain chapters on climate change – and the National Planning Commission integrates climate change into the Annual Development Programme (in the sectors agriculture, transport, rural development, and water)[106].

Priorities for climate change adaptation and mitigation are also elaborated in a number of sector policies and plans, including the Coastal Zone Policy, the National Water Management Plan[107], the National Water Act, the Master Plan for Agricultural Development in the Southern Region of Bangladesh, the National Agricultural Policy, and the Food Policy's Plan of Action[108]. In most of these, the focus is on adaptation.

In the implementation of these policies and strategies, various institutions are involved. The Ministry of Environment and Forests (MoEF) is the focal ministry for climate change and led the development of the NAPA and BCCSAP. A Bangladesh Climate Change Trust (formerly Climate Change Unit) within the MoEF coordinates the Climate Change Cells that were placed within relevant ministries[109]. A study on the network of finance and activities around climate change in Bangladesh found that this network is highly centralized, with a small number of core players, being MoEF, MoFDM (Ministry of Food and Disaster Management) and UNDP. Other actors of influence on climate change activities were found to be MoA (Ministry of Agriculture), DAE (Department of Agricultural Extension), FAO and USAID[110]. An All-Party Parliamentary Group (APG) on climate change and environment was established in 2009 as a cluster of 121 MPs, representing all major parties in the country. NGOs play an important role, both in development of the BCCSAP but also as implementing entities under the BCCRF and BCCTF (see below)[111].

[103] MoEF (2009)
[104] World Bank (2011)
[105] MoEF (2009); 7th Five Year Plan: http://www.plancomm.gov.bd/7th-five-year-plan/
[106] Ayers et al. (2014); http://www.plancomm.gov.bd/wp-content/uploads/2015/02/11a_Climate-Change-and-Disaster-Management.pdf
[107] World Bank (2010a)
[108] Ayers et al. (2014)
[109] Ayers et al. (2014)
[110] Aberman, N.; Birner, R.; Haglund, E.; Ngigi, M.; Ali, S.; Okoba, B.; Koné, D.; Alemu, T. (2015): *Understanding the Policy Landscape for Climate Change Adaptation*. IFPRI Discussion Paper 01408. http://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/128928/filename/129139.pdf;
Aberman et al. (2011)
[111] Ayers et al. (2014)

Effectiveness of the institutions involved in climate change adaptation is often hampered by limited capacity (e.g. in MoEF), lack of coordination, and limited participation of small farmers and fishers in planning. Corruption or mismanagement (see Bangladesh's high corruption index ranking) moreover affect effectiveness of governmental interventions, including those linked to climate change[112].

Intended Nationally Determined Contributions (INDC)

In its INDC Bangladesh presents itself as being highly vulnerable to climate change and projects that it will experience an annual loss of 2% of GDP by 2050 and a loss 9.4% of GDP by 2100[113]. Although its emissions are less than 0.35% of global emissions, in the INDC Bangladesh commits to play its part in the global collective action to reduce future GHG emissions, while working towards becoming a middle-income country by 2021 without exceeding the average per capital emission of the developing world, Supported by existing strategies and plans (e.g. BCCSAP, Renewable Energy Policy 2008, Energy Efficiency and Conservation Master Plan, Vision 2021 and the consecutive five-year plans)[114].Its INDC sets out a number of mitigation actions that will help the country's GHG emissions For its mitigation contribution the INDC includes both unconditional (based on existing resources) and conditional (subject to appropriate international support in the form of finance, investment, technology development and transfer, and capacity building) emission reduction goals for the power, transport and industry sectors, alongside further motional actions in other sectors.

Mitigation contribution consists of:

- an **unconditional contribution** to reduce GHG emission by **5%** (from Business as usual [BAU] levels by 2030 in the power, transport and industry sectors;
- a **conditional 15% reduction** in GHG emissions from BAU levels by 2030 in the power, transport and industry sectors;
- a number of further mitigation actions in other sectors which it intends to achieve subject to the provision of additional international resources (conditional).

The INDC also includes an adaptation component which includes the long-term vision for adaptation and synergies with mitigation actions. It was estimated by the World Bank in 2010[115] that Bangladesh will need to invest **$40 billion** from 2015 to 2030 in order to implement identified adaptation measures, such as improved early warning system, disaster preparedness, surge protection, flood-proofing and protection, climate resilient infrastructure and communication, drainages systems, stress tolerant variety improvement and cultivation |(Including livestock and fisheries), climate change impacts on health, biodiversity and ecosystem conservation and capacity building.

[112] Aberman et al. (2011)

[113] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Bangladesh/1/INDC_2015_of_Bangladesh.pdf

[114] http://www4.unfccc.int/submissions/INDC/Published%20Documents/Bangladesh/1/INDC_2015_of_Bangladesh.pdf

[115] World Bank. 2010. Main report. Washington, DC: World Bank. http://documents. worldbank.org/curated/en/2010/01/16420806/bangladesh-economic-adaptation-climate-change-vol-1-2-main-report

Climate finance

The World Bank calculated that the total costs of climate change adaptation in Bangladesh will be 5.7 billion dollars per year by 2050[116]. For the government of Bangladesh, the risks associated with climate change are significant. One analysis revealed that, out of the total USD 4.7 billion national budget for implementation of the Annual Development Plan, about USD 2.7 billion of investments are at risk due to climate change[117]. The government acknowledges this, and has between 1980 and 2010 invested over USD 10 billion to make the country more climate resilient and less vulnerable to natural disasters. These investments were made both for physical measures (polders, cyclone shelters, cyclone-resistant housing) and non-physical ones (early warning and awareness-raising systems)[118]. The current rate of government spending on climate change adaptation is about USD 1 billion per year – 6-7% of the total annual budget[119]. Although already quite significant, this amount will need to increase by five or six times in order to cover all the costs identified for climate change adaptation until 2050.

Bangladesh ranked second in a list of 'most successful low-income countries' in mobilising multilateral funding for climate change adaptation[120]. Climate funding from donors was reported to be USD 230 million in 2011 (from all financial sources), and USD 129 million in 2014 (only multilateral support). Multilateral support was given primarily for adaptation, and only 7% for mitigation[121]. These figures show that the vast majority of money spent on climate change comes directly from the government. The largest multilateral contribution is from the World Bank's Pilot Programme for Climate Resilience (PPCR), in which Bangladesh is one of the pilot countries and receives USD 110 million. The majority of this is used for long-term measures in coastal zones, such as roads, embankments and water supply infrastructure[122]. Its priorities resonate with investments under the national funds (see below). Bangladesh also received bilateral support for climate change adaptation/mitigation, among others from DFID, CIDA and USAID. DFID's pledged contribution of USD 132 million is a significant amount. In 2011, Germany also pledged to provide a EUR 10.9 million grant for adaptation and mitigation[123].

Bangladesh has two national climate change trust funds.
One is the **Bangladesh Climate Change Trust Fund** (BCCTF), created in fiscal year 2009-2010 and funded by the national government. As of June 2016, 440 BCCTF-funded projects have been undertaken: 377 projects are implemented by governmental bodies and autonomous agencies, while 63 projects are executed by NGOs. The government has allocated approximately USD 390 million during the last seven fiscal years, ranging from approximately USD 100 million in 2009-2010 to approximately USD 13 million for 2015-2016 as well as for 2016-2017 [124].

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[116] UNEP (2013): Bangladesh Uncovers the Crippling Cost of Climate Change Adaptation. http://www.unep.org/news-centre/default.aspx?DocumentID=2788&ArticleID=10864&l=en

[117] Hedger, M. (2011): *Climate Finance in Bangladesh: lessons for development cooperation and climate finance at national level*. http://www.edc2020.eu/fileadmin/publications/EDC_2020_-_Working_Paper_No_12_-_Climate_Finance_in_Bangladesh_Lessons_for_the_Development_Cooperation_and_Climate_Finance_at_National_Level.pdf

[118] MoEF (2009); World Bank (2010a)

[119] UNEP (2013)

[120] Nakhooda et al. (2014)

[121] Hedger (2011); Nakhooda et al. (2014)

[122] Hedger (2011); Nakhooda et al. (2014); Rai, N. (2013): *Climate Investment Funds: understanding the PPCR in Bangladesh and Nepal*. IIED. http://pubs.iied.org/pdfs/17151IIED.pdf

[123] World Bank (2011); Khatun and Nazrul Islam (2010); Mahmood (2012)

[124] http://www.bcct.gov.bd/index.php/trust-fund

The other is the **Bangladesh Climate Change Resilience Fund** (BCCRF), a multi donor trust fund, established in 2010, as a modality for the development partners to support Bangladesh in implementing the Bangladesh Climate Change Strategy and Action Plan. As of September 2016, 13 projects are funded through BCCRF, representing a worth of USD 146,4 million[125].

The creation of two climate funds arose from contested issues between the government and NGOs on one side and several donors on the other, concerning control of funds and fiduciary risk. Projects submitted to either fund must conform to BCCSAP priorities, whereas the BCCTF will follow procedures set up by MoEF and the BCCRF works by World Bank guidelines[126]. Although food security is a central theme of the BCCSAP and some national policies, only very little international climate finance targets this sector[127].

Climate change projects

A large number of projects related to climate change is being implemented in Bangladesh. Some of these are implemented by multilateral organisations or donor governments; others are NGO projects. Among the many NGOs that are active in climate change in Bangladesh, some of the most prominent are the Bangladesh Centre for Advanced Studies (BCAS), the Centre for Natural Resource Management (CNRS), IUCN Bangladesh, Action Aid Bangladesh, CARE Bangladesh, Oxfam Bangladesh, Practical Action Bangladesh, Bangladesh Red Crescent Society, Concern Worldwide, and Caritas. Funding from multilateral organisations over the past decades has included contributions from the World Bank Group, the Asian Development Bank, UNDP, and the European Commission[128].

Some climate change projects with a link to water and/or food security that are being implemented in the country (either bilaterally, multilaterally or through NGOs) are the following:

- BCAS's 'Climate Resilient Ecosystem and Livelihoods' (CREL) project (2012-2017, focusing on strengthened management of wetlands and forests);
- BCAC's 'Capacity Strengthening of the Least Developed Countries (LDCs) for Adaptation to Climate Change (CLACC): this project has been running since 2003, aiming to strengthen capacity of civil society in LDCs to adapt to climate change and enhance adaptive capacity. The project also focuses on integrating climate change adaptation into the NAPA process[129];
- various Bangladesh Institute of Development Studies (BIDS) research projects, including 'an evaluation of rural social service programme of the government of Bangladesh', 'baseline study on renewable energy technology systems in Bangladesh' and 'aquaculture and the poor'[130];
- BRAC (formerly Bangladesh Rural Advancement Committee)'s early warning systems project in vulnerable areas in south Bangladesh, addressing also salinity and erosion (duration unknown)[131];

[125] Website BCCRF: https://www.bccrf-bd.org/Project.html
[126] https://www.bccrf-bd.org/FAQ.html
[127] Ayers et al. (2014); Hedger (2011); MoEF (2009); Nakhooda et al. (2014); BCCTF website via http://www.bcct.gov.bd/index.php/ab-bcct.
[128] World Bank (2011)
[129] http://www.bcas.net/project-details.php?project_id=6&title=Capacity%20Strengthening%20of%20the%20Least%20Developed%20Countries%20
[130] Bangladesh Institute of Development Studies, ongoing projects: http://bids.org.bd/page/researches/?status=ongoing. Accessed on 6 September, 2016.
[131] Aberman et al. (2011)

- various projects initiated by CARE: CARE's 'Pathways' project (December 2014-November 2016) aims to strengthen the role of female farmers in climate resilient agriculture and to contribute to their empowerment and climate resilience. Another example is CARE's Agriculture extension capacity building activity project (October 2013 – October 2017), aiming to strengthen existing agricultural extension systems in South-West and Central Bangladesh to sustainably improve food security for 200,000 vulnerable women and smallholders;
- some projects under Practical Action's programme 'Disaster risk reduction and climate change'[132];
- a BCCRF-funded 'Climate Resilient Participatory Afforestation and Reforestation Project' (USD 34 million, started in 2013) to build resilience of communities in coastal and hill areas;
- a BCCRF-funded 'Rural Electrification and Renewable Energy Development Project II' (RERED II, USD 10 million, started in 2013), focusing on the use of solar irrigation pumps by farmers[133];
- Community Climate Change Project, a USD 12,5 million project, financed by the BCCRF focusing on strengthening resilience to climate change impacts of selected communities. Part of this project is establishing a USD 10 million fund to finance community-climate change adaptation projects implemented with support of NGOs. This fund is managed by the Palli Karma-Sahayak Foundation[134]. Projects under this Community Climate Change Project (CCCP) are listed on the Foundation's website[135].

For a complete list of all projects in Bangladesh funded through bilateral/multilateral climate funds, see the list in the Annex.

Climate contribution of the Netherlands Embassy: Pitch & Bid

Beginning in 2014, embassies with development programs have annually been preparing a climate Pitch & Bid. The *Pitch* communicates the embassy's climate-smart actions that will address climate change. Based on the actions described in the Pitch, assignment of the Rio Markers and budget information, the embassy prepares a *Bid* which is an estimate of how much of its budget is likely to be spent on projects that are relevant for climate in the coming three years. For Bangladesh the Bid estimates a climate contribution for 2016-2018 of €25,148,316 (10.3 million for 2016; 8.3 million for 2017; 6.5 million for 2018). Of this, all projects focus on adaptation; one project also focuses mitigation:

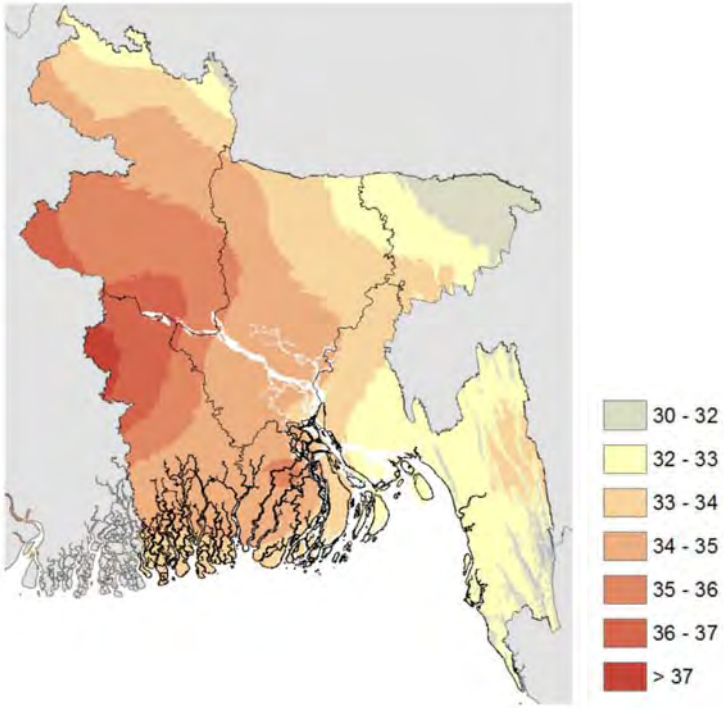
- **Bangladesh Delta Plan 2100 (BDP 2100)**: BDP2100 (a project focusing on improving climate resilience through a holistic, cross-sector approach for delta management) had made good progress. The project, in which climate change is one of the four most important drivers (next to population growth, economic development and transboundary water sharing agreement) is well embedded in the Government of Bangladesh's 7th five-year plan. Currently, an investment plan is being developed with support from the World Bank.
- **Integrated water management programs: addresses and builds the resilience of farmers and communities to the** long-term climate change consequences and inevitable short term effects of localized disasters through interventions such as raising embankments, improving water/polder management, disaster management capacity, introduction of building with nature techniques. A Gender and Water program supports these water programs to better

[132] Practical Action website: http://practicalaction.org/drr-climate-change-bangladesh
[133] BCCRF website: http://bccrf-bd.org/Project.html
[134] http://www.worldbank.org/projects/P125447/community-climate-change-program?lang=en&tab=overview
[135] http://www.pksf-cccp-bd.org

address gender, particularly women, who are more vulnerable than men to the effects of climate change;

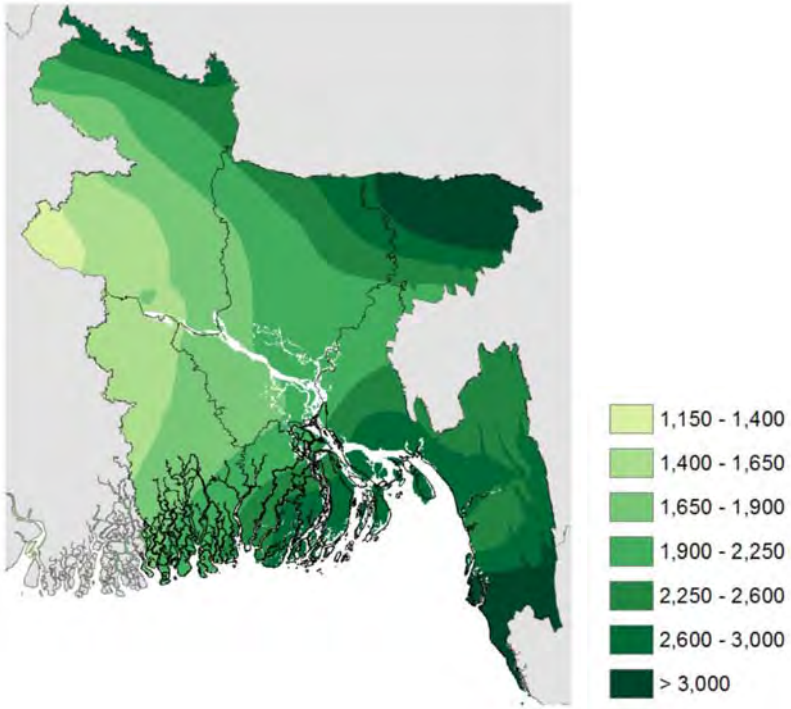
- **Sustainable, low cost and innovative technologies that enable availability, accessibility, sustainability and stability of food systems:** improved agricultural practices and farmer-market linkages will improve long-term food availability and access in times of climate change; to achieve this, innovative technologies will be used such as slow-release fertilisers, high-nutrition horticulture products, mixed cropping, short duration and pest and disease resistant rice and grain varieties, water treatment systems, rainwater harvesting, etcetera;
- **Sustainable agriculture:** increased productivity without depletion of the natural resource base, as well as climate-adaptive agricultural practices, will contribute to climate resilience; at the same time, integrated farming models covering livestock, fisheries and horticulture will assist in mitigating the effects of climate change while improving food security. Well-functioning and integrated will also contribute to resilience, disaster response initiatives and risk reduction.
- **Geodata for Agriculture and Water (G4AW) program:** innovative program using satellite and mobile data to enhance agricultural production in a changing climate.

Map 1: Current average maximum temperature (1950–2000) in degrees Celsius



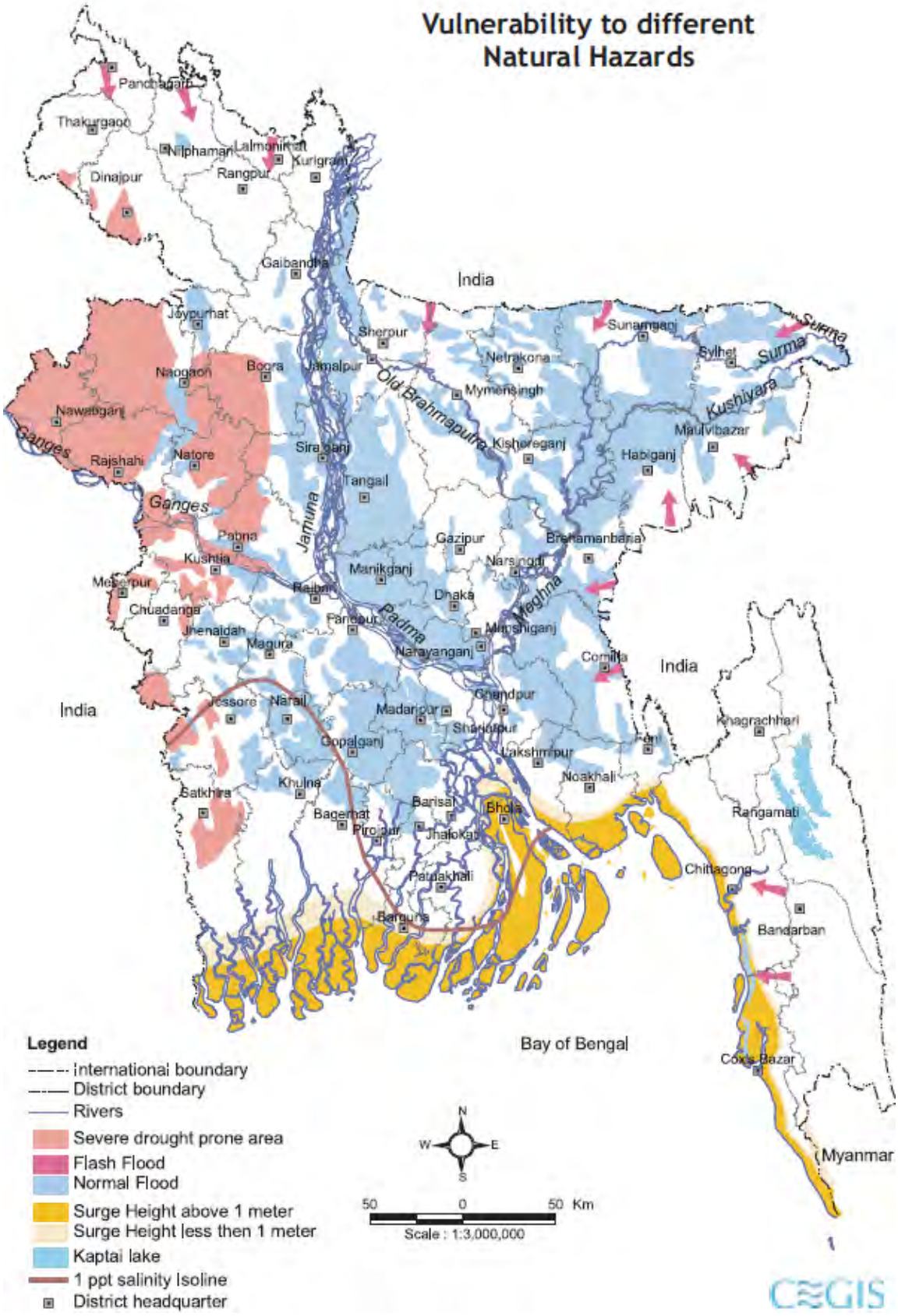
Source: Thomas et al. (2013)

Map 2: Current average annual rainfall (1950–2000)



Source: Thomas et al. (2013)

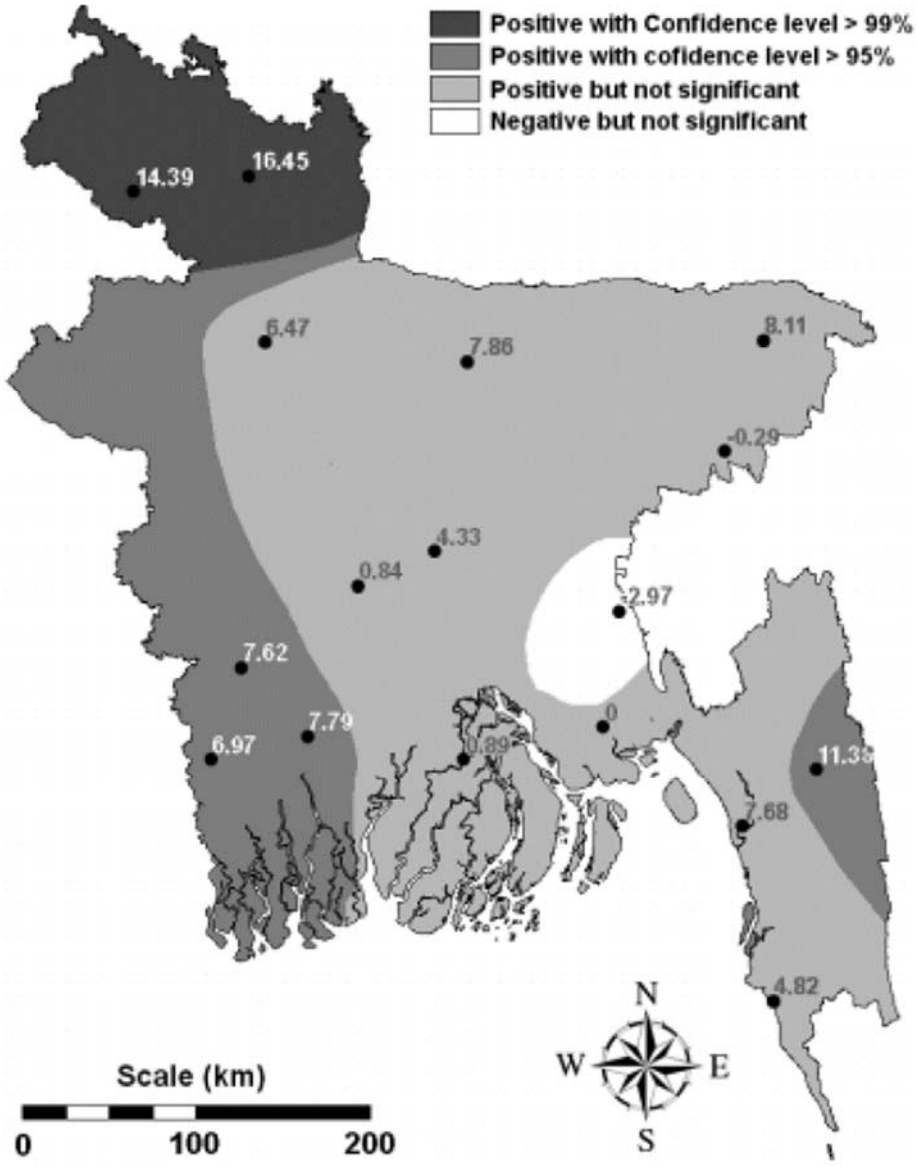
Map 3: Vulnerability to different natural hazards



Source: MoEF (2009)

Map 4: Current trends (1958–2007) in annual rainfall in Bangladesh

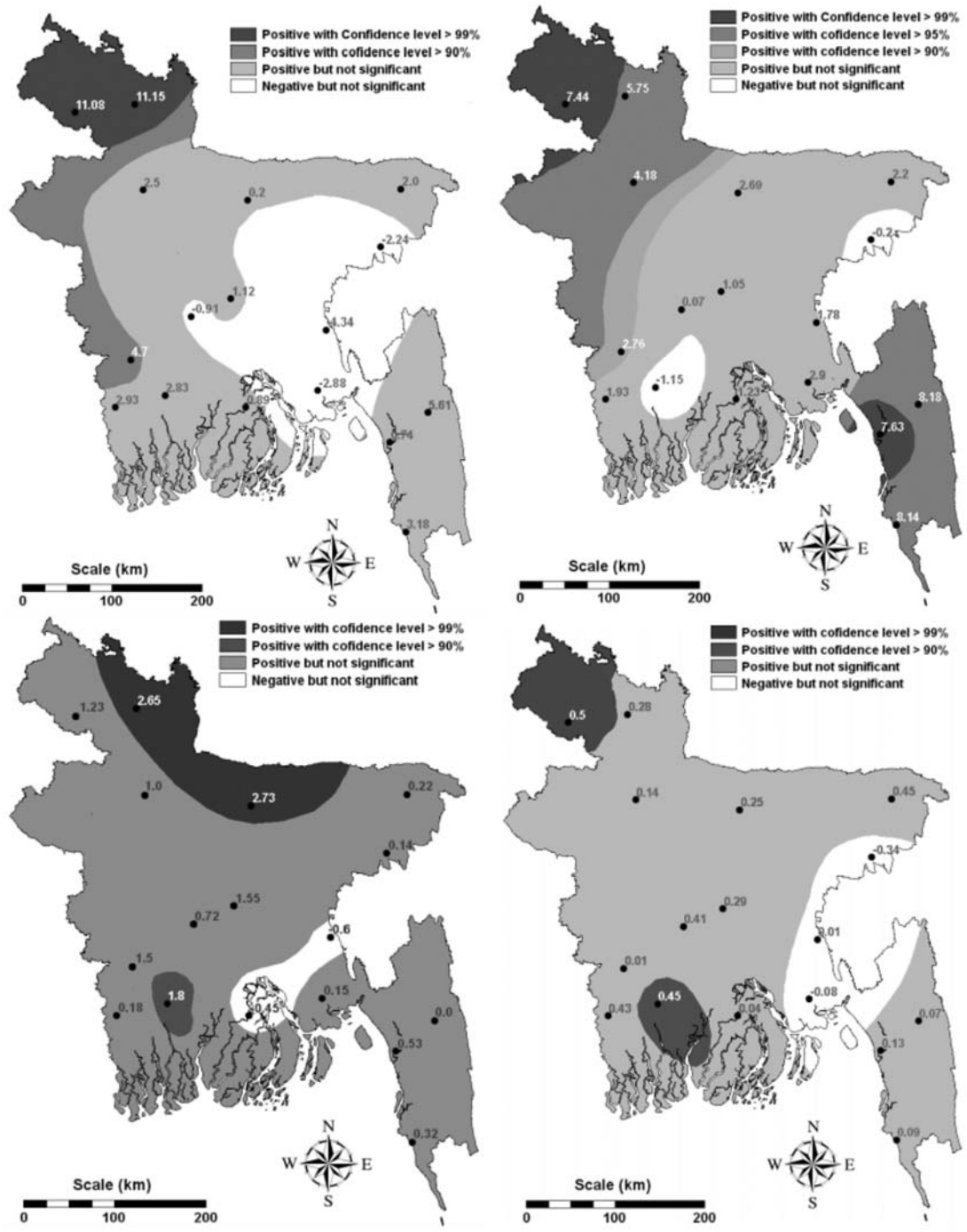
Positive: rainfall increase; Negative: rainfall decrease.
Numbers show the magnitude of total rainfall change (in mm/year) during the period 1958–2007.



Source: Shahid, S. (2009): Rainfall variability and the trends of wet and dry periods in Bangladesh. International Journal of Climatology *30: 2299–2313.* http://www.researchgate.net/publictopics.PublicPostFileLoader.html?id=549691f5d3df3ebe428b4573&key=726565c8-b616-43f9-b917-ea3e5f3391f3

Map set 5: Current trends (1958–2007) in resp. monsoon rainfall, pre-monsoon rainfall, post-monsoon rainfall, and winter rainfall

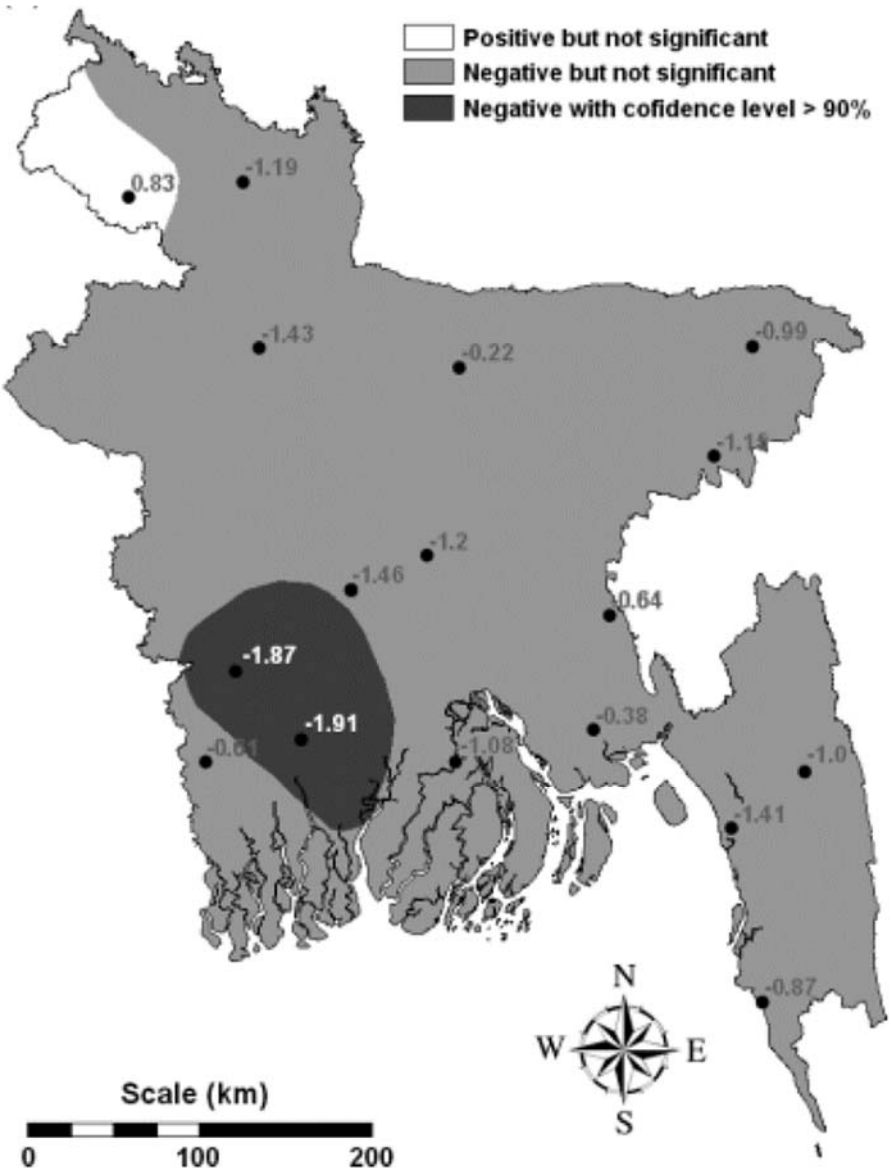
Positive: rainfall increase; Negative: rainfall decrease.
Numbers show the magnitude of total rainfall change (in mm/season) during the period 1958–2007.



Source: Shahid (2009)

Map 6: Current trends (1958–2007) in severe dry months during pre-monsoon season in Bangladesh

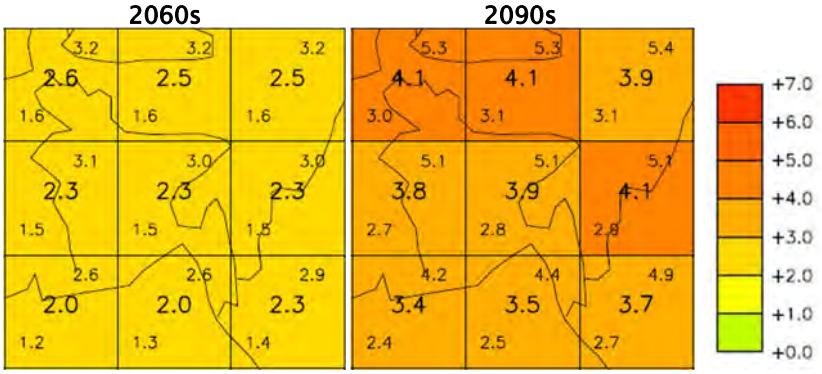
Positive: increase in severe dry months; Negative: decrease in severe dry months.
Numbers show the total increase in number of months that count as 'severe dry' during the period 1958–2007.



Source: Shahid (2009)

Map set 7: Projected change in mean annual temperature, relative to the 1970–2000 mean climate

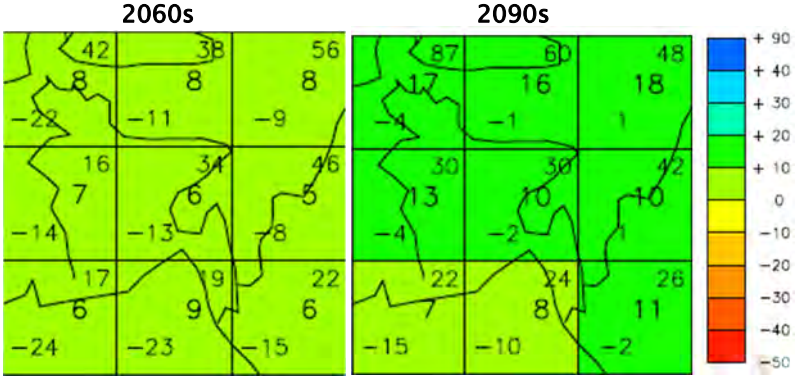
Numbers in each quadrant on the map indicate minimum change (lower left of quadrant), maximum change (top right), and median change (middle of quadrant), all in degrees Celsius.
NB: the shape of Bangladesh can be recognized in the lines on the map.



Source: Karmalkar et al. (2012)

Map set 8: Projected change in average monthly rainfall, relative to the 1970–2000 mean climate

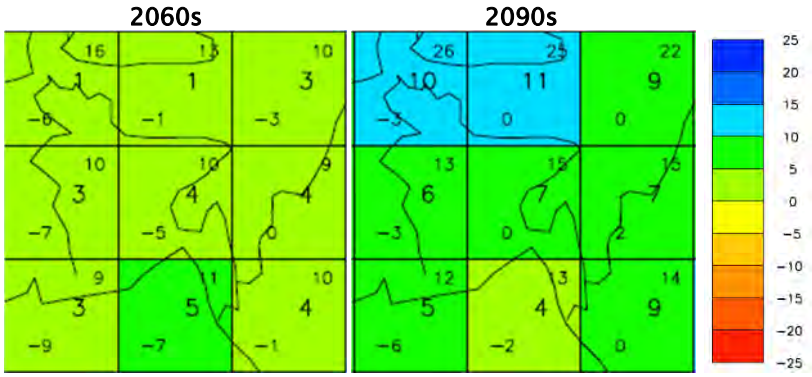
Numbers in each quadrant on the map indicate minimum change (lower left of quadrant), maximum change (top right), and median change (middle of quadrant), all in mm/month.



Source: Karmalkar et al. (2012)

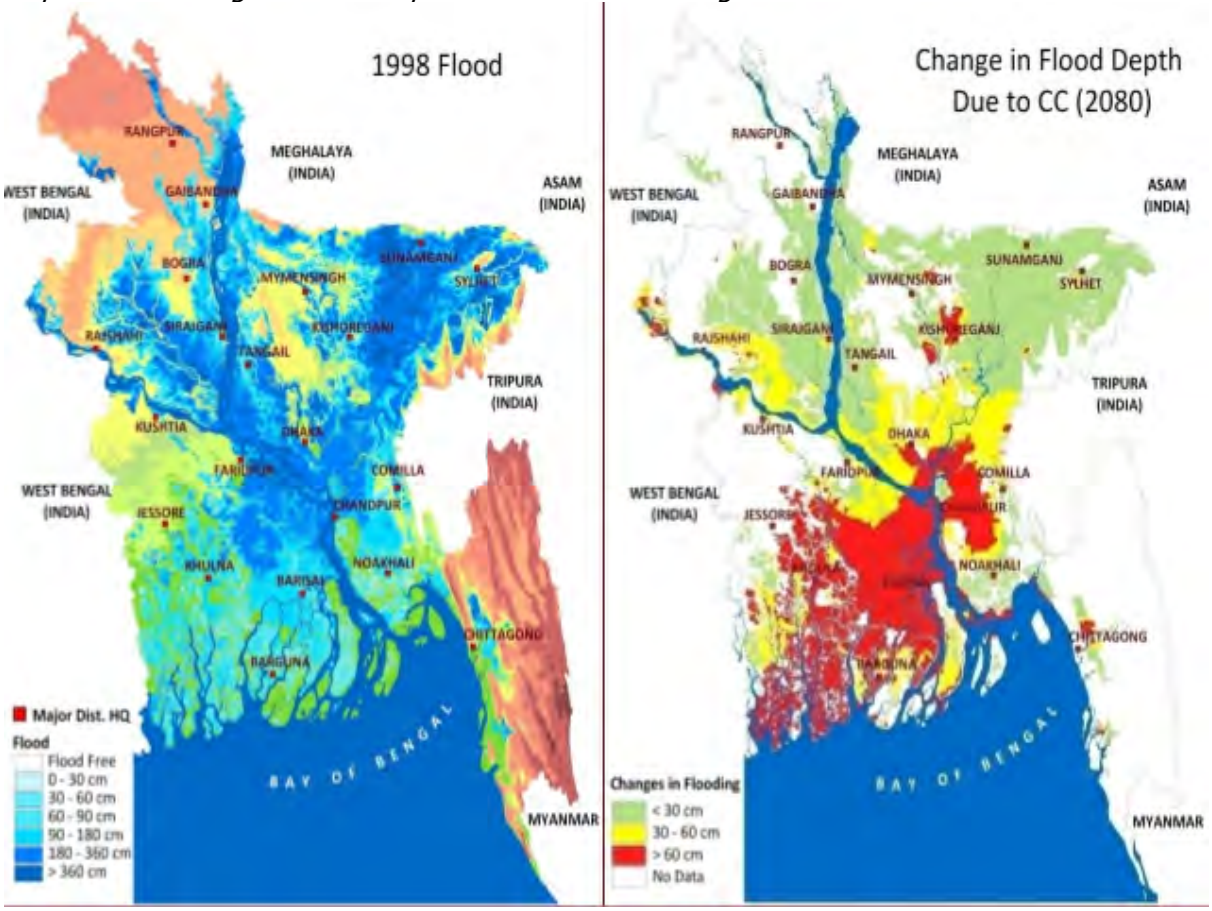
Map set 9: Projected change in % of total rainfall that falls in 'heavy rainfall events', relative to the 1970–2000 mean climate

Numbers in each quadrant on the map indicate minimum change (lower left of quadrant), maximum change (top right), and median change (middle of quadrant), all in %.



Source: Karmalkar et al. (2012)

Map set 10: Change in flood depth due to climate change

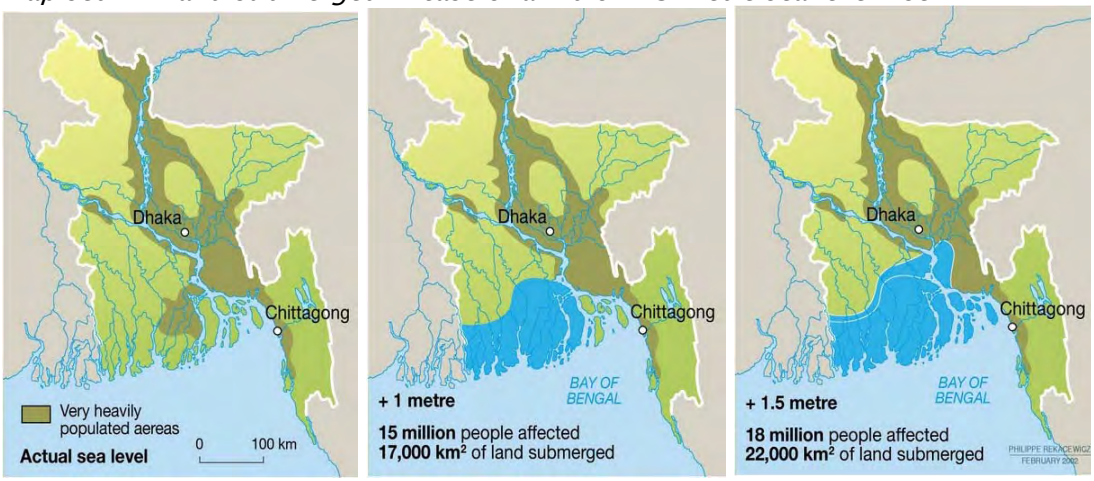


Source: CCAFS (2013): Flood Management in Bangladesh. *http://www.slideshare.net/cgiarclimate/flood-management-in-bangladesh-pd-cdmpii-upd-28-nov13*

Map 11: Likely salinity ingress in southern Bangladesh for different amounts of sea level rise (SLR)

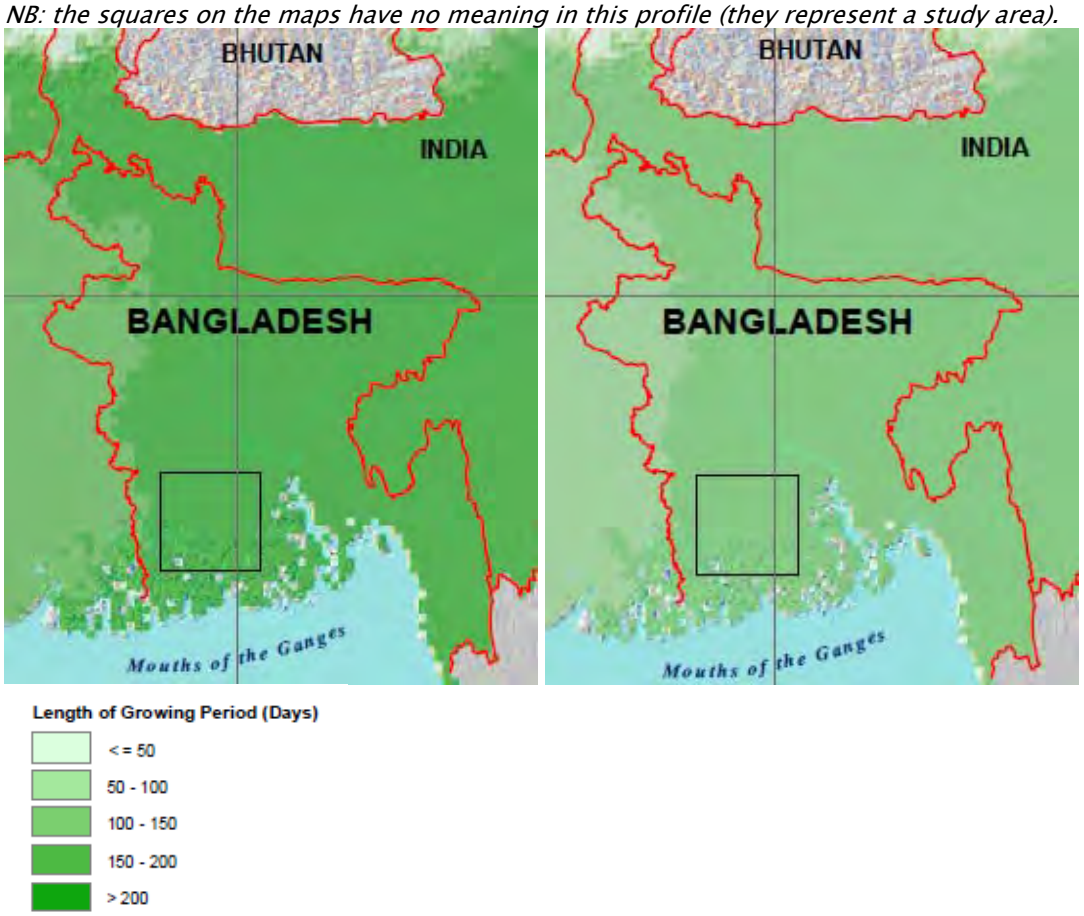
Source: MoEF (2009)

Map set 12: Land submerged in case of a 1.0 or 1.5 metre sea level rise



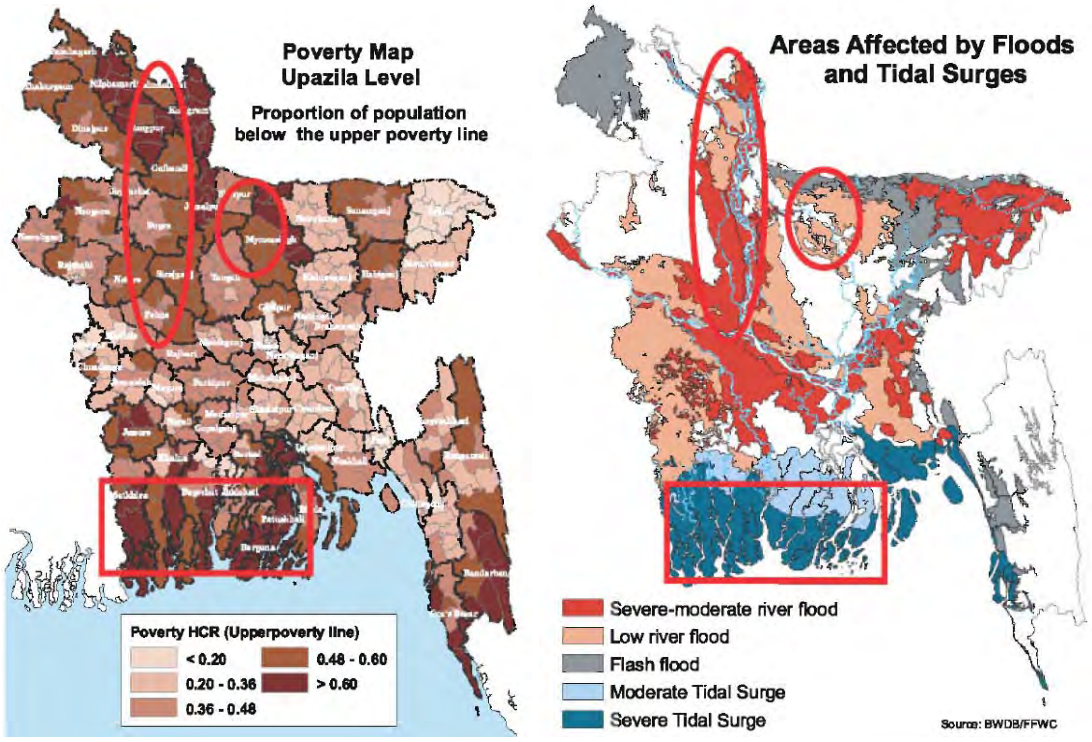
Source: Dacca University and IPCC, via Wilson Center (2011): Perfect Storm? Population Pressures, Natural Resource Constraints, and Climate Change in Bangladesh. http://www.new-securitybeat.org/2011/09/perfect-storm-population-pressures-natural-resource-constraints-and-climate-change-in-bangladesh/

Map set 13: Changing length of growing period between 2000 (left) and 2030 (right)
NB: the squares on the maps have no meaning in this profile (they represent a study area).



Source: Sijmons, K.; Kiplimo, J.; Förch, W.; Thornton, P.K.; Bhatta, G.; Aggarwal, P.K. (2013): Khulna/Morrelganj, Bangladesh. *CCAFS site atlas.* https://cgspace.cgiar.org/bitstream/handle/10568/33582/BangladeshMorrelganj.pdf?sequence=1

Map set 14: Poverty and climate risks in the same regions



Source: BBS, World Bank, and WFP (2009): Updating Poverty Maps of Bangladesh. *http://www.bbs.gov.bd/WebTestApplication/userfiles/Image/LatestReports/UpdatingPovertyMapsofBangladesh.pdf*

Annex: List of projects in Bangladesh under bilateral and multilateral climate funds

Main sources: Climate Funds Update (Updated May 2016)[136] and World Bank Active Projects[137] (accessed September 2016).

Name of Project	Fund	Amount of Funding Approved (USD millions)	Disbursed (USD millions)	Fund Type
Climate Smart SME Financing	Pilot Programme for Climate and Resilience (PPCR)	10		Multilateral
Climate Adaptation and livelihood improvement project in the Haor basin (CALIP)	Adaptation for Smallholder Agriculture Programme (ASAP)	15	3,3	Multilateral
Community-based Climate Resilient Fisheries and Aquaculture Development in Bangladesh	Least Developed Countries Fund (LDCF)	5,5		Multilateral
Community Based Adaptation to Climate Change through Coastal Afforestation	Least Developed Countries Fund (LDCF)	3,4	3,4	Multilateral
Integrating Community-based Adaptation into Afforestation and Reforestation Programmes in Bangladesh	Least Developed Countries Fund (LDCF)	5,7	5,7	Multilateral
Climate Resilient Infrastructure Mainstreaming	Green Climate Fund (GCF)	40		Multilateral
National Adapation Programme of Action	Least Developed Countries Fund (LDCF)	0,2	0,2	Multilateral

[136] http://www.climatefundsupdate.org/data

[137] http://www.worldbank.org/projects/search?lang=en&searchTerm=&countrycode_exact=BD. Accessed September 2016.

Name of Project	Fund	Amount of Funding Approved (USD millions)	Disbursed (USD millions)	Fund Type
Ecosystem-based Approaches to Adaptation (EbA) in the Drought-prone Barind Tract and Haor "Wetland" Area	Least Developed Countries Fund (LDCF)	5,3		Multilateral
Improving Kiln Efficiency in the Brick Making Industry in Bangladesh	Global Environment Facility (GEF4)	3	3	Multilateral
Direct support to the design and implementation of UN-REDD National Programmes	UNREDD Program	2,3	0	Multilateral
Bangladesh Climate Change Resilience Fund (BCCRF) Improving 10 million lives through climate change (CC) adaptation, mitigation and Disaster Risk Reduction measures	Global Climate Change Alliance (GCCA)	9,5	4,8	Multilateral
Coastal Embankments Improvement and Afforestation	Pilot Programme for Climate and Resilience (PPCR)	25		Multilateral
Promoting Climate Resilient Agriculture and Food Security	Pilot Programme for Climate and Resilience (PPCR)	13,1		Multilateral
Coastal town infrastructure improvement	Pilot Programme for Climate and Resilience (PPCR)	40,4		Multilateral
Climate Change Capacity Building and Knowledge Management (Technical assistance project)	Pilot Programme for Climate and Resilience (PPCR)	0,5	0,08	Multilateral

Name of Project	Fund	Amount of Funding Approved (USD millions)	Disbursed (USD millions)	Fund Type
Climate Resilient Infra-structure Improvement in Coastal Zone Project	Pilot Programme for Climate and Resilience (PPCR)	30	1,9	Multilateral
Feasibility Study for a Pilot Program of Climate Resilient Housing in the Coastal Region (Technical assistance project)	Pilot Programme for Climate and Resilience (PPCR)	0,4		Multilateral
Development of Sustainable Renewable Energy Power Generation	Global Environment Facility (GEF5)	4,1	4,1	Multilateral
ASTUD: Greater Dhaka Sustainable Urban Transport Corridor Project	Global Environment Facility (GEF5)	4,6	4,6	Multilateral
Third National Commu-nication to the UNFCCC	Global Environment Facility (GEF5)	0,5	0,5	Multilateral
Community Climate Change Project138.	BCCRF	12,5		Multilateral
Bangladesh Modern Food Storage Facilities Project139	BCCRF	210		Multilateral
Rural Electrification and Renewable Energy Development (RURED) II	BCCRF			
Solar Irrigation Program (part of Rural Electrifica-tion and Renewable Energy Development (RURED) II)140	BCCRF	24,5		Multilateral

[138] http://www.worldbank.org/projects/P125447/community-climate-change-program?lang=en&tab=overview

[140] https://bccrf-bd.org/ProjectDetails.html?ID=11

Name of Project	Fund	Amount of Funding Approved (USD millions)	Disbursed (USD millions)	Fund Type
Bangladesh weather and climate services regional project	Worldbank	113		Multilateral
Bangladesh Ghorashal Unit 4 repowering project	Worldbank	217		Multilateral
Bangladesh: National Agricultural Technology Program (NATP)-2	Worldbank	176		Multilateral
Scale up for RERED II	Worldbank	15		Multilateral
Multipurpose Disaster Shelter project	Worldbank	375		Multilateral
RERED II, additional financing	Worldbank	93,4		Multilateral
NATP - additional financing	Worldbank	23,7		Multilateral
Coastal Embankment Improvement Project Phase I (CEIP-I)	Worldbank	400		Multilateral
Climate Resilient Participatory Afforestation and Reforestation Project	Worldbank	33,8		Multilateral
Rural Electrification and Renewable Energy Development II (RERED II) Project	Worldbank	179,5		Multilateral
BD Rural Water Supply and Sanitation Project	Worldbank	75		Multilateral
Bangladesh Integrated Agricultural Productivity Project	Worldbank	46,3		Multilateral

Name of Project	Fund	Amount of Funding Approved (USD millions)	Disbursed (USD millions)	Fund Type
Emergency 2007 Cyclone Recovery and Restoration Project Additional Financing	Worldbank	75		Multilateral
Efficient Lighting Initiative for Bangladesh	Worldbank	15		Multilateral
BD Chittagong Water Supply Improvement and Sanitation Project	Worldbank	170		Multilateral
GPOBA: Rural Electrification & Renewable Energy	Worldbank	1,1		Multilateral
Emergency 2007 Cyclone Recovery and Restoration Project	Worldbank	109		Multilateral
Bangladesh climate Change Programme	UK's International Climate Fund	20,8	0	Bilateral
Climate Change Programme – Jolobayoo-O-Jibon	UK's International Climate Fund	44,1	0	Bilateral
Agricultural Extension Capacity Building Activity Project	US AID, implemented by CARE			Bilateral