A Detailed Analytical Study of Flood Management in Eastern and North-Eastern India and Bangladesh

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Abstract
This paper studies the causes, features and management measures for floods in eastern and north-eastern India and Bangladesh. An exposition of the climatic, topographical, hydrogeological, riverine and other relevant features of the region, placed in the context of floods and flood management, is present in this paper. The ambit of the paper is north-eastern India, West Bengal and Bangladesh.

1.Introduction
The north-eastern 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 China, 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 originates in China, then flows for a length of 918 Km in India of which 720 Km is through the plains of Assam, and the lower stretch is in Bangladesh. Thus, the central portion of the Brahmaputra is in India. In Assam, 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 October. The average annual rainfall in the region is very high and ranges from 1750mm in the plains to about 6400 mm in the hills, this huge volume of water rushes through the narrow bowl shaped valley of Assam through Bangladesh 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. 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 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 channels reducing carrying capacity. In addition, there is human encroachment on some channels hampering renovation of those channels.

Bangladesh stretches between latitudes 20034'N and 26038'N and longitudes 88001'E and 92041'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 in north-eastern India 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 Fig. 1, can create major hardship and health problems. The climate of Bangladesh is tropical monsoon. High monsoon rains, associated with Bangladesh's geographical location in the eastern part of the delta of the world's second largest river basin, make it extremely vulnerable to recurring floods. The dominant land usage in the country is for agriculture, covering about 59% of the land; rivers and other water bodies take up another 9% (Bangladesh Bureau of Statistics, 2002).

River Erosion due to Flood

Lack of Flood Shelter Facilities

Fig. 1: Erosion and inadequate facilities during and after major floods in Bangladesh
(Source: The Daily Prothom Alo, 2004)

Fig. 2: Flood in Assam, India
(Source: Assam_Disaster_Management.htm)

2.India-Bangladesh and India-China Co-operation in Water Resources

2.1.India–Bangladesh Co-operation in Water Resources (http://www.wrmin.nic.in)

The signing of the Treaty between the Governments of India and Bangladesh on sharing of Ganga water at Farakka on December 12, 1996 ushered a new era of co-operation in water resources sector. The signing of this Treaty generated tremendous goodwill between the two countries. As a follow up, a Joint Committee consisting of equal number of representatives from both the countries was constituted immediately after signing the Treaty for implementing the arrangements contained in the Treaty including setting up of joint teams at Farakka in India and Hardinge Bridge in Bangladesh to measure and record the flows for the purpose of monitoring the sharing of waters. Secretarial and Ministerial contacts through the Joint Rivers Commission are also made from time to time between both the Governments. Since the signing of this Treaty in December 1996, sharing of the lean season (January to May) flow of Ganga Waters at Farakka during 1997 and in subsequent years has been carried out to the satisfaction of both the countries. The existing system of transmission of flood forecasting data on major rivers, that is, Ganga, Teesta, Brahmaputra and Barak during the monsoon season from India to Bangladesh was continued. The transmission of flood forecasting information from India during the monsoon has enabled Bangladesh to take appropriate measures.

As a follow up of the 34th meeting of India-Bangladesh Joint Rivers Commission meeting held at Dhaka, Bangladesh in January, 2001, discussions were held on the unprecedented floods of September, 2000, which had affected West Bengal and adjoining areas of Bangladesh. In this connection, a Joint Task Force for Flood Management in the Ichhamati Basin was set up to formulate an Action Plan for tackling such flood calamities jointly.

2.2.India - China Co-operation in Water Resources (http://www.wrmin.nic.in)

A Memorandum of Understanding was signed between India and China on January 14, 2002, for provision of hydrological information namely rainfall, water level, discharge and other relevant information on Brahmaputra river in respect of three stations, namely, Nugesha, Yangcun and Nuxia in the flood season by China to India. The information is furnished from June 1 to October 15 every year and is useful for flood forecasting purposes in the north-eastern region of India as well as Bangladesh. As a follow-up of this Memorandum of Understanding, an Implementation Plan has also been signed between the Central Water Commission, Ministry of Water Resources of India and the Bureau of Hydrology and Water Resources, Tibet Autonomous Region of China. The Chinese side has transmitted data to India for the above-mentioned three stations during the year 2002 and thereafter. Considering that the floods in Brahmaputra affect the states of Arunachal Pradesh and Assam in India as well as Bangladesh, very accurate data on streamflow into India from China is important.

3.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 flood plains 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).

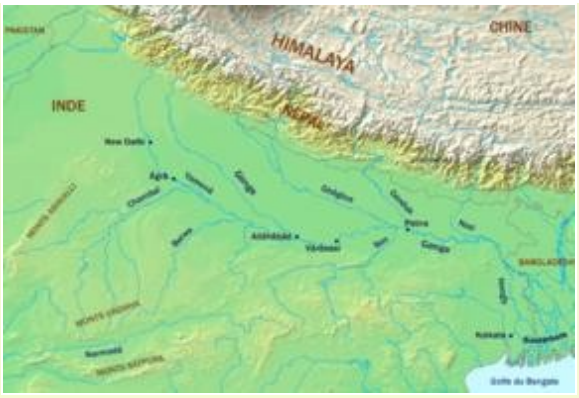

Fig. 3: Ganga Basin in India, Bangladesh and Nepal

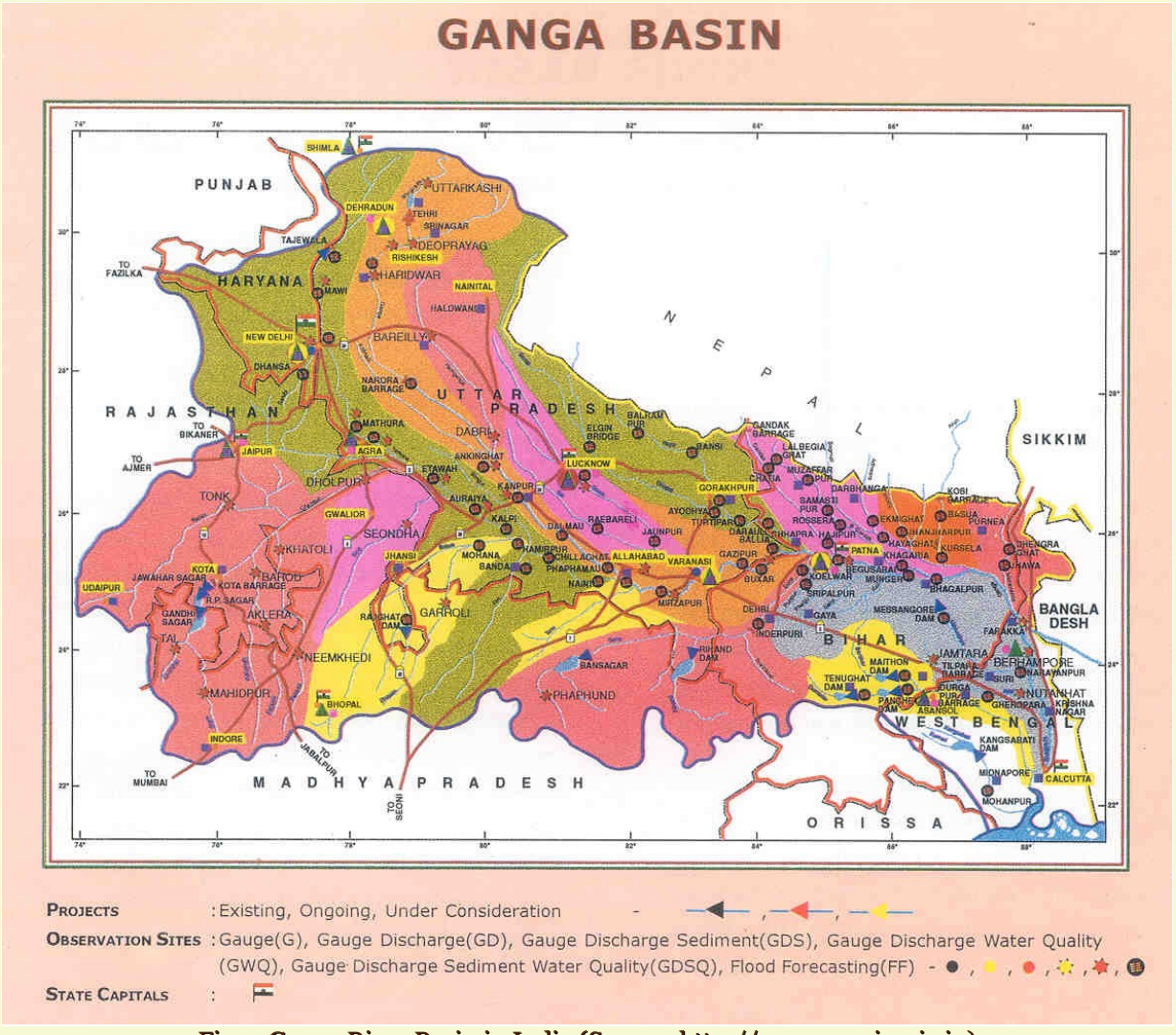

Fig 4: Ganga River Basin in India (Source: http://www.wrmin.nic.in)

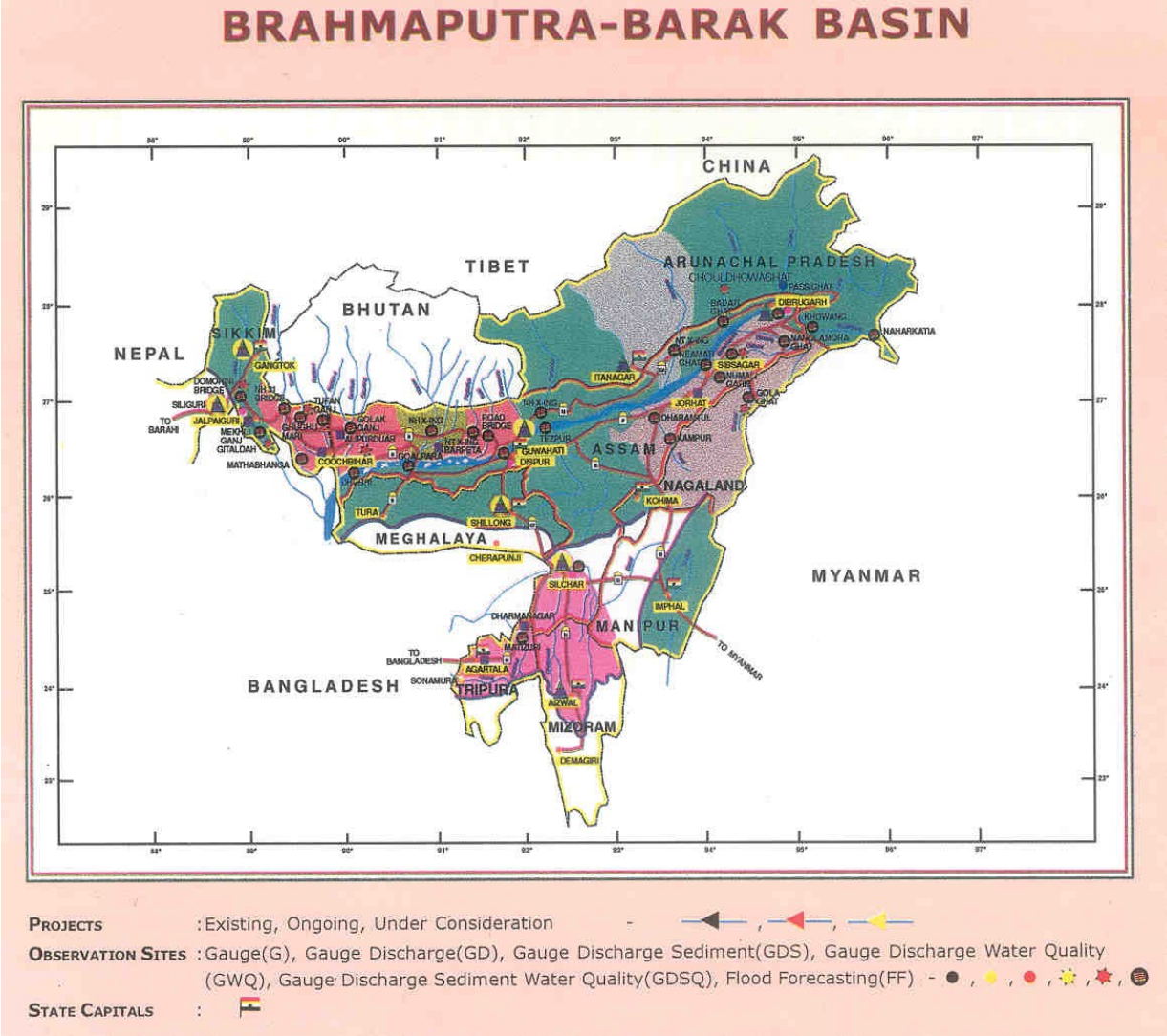

Fig. 5: Brahmaputra and Barak River Basins in India (Source: http://www.wrmin.nic.in)

Fig. 6: Confluence of a distributary of the Ganga, Brahmaputra and Meghna (lower Barak) River Basins in Bangladesh (Source: Flood Forecasting and Warning Centre, Dhaka, Bangladesh)

Fig. 7: The Indo-Gangetic Basin (Source: International Water Management Institute, Colombo, Sri Lanka)

3.1.Flash Floods in Mountainous and Hilly Areas

Flash flood prone areas of the India and Bangladesh are occur in mountainous and hilly areas. Intense local and short-lived rainfall, often associated with meso-scale convective clusters, is the primary cause of flash floods. These are characterised by a sharp rise followed by a relatively rapid recession. Flash floods can occur within a few hours and are particularly frequent in. the pre-monsoon months of April and May.

3.2.Floods during Monsoon

Floods during Monsoon are a common phenomenon in India and Bangladesh. Of the total river flow, around 80% occurs in the five months of monsoon from June to October (Water Resources Planning Organisation, 2004). A similar pattern is observed in case of rainfall also. Therefore, to these skewed temporal distribution of river flow and rainfall, India and Bangladesh suffer from 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 early monsoon in June and July whereas in the Ganga maximum discharge occurs in August and September. Synchronisation of the peaks of these rivers results in devastating floods in India and Bangladesh.

It may be mentioned that India has a River-Linking Plan (National Water Policy, 2002) to ensure equitable distribution of water and manage floods. With reference to Fig. 3 and Fig. 7, the Indus River Basin and the Ganga River Basin are separated by a low watershed. As per the India-Pakistan Water Treaty, 1960, 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 Sutlej, Beas and Ravi rivers while Pakistan gets the full share of water flowing through the Chenab, Jhelum and Indus Rivers. It is envisaged to construct a canal connecting the Sutlej River in the Indus basin with the Yamuna River in the Ganga basin so as to divert some water 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.

3.3.Floods due to Storm Surges

This kind of flood mostly occurs along the coastal areas of Bangladesh and West Bengal. The continental shelf, in this part of the Bay of Bengal is shallow, and extends upto about 20-50 km from the coastline. Because of this, storm surges generated due to any cyclonic storm are comparatively higher compared to those due to an equivalent cyclonic storm in several other parts of the world. In case of super-cyclones, the maximum height of surges are found to be 10-15 m, which cause flooding in the entire coastal belt. The worst kind of such flooding was on November 12, 1970 and April 29, 1991, which caused loss of 300,000 and 138,000 human lives respectively (Flood Forecasting and Warning Centre, 2005). Coastal areas are also subjected to tidal flooding during the months from June to October when the sea is in spate due to the monsoon wind.

4.Flood Management in Bangladesh

Bangladesh tries to deal with flood and disaster with structural and non-structural measures. Systematic structural measures were begun by implementing flood management projects after the flood of 1963. Non-structural measures have been introduced in the seventies. Flooding is a natural phenomenon, which cannot be prevented. Resources should be allocated to help people adopt a life style that is conformable to their natural environment. Indigenous solutions such as changing the housing structures and crop patterns can help reduce flood damage. Moreover, good governance, appropriate environmental laws, acts and ordinances are 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. In recent years, improved forecasting and early-warning system and disaster-preparedness measures have helped to reduce the number of lives lost by natural disasters.

4.1.Flood Management by Structural Measures

The structural option provided some benefits, especially in increase in agricultural production (Bangladesh Water Development Board, 2005 and Bangladesh Bureau of Statistics, 2002), initially but some adverse effects were observed later on. Notably, the construction of high embankment along both banks of rivers resulted, in some cases, in rise in bed levels due to siltation causing obstruction to drainage. In the coastal areas, although the construction of polders prevented saline water intrusion, some adverse effects were restriction in the movement of the tidal prism, sedimentation of tidal rivers and obstruction to gravity drainage. An important impact on agriculture was that the farmers, in most cases, opted for production of cereal crops, especially HYV rice, after enjoying a flood-free situation, rather than going in for crop diversification. Structural measures caused many adverse effects on aquatic life, 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 and erosion control: River maintenance through dredging is also going on in a limited case due to the high cost. Erosion control efforts are continuing in medium and small rivers.
Flood control and drainage project: Where possible Flood Control, Drainage and/or Irrigation projects have been constructed. Flood Control, Drainage and/or Irrigation projects are of two types, namely (i) full flood control facilities; and (ii) partial flood control. Until date Flood Control, Drainage and/or Irrigation projects provide facilities in about 5.38 million ha which is about 59% of the country's net cultivated land (Bangladesh Water Development Board, 2000-01). Flood control and drainage structures have also been provided in major cities to make the cities flood free.

4.2.Flood Management by Non-Structural Measures

Introduction of non-structural option, i.e. Flood Forecasting and Warning System, was started in Bangladesh from the early 1970s and contributed to the improvement of the capacity for flood preparedness and mitigation/minimisation of flood losses. Other non-structural measures are discussed in what follows.
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 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.
Flood proofing: Efforts have been made to provide vulnerable communities with mitigation by raising homesteads, schools and marketplaces in low-lying areas (rather than flood control) so that peasants can save their livestock and food stuff.
Flood zoning and flood insurance are not practised in the country till 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 practised are:

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

4.3.Flood Forecasting and Warning in Bangladesh

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. Initially co-axial correlation, gauge-to-gauge relationship and Muskingum-Cunge Routing Model were used for forecasting. From the early nineties a numerical modelling 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 a hydrodynamic simulation model. Research on Modelling System and capacity building in the forecasting is currently emphasised. During the severe flood in Bangladesh and West Bengal, India in 1998, loss of lives and damage of Flood Control, Drainage and/or Irrigation projects in Bangladesh were minimum mainly because of flood forecasting and early warning (Islam and Dhar, 2000).

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 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 reduction of vulnerabilities and risks. The United Nations Development Programme has been a partner of the Government of India in such efforts. Vulnerability reduction and linking with sustainable development efforts has been one of the key approaches of United Nations Development Programme. 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 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 stand-by 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, Kolkata, West Bengal, India (Monograph on Flood Management, 2006) has emphasised 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 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 for flood management (http://www.wbgov.com).

The Government of Bangladesh established the Disaster Management Bureau in 1993, which has prepared comprehensive Disaster Management Plans. The Disaster Management Bureau is working under the Ministry of Disaster Management and Relief. Standing orders on Disaster has been prepared in 1997 and upgraded in 1999 by the Disaster Management

Bureau (Chowdhury, 2003). A National Disaster Management Council has been formed headed by the Prime Minister. This includes Ministers from different ministries as members. Inter-Ministerial Disaster Management Co-ordination Council has also been formed which guided by the National Disaster Management Council. Beside this, District, Thana (Area under 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 (Ministry of Disaster Management and Relief, 1997). By all these steps the Government of Bangladesh has strengthened the disaster response capacity through institutional capacity building activities; community disaster response simulation drills; and stockpiling of essential relief items.

6.Conclusion

Structural as well as non-structural measures are being emphasised for flood management in both India and Bangladesh who have very significant co-operation in water resources management. It has been proved that non-structural measures have significant effect on flood damage minimisation. Flood and disaster cannot fully be controlled, prevented or eliminated, but damages can be reduced significantly by integration of measures and co-ordination 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.

7.References

Assam_Disaster_Management.htm

Bangladesh Bureau of Statistics, 2002, Ministry of Planning, Government of Bangladesh.

Bangladesh Water Development Board, 2000-2001, Annual Report, Dhaka, Bangladesh.

Bhattacharya, A.K. and Rahman, M.M. An Analysis of Flood Control in Eastern South Asia, IETECH Journal of Civil and Structures, Vol. 1, No. 2, 2008. Pages 59-66.

Chowdhury, J.R., 2003, Technical Paper presented in the 47th Annual Convention of the Institution of Engineers, Bangladesh, 5-7 January, 2003, Chittagong, Bangladesh.

Flood Forecasting and Warning Centre, 2005, Consolidation and Strengthening of Flood Forecasting and Warning Services, Final Report, Volume II – Monitoring and Evaluation, Bangladesh Water Development Board, Dhaka, Bangladesh.

Hossain, A.N.H. and Akhtar, 2004, Flood Management: Issues and Options. Presented in the International Conference organised by the Institution of Engineers, Bangladesh.

India-Pakistan Water Treaty, 1960, New Delhi, India and Karachi, Pakistan.

Islam, S.R., and Dhar, S.C., 2000, Bangladesh Floods of 1998: Role of Flood Forecasting and Warning Centre, Bangladesh Water Development Board, Dhaka, Bangladesh.

Monograph on Flood Management, 2006, Disaster Management Department, Government of West Bengal, Kolkata, West Bengal, India.

National Water Policy, 2002, Ministry of Water Resources, Government of India.

Ministry of Disaster Management and Relief, 1997, Standing Order for Disaster Management, Dhaka, Bangladesh.

Rahman, M. M., 2005, Geo-Informatics Approach for Augmentation of Lead Time of Flood Forecasting- Bangladesh Perspective, Proceedings of International Conference on

Hydrological Perspectives for Sustainable Development in Department of Hydrology, Indian Institute of Technology, Roorkee, India, Feb 23-25.
Rahman M.M., Hossain, M.A., Bhattacharya, A.K., 2007 Flood Management in the Flood Plain of Bangladesh, Proceedings, International Conference on Civil Engineering in the New Millennium: Opportunities and Challenges, Bengal Engineering and Science University, Shibpur, Howrah, West Bengal, India, Jan 11-14. Paper No. WRE 015.
Water Resources Planning Organisation, 2004, National Water Management Plan, Ministry of Water Resources, Government of Bangladesh, Dhaka, Bangladesh.
http://www.wrmin.nic.in
http://www.wbgov.com