Chapter 1
Floods of Ganga-Brahmaputra-Meghna Delta in Context

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Abstract The Ganga-Brahmaputra-Meghna (GBM) delta is the world's one of the most populated regions and has the highest concentration of population affected by floods. Millions of people become displaced, and tens to hundreds die each year of the flood incidents. Principally, the heavy rainfall and cyclonic storm are the key drivers of floods in the GBM delta. Although the GBM system covers a vast area of varying topography, diversified lithology, heterogeneous soils, and varying vegetations, the delta formed by the rivers is one and unique geomorphic unit. In this chapter, we focused broadly on the geology, relief, and river systems of this geomorphic unit. We also discussed the nature of floods in the region and their causes – natural and anthropogenic. The seasonality of floods in the GBM delta is also addressed in this chapter. This is not the age of combating floods, but rather the age of coexistence of man with floods. We illuminated this issue of living with floods. Finally, we outlined the prime theme of all other chapters.

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1 Backdrop

The Global Flood Database (Tellman et al., 2021) has reported about 3054 flood events worldwide during the 2000–2018 period only from different sources (mostly from news reports); however, the organization has successfully mapped 913 flood events in 169 countries using satellite imageries, which were cumulatively inundated about 2.23 million km^2 of land with a major concentration in Southeast Asia (Fig. 1.1). During this time period, the most severe rain-induced flood event has been noticed in the adjoining area of the Ganga-Brahmaputra-Meghna (GBM) delta on 21 July 2007, when about 27 million human population were directly affected by flooding over an area of 78.8 thousand km^2 and about 5 million population were displaced with 1071 causality (Global Flood Database (cloudtostreet.ai) (Fig. 1.1). The table of the top 15 flood events over the GBM basin, including some parts of Myanmar, shows, except one, all the 14 events occurred mainly due to intensive rainfall during the monsoon period (July–October), only with an average exposure of 19 million population (Table 1.1). The region holds over 10% population of the world from the two most populated countries, India and Bangladesh (Rasul, 2014). Although the GBM basin spatially covers about 174.5 million hectares and comprises five countries, i.e., India, Bangladesh, Bhutan, Nepal, and Tibetan China (Rasul, 2014), however, the major concentration of severe and devastating flood events have been frequently observed only in the north and eastern India and over

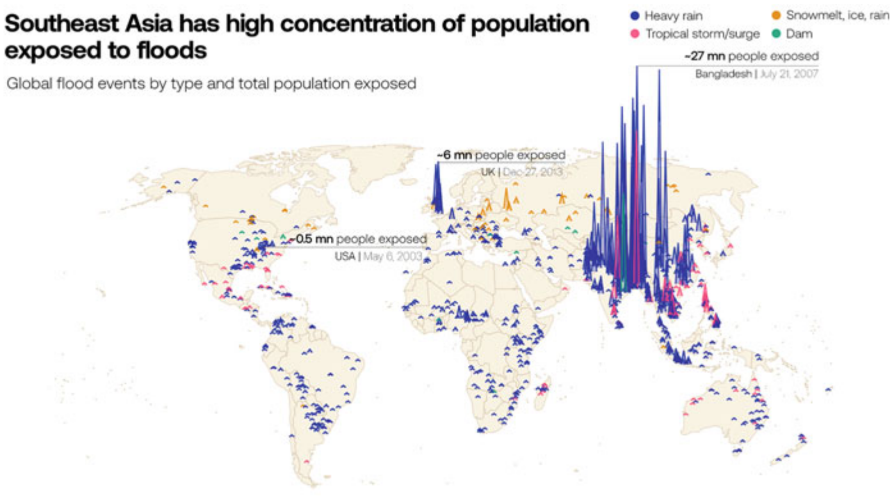

Fig. 1.1 Exposer of the global population to the flood events during 2000–2018. (Source: after The Global Flood Database, Global Flood Database (cloudtostreet.ai) accessed on December 2021)

Table 1.1 List of top 15 flood events over the GBM basin including some parts of Myanmar as per data provided by Global Flood Database (cloudtostreet.ai)

Date	Population exposed	Population displaced	Causality	Duration (Days)	Cause
7/21/2007	2,77,12,991	50,00,000	1071	86	Heavy rain
09/09/2010	2,31,37,894	1,40,000	0	21	Heavy rain
8/30/2008	2,16,31,628	6,00,000	0	9	Heavy rain
8/18/2008	2,15,29,060	1,00,00,000	400	37	Heavy rain
07/12/2007	2,14,88,636	1,11,00,000	96	90	Heavy rain
6/20/2004	1,98,55,086	4,00,00,000	3000	109	Heavy rain
10/01/2010	1,93,62,985	5,00,000	15	11	Tropical storm, surge
7/25/2016	1,84,56,496	25,000	42	32	Heavy rain
09/01/2018	1,72,13,562	1000	20	6	Heavy rain
06/11/2003	1,68,22,143	95,00,000	600	121	Heavy rain
7/21/2002	1,65,41,422	2,50,000	380	25	Heavy rain
07/03/2007	1,64,86,188	30,00,000	958	81	Heavy rain
08/02/2018	1,64,24,780	25,000	0	8	Heavy rain
9/16/2012	1,55,26,445	200	45	2	Heavy rain
8/15/2011	1,48,30,495	70,000	158	48	Heavy rain

entire Bangladesh, in particular the delta region of GBM (Fig. 1.2). The area of the GBD delta is approximately 1,00,000 km^2 and is also a habitat for over 170 million people (Edmonds et al., 2020; Auerbach et al., 2015; Paszkowski et al., 2021).

The GBM delta is a unique example of multilateral interaction between water (fresh and saline), land (including livelihood), and forest, which consists of distinguished features like the world's largest and most populated delta (Paszkowski et al., 2021); about 75% of the Himalayan water (~1200 km^3) drains here with containing about 1 billion tonnes (BT) of sediment annually (Reitz et al., 2015; Allison, 1998; Wilson & Goodbred Jr., 2015; Paszkowski et al., 2021); the interplay between higher sediment input and tidal forces makes this region an active zone of land formation and degradation by accretion – erosion and aggradation – and progradation processes (Sarker et al., 2011), holding largest mangrove system of the world (Sundarbans) (Spalding & Leal, 2021) and facing significant changes in the processes of geomorphology naturally and anthropogenically (Paszkowski et al., 2021). The period of formations is still active since the early Holocene (~12,000 years) as a part of the Bengal Basin, which is a result of about 8500 km^3 of sediment deposited from the Ganga, Brahmaputra, and Meghna Rivers (Goodbred Jr. et al., 2014). The GBM delta is also experiencing active tidal action ranging from 3 m to 6 m high with an influence up to 100 km inland (Haque & Nicholls, 2017).

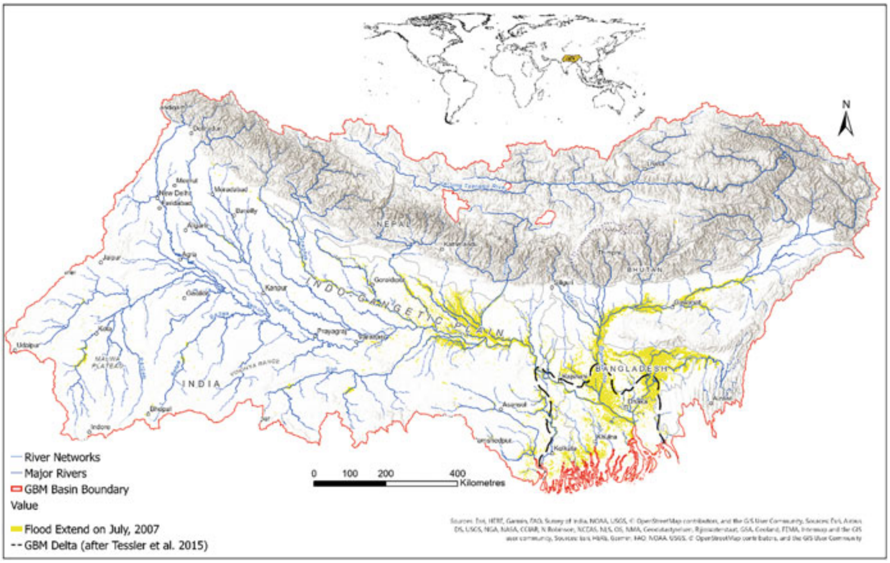

Fig. 1.2 The outline of the Ganga-Brahmaputra-Meghna (GBM) basin marked with its deltaic zone (in black dashed line) after Tessler et al. (2015) and showing the extension of the most severe flood during July 2007 as per mapped by Dartmouth Flood Observatory (DFO). (Sources: Esri, HERE, Garmin, FAO, Survey of India, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community. Sources: Esri, Airious DS, USGS, NGA, NASA, CGIAR, N Robinson, NCEAS, NLS, OS, NMA, Geodatastyrelsen, Rijkswaterstat, GSA, GEoland, FEMA, Intermap and the GIS, user community. Sources: Esri, HERE, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community)

2 The Ganga-Brahmaputra-Meghna Delta: A Geomorphic Unit

The cradle of the GBM delta is the tectonically active Bengal Basin (Fig. 1.3), which spans the western margin of the Indian Shield or Craton, getting maximum sediments from the Himalayan Rivers. The basin is situated at a plate boundary of the Indian Plate, Burma Plate, and Eurasian Plate, as a continent–continent collision (forming the Himalayan Arc). Flexural subsidence over a broad area, in addition to faulting, folding and localized compaction, allows the subaerial portion of the GBM delta to trap and store ~30% of the 1.1 billion tonnes of sediment delivered to the fluvial system by the rivers (Reitz et al., 2015). The important studies (Bandyopadhyay, 2007; Auerback et al., 2015; Reitz et al., 2015; Akter et al., 2016; Rudra, 2018; Wilson & Goodbred Jr., 2015; Becker et al., 2020; Paszkowski et al., 2021) revealed that the GBM delta is fed by the combined sediment load of ~1 billion tonnes by the fluvial system of Ganga, Brahmaputra and Meghna and most of the delta lies within 20–25 m from present mean sea level. The course of the Ganga, Bhagirathi, Jamuna, Meghna, and other rivers divides the Bengal Basin or

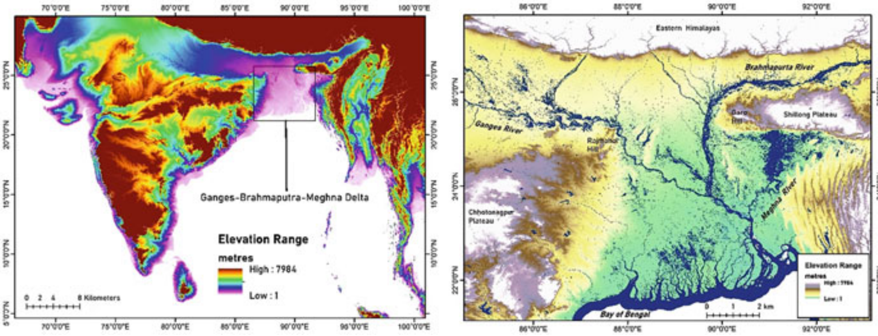

Fig. 1.3 Location of Ganga-Brahmaputra Delta at the eastern part of Indian Craton, showing the fluvial system and seasonally inundated region

undivided Bengal into six geological regions. These regions are: (1) the plains adjoining the Himalayas of North Bengal, (2) the Barind region between the Ganga and the Jamuna, (3) the Rarh region west of the Bhagirathi, (4) the delta east of the Bhagirathi and south of the Ganga, (5) the Meghna Basin, and (6) numerous coastal areas consisting of numerous river creeks and islands.

The GBM delta has morphologic and stratigraphic attributes of an upland fluvial fan, a lowland fluvial delta plain below the backwater transition, a tide-dominated portion amalgamated to its seaward edge, and a large, actively prograding subaqueous-delta clinoform. It is, therefore, best characterized as a composite delta system. Although much of the GBM delta is robust in terms of its construction and maintenance through the Holocene, there are some portions of the delta where sediment supply is insufficient to offset subsidence rates or erosion. These areas are considered most at risk of flooding (e.g., from monsoons, cyclonic storm surges, and high astronomical tides) or erosion (from tidal action). The three regions undergoing this type of decline in the landscape are located in the Sylhet basin, along the Indian tidal delta plain, and at the fluvial-tidal transition in the western and central areas of the delta.

The main geomorphic characteristics of this delta are mentioned as follows (Steckler et al., 2022).

- The GBM delta originated with the opening of the Rajmahal-Garo Gap in the Plio – Pleistocene while it acquired its present form during the Late Holocene after the sea level near its present position following the mid-Holocene transgression.
- The entry of the Ganga (at the Rajmahal Hills of Chotanagpur Plateau) and the Brahmaputra (at the Garo Hills of Shillong Massif) form the apex of the GBM delta, with maximum inputs of water and sediments since Palaeocene. The upper part of this delta exhibits fan-like behaviours of rivers and the apex serves as a principal node of river avulsion. Similarly, the peninsular rivers of India also have formed the vast span of fan-delta at the west (10–40 m elevation range), as a part

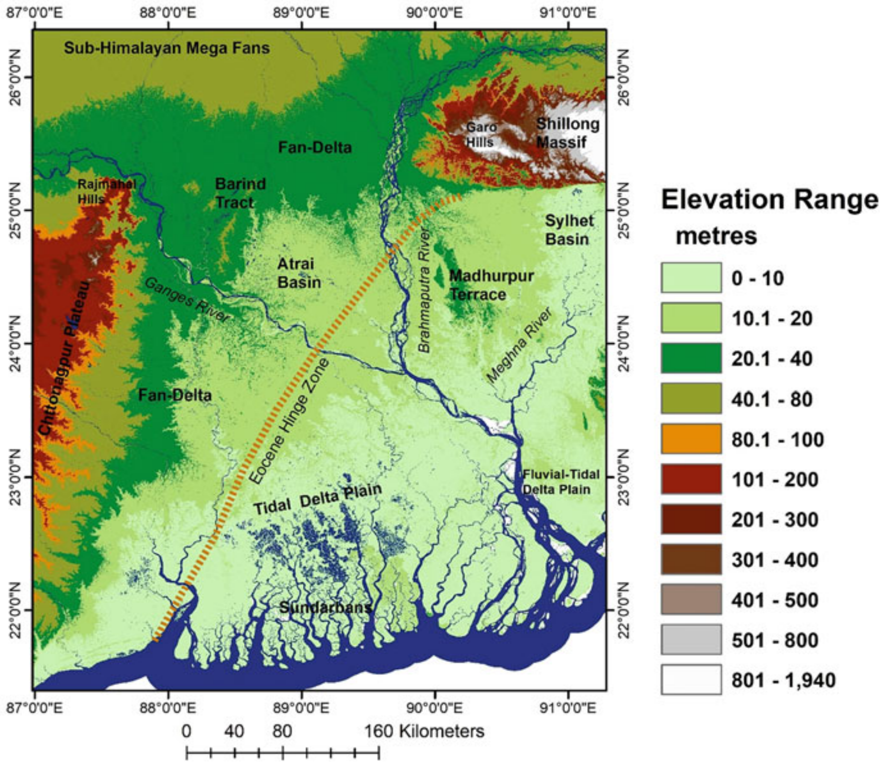

Fig. 1.4 Topographic variation of GBM delta and its important geomorphic units

of Bengal Basin's shelf deposits (Fig. 1.4). Downstream of fan deltas the relief becomes less and the topography is very flat, defining the low-lying tidal or fluvial-tidal delta plain and coastal swamps (Sundarbans).

- In the northern part of the GBM delta, mega-fans of Himalayan Rivers (viz., Teesta, Torsa, Mahananda, Jaldhaka, etc.) are observed. Downstream of the rivers, the dominance of fan deltas, and bed-load alluvial channels are the major landforms. Braided rivers of the Brahmaputra fluvial system undergo rapid channel aggradation, lateral migration, and avulsion.
- The fluvial delta parts of the region also exhibit braided pattern with intensive bank erosion, and some alluvial reaches shows anastomosing pattern where channel braids are reconnected again downstream with mature islands. Many rivers (like Bhagirathi-Hooghly and Meghna) show active meander belts where the channel shows increasing lateral migration and bank-line shifting with the development of oxbow lakes, abandoned channels, and meander scars (Fig. 1.5). The active river-mouth distributaries, in between Padma and Bhagirathi-Hooghly, have developed ~5000 km^2 of large coalescing islands toward the Bay of Bengal. This tidal mud-flat region of more than 100 islands is recognized

Fig. 1.5 Aerial views of river morphology and pattern: (**a**) Braided Brahmaputra River with its tributary confluences, (**b**) mature fan-delta of Ganga River at downstream of Farakka Barrage with its bifurcated western branch Bhagirathi-Hooghly River, (**c**) anastomosing pattern of Meghna River, and (**d**) active deltas of tidal mud-flats at the river mouth of Padma. (Image collected from Google Earth Pro)

as a UNESCO World Heritage Site (World's largest mangrove ecosystem; an area of about 10,000 km^2).

- Development of bars and channel migration (braided channel) force bank erosion rates up to 1 km year^{-1} along the Brahmaputra River. Sediment accretion rates in the floodplains or fan deltas vary from 1 to 4 cm year^{-1} near the Brahmaputra. The observed periodicity of major avulsions varies from 1500 to 2500 years in the Ganga and Brahmaputra. With the decrease in sediment load and monsoon discharge, many rivers of the GBM delta display a phenomenon of metamorphosis, i.e., the transformation of braided to meander pattern in two parts – (a) Ganga fluvial fan in the south-west and (b) Old Brahmaputra fluvial fan near the Sylhet Basin in the north-east. In the last five decades, the GBM has prograded at a rate of 17 km^2 year^{-1} (Akter et al., 2016).
- Near the tidal mud-flat region (i.e., Sundarbans), the monsoon river discharge varies from 50,000 to 1,00,000 m^3 s^{-1} and the suspended sediment load of the estuary ranges from 0.5 to 9.0 gm l^{-1}. About 11,200 km^2 of the lower tidal delta plain is densely inhabited (population density of 500–1000 person km^{-2}) and embanked for settlements and agriculture. This part is extremely vulnerable to natural hazards, like cyclones, storm surges, coastal floods, tsunamis, and sea-level change.
- Due to natural and anthropogenic processes at different spatial scales, the subsidence of unconsolidated deltaic sediments is a natural process in the deltas (Akter et al., 2016). Subsidence of the Bengal Basin is a relevant issue, though the Madhupur Terrace and Barind Tract show regional upliftment. The estimated short-term subsidence rate varies over the delta from 0 to 12 mm year^{-1}. The Sylhet Basin shows a very high subsidence rate of 7–12 mm year^{-1}, and the coastal belt shows a moderate rate, i.e., 3–8 mm year^{-1}. The maximum tilting rate is 1.4×10^{-7} radians year^{-1}. The regions of greater subsidence and tilting show increased river avulsion and channel migration.
- The evidence of climate change is that the probable maximum change in precipitation in the Ganga Basin and the Brahmaputra Basin might be 13.1% and 10.2%, respectively, for a temperature increase of 2 °C (Akter et al., 2016). Between 1968 and 2012, the mean sea level raised at a rate of ~2 mm year^{-1}. The sea level observed from the data collected by three different stations showed rises in sea level by 1.0 mm year^{-1} (Khepupara), 2.7 mm year^{-1} (Haldia), and 3.9 mm year^{-1} (Diamond Harbour), respectively (Jabir et al., 2021). By 2100, even under global warming and greenhouse gas emission mitigation scenario, the subsidence could double the projected sea level rise, mounting it 85–150 cm across the delta (Becker et al., 2020). In addition, in the previous years, tropical cyclones such as *Aila*, *Fani*, *Bulbul*, *Amphan*, and *Yass* devasted the coastal region to a great extent, making the region more vulnerable to floods and biodiversity loss.

3 Living with Monsoon Floods

The Ganga-Brahmaputra-Meghna and their numerous tributaries and distributaries carry a giant volume of sediments, through floods, in the monsoon months, and the deltaic floodplains have been formed by the accumulation of sand, silt, and clay in the Bengal Basin to develop it as world's largest delta. Three river systems drain a catchment of about 1.72 million km^2, from the Himalayas to the Bay of Bengal. Rivers of the GBM delta, like the pendulum of a wall clock, are constantly moving and shifting within a certain range. The range within which the river is constantly moving is called the "Meander Belt" (Islam et al., 2020). The river "Meander Belt" can be called its playground where the river is always active with recurrent floods, changing landforms, and bank-line shifting. Although this area can be used for agriculture, it is not suitable for the construction of railways or roads, but now with the pace of economic development, the natural floodplains are delinked (horizontal disconnectivity) from the rivers, and the lands are utilized for settlements and communicating network. The danger is bound to come when people enter the river playground without realizing it. Ten or twenty years later, the river will return to its old course. With this dynamic character of the river in mind, floodplains can be used scientifically to protect people from erosion damage (Islam, 2011). But as the country's population has grown, settlements have moved to the riverbanks, increasing the risk of erosion (e.g. Islam & Guchhait, 2017, 2018) and flooding (e.g. Islam & Ghosh, 2021). The land use – land cover map (Fig. 1.6) – shows the dominance of the population in the river valleys of the Bengal Basin, showing the maximum area of cropland and patches of settlements. With some 130 million inhabitants, the GBM delta belongs to the most densely populated areas in the world (1300 persons/km^2).

In the GBM delta, the average rainfall is 1474 mm $year^{-1}$, with maximum rainfall of 2269 mm $year^{-1}$ and minimum rainfall of 341 mm $year^{-1}$. From the maps (Fig. 1.7), it is observed that the eastern and south-eastern part receives a maximum annual rainfall of greater than 2800 mm, and the western and north-western part receives rainfall of less than 1600 mm. The annual average discharge of the Padma River is 29,692 m^3s^{-1}, with a maximum discharge of 80,984 m^3s^{-1} and a minimum discharge of 6041 m^3s^{-1}. With high monsoon discharge, flood is a normal occurrence and recurrent hazard in the GBM delta. There are two types of flooding: (a) first, strong cyclones occasionally flood coastal areas and (b) second, in case of low-pressure rainfall. The Himalayan-adjacent plains of North Bengal; the flood plains of North and South Dinajpur, Malda, and Murshidabad; the entire Rarh plain; and Brahmaputra floodplains of Bangladesh are prone to monsoon floods due to their location, topography, type of rainfall, variability of water flow in rivers, etc. Carrying a huge volume of sediment-laden flood water, the Ganga and the Brahmaputra, between the Garo and Rajmahal Gap, have entered into the Bengal Basin Bengal through the two ends of the plain between Meghalaya/Shillong Plateau and Eastern Chotanagpur Plateau. The other four tributaries that flow in the same direction are Mahananda, Teesta, Jaldhaka, and Torsa. The main tributary of the Meghna enters Bengal through the Barak Shrihat or Sylhet Basin. The Ganga, Brahmaputra, and

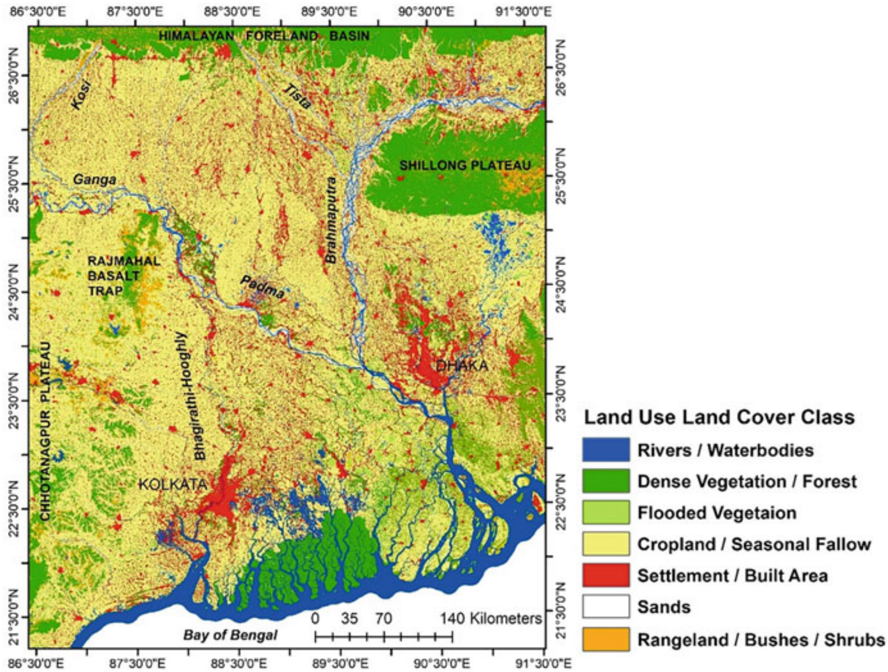

Fig. 1.6 Major land use and land cover classes in the GBM delta

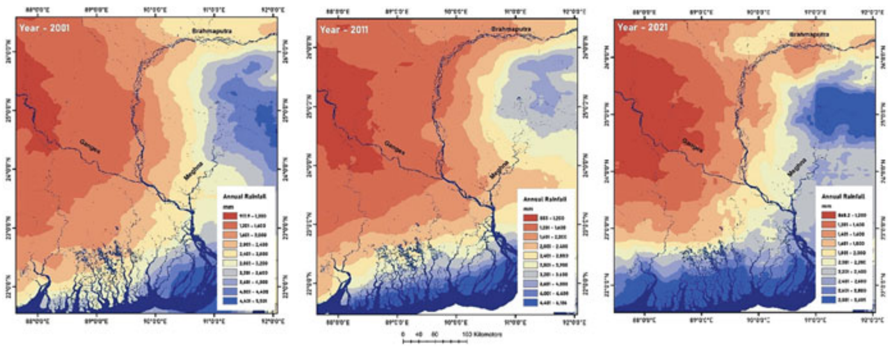

Fig. 1.7 Pattern of mean annual rainfall distribution in the GBM Delta: 2001 (**a**), 2011 (**b**), and 2021 (**c**)

Meghna carry about 1375 km^3 of water per year from a basin of about 16.21 lakh km^2, and the Padma reaches the Bay of Bengal through Bangladesh. The annual flow of these three rivers is unequal, during the monsoon season 69,000 m^3s^{-1} of water flows and at other times it decreases to 5714 m^3s^{-1}.

The severity and extent of floods depend on the amount of water flowing across the border, the intensity of rainfall, the slope of the land, the carrying capacity of the

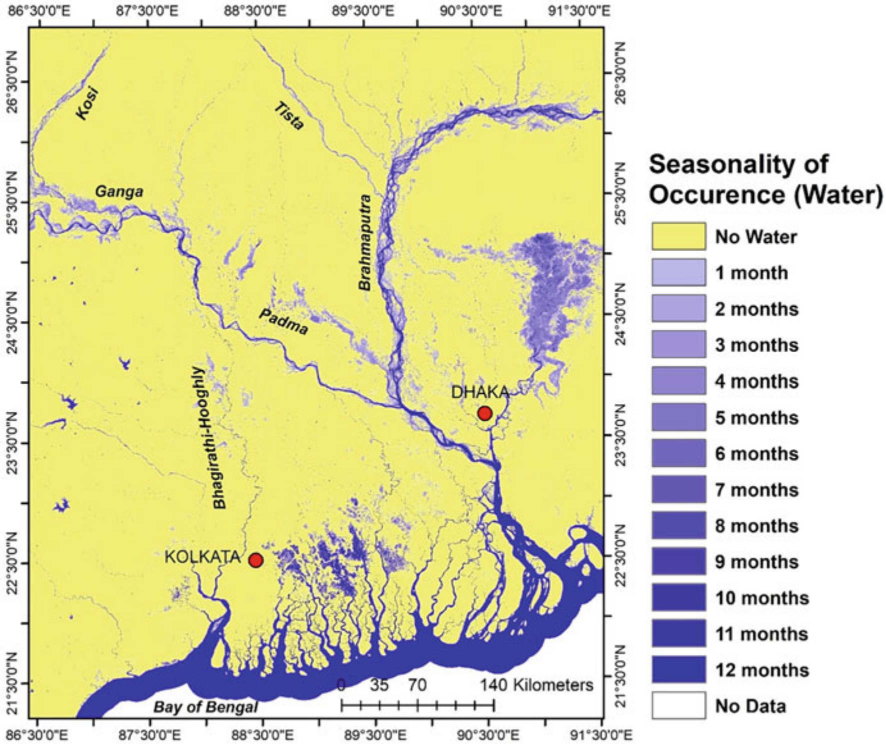

Fig. 1.8 The regions of seasonal inundation and recurrent floods in the GBM Delta (1984–2020)

river, and so on. The major floods in the GBM delta (including other parts of the Bengal Basin) are usually in the last part of the monsoon season, i.e., August or September (Fig. 1.8). The rains in the first part of the monsoon saturate the soils, filling the shallow groundwater table, which goes down a lot in the summer, and the wetlands fill up with the water including the reservoirs and rivers. In the second phase, i.e., in August or September, heavy rains due to depression bring floods. Therefore, September is a "black month" in the history of floods in the GBM delta. Exceptions to this rule have sometimes caused floods in June, July, or even October. The basins of Teesta, Torsa, and Jaldhaka of North Bengal, adjacent to the Himalayas, are prone to more floods in July–August as the south-west monsoon hits the foothills about a month ago. Floods are usually caused by low pressure and heavy rains during the monsoons but have sometimes occurred twice in a row. Due to the heavy rainfall of the late monsoon, the water level of the river rises in such a way that the shallow channels cannot hold so much water, flooding the villages and towns on both sides. Approximately 42% of West Bengal, India, and about 80% of Bangladesh are prone to annual floods (Fig. 1.8). Areas of the Bengal Basin, which are frequently flooded, are:

(A) The Himalayan-adjacent plains of North Bengal where the rivers like Teesta, Jaldhaka, Torsa, Raydak, etc. are flooded.
(B) The Srihatta Basin and the Meghna Basin are flooded – burning down from the southern slope of the Meghalaya Plateau– and this low-lying area remains submerged for about six months.
(C) Floodplain of Jamuna and Atreyee located to the south-east of Barind land.
(D) Rarh plain of West Bengal, especially the lower basins of Damodar, Ajay, Mayurakshi, and Kangsabati.
(E) Floodplains on both banks of Ganga, Jamuna, and Bhagirathi.
(F) The coastal area is submerged by the tidal wave and storm surges.

The rainfall distribution of this region is not even, and the extremity of weather events is now enhanced due to global climate change. Darjeeling, Jalpaiguri, Alipurduar, and Cooch Behar in North Bengal (West Bengal) receive 2500–3000 mm of rainfall annually, whereas the Rarh region (western part of the Bengal Basin) receives an average of 1500 mm of rainfall per year, while the plains of South 24 Parganas receive 1600–1600 mm of rainfall from Murshidabad. Although the average annual rainfall in Bangladesh is 2300 mm, the rainfall is 1200 mm in the Barind region and 5000 mm in the north-eastern part of the country. The trend of heavy rains has been increasing in recent times. Renowned Indian scientist Dr. Meghnad Saha said that surplus water and its unequal distribution is the problem of West Bengal and Bangladesh. Till today, the problem has not changed much; floods and river erosion in the rainy season and severe waterlogging and drainage congestion during the monsoon season are the innate problems. Crying for relief in case of floods, the government trying its best, and mutual blame are all familiar to us. Attempts to control flooding have not diminished since the seven decades of independence from that colonial period, but not much success has been achieved; Many studies reveal that people are largely responsible for this flood. If there was a proper drainage system under the railway line, the damage to crops and property would be much less.

Alongside, the reservoirs and floods are other key issues that deal with downstream changes in flood dynamics due to anthropogenic interventions. The capacity of reservoirs is limited, and the accumulation of sediment is decreasing every year. For example, the Massanjore Dam lost about 474.82 mcm of live storage capacity with a 0.295% annual loss rate, and the annual siltation rate is 1.617 mcm/ year (World Commission on Dams, 2000). Not all upstream waters can be caught in this limited capacity. If it rains heavily at the upper catchment, the water has to be released; otherwise, the dam could break and cause more catastrophes. As a result, the reservoirs built for flood control increase the flooding (evidenced in the Damodar River Basin). Bangladesh has not tried to control floods by trapping water in large reservoirs because of the type of hilly valleys required for reservoir construction. There is no such topography anywhere except Chittagong. As a result, attempts have been made to control the flood only through embankments and polders. In a nutshell, the flood dynamics of the GBM delta can be categorized in the following points:

- The Ganga carries the highest streamflow about one month earlier than the Brahmaputra or Jamuna Ganga, i.e., at the end of July or the beginning of August. On the other hand, the highest currents of the Ganga and its tributaries enter West Bengal and Bangladesh at the end of August or September. When the Ganga water reaches Goalanda, the Jamuna swells and blocks the south-easterly flow of the Ganga, causing the Ganga to overflow its banks.
- Many scholars believe that the erosion and landslides in the Himalayan region have resulted in huge amounts of gravel–sand–silt coming down and blocking the river basin of Bengal and consequently increasing the extent of floods,
- The extent of floods in West Bengal is increasing. Normal floods in the 1950s flooded areas up to 16.764 m high from the mean sea level. In the late 1970s, the reach of flooded areas increased to 19.812 m. The area was submerged up to 20 m during the 1986 floods. During the floods of 2000, the current rose to a height of 68.58 m and crossed the railway line near the Subarnamrigi station in Murshidabad. The same thing is happening in Bangladesh; natural reservoirs, such as Chalonbil or Hurasagar, have become increasingly shallow, causing floodwaters to spread further.
- Floods often disrupt the normal life and livelihood almost year. The agrarian economy is paralyzed by floods during the monsoon period, and rural livelihood becomes at stake. However, sometimes flood blesses the agriculture with fertile silt producing bumper crops. For example, the Panskura region in Medinipur, West Bengal, India, produces good floriculture and vegetables after the monsoon flood enriches the soil with fertile silt.
- Flood pushes the local people to migrate to stabilize the economy. The labour migration in turn earns good remuneration and remittances are sent by the economic migrants to the source region, thus elevating the economic profile by creating an economic multiplier. For example, there has been observed an uplift in the economic profile of the flood-inundated areas of the Mayurakshi River basin, India, i.e., the higher the flood propensity, the higher the labour migration and the higher the receipt of the remittance to rebuild the rural economy (Islam & Ghosh, 2022).
- That huge body of flood water cannot be contained in the rivers or reservoirs; it is inevitable to spread in the floodplains. Technology does not check floods totally, but it can manage to an extent only. The simple fact is that there is research that needs to adapt strategies for living with floods, not to be controlled low-magnitude floods in the fertile floodplains. Thus, instead of controlling floods and living with floods, social various social side management measures like in situ and ex situ livelihood strategies may be encouraged (Islam et al., 2022).

4 The Present Volume and Its Focus

Having this context in mind, the present volume of floods in the GBM delta was conceived. There are 22 chapters in this volume including this chapter. The chapters of this volume are primarily concerned with the floods; their nature, drivers, impacts, and management. The book is arranged systematically with a beginning introducing the general nature of floods in the GBM delta and various issues and challenges for future modeling. This introduction is completed considering two chapters (Chaps. 1 and 2). Therefore, the rest 20 chapters are primarily concerned with floods at the regional scale (basin scale) in regions of both India and Bangladesh. Thus, the book presents a good blend of a systematic and regional approach. The first chapter is mainly focused on the existing nature of floods in the GBM delta, living with monsoon floods and briefing on other chapters included in this volume. The second chapter deals with flood inundation modeling in a data-sparse environment like flatland in the lower Ganga region. This chapter has clearly uttered the main problems, challenges, and prospects while dealing with the floods in a systematic way. The Chap. 3 is concerned with the nature of floods and channel sedimentation in the Torsa River Basin of North Bengal. The fourth chapter is a clear manifesting of similar issues of floods in the Teesta River Basin in India and Bangladesh. Flood Risk Assessment has been done on the Himalayan foothill basin of Jaldhaka river in Chap. 4. Similarly, Chap. 5 is concerned with the flood dynamics and problems of river erosion and channel oscillation with their impacts on the life and livelihood patterns of the people in the Dudhkumar and Dharala Rivers in Bangladesh. Chapter 6 is focused on another investing problem of channel platform development in response to the flood dynamics and anthropogenic interventions in the Mahananda Balason River Basin in the Northern part of West Bengal. Chapter 7 deals with the flood intensity and propensity in the context of dam construction in the Punarbha River Basin of Indo-Bangladesh. Moreover, Chap. 8 explores the morphometry of a small river basin in the Himalayan foothill and relates to the floods based on the prioritization of the subbasins using GIS tools. Chapter 9 is concerned with the flood dynamics of the lower Ganga River in Malda district, India, using multi-criteria analysis. Chapter 10 is focused on the socio-infrastructural vulnerability in the wake of floods in the Mayurakshi River Basin, India, based on the empirical field survey. Moreover, Chap. 11 is focused on the characteristics of floods and their future condition in the Ajay River basin, India. Similarly, Chap. 12 is a clear manifestation of the present flood characteristics and vulnerability of the people in the Khari River Basin, a small basin in the Lower Ganga system. Floods of the Damodar River are very popular among flood geomorphologists because it has a long history of floods that devastated the then Bengal and hence the once sorrow of the Bengal. Thus, Chap. 13 is deals with the floods of the Damodar River and risk assessment using numerical modeling of flood simulation in the Damodar River Basin, Eastern India. Furthermore, the floods and associated changes in the channel shifting of the Shilabati River, the western part of Bengal, are discussed in Chap. 14 of this volume. Chapter 15 is concerned with the flood history of the Ghatal region, India. Similarly, the next chapter (Chap. 16) portrays the future flood scenario of the Brahmaputra River using the multi-model ensemble of CMIP6 projections. This would help the planners and stakeholders for future preparations. Chapter 17 explores the various dimensions of the floods in the Old Brahmaputra River Basin with implications for the sustainable management of the flood. Thus, Chap. 18 deals with the major characteristics of floods of the Meghna River in Bangladesh. Problems of Buriganga and Shitalakhya Rivers with special reference to floods in and around Dhaka City in Bangladesh are discussed in Chap. 19. It would help the various stakeholders how to manage the floods of an urban river. Furthermore, Chap. 20 deals with other fluvial floods mainly triggered by the monsoon rainfall in the context of the Jalangi–Churni River system, which was once active and now decayed. Geospatial assessment of the fluvial dynamics and flood vulnerability is assessed in the Bhagirathi-Hooghly River, India, in Chap. 21. Finally, Chap. 22 is mainly concerned with tidal floods of the Madhumati–Arial Khan Rivers in Bangladesh.

5 Concluding Remarks

Flood in the GBM delta is inevitable because of its hydrogeomorphic, climatic, and anthropic set-up. On the one hand, every year flood takes a toll on thousands of humans and assets, and on the other hand, agriculture gets benefitted through the receipt of the fertile silts derived from the floods. To protect the social and economic infrastructure from the wrecks of the floods, mainly structural interventions are popularly undertaken by the Govt. and other organizations in the form of constructing concrete embankments, dams, barrages, and weirs across the major rivers of the GBM Delta. However, breaching of the embankment and dam failure is commonly observed in these regions, especially during the heavy monsoon downpours. Therefore, it is true that instead of controlling the floods, understanding flood behaviour and social side management measures would be embraced to better live with the floods. In brief, the focused attention on the floods in the context of the GBM delta is really vital for the management of future floods. Thus, this book will cater to the need of the diverse communities from land to laboratory.

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