CHAPTER 17

AN ANALYSIS OF FLOOD CONTROL IN EASTERN SOUTH ASIA

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ABSTRACT

This chapter studies the causes and features of floods and measures for the control of floods in eastern India and Bangladesh. Structural as well as non-structural measures are being emphasized for flood management in both India and Bangladesh. It has been proved that non-structural measures have a significant effect on flood damage minimization.

17.1 INTRODUCTION

The northeastern region of India comprises seven states, namely Assam, Meghalaya, Mizoram, Manipur, Nagaland, Tripura, and Arunachal Pradesh and the region borders the countries of Bhutan, China, Bangladesh, and Myanmar. The entire region is one of the most hazard-prone regions in the Asian continent, with different areas being prone to multi-hazards like earthquakes, floods, landslides, and cyclonic storms. The rivers Brahmaputra and Barak drain the region. The Brahmaputra river has a catchment area of 5,80,000 km in Tibet, Bhutan, India, and Bangladesh and in terms of discharge is the third largest river in the world, in terms of sediment load it is second after the Hwang-Ho river of China. The river flows for a length of 918 km in India of which 720 km is in through the plains of Assam. In this valley, about 20 major tributaries on its North bank and about 13 on its South Bank join the river Brahmaputra. The precipitation here is mainly due to the South-West monsoon. Heavy rainfall occurs from June to September. Average annual rainfall in the region is very high and ranges from 1750 mm in the plains to about 6400 mm in the hills, this huge volume of water rushes through the narrow bowl-shaped valley of Assam to the Bay of Bengal ravaging the area through floods and land erosion. The recurring floods on an average devastate about 20% of the total area of the plain districts of the state of Assam, and in the high floods years, the devastation has been recorded to be as high as 67%. The region lies at the junction of the Himalayan arc to the north and the Burmese arc to the east and is one of the six most seismically active regions of the world.

The monsoon in the region normally commences around the months of April, May, and is active until the end of October. The pre-monsoon period is often marked by severe cyclonic storms and hailstorms. The annual cyclonic depressions in the Bay of Bengal along the coast of Bangladesh cause severe storms to hit the bordering states of Meghalaya and Tripura. Bangladesh stretches between latitudes 20°34'N and 26°38'N and longitudes 88°01'E and 92°41'E. The country contains the confluence of a distributary of the Ganga (the other distributary, also called Ganga, passes through West Bengal and drains into the sea at Ganga Sagar), Brahmaputra, and Meghna Rivers and their tributaries, which originate in the Himalayas (except the Meghna, which in its upstream portion is called the Barak) and discharge into the Bay of Bengal. The terrain is mainly flat, and with 90% of its landmass, up to 10 meters above the mean sea level, is a primarily low-lying riverine country. It is frequently hit by natural disasters, particularly floods, riverbank erosion, cyclones, and droughts. Each affects the livelihoods of those affected, but with different severity. Displacement due to flood, erosion, and inadequate facilities during and after major floods, as shown in Figure 17.1, can create major hardship and health problems.

The climate of Bangladesh is a tropical monsoon, influenced by the Himalaya Mountains in the north and the Bay of Bengal in the south. High monsoon rains associated with Bangladesh's unique geographical location in the eastern part of the delta of the world's second largest river basin make it extremely vulnerable to recurring floods. Agriculture is the dominant land use in the country covering about 59% of the land, rivers, and other water bodies constitute about 9% (BBS, 2002). Monsoons with varying degrees of associated flooding are anticipated annual events in Bangladesh.

The state of West Bengal lies in the eastern part of India and is flood-prone with floods occurring with a depressing regularity. A number of factors combine to cause floods in southern West Bengal. There is extremely high rainfall in the monsoon season. The seaward slope of southern West Bengal is very low, and the Ganga delta is tidal in nature. There are several low-lying areas where water lies stagnant. There is silting of several outlet canals reducing carrying capacity. In addition, there is human encroachment on some channels hampering renovation of those channels (Figure 17.2).

FIGURE 17.1 Erosion and inadequate facilities during and after major floods in Bangladesh (*Source*: The Daily Prothom Alo, 2004).

FIGURE 17.2 Flood in Assam, India (*Source*: Assam_Disaster_Management.htm).

17.2 TYPES OF FLOODS

The term flood is generally used when the flows in the rivers and channel cannot be contained within natural or artificial riverbanks. By spilling the riverbanks, when water inundates floodplains and adjoining high lands to some extent or when the water level in the river or channels exceeds certain stage, the situation then termed as flood (Hossain, 2004). Important river basins and type of floods are shown in Figures. 17.3–17.8.

FIGURE 17.3 Ganga Basin in India and Bangladesh.

17.2.1 FLASH FLOOD FROM HILLY AREAS

Flash flood-prone areas of the India and Bangladesh are at the foothills. Intense local and short-lived rainfall often associated with mesoscale convective clusters is the primary cause of flash floods. These are characterized by a sharp rise followed by a relatively rapid recession. Often with high velocities of on-rush flood damages crops, properties, and fish stocks of the wetland. Flash flood can occur within a few hours and are particularly frequent in the months of April and May.

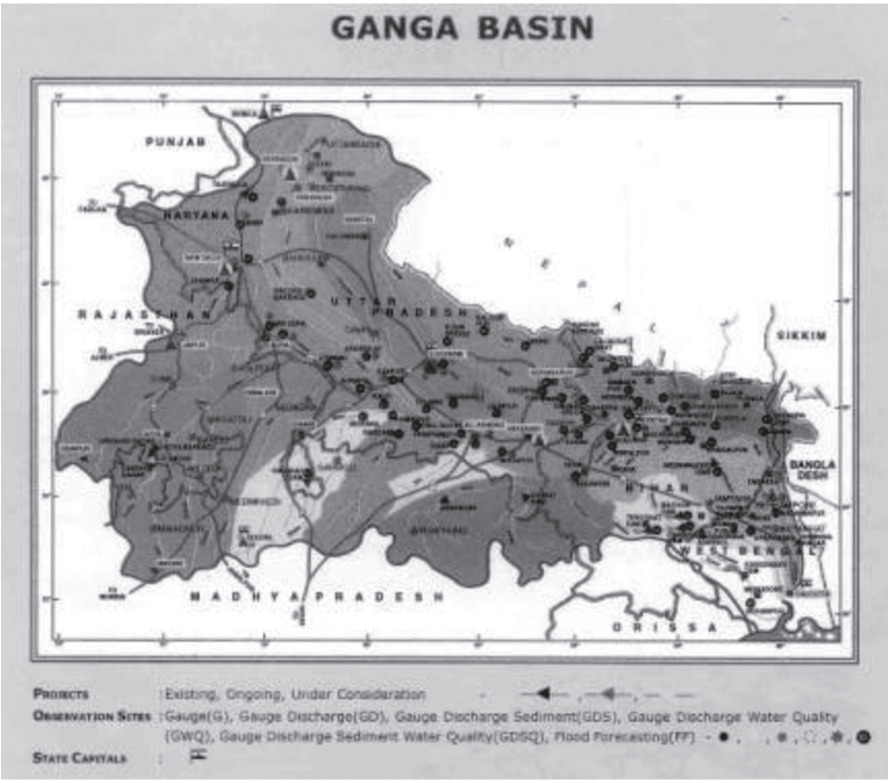

FIGURE 17.4 Ganga river basin in India (*Source*: www.wrmin.nic.in).

17.2.2 MONSOON FLOODS OR NORMAL FLOOD FROM MAJOR RIVERS

River flood is a common phenomenon in India and Bangladesh and is caused by bank overflow. Of the total flow, around 80% occurs in the 5 months of monsoon from June to October (WARPO, 2004). A similar pattern is observed in case of rainfall also. Therefore, to these skewed temporal distributions of river flow and rainfall, India, and Bangladesh suffer from an abundance of water in monsoon, frequently resulting into floods and water scarcity in other parts of the year, developing drought conditions.

In the Brahmaputra, maximum discharge occurs in an early monsoon in June and July whereas in the Ganga maximum discharge occurs in August and September. Synchronization of the peaks of these rivers results in devastating floods in India and Bangladesh. The rivers of Bangladesh drain about 1.72

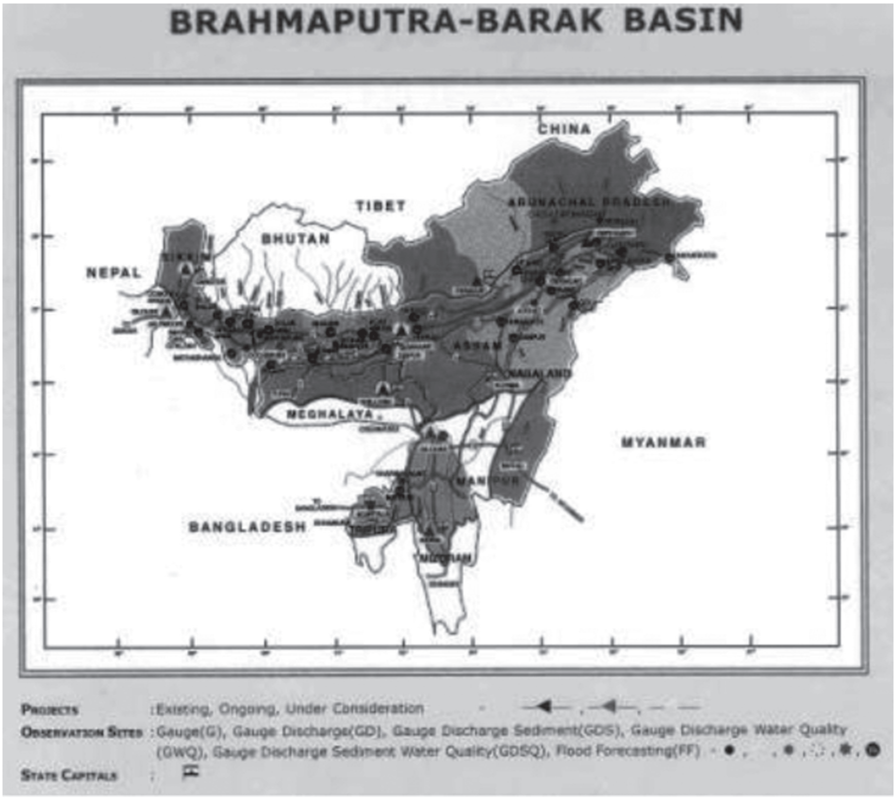

FIGURE 17.5 Brahmaputra and Barak river basins in India (*Source*: www.wrmin.nic.in).

million sq km area of which 93% lies outside its territory in India, Nepal, Bhutan, and China. The annual average runoff of the transboundary rivers of Bangladesh is around 1200 cubic kilometers (WARPO, 2004). A major impediment is the lack of accurate data on a real-time basis on stream flow in the vast upper reach of the Brahmaputra in Tibet in China (the river is called Tsangpo there) and the IRS (Indian Remote Sensing) series of satellites launched from, first the ASLV, and now the PSLV series of rockets from Shriharikota in southern India have to be used to get data. Considering that the floods in the Brahmaputra affect the state of Assam in India as well as Bangladesh, very accurate data on streamflow into India from China on a real-time basis would indubitably be very helpful. However, some streamflow data is being made available to India by China. A cause of concern for the subcontinent as a whole is the Chinese River Linking Plan in which the waters of the Brahmaputra would be diverted northwards via the Yangtze-Kiang River to the Hwang-Ho

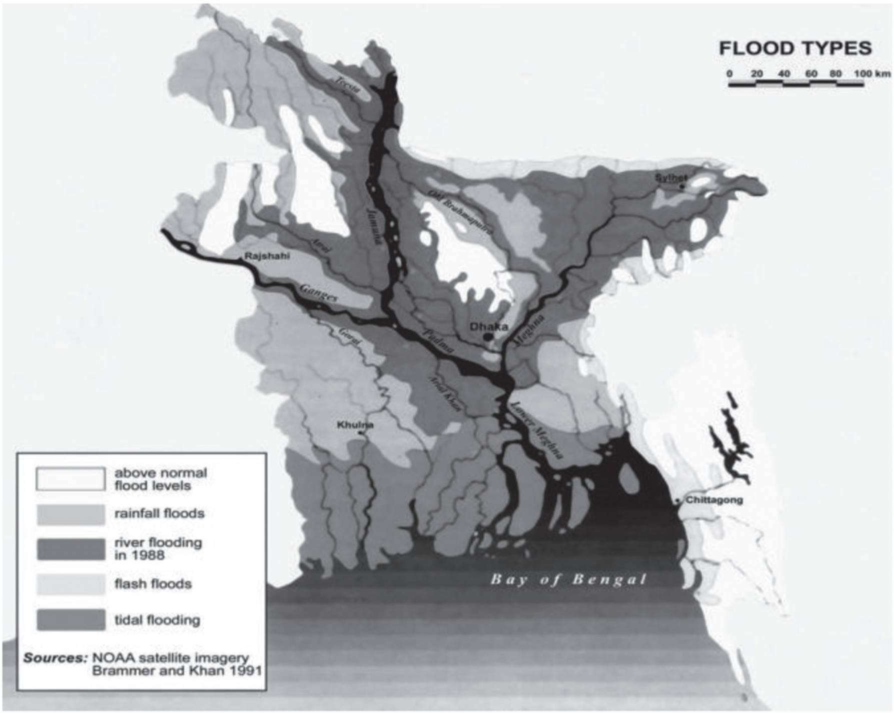

FIGURE 17.6 Types of the flood in Bangladesh (*Source*: FFWC, Dhaka).
(**Note:** Rivers outside the boundaries of Bangladesh are not shown in the figure).

river. This plan, if implemented excluding the water needs of the subcontinent, would result in severe water deficit in the subcontinent.

It may be mentioned that India too has a River Linking Plan (NWP, 2002) to ensure equitable distribution of water and control of floods but much debate is on this issue and Bangladesh, Nepal, and Bhutan would certainly be included in the plan, if it is at all implemented, so that all the countries can get their share of the benefits of this integrated and holistic sub-continental River Linking Scheme. With reference to Figures 17.3 and 17.8, the Indus River Basin and the Ganga River Basin are separated by a low watershed. As per the India-Pakistan Treaty, 1961, the waters of the Indus River Basin are to be shared by the two countries such that India gets the full share of water flowing through the basin via the Sutlej, Beas, and Ravi rivers while Pakistan gets the full share of water flowing through the basin via the Chenab, Jhelum, and Indus Rivers. It is envisaged to construct a canal connecting the Sutlej River in the Indus basin with the Ganga basin so as to divert some water

FIGURE 17.7 Confluence of a distributary of the Ganga, Brahmaputra, and Meghna (lower Barak) River Basins in Bangladesh (*Source*: FFWC, Dhaka).

FIGURE 17.8 Indo-Gangetic basin (*Source*: IWMI).

from the Indus Basin to the Ganga Basin without, in any way, impinging on the water rights of Pakistan because the waters of the Sutlej are fully allocated to India. The objective is to augment and increase the discharge in the Ganga to meet the needs of the Ganga basin fully.

17.2.3 FLOODS DUE TO STORM SURGES

This kind of flood mostly occurs along the coastal areas of Bangladesh and West Bengal. Continental shelves in this part of the Bay of Bengal are shallow and extend to about 20–50 kms. Moreover, the coastline in the eastern portion is conical and funnel-like in shape. Because of these two factors, storm surges generated due to any cyclonic storm is comparatively high compared to the same kind of storm in several other parts of the world. In case of the super-cyclones maximum height of the surges were found to be 10–15 m, which causes flooding in the entire coastal belt. The worst kind of such flooding was on 12 Nov 1970 and 29 April 1991, which caused loss of 300,000 and 138,000 human lives respectively (FFWC, 2005). Coastal areas are also subjected to tidal flooding during the months from June to September when the sea is in spate due to the southwest monsoon wind.

17.3 GENERAL PATTERN

The Brahmaputra starts rising in March due to snowmelt on the Himalayas, which causes the first peak in May or early June. It is followed by subsequent peaks up to the end of August caused by the heavy monsoon rains over the catchments. The response to rainfall is relatively quick, resulting in rapid increases in the water level. The Ganga starts rising gradually in May-June to a maximum sometime in August. High water levels are normally sustained until mid-September. The Meghna may not attain its annual peak until August-September. The upper Meghna carries only about 10% of the flow in the Ganga and Brahmaputra. The total volume of runoff in the GBM is determined by the net precipitation over all the catchments. The normal sequence of floods with flash floods in the eastern hill streams during the pre-monsoon period in the months of April and May. High floods occur if the peaks of the Ganga and Brahmaputra coincide; this may happen during August-September (Rahman et al., 2007).

17.3.1 FLOOD DAMAGES IN BANGLADESH

The terrain has experienced seventeen highly damaging floods in the 20th century. Since independence in 1971, Bangladesh has experienced floods of vast magnitudes in 1974, 1984, 1987, 1988, 1998, 2000, and 2004 (FFWC, 2005). The largest recorded flood in depth and duration of flooding in its history occurred in 1998 when about 70% of the country was under water for several months (FFWC, 2005; Nishat et al., 2000). The area affected in percent of the total area during major flood event inundating more than 20% of the country's land area of the country is presented in Figure 17.9. The damages during some severe floods are presented in Table 17.1.

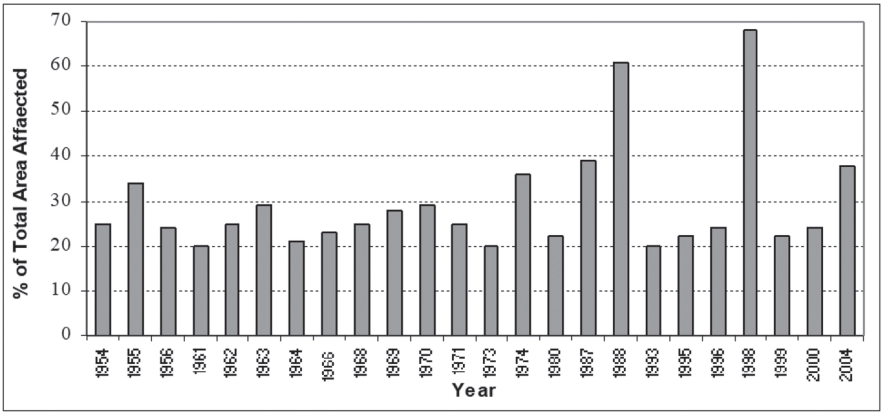

FIGURE 17.9 Area of Bangladesh affected during major flood events (in percent of the total area).

17.4 FLOOD MANAGEMENT IN BANGLADESH

Bangladesh tries to deal with flood and disaster with structural and non-structural measures. Systematic structural measures began by implementing flood control projects in the sixties after the colossal flood of 1963. Non-structural measures have introduced in the seventies. Flooding is a natural phenomenon, which cannot be prevented. Complete flood control is not in the interests of most Bangladeshi farmers. The flood control measures and policies should be directed to mitigation of flood damage, rather than flood prevention. Resources should be allocated to help people adopt a lifestyle that is conformable to their natural environment. Indigenous solutions such as changing the housing structures and

TABLE 17.1 Some Notable Flood and Cyclone Induced Storm Surge Events in Bangladesh

Event	Impact
1974 flood	Inundated 36% of the country (FFWC, 2005), estimated damages US$ 57.9 Million, over 28,700 deaths, (http://www.em-dat.net/disasters/Visualisation/profiles/natural-table-emdat.php?country=Bangladesh dated 2.3.2006)
1987 flood	Inundated over 57,000 sq-km area, estimated damage US$ 1.0 billion and human death 2055 (The World Bank, 2002)
1988 flood	Inundated 61% of the country, persons affected 45 million, 2300 deaths, damage worth about US$ 1.2 billion (The World Bank, 2002)
1998 flood	Inundated 100,250 sq-km (68%) of the country, 1100 deaths, persons affected 31 million, damaged 500,000 homes, 23,500 km roads and 4500 km embankment, destroyed crops of 500,000 ha of land, damage worth about US$ 2.8 billion (The World Bank, 2002)
2004 flood	Inundated 38% of the country, 750 deaths, persons affected 36 million, damaged 58,000 km roads and 3,100 km embankment, crop damage 1.3 million ha, damage worth about US$ 2.2 billion (ADB-World Bank, 2004)

crop patterns can help reduce flood damage. Moreover, good governance, appropriate environmental laws, acts, and ordinances will be necessary to achieve sustainable economic development and to reduce any environmental degradation. In addition, implementation of an improved real-time flood and drought control warning system can reduce the damage caused by floods (http://www.bytesforall.org/8th/control_flood.htm dated 2.3.2006). In recent years, improved forecasting, early warning system, and preparedness measures have helped to reduce the number of lives lost by natural disasters.

17.4.1 FLOOD MANAGEMENT BY STRUCTURAL MEASURES

The structural option provided some benefits especially increase in agricultural production (BWDB, 2005; BBS, 2002) at an earlier period but some adverse effects were observed later on (Nishat et al., 2000). Notably, the construction of a high embankment along both banks of the rivers in some cases resulted in a rise in bed levels due to siltation causing obstruction to drainage. In the coastal areas, although the construction of polders prevented salinity intrusion, but resulted in restriction of the movement of the tidal prism, sedimentation of tidal rivers and obstruction to the gravity drainage. Another important impact on agriculture was found that the farmers in most cases opted for production of cereal crops, especially HYV rice enjoying a flood free situation rather than going for crop diversification. Structural measure caused many adverse effects on the aquatic lives, especially on open water fisheries. National and regional highways and railways, to the extent feasible, have been raised above flood level. Raising feeder and rural roads will be determined in the context of disaster management plans. River maintenance through dredging is also going on in a limited case due to the high cost. Efforts are continued for erosion control on medium and small rivers. Several Flood Control, Drainage, and/or Irrigation (FCD/I) projects have been constructed. FCD/I project are of two types, namely, (i) full flood control facilities; and (ii) partial flood control. Until date, FCD/I projects provide facilities in about 5.38 million ha which is about 59% of the country's net cultivated land (BWDB, 2000). Flood control and drainage structures have also been provided in major cities to make the cities flood free.

17.4.2 FLOOD MANAGEMENT BY NON-STRUCTURAL MEASURES

Introduction of non-structural option, i.e., Flood Forecasting and Warning System I Bangladesh started from the early '70s and contributed to the improvement of the capacity for flood preparedness and mitigation/ minimization of flood losses. Other non-structural measures are discussed in the following.

Flood cum Cyclone Shelter: School buildings are so constructed that they can be used as flood-cum cyclone shelter especially in the coastal zone with the highest risk of flood and storm surge. These structures are not intended to change the flood regime, and therefore, considered as no-structural measures of flood management.

Floodproofing: Efforts have been made to provide vulnerable communities with mitigation by raising homesteads, schools, and marketplaces in low-lying areas (rather than flood control) and in the charred land so that peasants can save their livestock and foodstuff.

The concept of *flood zoning* and *flood insurance* are not practiced in the country until date. Flood zoning will facilitate development in a co-coordinated way to avoid expensive investments in vulnerable areas. Proper land development rules need to be developed based on the flood-zoning map.

Other non-structural measures practiced are:

- Working with communities to improve disaster awareness.
- Developing disaster management plans.
- Relief and evacuation.

17.4.3 FLOOD FORECASTING AND WARNING IN BANGLADESH

A flood warning is concerned to reduce sufferings to human life and damages of economy and environment. Flood Forecasting and Warning Service of Bangladesh was established in 1972 as a permanent entity under Bangladesh Water Development Board (BWDB). Initially, co-axial correlation, gauge-to-gauge relationship, and Muskingum-Cunge Routing Model were used for forecasting. From the early nineties, a numerical modeling based approach has been applied for flood forecasting and warning. Using the principal concept of mass transfer based on the continuity and momentum equations, dynamic computation has been used in this method. Very briefly, it comprises of estimating water levels using hydrodynamic simulation model (MIKE 11). Research on Modeling System and capacity building in the forecasting is currently emphasized. During the severe flood in Bangladesh and West Bengal, India, in 1998, loss of lives and damage of FCD/I projects in Bangladesh were minimum mainly because of flood forecasting and early warning (Islam and Dhar, 2000).

17.5 DISASTER MITIGATION

Disaster management (including disaster preparedness) involves prevention and mitigation measures, preparedness plans and related warning systems, emergency response measures, and post-disaster reconstruction and rehabilitation. The main aims for water-related disaster management are to provide the means by which, through a combination of structural and non-structural measures and to the extent feasible and affordable, people are adequately warned of an approaching disaster, and are adequately supported in rebuilding their lives thereafter. The vulnerability to natural disasters combined with the socio-economic vulnerability of the people living in the different states of India poses a great challenge for the government machinery and underscores the need for a comprehensive plan for disaster preparedness and mitigation. The Government of India since the last decade has been actively supporting programs for the reduction of vulnerabilities and risks. UNDP has been a partner of the Government of India in such efforts. Vulnerability reduction and linking with sustainable development efforts have been one of the key approaches of UNDP. Strengthening capacities for disaster risk reduction and sustainable recovery process across the country and bringing together skills and resources for making communities disaster resistant is one of the first steps taken in the long term for achieving a reduction in loss of lives and protecting the development gains.

Quite a few measures may be taken to reduce floods in West Bengal. The network of drainage canals is to be increased, and silted drainage canals are to be dredged to augment channel capacity and allow free flow of excess water through those channels. More dykes are to be built to prevent floodwater from entering low-lying areas, and existing dykes are to be strengthened to prevent their breaching. If possible, human habitation is to be evacuated from flood-prone areas. Pumps of adequate capacity are to be kept on standby to pump out water particularly from low areas. Better meteorological forecasting is necessary so that the water levels in the Damodar Valley Corporation reservoirs can be brought down early enough to accommodate high inflows from upstream in flood periods. Adequate discharge channels are to be provided in the lower Damodar basin; this area is suffering from flood due to inadequate discharge channels. The capacity of the Mayurakshi river also needs to be augmented. Floods in West Bengal can be prevented or reduced by taking adequate structural and non-structural measures.

The Disaster Management Department, Government of West Bengal, India, (MOFM, 2006) has emphasized that during floods, large tracts of land get inundated and, thereby, disconnected from the adjoining areas resulting in disruption of normal day-to-day activity in that area. Though natural calamities like a flood cannot be avoided, its impact in terms of loss of lives and damage to properties can be minimized by undertaking appropriate management practices for preparedness, prevention, and mitigation measures. This constitutes a holistic approach towards management of flood with emphasis not only on the traditional post-disaster response; but also on pre-disaster preventive/mitigation preparedness as well, thereby, laying down a Standard Operating Procedure (SOP) for a Disaster Manager for flood management (www.wbgov.com).

The Government of Bangladesh (GoB) established the Disaster Management Bureau (DMB) in 1993, which has prepared comprehensive Disaster Management Plans. DMB is working under the Ministry of Disaster Management and Relief. Standing orders on Disaster have been prepared in 1997 and upgraded in 1999 by the DMB (Chowdhury, 2003). At the central level, a National Disaster Management Council (NDMC) has formed headed by the Honorable Prime Minister including Ministers from different ministries as a member. Inter-Ministerial Disaster Management Co-ordination Council (IMDMCC) has also been formed which guided by the NDMC. Beside this, District, Thana (area under the jurisdiction of a Police Station) and Union (lowest level of local government) level committees have also formed with the participation of local community for post-disaster management and mitigation. Task and responsibilities of each committee are stated in the standing order (MoDMR, 1997). By all these steps GoB has strengthened the disaster response capacity through institutional capacity building activities; community disaster response simulation drills; and stockpiling of essential relief items.

Forecasting facilities, preparedness planning, during, and post-disaster relief efforts have reduced the severity of flood disaster impacts. Non-Government Organizations (NGOs) have also responded in an important way. It has been observed that emergency flood fighting during peak flood, evacuation, and relief operation can best be achieved with peoples' participation along with deployment of the army.

17.6 CONCLUSIONS

Structural as well as non-structural measures are being emphasized for flood management in both India and Bangladesh. It has been proved that non-structural measures have a significant effect on flood damage minimization. Flood and disaster cannot fully be controlled, prevented or eliminated, but damages can be reduced significantly by the integration of measures and coordination of agencies. Flood forecasting and early warning are very important. Co-operation is needed at all levels for research and development for improvement of flood mitigation measures.

KEYWORDS

- **Bangladesh**
- **flood control**
- **flood damages**
- **flood mitigation**
- **India**

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