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Policy brief

Tackling flooding in Bangladesh in a changing climate

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Summary

- Bangladesh is highly prone to flooding because of its location in the Bengal Delta and its low-lying, flat topography. Over half of its population is exposed to high flood risk.
- Several factors linked to climate change are increasing the country's flood risk, including the increasing frequency of extreme precipitation events and more erratic rainfall.
- The magnitude of peak river flow could increase by 36% on average under a high-emissions scenario and by 16% under a low-emissions scenario by 2070–2099 relative to 1971–2000.
- Effective flood policies are ever more important to increase resilience and adaptation and reduce the likelihood of cascading humanitarian and economic impacts.
- Twentieth century efforts to address flooding that focused on structural measures such as building embankments have not been fully effective and in places may have made flood-prone areas appear safer than they are, in turn exposing a higher share of the population to flood risk.
- More recent government policies have adopted a 'living with floods' approach, using measures such as discouraging settlements in high-risk zones and providing water-resistant construction materials and salt-resistant crops.
- Barriers to implementing more effective flood risk management in Bangladesh include insufficient knowledge about vulnerabilities and local needs; a lack of capacity in local institutions such as the Ministry of Disaster Management and Relief; governance issues; and poor access to funding for investment in adaptation.
- Governance of flood and disaster risk could be improved through needs assessments, more community participation, better coordination between government and non-governmental organisations, and between government agencies themselves.

Policy briefs provide analysis on topical issues, presenting specific recommendations to inform ongoing policy debates. Drawing on the Grantham Research Institute's expertise, they summarise either our research findings or the state of knowledge about a particular issue.

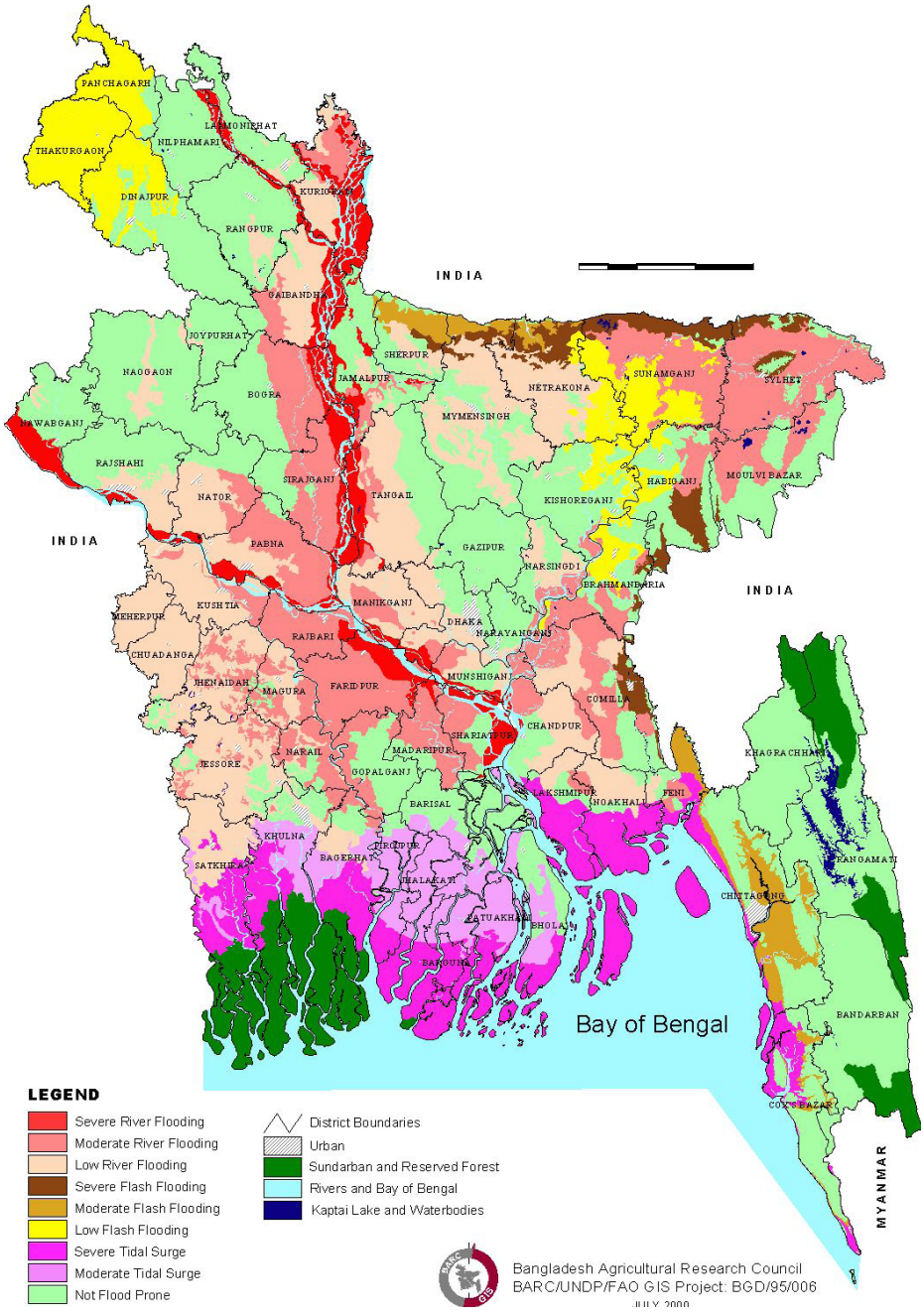
This policy brief has been written by **Lucia Letsch**, **Shouro Dasgupta** and **Elizabeth JZ Robinson**.

Introduction: why is flood risk in Bangladesh so high?

Nearly 60% of Bangladesh's population is exposed to high flood risk, a greater proportion of the population than in any other country in the world other than the Netherlands, and around 45% are exposed to high fluvial flood risk, the highest figure in the world (Rentschler et al., 2022). Climate change is exacerbating this risk and causing damage with an increasingly high financial and humanitarian cost.

This policy brief examines the physical and socioeconomic factors that make Bangladesh so vulnerable to flooding, particularly in a changing climate, before reviewing how the country has addressed this challenge to date and how it might respond better in the future.

Figure 1. Flood-prone areas in Bangladesh



Source: Bangladesh Agricultural Research Council (BARC)/GIS Project, BGD/95/006)

"Climate change is exacerbating flood risk and causing damage with an increasingly high financial and humanitarian cost."

Why is flood risk in Bangladesh so high?

Geographical features

Bangladesh's location in the Bengal Delta and its flat, low-lying topography make it one of the most flood-prone countries in the world (Dastagir, 2015). Nearly 80% of the country's surface area is floodplain formed by three major rivers – the Ganges, Brahmaputra and Meghna (which together form the 'GBM basin') – and a complex network of about 700 rivers in total (see Figure above). Around two-thirds of the country is less than five metres above sea-level.

Bangladesh and India share 54 rivers, most of which flow from India southwards into Bangladesh. The upstream flow of water from India, and also from China, influences downstream river discharge. This means that interventions in those countries, such as the control of water flow during the flooding season, can have significant impacts on flooding in Bangladesh. In the past, Bangladesh has suffered due to flood management policies in these upstream countries, with water receding into low-lying Bangladesh and worsening the flood situation.

Bangladesh experiences four different types of flood: monsoon, flash, rainfall-induced and tidal (Rumana et al., 2018). The main short-term causes of flooding are monsoon downpours and the synchronisation of the major rivers' flood peaks, while the long-term causes include compaction and subsidence of sediment, build-up of riverbed sediment (aggradation), deforestation, river damming, and soil erosion resulting from tilling (ibid.).

The changing climate

Floods currently submerge an average of 20–25% of Bangladesh's land area every year, and extreme flood events,[1] when they happen, submerge 55–60% of the country (Mojid, 2020) (see Figure 2). Research suggests that the magnitude of peak river flow could increase by 36% on average under a high-emissions scenario, and by 16% under a low-emissions scenario by 2070–2099 relative to 1971–2000 (Gädeke et al., 2022; Dastagir, 2015); see Table 1 below Overall, between 2000 and 2019, Bangladesh was ranked seventh among the countries most affected by climate change globally (Germanwatch, 2021), with much of this impact being associated with flooding.

"Bangladesh's location in the Bengal Delta and its flat, low-lying topography make it one of the most flood-prone countries in the world."

1. These are '1-in-100-year floods' or flood events 'with a 100-year return period', which refers to a flood height that has an annual probability of occurrence of 1% or less in any given year.

Figure 2. Land area affected during major floods in Bangladesh (%)

Source: Authors' calculations using ERA5-Land data on precipitation

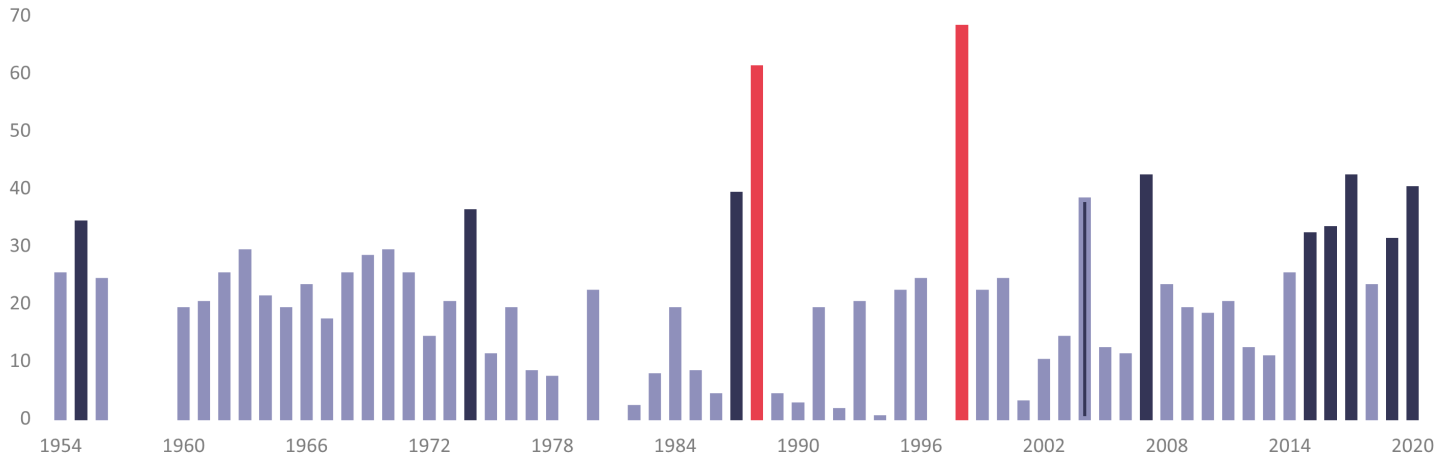


Table 1. Percentage increase in water flows during extreme flooding with an annual probability of occurrence of 1% or less compared with the 1986–2005 baseline

River	Low-emissions scenario (1.5°C by 2030)	Medium-emissions scenario (2°C by 2050)	High-emissions scenario (4°C by 2080)
Ganges	27%	29%	54%
Brahmaputra	8%	24%	63%
Meghna	15%	38%	81%

Source: Mohammed et al. (2018)

These increases in river flows and flood risk are being caused through multiple pathways associated with climate change: changing rainfall patterns, an increase in flash flooding, rising sea levels and accelerated glacial melting.

Changing rainfall patterns: Bangladesh depends on the South Asian monsoon for almost all its rainfall (Dastagir, 2015). The probability of extreme pre-monsoon rainfall over north-eastern Bangladesh has doubled due to climate change (Rimi et al., 2019). More broadly, pre-monsoon rainfall, average annual rainfall and the number of 'wet' months are all increasing overall (Shahid, 2010), but with considerable geographical variation: average annual and seasonal precipitation are increasing in the south-east, north-east and south-west but decreasing in the south, central area and west (Das et al., 2021).

With rainfall becoming erratic and increasing in intensity, rivers are rising above safe levels more often, with increasing river discharge and greater inundation depth (Mohsenipour et al., 2020).

Flash flooding: A warmer atmosphere can hold more moisture, which can result in a higher intensity of rainfall, in turn increasing the risk of flash flooding. A change in intensity and frequency of rainfall across the entire GBM basin (including India, Nepal, China and Bhutan as well as Bangladesh) may increase the number of floods and people affected in Bangladesh (Rumana et al., 2023; Nishat and Mukherjee, 2013).

Sea level rise: The sea level rise experienced as a result of global warming is increasing the duration of floods and the size of the flooded area in low-lying Bangladesh, due to the backwater effect of the sea (Ali et al., 2013). A rise in sea level of 0.53 metres under 1.5°C to 2°C of warming[2] by 2100 is predicted to result in 16% of the land area in Shariatpur and 7.4% of the land area in Chandpur being permanently submerged (Davis et al., 2018). Sea level rise also leads to salinity intrusions, making land less productive (Khan et al., 2015), and increases the intensity of storm surge flooding caused by cyclones.

Glacial melting: The acceleration of glacial melting in the Himalaya-Tibetan Plateau is increasing the Ganges and Brahmaputra flows, another potential driver of increased flood risk (Dastagir, 2015).

Under a low-emissions scenario, by 2030, water flow during extreme floods (with an annual probability of occurrence of 1% or less) is projected to increase by 27% in the Ganges, 8% in the Brahmaputra and 15% in the Meghna Rivers, compared with the 1986–2005 baseline. Under a high-emissions scenario, these increases are projected to be 54%, 63%, and 81%, respectively (see Table 1).

"Increases in river flows and flood risk are being caused through multiple pathways associated with climate change: changing rainfall patterns, an increase in flash flooding, rising sea levels and accelerated glacial melting."

2. i.e. under Representative Concentration Pathway (RCP) 4.5.

Social and economic factors

A large proportion of Bangladesh's population lives near its major rivers. These riverside communities, and also coastal residents, are especially vulnerable to flooding both because of the direct exposure they face and because of their low capacity to adapt. Difficult economic conditions and unequal power structures, linked in part to race, ethnicity, religion, gender and age (Ahmed and Eklund, 2021), have a bearing on these vulnerabilities. Communities living in the 'Char lands', new areas of land formed by river sediment deposits, have been found to be the most vulnerable to climate change, including its impacts on flooding (Chowdhury et al., 2022).

Rapid population growth (from 48 million in 1960 to 171 million in 2022) and urbanisation (including unplanned urbanisation) have resulted in land use change as more land is given over to agriculture, settlement and infrastructure such as roads and highways. These changes in land use and land cover have increased the risk of flooding, especially in urban areas: for example, increasing the risk of subsidence, creating more impermeable surfaces, and removing the stabilising effect of trees.

Without greater adaptation action and resilience-building, the humanitarian and economic costs of flooding in Bangladesh, which are already high, are expected to increase further due to climate change. Between 1971 and 2014, 78 floods caused the deaths of 41,783 people and total economic damages of US$12.2 billion, mainly through damage to crops and property (Kabir and Hossen, 2019), and exacerbated by a lack of insurance. The Asian Development Bank estimates that in 2014 alone, flood-related damages cost the Bangladesh economy approximately US$2.2 billion (Ozaki, 2016), equivalent to 1.5% of its GDP. The 2022 flood is estimated to have cost US$1.0 billion and affected 7.3 million people (Ministry of Disaster Management and Relief, 2022). Increased damages from floods and other climatic disasters further reduce the adaptive capacity of institutions and exert additional stress on public finances, because funds often have to be reallocated for rebuilding infrastructure.

How has Bangladesh tackled its flooding challenge in the past?

Twentieth century flooding policies in Bangladesh, such as the 1960s Coastal Embankment Project (CEP), focused on flood control through structural interventions such as building embankments (or levées) and polders (islands surrounded by embankments) along rivers and coastlines. While these early interventions have provided some protection against storms and fluvio-tidal events, many have been criticised for their ineffectiveness (Adnan et al., 2019) and for causing disruption to natural processes. For example, the number of flash floods and the extent of flooded areas increased after the construction of coastal polders (ibid.; Choudhury et al., 2004) because they caused silt accumulation. This interruption to normal sedimentation processes can increase the amount of runoff during extreme rainfall and monsoons. Also, the separation of floodplains from rivers and channels hinders the deposition of sediment, which increases land subsidence. Islands in south-western Bangladesh have lost 1–1.5 metres of elevation since being enclosed by embankments in the 1960s (Auerbach et al., 2015). The elevation loss, together with drainage problems, makes the affected island more vulnerable to tidal flooding.

"Riverside communities and coastal residents are especially vulnerable to flooding because of the direct exposure they face and because of their low capacity to adapt."

3. The annex table contains further details on all the policies, past and present, mentioned in this brief, plus some in addition to these. It is available at: www.lse.ac.uk/granthaminstitute/publication/tackling-flooding-in-bangladesh-in-a-changing-climate/

The new embankments and polders also allowed agricultural and urban expansion into former wetlands while not fully protecting against flooding. This has caused the so-called 'levée effect' (White, 1942), whereby structural flood defence systems give a false sense of security and increase population exposure to flood risk. Both flood risk and flood damages are therefore affected by these structural flood control policies.

In the 1990s there was a shift away from flood control towards flood risk management that uses both structural and non-structural measures to limit flood damage. Recent government policies have adopted a 'living with floods' approach, seeking to protect the population with measures such as discouraging settlements in high-risk zones and providing water-resistant construction materials and salt-resistant crops. This occurred alongside the growth of civil society organisations, who were often able to mobilise resources in the flood affected areas more rapidly than could government agencies, who at that time had limited resources. Local livelihoods and adaptation strategies already used by the population were starting to receive more attention in policymaking (e.g. in the Flood Action Plan 1990–1995). As a result, the Government's response to the devastating floods of 1998 was more effective than it was to the floods of 1988 (Beck, 2005) – although it was still found to lack coordination. For example, government agencies such as the Disaster Management Bureau and local authorities often made decisions independently of each other.

"Recent government policies have adopted a 'living with floods' approach."

Addressing flooding today: the Bangladesh Delta Plan 2100

The Bangladesh Delta Plan 2100 (BDP 2100) was approved in 2018. It aims to integrate all sector plans and policies related to the delta into a new long-term plan to address flooding and: "ensure long term water and food security, economic growth and environmental sustainability while effectively reducing vulnerability to hazards and building resilience to climate change and other delta challenges through robust, adaptive and integrated strategies, and equitable water governance" (General Economics Division, 2018). However, what impacts the plan will have are not yet fully understood. Its successful implementation also requires various barriers to be overcome, including a lack of adequate financing, the absence of an institutional framework to coordinate the activities of government agencies, and a lack of planning for marine protected areas – in essence, a lack of governance for flood risk management. Additionally, economic growth and rapid urbanisation are already exerting pressure on water governance and infrastructure, and the BDP 2100 will need to identify which locations are vulnerable to these specific issues.

The BDP 2100 has also been criticised for relying in part on solutions that have been tried before in the country, such as raising embankments, constructing barrages and strengthening drainage projects. This reflects the fact that the plan was developed with support from Dutch experts, being built on the Dutch Delta Approach (DDA), which may not be universally suitable for the Bangladeshi context. Certainly, previous instances of applying the DDA outside the Netherlands have not always been successful. For example, in Jakarta, Indonesian policymakers were hesitant to implement the transferred ideas prepared for it by Dutch private-sector actors (Minkman et al., 2019), leading to project stagnation: only a small proportion of the planned embankments have been built and Jakarta remains regularly affected by floods (Indonesia Water Portal, 2023).

The role of climate change mitigation

Bangladesh is a low-emitting country, contributing just 0.25% of total global greenhouse gas emissions in 2021 (Ritchie et al., 2020). Therefore, limiting climate change's contribution to increasing the risk of flooding depends on global mitigation efforts, especially from high-emitting industrial countries.

However, Bangladesh must still make efforts to fulfil its Nationally Determined Contribution (NDC) in support of the Paris Agreement. The agriculture and energy sectors are responsible for most of the country's emissions, contributing 44% and 39% respectively (Chowdhury et al., 2021). Its emissions are forecast to peak in 2040 (Hasan and Chongbo, 2020). Energy supply in Bangladesh comes mainly from natural gas, with oil, coal and hydropower also contributing to the mix (Sarkar et al., 2018). While Bangladesh has mitigation plans and commitments in place, its current and planned actions to reduce power sector emissions are insufficient to put it on a pathway to decarbonise the energy system. Large-scale deployment of renewable energy sources could be one step towards meeting global climate goals and securing sustainable growth for Bangladesh.

Implications for future flood policy in Bangladesh

As we have described, Bangladesh's early experience of flood management focused primarily on structural engineering and post-flood relief operations. This has proven to be insufficient, cost-ineffective and sometimes has even increased the level of risk. More recently, a 'living with floods' approach and the creation of the Bangladesh Delta Plan 2100 have led to more integrated policies, also addressing economic growth and resilience, and including ecological approaches to water resource management and developing water-sharing agreements for transboundary rivers.

Bangladesh should build on this paradigm shift towards flood risk management, creating a long-term strategy that promotes the health of affected ecosystems, societies and economic systems through a combination of structural and non-structural interventions.

Governance of flood and disaster risk could be improved through needs assessments, more community participation, better coordination between government and non-governmental organisations (NGOs), and between government agencies themselves.

The following specific measures could help further enhance Bangladesh's approach to flood risk management:

- **Early warning systems** are a key tool for flooding preparedness, and are increasingly important given the growing frequency of flash floods. Forecasting and early warning systems can be strengthened through flood hazard mapping and flood monitoring tools based on remote sensing technologies. The timely dissemination of relevant information is also critical. This requires improved knowledge about vulnerabilities and local needs; greater capacity in local institutions such as the Ministry of Disaster Management and Relief, including to improve the technology needed for early warning systems; and more funding.
- **Integrating local knowledge** into policies, plans and decision-making processes is likely to make flood risk management more effective.

"Bangladesh should build on its paradigm shift towards flood risk management, creating a long-term strategy that promotes the health of affected ecosystems, societies and economic systems."

For example, tidal river management, a water resource management practice based on indigenous knowledge, is a more cost-effective and less environmentally-impactful alternative to structural interventions (Masud et al., 2018).

- **Nature-based solutions**, which aim to protect and manage ecosystems to the benefit of both biodiversity and the human population, are a promising alternative to structural flood protection measures. Mangroves, for example, already protect an estimated 1.11 million people and US$1.56 billion in property from floods in Bangladesh (Menéndez et al., 2020). Mangrove plantations, along with re- and afforestation, are also identified in Bangladesh's NDC as important for climate change mitigation, for their carbon sequestering properties.
- **Coordination between national and local government bodies and NGOs** could support a more effective flood response and disaster risk management. Currently, flood response is often disconnected from flood management plans and policies. NGOs in Bangladesh are actively involved in disaster response alongside government agencies and are often able to partner with local communities and organisations working at the grassroots level. NGOs that work in this way often have higher operational flexibility and can provide a faster response, which is critical for reaching more remote parts of Bangladesh. They can also provide assistance in areas such as health and education, including helping to restart schools after a flood. Implementing a whole-of-society approach – involving all relevant institutions and organisations, including civil society organisations, the private sector, research and academia – alongside a whole-of-government strategy that establishes cooperation and collaboration between different levels of government, would improve the effectiveness of flood risk management in Bangladesh.
- **Climate adaptation and mitigation** at the global level will be needed for decades to come. While lower-income countries including Bangladesh do not currently have mitigation obligations and instead are focused on the need for adaptation, these countries are aware, too, of the opportunities that come with low-carbon-emissions pathways. The current contribution of renewables to the energy mix in Bangladesh is low, and the goal of generating 10% of electricity from renewable sources by 2021 was not met. At COP26 it pledged to achieve 40% electricity generation from clean energy sources by 2041. This will require a shift in policymaking to move away from fossil fuels, with holistic and sustainable power sector policies, including phasing out measures that create price distortions such as capacity payments to oil-based power plants, reducing import dependence and improving energy efficiency; in turn this will also better ensure energy security and affordability and bring co-benefits for health, as air becomes cleaner.

Annex – references and overview of policies

The in-text citations within this briefare hyperlinked. For a separate, downloadable list of the cited references and a four-page overview of existing policies relevant to addressing the risks of flooding in Bangladesh, please visit: www.lse.ac.uk/granthaminstitute/publication/tackling-flooding-in-bangladesh-in-a-changing-climate/

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