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SUSTAINABLE FLOOD MANAGEMENT IN BANGLADESH: ADDRESSING THE CHALLENGES

Abstract

Floods are a common and longstanding natural hazard in Bangladesh. Nowadays, it is worsening due to unplanned urbanization and development activities, rapid population growth, faulty structural interventions and adverse impact of climate change, with more intensity and frequency than ever before. Despite various policy initiatives and institutional mechanisms, the country is yet to achieve sustainable flood management (SFM) that aims at developing maximum possible socioeconomic resilience against flooding, while protecting natural flow of rivers and the environment. Flood management in Bangladesh focuses heavily on structural measures than non-structural ones albeit the latter in many cases, more viable and useful for the country considering its geophysical location and hydrological characteristics. In this backdrop, the paper is an attempt to find out challenges that impede SFM in Bangladesh and provide recommendations to address those. It identifies unplanned use of floodplains, altering natural flow of water bodies, fragmented water resource management, lack of regional and international cooperation in river basin management, overreliance on structural measures, lack of good governance, absence of supervision, monitoring and evaluation process in management, limited participation of community people and local level disaster management committees in policy decisions and lack of knowledge-based management as key challenges for Bangladesh. The paper advocates for proper floodplain management, integrated water resource management, catchment based river basin management, establishing good governance, effective supervision, monitoring and evaluation procedure, strengthening local-level disaster management committees, participation of community people in policy decision and knowledge-based management to overcome the challenges.

Keywords: Climate Change, Disaster Management, Risk Transfer, Floodplain Management, Flood Control Drainage and Irrigation (FCDI), Natural Hazards

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1. Introduction

Bangladesh, a country with a landmass of only 147 thousand sq km and habitat of over 160 million people, is one of the most densely populated countries in the world and a disaster hotspot. It is because of its unique geophysical location that Bangladesh is afflicted by a multitude of natural hazards including, but not limited to flood, tropical cyclone, tornado, thunderstorm and lightning, drought, earthquake, riverbank erosion, landslide, salinity intrusion, arsenic contamination, etc. It has been projected that the severity and intensity of some hazards, e.g., flood, cyclone, drought, etc., will increase in the near future due to global warming and adverse impact of climate change. Impacts of these hazards are exacerbated manifold by the fact that almost one fourth of the nation's population lives below the upper poverty line and one tenth below the lower poverty line¹ with very limited capacity and resources to adapt.² These combinations of multifaceted hazards coupled with the country's demographic characteristics and adverse impact of climate change are posing serious threat to the life and livelihood of the country's population and its growing economy.

Among all natural hazards affecting Bangladesh, flood is the most common and recurring phenomenon. In general terms, flood is known as temporary condition of partial or complete overflowing of normally dry land area.³ Bangladesh ranked top among countries regarding exposure of GDP to floods.⁴ About 80 per cent of its landmass is flood prone while about 20-30 per cent is inundated regularly which sometimes reached up to 70 per cent in extreme years.⁵ Floods, to some extent, are an expected and required annual event for many reasons but ill-timed and extreme floods, inundating more than 30 per cent of the country's landmass, cause severe damage and immense sufferings.

People of Bangladesh have been living with floods for long and adopted various indigenous methods to cope with it. However, floods of 1954 and 1955, and their sheer devastation forced the government of the then East Pakistan to consider a Master Plan for Water Resource Development which identified various flood control, drainage and irrigation (FCDI) measures to address normal as well as unusual

¹ Bangladesh Bureau of Statistics, *Preliminary Report on Household Income and Expenditure Survey 2016*, Dhaka: Ministry of Planning, Government of the People's Republic of Bangladesh.

² Md. Abdul Quayyum, "Comprehensive disaster management: The road to resilience", *Dhaka Courier*, Vol. 32, Issue. 25, 01 January 2016, p. 30.

³ Mahfuz Kabir, "Managing Flood in Bangladesh 2004: Facts and Caveats", *Bangladesh Journal of Political Economy*, Vol. 22, Nos. 1 and 2, 2005, p. 143.

⁴ Tianyi Luo, Andrew Maddocks, Charles Iceland, Philip Ward and Hessel Winsemius, "World's 15 Countries with the Most People Exposed to River Floods", *World Resources Institute*, 05 March 2015, available at <http://www.wri.org/blog/2015/03/world%E2%80%99s-15-countries-most-people-exposed-river-floods>, accessed on 01 December 2017.

⁵ Ministry of Disaster Management and Relief, *National Plan for Disaster Management (2016-2020): Building Resilience for Sustainable Human Development*, 27 March 2017, Dhaka: Ministry of Disaster Management and Relief, Government of the People's Republic of Bangladesh.

flooding. Since then, the government, in association with development partners, intergovernmental bodies, NGOs and community people has been implementing various measures to better deal with the disaster. Flood management in Bangladesh is dominated by structural measures consisting of embankments, polders, river closures and drainage control installations. Various non-structural measures are also in place, like flood forecasting and early warning, flood proofing, flood hazard mapping and zoning, awareness building, etc., to better prepare the community against floods and mitigate their impact. There also exist various regulations, plans and policies to regulate all activities related to flood management and ensure proper organization and coordination among the institutions vested with the responsibility to manage floods.

Despite various measures, the country is still struggling to minimize flood related damages. People, those are living under the poverty line, find it very difficult to cope with flood devastation and are extremely vulnerable to it. According to the latest edition of *Household Income and Expenditure Survey* conducted in 2016, among the top ten poorest districts of the country, where extreme poverty is prevalent, majority faces a wide range of vulnerabilities presented by river-flooding and water logging.⁶ This statistics reflects the poor's vulnerability to various waterborne hazards, including floods. Furthermore, post-disaster management, namely, appropriate response, adequate relief, quick recovery and long-term rehabilitation is still not up to the mark. Though flood related fatalities are in decline, economic losses have been soaring over the years. The ever increasing population, severe land scarcity, ill-planned infrastructural development, rapid urbanization and industrial expansion, overreliance on structural measures, and massive flood control interventions in floodplain environment have resulted in floods becoming more intensive and frequent in recent times.⁷ The floods of 2017 are a glaring example of how the country's flood management was in grave peril to mitigate the disastrous impact, raising serious concern about its sustainability; where eight million people of 32 districts were affected, with the death toll of 157 and estimated financial loss of BDT 158 billion.⁸ The extensive damage and number of casualties imply there remain lots of challenges for Bangladesh to achieve SFM.

In this context, the paper is an attempt to identify the challenges for Bangladesh towards achieving SFM and possible options to address those. It will try to seek answers to the following questions: What is sustainable flood management? What are the challenges for Bangladesh to achieve sustainability in flood management and how can those challenges be addressed? The paper has five sections. The first

⁶ Sadiq Ahmed, "Can Bangladesh eliminate extreme poverty by FY2031", *The Daily Star*, 07 January 2018.

⁷ Rezaur Rahman and Mashfiqus Salehin, "Flood Risks and Reduction Approaches in Bangladesh", in Fuad Mallick and Aminul Islam (eds.), *Disaster Risk Reduction Approaches in Bangladesh*, Tokyo: Springer, 2013, p. 65.

⁸ Md. Zafar Sadique and Estiaque Bari, *Flood 2017: Assessing Damage and Post-flood Management*, Centre for Policy Dialogue, 19 October 2017.

section is the introduction followed by conceptual understanding in section two. A brief discussion of flood management in Bangladesh has been incorporated in section three. Section four discusses the challenges and provides recommendations. The paper concludes in section five with remarks.

Qualitative research method that is exploratory in nature and based on both primary and secondary data, has been followed to conduct the study. Primary data has been collected through in-depth interviews. Convenience sampling, a non-probability sampling method has been applied to select respondents involved directly with flood management. Secondary data sources include government reports, regulations, plans and policies related to disaster management and water resource management, academic books, journals and newspapers. Statistical data has been collected from various sources, e.g., Bangladesh Water Development Board (BWDB), Bangladesh Flood Forecasting and Warning Centre (FFWC) and Bangladesh Bureau of Statistics (BBS).

2. Sustainable Flood Management (SFM): Conceptual Understanding

Floods have been a common natural disaster worldwide since time immemorial. Many countries have undertaken different measures for dealing with floods according to their perspectives and requirements. However, certain issues have to be noted that floods or any other natural disaster cannot be totally prevented but the damage they inflict can be reduced.

Flood control is conducted for reducing the devastation they cause. It is an ancient method in this regard differing from country to country. In low-lying coastal regions of Europe, namely Belgium, the Netherlands, France, Germany, etc., dyke construction has been common. In China, the Yellow River has undergone extensive dredging, damming and digging of channels for flood control. In the Thames River (England), Neva River (St. Petersburg Dam, Russia), Seabrook Floodgate (USA), etc., are protection barriers built to save respective regions from floods and storm surges as they are vulnerable to and have several times been hit by these disasters.

Compared to flood control, flood management is a much broader concept. It means assessing the risk of flooding, and then, using this information to implement appropriate management measures. These may include constructing flood defences, building of early warning systems or development of plans and policies, etc., which will reduce flood risk. According to Kabir, "flood management is a broad concept that focuses on reducing flood hazards through a combination of policy, institutional, regulatory and physical measures while recognizing that floods can never be fully controlled."⁹ It is the complete process of flood mitigation including flood risk

⁹ Mahfuz Kabir, op. cit., p. 152.

management.¹⁰ It focuses on dealing with floods before, during and after they happen, for example, how to use the excess water brought in, taking more effective precautionary measures, increasing adaptive ability, lessening negative impacts to better cope with future floods, etc. In flood management, efforts are engaged not only in effective handling of floods, but also manage them efficiently.

Flood management is conducted mainly in combination with two methods: structural and non-structural. The first one includes building physical infrastructures like embankments, dams, floodgates, reservoirs and other barriers to reduce the severity of floods and protect the vulnerable areas while the second includes undertaking various measures like enacting regulations and policies, preparedness for handling flood related emergencies, issuing forecast and early warning, creating awareness, conducting rescue and evacuation, providing relief and rehabilitation for people affected, and social safety net programmes for the vulnerable, etc. Structural method, however, mostly focuses on draining flood water as quickly as possible or storing it temporarily, and separating the exposed population and resources from floodwater without considering upstream and downstream flood risks, impact on society, economy and environment. Engineered solutions, a core component of flood management, sometimes adversely affect the free flow of water and its quality. Biodiversity of freshwater also suffers due to major physical changes in rivers, lakes and wetlands from various flood management practices.

As a result, in recent times, sustainable management of floods has been receiving growing attention worldwide, especially in regions where they occur frequently. While both flood management and flood control stress dealing with floods efficiently, sustainable management endeavours for their long-term, functional and conducive (for environment and people alike) purposes. For example, in flood control, infrastructures are built to prevent floods which can have negative impacts like hampering environmental stability, reducing water sources' carrying capacity and navigability, displacing people, destroying property, livelihoods and lands. As flood control and management have many things in common, there can be similar damages if measures are not sustainable, some of which may be irreversible. Therefore, SFM is aimed simultaneously at mitigating flood devastation and using benefits they accrue, saving the environment and people without harming each other.

However, the term SFM is not well-defined and has no universal definition either. According to the Flooding Issues Advisory Committee (FIAC) of Scotland, "SFM provides the maximum possible social and economic resilience against flooding, by protecting and working with the environment, in a way which is fair and affordable both now and in the future."¹¹ FIAC also suggests the general goal of SFM should

¹⁰ A. A. Olsthoorn and R. S. J. Tol, *Floods, Flood Management and Climate Change in The Netherlands*, Netherlands: Institute for Environmental Studies, 2001.

¹¹ "What is Sustainable Flood Management?"; Flooding Issues Advisory Committee, Scottish Government, available at <http://www.gov.scot/Resource/Doc/1223/0028633.pdf>, accessed on 22 September 2017.

be meeting requirements for flood resilience. The definition focuses on the term resilience, which denotes “the ability of a community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.”¹² The Scottish Rural Development Programme (SRDP) defines SFM as, “planning at a catchment level and considering a wide range of measures to reduce the risk of flooding. It is being considered that natural land use management techniques - such as, managing floodplains and restoring wetlands, are the important components of SFM.”¹³ According to the International Conference on Flood Resilience, SFM is defined as protecting people and property from floods, using resources economically and equitably, while taking into consideration the future and the environment.¹⁴ Samuels suggests the following characteristics for sustainable flood management:

- ensuring the quality of life by reducing flood impact as well as being prepared for it;
- mitigating the impact of flood defence activities on ecological systems at a variety of spatial and temporal scales;
- using resources wisely in providing, maintaining and operating flood defence infrastructure for the functioning of economic activity (agricultural, industrial, commercial, residential) on the floodplain.¹⁵

An important feature of SFM is its advocacy towards properly utilizing the environment itself (e.g., sound management of floodplains and river basin, natural land use techniques, restoring water bodies and wetlands, etc.) for mitigating purposes and lessening damages. It will ensure the balance between flood management for the present generation leaving a sufficient degree of freedom to the future generation. It tries to provide long-term and viable solution to floods, notwithstanding climate change and related risks. It prioritizes the shifting paradigm of traditional engineering approach to management of flood risk and “living with it” approach. SFM helps to reduce the threat of flooding by:

¹² International Strategy for Disaster Reduction (ISDR), *2009 UNISDR Terminology on Disaster Risk Reduction*, 2009.

¹³ “Sustainable Flood Management”, Scottish Government, available at <http://www.gov.scot/Topics/farmingrural/SRDP/RuralPriorities/Packages/SustainableFloodManagem>, accessed on 22 September 2017.

¹⁴ Ick Hwan Ko, Min Goo Kang, Sung Je Park, “Flood Risk Management Framework and Strategies for Sustainable Flood Management”, paper presented in *International Conference on Flood Resilience (ICFR)*, organized by University of Exeter, UK, on 05-07 September 2013.

¹⁵ P. G. Samuels, “A New Tool for Sustainable Flood Defence Planning — An Overview of the EUROTAS Research Project”, paper presented in the European Conference on *Advances in Flood Research*, organized by PIK, Potsdam, Germany, on 01 November 2000.

- acknowledging floods as part of natural hydrological cycle;¹⁶
- maintaining natural flow regimes and water levels;
- protecting and using natural systems and habitats, such as floodplains and wetlands;
- promoting soft-engineering techniques; and
- improving floodwater storage capacity and flood control.¹⁷

Now, for the purpose of this paper, it is imperative to conceptualize SFM in the context of Bangladesh that will take the geophysical and hydrological setting of the country into account, and comply with its demographic conditions and socio-economic compulsions. For Bangladesh, SFM can be seen as a shift from predominantly structural approach to an integrated water resource management approach involving multilevel stakeholders that considers the long-term social, economic and environmental factors, focuses on use of natural processes and systems to slow down and store floodwater in order to reduce the risk of flooding, and minimize its economic, environmental and social costs. It is a holistic approach based on a balanced combination of both structural and non-structural measures involving a wide range of initiatives like river basin management (RBM), floodplain and wetland management, natural water flow management, flood forecasting and warning, flood preparedness and awareness, and effective flood response, recovery and rehabilitation. The core target of SFM will be to build a flood resilient community by focusing on preparedness, adaptation and mitigation instead of prevention. This paper will limit its scope to the following aspects of SFM and try to identify the challenges for Bangladesh based on those in achieving SFM:

- floodplain management
- integrated water resource management
- catchment based RBM
- preparedness and early warning
- good governance in management
- community based management
- knowledge based management

¹⁶ Edyta Kiedrzyńska, Marcin Kiedrzyński, Maciej Zalewski, "Sustainable Floodplain Management for Flood Prevention and Water Quality Improvement", *Natural Hazards*, Vol. 76, No. 2, 2015, pp. 955-977.

¹⁷ "Sustainable Flood Management", op. cit.

3. Flood Management in Bangladesh

The unique geophysical location and low-lying deltaic topography of Bangladesh are primarily responsible for frequent floods. Bangladesh is situated at the lowest part of the basin of three mighty rivers – the Ganges, the Brahmaputra and the Meghna (GBM) with very low mean elevation from the sea level.¹⁸ These rivers have a combined peak discharge in the flood season of 180,000 m³/sec (ranked second in the world after the mighty Amazon) and carry about two billion tonnes of sediment each year.¹⁹ Besides, there are more than 310 rivers in the country including 57 trans-boundary rivers.²⁰ Floods occur annually with an increasing severity during July and August due to heavy monsoon shower. Regular river floods affect 20 per cent of the country increasing up to 70 per cent in extreme years. When normal floods are considered a blessing for Bangladesh, providing vital moisture and fertility to the soil through alluvial silt deposition in floodplains, moderate to extreme floods are of great concern, as they inundate large areas and cause widespread damage to crops and properties. Bangladesh generally experiences four types of floods: river flood, rain-fed flood, flash flood and flood due to storm-surge. During the last 55 years, at least seven severe floods have devastated Bangladesh with inundation of 35-70 per cent land area.²¹ Immediate outcome of flood is not as devastating as cyclones or earthquakes in terms of loss of lives, but its long-term effect, especially on economy and food security is catastrophic, resulting in large scale destruction of crops, infrastructures and substantial loss of country’s GDP. The following table shows the damage statistics of major floods of Bangladesh since independence.

Events	Area Inundated (% of the country)	Total Deaths	Estimated Damage (in million US\$)
1974	36	28,700	57.9
1987	39	2055	1000
1988	61	2300	1200
1998	68	1100	2800
2004	38	750	2200
2007	43	831	1800
2017	40	157	1975

Source: Bangladesh Water Development Board; World Bank; Asian Development Bank; Department of Disaster Management, Ministry of Disaster Management and Relief; Centre for Policy Dialogue.

¹⁸ The altitudes up to 105 metres (344 ft) above sea level occur in the northern part of the plain and most elevations are less than 10 metres (33 ft) above sea level; elevations decrease in the coastal south, where the terrain is generally at sea level.

¹⁹ Ministry of Environment and Forest, *Bangladesh Climate Change Strategy and Action Plan*, Dhaka: Government of the People’s Republic of Bangladesh, 2009, p. 7.

²⁰ Department of Disaster Management, *Disaster Report 2013*, Dhaka: Ministry of Disaster Management and Relief, Government of the People’s Republic of Bangladesh, p. 13.

²¹ Naimul Karim, “An ominous trend”, *The Daily Star*, 08 September 2017.

Flood management in Bangladesh can be seen from two different aspects: one relating to water resource management and the other, disaster management. The first one at the national level is coordinated by the Ministry of Water Resources under the supervision of the National Water Resource Council while the latter is coordinated by the Ministry of Disaster Management and Relief under the National Disaster Management Council's supervision. Both activities are also coordinated at local levels by appropriate bodies. The government has formulated legal instruments like, Disaster Management Act and Water Act to provide legal basis for plans, policies and measures related to flood and water resources management.

Flood management in Bangladesh involves lots of funding, mainly from the government. During the last 40 years, the government has invested approximately BDT 200 billion in water and flood management, primarily in FCDI projects. Annually, the government spends about BDT 10 billion in water and flood management.²²

3.1 Policy Initiatives and Institutional Mechanism

Flood management measures adopted in Bangladesh have continuously evolved over the last 40 years. Initially, the emphasis was on structural measures through implementation of some large-scale FCDI projects. After devastating floods in three consecutive years - 1954, 1955 and 1956 - the United Nations Water Control Mission with J. A. Krug as head of the Mission was invited to Bangladesh. The report prepared by Krug is considered by many as the Magna Carta of flood control in Bangladesh.²³ It resulted in the formation of Water and Power Development Authority (WAPDA). The WAPDA soon started to work on a 20-year Master Plan (1965-85) for FCDI works focused on increasing agricultural input. However, it was soon recognized that most FCDI projects involved large-scale investments, long time for completion, and thus required more time to derive benefits. Therefore, the government opted for constructing small and medium scale FCDI projects to obtain early benefits.

After disastrous floods in 1987 and 1988, formulation of a National Flood and Water Management Strategy came to forefront. International development partners supported a project titled Flood Action Plan (FAP) from 1990 to 1996 to formulate the strategy. FAP was mainly a study project involving 26 components. Based on FAP activities, the government formulated Bangladesh Flood and Water Management Strategy (BFWMS) in 1996.

At the end of FAP studies, the government realized that all issues concerning water resources development and utilization had not been addressed in the light

²² A. N. H. Akter Hossain, "Bangladesh Flood Management", in *Integrated Flood Management; Case Study Bangladesh: Flood Management*, September 2003, p. 11.

²³ A. M. Choudhury, *Protecting Bangladesh from Natural Disasters*, Dhaka: Academic Press and Publishers Library, 2009, p. 50.

of Integrated Water Resources Management (IWRM). As a result, it again embarked on formulating a National Water Management Plan (NWMP) crosscutting different sectors of national economy in the light of IWRM. BFWMS was the major strategy follow-up to FAP and became the working policy document for the water sector. The government formulated National Water Policy (NWP) in 1999 and NWMP in 2001 with 25-year projection. The *Jolmohal* Policy was formulated in 2009 where provisions had been incorporated to protect the rights of fishermen, ecological balance and water resources. In 2013, the Bangladesh Water Act was formulated to make arrangements for integrated development, management, abstractions, distribution, use, protection and conservation of water resources which also includes provisions for flood management.

To manage flood as part of overall disaster management, the government has formulated Standing Orders on Disaster (SOD), National Disaster Management Policy (NDMP) and Flood Response Preparedness Plan. The latest plan for managing flood is incorporated in National Plan for Disaster Management (2016-2020) which has been formulated in 2017. The Disaster Management Act, formulated in 2012 and revised in 2016, provides legal basis for disaster management plans and activities in general and flood management plans and policies in particular.

About 53 central government organizations and 13 ministries are involved in flood and water resource management.²⁴ Principal national institution engaged in flood management is the Bangladesh Water Development Board (BWDB). Some other crucial organizations involved are - Water Resources Planning Organization (WARPO), Joint River Commission (JRC), Bangladesh Meteorological Department (BMD), Flood Forecasting and Warning Centre (FFWC), Space Research and Remote Sensing Organization (SPARSO), Centre for Environmental and Geological Information System (CEGIS), Local Government Engineering Department (LGED), Department of Disaster Management (DDM), Department of Haor and Wetland Development (DoHWD), etc.

4. Sustainable Flood Management: Addressing the Challenges

SFM is an arduous and complex undertaking involving substantial amount of resource mobilization, long-term planning and coordination, and local, national, regional and international cooperation. Even in highly developed countries, flood management measures may not always be sustainable owing to different factors. In Bangladesh, there exist multiple challenges, both natural and manmade, to achieve SFM. Globally, it is now accepted that no single strategy is enough to reduce or mitigate flood risk; therefore, a combination of risk management strategies is required. This approach may include flood sensitive land use regulation, structural defences and improvement of community preparedness for floods via early warning and

²⁴ A. N. H. Akter Hossain, op. cit.

emergency management. Nevertheless, application of flood management measures needs to comply with local environmental, socioeconomic and institutional set-up of the country.²⁵ This section attempts to discuss the challenges for Bangladesh towards achieving sustainability in flood management and possible options to address those.

4.1 *Floodplain Management and Opening-up Approach*

Floodplain management is an indispensable part as well as one of the most challenging tasks of SFM. Floodplains are diverse landscapes known as lowland areas alongside rivers and streams, more or less regularly inundated by floodwater. Floodplains in Bangladesh are formed from the deposition of sediments carried by the rivers. Any disturbance in the water sediment regime, thus, has severe consequences on the physical sustainability of the floodplains. In Bangladesh, human settlements have occupied most floodplains, which is one of the major causes of flood related damages and casualty. Poor socioeconomic conditions of most people living in rural areas are mainly responsible for that. Furthermore, many are either unaware that there is a danger of flooding or lack alternative choices. Constant pressure on land for growing human settlements, activities and financial inability to live elsewhere have forced people to live on floodplains. Besides, land grabbing is going on for decades under various excuses where floodplains and other water outlets are common and easy targets, posing serious threat to sustainable land use regulations. Authorities are struggling against such encroachments, yet failure is increasing flood intensity and damages. Filling up and dumping waste into floodplains and water bodies are similar threats going on unchecked, where major cities are the worst victim. Around 84 per cent wetlands and water-bodies in and around Dhaka have been filled up since 1947, either for human establishment or economic purpose.²⁶ The scenario is no different for other major cities of the country. This practice is pursued by both public and private organizations alike. Whenever there is any project, for example, housing, industries, roads, etc., they are built in most cases either filling water bodies or lands or both without considering the devastation these will wreak in future. Once established, more people and businesses flock around such facilities which never stop, leaving no place for floodwater outlet. Despite having specific provisions in various government policies to protect water bodies and *Khas* lands, grabbing goes unabated, thus increasing severity of flooding.²⁷ In addition to flood water, rainwater creates similar havoc with massive water-logging at light rainfall in major cities of the country, specifically Chittagong and Dhaka are the real witnesses to these. Dhaka

²⁵ M. A. R. Shah, A. Rahman and S. H. Chowdhury, "Challenges for Achieving Sustainable Flood Risk Management", *Journal of Flood Risk Management*, August 2015.

²⁶ Md Shahnawaz Khan Chandan, "Cutting off Dhaka's lifeline", *The Daily Star*, 02 June 2017.

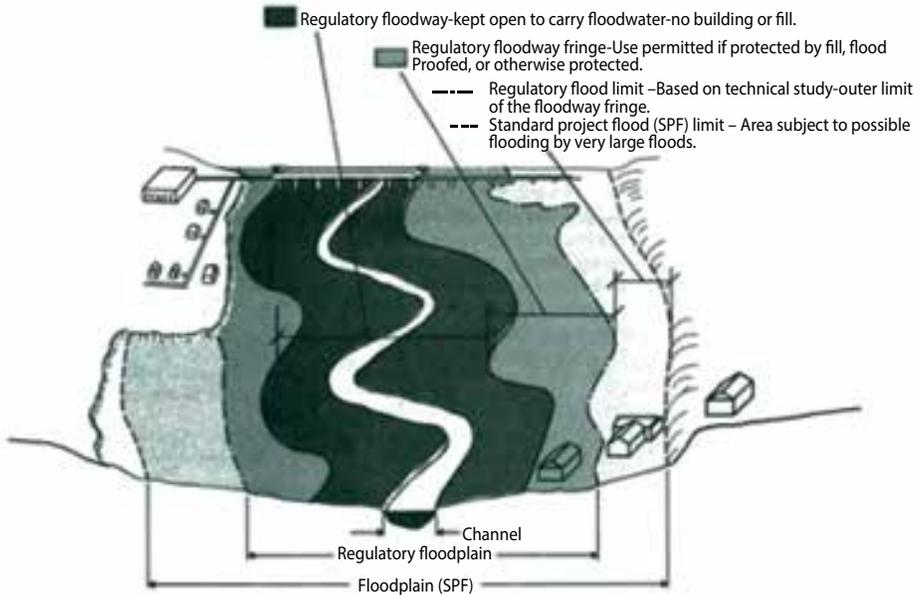
²⁷ According to Article 3.1.10, National Environment Policy 2013 - Common property resource bases (viz. *Khas* River, canal, *beel*, *haor*, *baor*, etc.) should be identified and protected and their status cannot be changed or re-classified; in Bangladesh's National Land Use Policy 2001, there is a mention of various land types and their sustainable management including management of wetlands.

division (and the city) once had large numbers of canals, rivers and fallow lands (vast areas were thickly forested), but nowadays those have all but vanished. Dhaka and the nearby areas almost regularly experience harmful results with widespread damage by flood and rain water. But there is little initiative to stop grabbing, stop inflow of people or curtail unplanned and unnecessary development activities on the floodplains, thus, severely hampering flood management initiatives and their sustainability.

Recommendations: To achieve SFM, Bangladesh needs to ensure effective floodplain management with proper floodplain regulation and open up as much space as possible to accommodate river overflow. Conservation and restoration of natural functions of wetlands and floodplains, with their ability to retain floodwater and reducing flood velocity, are vital for protection from flood damage. Sustainable floodplain management focuses on restoring natural floodplains in water bodies and river valleys, developing mechanisms for increasing retentiveness of water and matter in the landscape, which contributes to correct functioning of floodplain ecosystems in a catchment.²⁸ It is essential to give enough space to the volume of floodwater so that the height of flooding can decrease proportionately with growth of area over which water can spread. This can be ensured through effective floodplain management consisting of proper land use regulation and land zoning, with a vision of living with floods and reaping the benefit out of them. Figure 1 demonstrates how floodplain regulation can be introduced in flood prone areas. Flood hazard mapping is another important component of floodplain management that helps quantify flood risk in terms of projected damage. Floodplains can be mapped in terms of low, medium and high risks. In turn, development planning may be informed directly by mapping. Human uses of floodplains need to be adapted to existing flood risk with the help of proper mapping. Expansion of development activities in floodplains should also be regulated; e.g., low risk locations therein should be used for important establishments which can be used as evacuation sites during floods. The existing establishments at the risk of flooding in the floodplain should either be made flood compatible or relocated. To materialize floodplain management and open-up approach, reclamation and rejuvenation of dying water bodies and wetlands are essential that will help maintain and increase water flow in major rivers, thus reduce impact of flood on life and livelihood.

²⁸ Edyta Kiedrzyńska, Marcin Kiedrzyński, Maciej Zalewski, op. cit.

Figure 1: Floodplain Regulation in Flood Prone Area



Source: Bulent Cengiz, "Urban River Landscapes", in Murat Özyavuz (ed.), *Advances in Landscape Architecture*, In Tech Publisher, July 2013.

4.2 Integrated Flood and Water Resource Management

SFM cannot be achieved in isolation, rather it demands sustainable development, allocation, operation and monitoring of water, land and related resources involving all pertinent stakeholders in all dimensions without compromising sustainability of vital ecosystems. But in Bangladesh, water resource management and development are fragmented causing lack of coordination, wastage of resources, ecological degradation and increasing vulnerability to disasters. There seems lack of consultation across sectoral and institutional boundaries, and many structural flood management projects did not fully take account of the potential impacts on agriculture, fisheries, navigation, forests, domestic and industrial water supply, biodiversity and salinity management. This is also true for other structural constructions. For instance, alignment of majority of roads in Bangladesh does not appear very rational considering the natural flow of floodwater which is a clear manifestation of lack of coordination between and among different agencies, in this case, Ministry of Water Resources, Ministry of Road Transport and Bridges, and Local Government Engineering Department (LGED). Roads have been built rather in unplanned manner, cross-wise to the direction of water flow. Many rivers have disappeared due to road construction and some are near extinction. In many cases, roads were not necessary,

and river transportation could easily be utilized. Even if these were necessary for communication linkages, there should have been more openings like bridges and culverts, with adequate capacity for ensuring efficient drainage without harming the rivers, whose shortcoming leads to congestion of water and inundation of vast areas even with small scale flooding, which become regular phenomena. Moreover, in a country with so many rivers and waterways, overdependence on roads is not sustainable for transportation and trade.²⁹ Such reliance is becoming a major challenge for flood management as freight and passenger traffic severely hamper during any flood situation. Furthermore, integrated water resource management not only focuses on the preservation of water bodies or water resources but also environment, lack of which is gravely hurting flood management efforts of Bangladesh.

Recommendations: For flood protection, mitigation and sustainable management, a balanced combination of structural and non-structural, mitigation and operational measures is necessary involving all concerned authorities and stakeholders. Also necessary is interdisciplinary cooperation at government and local levels for effective coordination of flood and water resource management policies consisting of environmental protection, physical planning, land use planning, agriculture, transport and urban development, with proper emphasis on all phases, assessment and management of flood risk, mitigation, planning, response, rehabilitation and reconstruction as well as implementation of measures. A holistic and integrated approach, taking care of everything in its aspect: in nature, environment and society, is a prerequisite for SFM. Within integrated flood and water resource management, land and water resources in river basins are developed in a coordinated and integrated manner for maximizing efficient use of floodplains and minimizing loss of life, and damage to property and environment. It incorporates environmental aspects into its activities to preserve the ecosystem and improve its services such as restoring water bodies' natural ability to store and slow down floodwater. Moreover, as mentioned earlier, around 53 government agencies are directly or indirectly involved in flood and water resource management in Bangladesh. Without an integrated and holistic approach, there is always a possibility of wastage of resources. Sometimes, initiative of one agency remains unknown to other agencies, resulting in duplication of efforts, or endeavours may sometimes even contradict. Hence, an integrated approach with strong coordination is needed to make flood management measures sustainable and effective. Along with Environmental Impact Assessment (EIA) and Social Impact Assessment (SIA), Strategic Environmental Assessment (SEA) should be introduced as a legally binding procedure to integrate environmental considerations into policies, plans and projects of flood management to make them environmentally sustainable. Integrated planning, design and construction of all rural roads,

²⁹ Khondaker Golam Moazzem, cited in Sajjadur Rahman and Sohel Parvez, "Flood, rundown roads: supply chain affected", *The Daily Star*, 01 September 2017.

highways and railways, embankments with the provision of unimpeded drainage should be ensured as well.

4.3 Catchment Based River Basin Management

Water does not recognize administrative or political boundaries, nor does flooding. Therefore, an effective way to manage flood and make the initiatives sustainable is by ensuring close bilateral, regional and international cooperation amongst all riparian countries within the natural hydrological unit of the river basin — bringing together interests of all placed both upstream and downstream. Bangladesh is situated at the lowest part of the GBM basin which has a catchment area of 1.7 million sq km, of which only 7 per cent is within the geographical boundary of the country. Unplanned construction of structural measures in upper catchment severely affects river flow, as well as frequency and intensity of flooding in Bangladesh. Therefore, it will be quite impossible for Bangladesh to achieve SFM without effective cooperation from other riparian countries of the basin. However, to introduce catchment based RBM, there are several challenges before Bangladesh in political, social and diplomatic areas. Bangladesh has to negotiate with its neighbours, especially with India from which 54 international rivers have entered. On numerous occasions, India has unilaterally taken various measures which severely augmented water related crises in Bangladesh, especially flooding and drought. Furthermore, water is a very sensitive issue in the South Asian context and water related disputes also exist here. Water related issues have tremendous political and social connotations. It will thus, be a daunting task for Bangladesh to bring all involved parties onto the same platform for viable and cordial solution to these crises and introduce catchment based RBM.

Recommendations: To ensure effective and SFM, protection measures have to be taken at the level of river basins, taking into account the interdependence and interaction of effects of individual measures implemented along watercourses. It is a pre-requisite of SFM to organize water management systems and improve flood forecasting, defence measures and crisis management on a river basin basis, cutting across regional boundaries and national borders. This needs to be done in cooperation with relevant organizations of co-riparian countries focusing on equitable water governance for trans-boundary rivers. Building of physical infrastructures, like dams, in the upstream can be considered to store flood water which can be used in the lean period. However, the impact of all major human activities concerning flood protection in the catchment area on society as a whole should be properly considered. Sharing water and climate related information, computer modelling information for flood forecasting and early warning among co-riparians are also essential in this regard. These can be done through various policy initiatives and data sharing, generation and exchange of knowledge and experience through seminars and workshops. It should be noted that trans-boundary water management is a sensitive issue, thus requires multi-track, multi-layered dialogues between participating countries.

Alongside governmental initiatives and efforts, cooperation between academic and technical institutions can immensely help building trust and increase resilience on a region-wide scale through track 1.5 and track 2 diplomacy. In addition, Bangladesh in particular and the region as a whole can follow the best practices of successful RBM cooperation initiatives. For instance, the Mekong River Commission (MRC) is an organization currently facilitating catchment based river basin cooperation in the region by working with six countries through which the Mekong River flows. The MRC issues flood forecasts twice on a daily basis during the flooding season. Bangladesh can follow the path of MRC and push forward the idea of basin management to ensure SFM. Other examples of regional cooperation in this regard are: Danube Flood Risk Management Plan,³⁰ European Union Water Framework Directive,³¹ European Union Floods Directive,³² etc.

4.4 *Flood Forecasting and Warning*

Flood forecasting and warning are regarded as one of the crucial non-structural measures to ensure SFM. Bangladesh has made good progress in flood forecasting with its 85 water level and 56 rainfalls observation stations collecting and disseminating information based on real time data. But, for a country with more than 300 rivers and a vast catchment area, this number is still inadequate to make accurate forecast. Moreover, forecasts are issued for large and heterogeneous areas, making it very difficult to decipher its spatial impact. Location specific inundation projection is also absent in the current system. These monitoring stations still depend on manual measurement which is a significant downside as they may not always produce correct results. Besides, the present practice is to forecast the rise of water level in different rivers which do not provide information of flood impact. Therefore, people at risk are unable to interpret warning messages for reducing risk of flooding. Furthermore, there is no facility right now to issue forecast and warning based on the entire river basin, which is crucial to understand the nature and intensity of flood with adequate lead time to respond.

³⁰ Under International Commission for the Protection of the Danube River (ICPDR), Danube Flood Risk Management Plan is formulated to ensure damage-free flood on the river basin. For details, see, "Flood Risk Management Plan for the Danube River Basin District", ICPDR, available at <https://www.icpdr.org/main/sites/default/files/nodes/documents/1stdfrmp-final.pdf>, accessed on 28 December 2017.

³¹ European Union Water Framework Directive deals with the challenges of water protection and advocates for a single system of water management, that is river basin management. For details, see, "The EU Water Framework Directive - Integrated River Basin Management for Europe", European Commission, available at http://ec.europa.eu/environment/water/water-framework/index_en.html, accessed on 28 December 2017.

³² The EU Floods Directive entered into force on 26 November 2007 which requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk. For details, see, "The EU Floods Directive", European Commission, available at http://ec.europa.eu/environment/water/flood_risk/, accessed on 11 December 2017.

Recommendations: Effectiveness of flood forecasting and warning largely depends on timely dissemination of accurate, reliable data and proper response mechanism. Initiatives are necessary to provide such forecasting and warning, supported by meteorological information and earliest possible warning of extreme weather conditions with adequate lead-time to respond. Absence of impact based flood forecasting in local language is a major setback for Bangladesh's flood management. As FFWC collects information of water level status of different rivers at regular interval, the numeric data can be difficult for people to understand. Hence, attention needs to be paid on disseminating impact based flood forecasting and warning. Forecasting and issuing early warning for flash flood is very challenging due to its shorter reaction time. Thus, such warnings should be based on real-time data from automatic precipitation gauges network combined with quantitative radar precipitation data and supported by quantitative rainfall forecasts. To disseminate warning, government and non-government stakeholders need to work together and train volunteers in the form of cyclone preparedness programme, especially in remote areas. Ensuring effective participation of local level disaster management committees is also important in this regard.

4.5 *Impact of Climate Change*

Climate and water are intimately linked, as water influences and simultaneously is influenced by climate. Every change in the climatic system induces a change in the water system and vice versa.³³ It is anticipated, future climate change will be higher than that experienced historically while the frequency of storms and intensity of river floods may increase worldwide.³⁴ In Bangladesh, from the latter part of the last century, there has been, on average overall warming of about 0.51°C, comparable in magnitude to the observed global mean warming.³⁵ Erratic rainfall and climate variation are visible for last couple of decades. Different studies have already predicted that consecutive wet days will decrease in the future, although the total amount of rainfall will increase. That means the intensity of rainfall will grow in the future, which can lead to an increase in extreme events such as floods and flash floods.³⁶ The flash flood in 2017 in the *haor* region is a conspicuous case in this regard. Changing nature of precipitation and rainfall pattern is believed to be responsible for the early arrival of flash flood in 2017 which can be linked with global warming and impact of climate change. It is also one of the major impediments towards achieving sustainable economic growth and development of the country.

³³ Zbigniew W. Kundzewicz, "Climate Change Impacts on the Hydrological Cycle", *Ecohydrology & Hydrobiology*, Vol. 8, Nos. 2-4, 2008, pp. 195-203.

³⁴ Edyta Kiedrzyńska, Marcin Kiedrzyński, Maciej Zalewski, *op. cit.*, p. 958.

³⁵ M. Monirul Qader Mirza, *Global Warming and Changes in the Probability of Occurrence of Floods in Bangladesh and Implications*, Adaptation and Impacts Research Group (AIRG), The Institute for Environmental Studies (IES), University of Toronto, 2001.

³⁶ A. K. M. Saiful Islam, cited in Naimul Karim, *op. cit.*

Recommendations: To minimize the negative impact of climate change and adapt to the changing environment, Bangladesh needs climate change adaptation and mitigation measures and strong commitment from international community. All flood management measures must take adverse impact of climate change into account and integrate climate change adaptation measures for their sustainability. Furthermore, substantial funding will be needed for climate change adaptation and mitigation, the lion share of which needs to be ensured from development partners and developed countries. The country needs to develop its negotiation skills so that international finance can be ensured and for that, it must pursue climate diplomacy vigorously. To protect the agricultural sector from the devastation of floods induced by climate change, the country needs to prioritize climate smart agriculture techniques to adapt with the changing environment.

4.6 *Operation, Supervision, Maintenance and Feedback*

Ensuring proper supervision and maintenance of flood management measures is a major obstruction for the country's flood management sustainability. In Bangladesh Water Act, there is a clear provision for protecting flood control embankments.³⁷ But in fact, there are no clear rules or authorities to take care. Many infrastructures, built many years ago, remain in need of rigorous repair or renovation. Most embankments in Bangladesh are made of earth; they can be easily breached and damaged by riverbank erosion, even several times during their construction, causing extensive damage to nearby communities. The Director General of BWDB also admitted that the effort of BWDB to control floods with embankments proved quite ineffective in many cases due to construction flaw and lack of maintenance.³⁸ There is a strong allegation that low quality of construction and improper maintenance are responsible for the premature collapse of the embankments. Due to poor implementation and maintenance, structural facilities, which were established to protect agricultural land and investment from flood water, are now exacerbating flood situation in many affected areas leading to severe damage. Furthermore, various anthropogenic factors like building human settlements on embankments, digging holes there for personal interests, stealing concrete blocks and earth from embankments are some common, detrimental practices in Bangladesh which make them weak and vulnerable. Lack of supervision is mainly responsible for that. On many occasions, flood control gates or levees malfunctioned due to obstruction created by fishing nets set up by local fishermen, thus, caused flooding and water logging.

Recommendations: There is no alternative to constant supervision, proper maintenance and regular feedback for ensuring sustainability of different flood management measures, especially structural interventions. Therefore, proper

³⁷ Article 21, *Bangladesh Water Act, 2013*, Government of the People's Republic of Bangladesh.

³⁸ Eresh Omar Jamal, "A disaster we made worse", *The Daily Star*, 18 September 2017.

mechanisms in these regards should be developed by the government as well as concerned authorities to evaluate various flood protection measures and identify loopholes of the existing management system. Especially, after a flood, experience feedback should be organized by mobilizing experts from different ministries and others concerned, who will meet with various parties affected by the disaster, including those managing it and its victims; after consultation, produce a comprehensive report including lacks, challenges, and recommendations for further improvements. Methods should be devised to regularly supervise various flood protection measures to ensure their effectiveness, especially during and after any flood. Information should be gathered from grassroots to propose recommendations reflecting the needs, will, knowledge and expertise of local people, in feedback reports. Local level disaster management committees should be empowered with adequate authority so that they can play effective role in this regard.

4.7 Good Governance

Good governance remains a priority, but challenging task as governance regulates all other activities. Maintenance of flood control projects is not without faults, and anomalies still exist due to absence of accountability and transparency. In flood response and recovery phase, especially in relief distribution, there are always allegations of poor coordination and mismanagement, favouritism, looting, ransacking and pilferage, many areas complain of receiving inadequate or no relief at all. There remain inconsistency and corruption in post-disaster activities. Regarding encroachment into floodplains and water bodies, elitism and political pressure are mostly responsible, hampering the smooth functioning of various flood and water related projects, hurting their sustainability. Most of the times, flood is associated with riverbank erosion, which is responsible for the loss of 5,000 hectares of land each year. Unlawful sand lifting is intricately linked with such erosion that sometimes changes the course of a river. Although sand lifting is banned within 6 km radius of vital establishments like bridges, this crime commonly occurs, with or without knowledge of concerned authorities. Sometimes, it cannot be controlled due to the absence of a strong political will, unlawful influence and lack of rule of law.

Recommendations: Every effort to ensure SFM will be futile without good governance. There should be proper mechanism to establish transparency and accountability in various flood control and mitigation projects, especially those involving large funds. Publication of budget and audit reports of flood and water resource management projects needs to be ensured. To save water bodies from encroachment, the government should not tolerate any political pressure from powerful elites. There has to be exemplary punishment for corrupt practices in construction of any structural measures like embankments, dams and other flood management projects. Required funds should be ensured for maintenance of FCDI infrastructures so that annual maintenance works can timely start; proper audit and

transparency also need to be ensured in this regard. Media can play crucial role in curbing corruption in flood management projects, and thus establish transparency and accountability. It can also play effective role to stop land grabbing and encroachment on wetlands, necessary for maintaining the normal flow of rivers. Local level disaster management committees should be equipped with adequate resources and jurisdictions to fight crimes related to water resource management and ensure transparency and accountability at the local level.

4.8 *Management of Residual Risk*

The perception of residual risk and efforts towards dealing with it related to floods in the context of Bangladesh are extremely scarce. Residual risk refers to the risk of flooding that exists in an area from potential floods exceeding the design of current protection measures, due to the possibility that the existing system can experience an unexpected failure. Examples of residual flood risk may include: failure of flood management infrastructure such as breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system; failure of a reservoir; or a severe flood event that exceeds the flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.³⁹ In spite of various measures on planning and operational level, residual risk cannot be eliminated totally. Severe floods, which are not uncommon in Bangladesh, may cause overflow and severe inundation in both rural and urban areas where outlets for water retention is almost nonexistent already. Furthermore, in this highly-populated country, there is very little room for using floodplain zones for greater floodwater storage. Therefore, specific strategy is needed for flood management to cope with residual risk which the country lacks severely. Besides, most organizations situated in flood prone areas do not have any flood disaster contingency and recovery plan. The absence of these plans becomes vital during any flood situation and its aftermath. Not only that, people exposed to moderate and severe flooding have very limited knowledge of residual risk which makes them extremely vulnerable to the disaster.

Recommendations: No flood protection measure is absolute; with all efforts in place, only a certain level of protection can be attained or guaranteed. The concept of residual risk, which is ignored in most of the cases in Bangladesh, should be taken into consideration for each flood control measure to make management sustainable. In any flood protection initiative, there should be clear manifestation of the level of protection to which the flood control structure might be reliably defended, or local conditions that might weaken it; determine flood risks in protected floodplain basin related to performance characteristics, the overtopping and failure probability of

³⁹ Ruth Burnham, "Residual Risk", *Northamptonshire County Council Flood Toolkit*, 13 February 2015, available at <https://www.floodtoolkit.com/glossary/residual/>, accessed on 02 December 2017.

flood defence structures and explain it to public. It is important to take upstream, downstream and environmental consequences into consideration to evaluate the residual risk and take protective measures accordingly. To have a holistic understanding of the risk, the flood situation in the whole river basin and catchment area should be considered. In Bangladesh, there are numerous evidence that structural measures, like embankments generate false sense of security, which sometimes makes the exposed communities more vulnerable to flooding and responsible for widespread damage and casualty. Therefore, the concept of residual risk with clear manifestation of potential failure or breach should be analyzed and disseminated so that people do not adopt any false sense of security, rather take appropriate precaution beforehand. All vital facilities, especially health, education, power and water supply, should have a contingency plan to continue essential services during the time of flooding.

4.9 Community Based Management

People's participation, mainly regular victims of floods, in framing, decision-making concerning flood mitigation and protection is essential, both to improve sustainability and implementation of decisions and give public the opportunity for expressing concerns and enable authorities to take due account of such concerns. All measures linked to public information and raising awareness are most effective when they follow the bottom-up approach and ensure participation of people from all levels. But, in Bangladesh, the participation of community people in decision making is very limited, which is a major impediment for SFM. Almost always, decisions related to flood and water resource management are made in top-down approach, ignoring the knowledge of community people as well as the local dynamics and spatial characteristics thus, become ineffective after a short period. Besides, members of local level disaster management committees are not included in the mainstream decision making process. Therefore, the sustainability of various measures taken for flood management suffers immensely due to lack of understanding of local context and environment.

Recommendations: People should be encouraged and assisted in taking their own flood protection measures and trained in how to react to any flood emergency. Practical guides for private individuals and local communities should be published and regularly disseminated on how to respond during and after any flood disaster. In flood prone areas, specific preparedness to alert, rescue and safety measures should be planned and implemented through training actions, drills and information strategy. This also requires that flood forecasts with enough lead time and related information are easily accessible by the community people and real-time media coverage is ensured. Furthermore, to make people flood resilient, all stakeholders, including the poor and marginalized groups need to be trained and included in the decision-making and implementation process so that they can make their contribution. Instead of top-down approach, bottom-up approach should be prioritized in case of flood

management activities at the grass-root level. It should be noted that local people are the first responders during any disaster. Therefore, community based flood warning system should be developed for effective dissemination of flood warning in local language. Efforts should be made to harness local knowledge of flood adaptation which is sometimes more environment friendly and sustainable compared to other measures.

4.10 Risk Transfer Measures

Farmers and cattle herders suffer the most from loss of crops, death of animals from floods in Bangladesh and there is no option of insurance coverage for them to cope with the damage. For instance, due to the floods in 2017, Department of Livestock Services estimated it affected 1,234 farms and caused deaths of nearly 50,000 livestock, including poultry and cattle in 113 *upazilas* along with the destruction of about two million tonnes of rice.⁴⁰ It is a massive setback for people who depend on agriculture and livestock farming for livelihood. In Bangladesh, crop insurance was first introduced in 1989 but failed to continue after 1995, due to manipulation by both insurers and policyholders. No scientific method to measure the adversity of weather was devised that eventually led to the failure of the scheme. Still, no practical effort has been made to introduce risk transfer measures for farmers and animal herders to minimise their losses due to floods. The Sadharan Bima Corporation launched a crop insurance programme in March 2014 with financial assistance from the Asian Development Bank but it expired in June 2017, and the government is yet to decide whether crop insurance on a nationwide basis will be launched again.⁴¹ Thus, in the absence of such a safeguard measure, people dependent on agriculture and animal husbandry are immensely suffering from floods and their devastation.

Recommendations: It is imperative for Bangladesh to consider introducing flood and crop insurance to reduce the financial impact of flood, especially on rural poor who largely depend on agriculture. Proper insurance can considerably mitigate the effects of flood and save the victims from total ruin. While introducing flood insurance, it is important to find a balance between taking and transferring risks. Where risk taking is feasible and makes financial sense, it can be transferred to the private sector and markets in the form of flood insurance. Public and private sectors have to work together to address underlying risks together to materialize the initiative. Bangladesh can follow best practices of other countries in this regard. For instance, crop insurance scheme is very popular in India, where the government pays 70 per cent of the premium as subsidy.⁴² Sri Lanka, Indonesia, Thailand and the Philippines

⁴⁰ "Cattle insurance essential: analysts", *The Daily Star*, 27 August 2017; "Aman output likely to fall", *The Daily Star*, 08 November 2017.

⁴¹ "Crop insurance helping farmers weather storm", *The Daily Star*, 06 April 2017.

⁴² Jebun Nesa Alo, "Crop insurance gains popularity", *The Daily Star*, 29 August 2017.

have also introduced subsidized crop insurance programmes that Bangladesh can follow.

4.11 *Recovery, Rehabilitation and Reconstruction*

Ensuring quick recovery and long-term rehabilitation of flood affected communities, conducting reconstruction work and ensuring return of the victims to their normal life after any flood event remain major drawbacks for Bangladesh to achieve SFM. Education is one of the sectors that bear the major burden of post-flood impact. A large number of schoolchildren is forced to stay away from schools due to moderate and long-term flood events, as they are forced to join different types of works for supporting their hard-pressed families. That severely disrupts their education and mental construction, mainly those living in poor and rural areas. The post-flood challenges that a farmer has to face are: water stagnation on fields, extra labour cost for clearing weeds, high prices of seedlings, fodder crisis, and lack of pure drinking water and household works. In addition to the physical and economic loss, disasters like flood can cause severe mental health problems that may continue over extended periods of time. It can challenge the psychosocial resilience of the people affected which are more difficult to detect and describe than the physical effect, but they do play a critical role, particularly on children.⁴³ Post-traumatic disorder is an area that has not been explored by policymakers of the country. Bangladesh is yet to develop any mechanism or policy to address the increased risk of psychological distress in victims of flooding within its strategies for flood management in different stages spanning from preparedness to rehabilitation.

Recommendations: The ultimate goal of SFM is to build a flood resilient community who can rebound after any flood disaster to their normal life with minimum effort. In this regard, quick recovery, long-term rehabilitation and reconstruction are crucial. Effective flood management strategy should be devised to ensure proper rehabilitation, especially for the rural poor and marginalised communities, who largely depend on agriculture, fishing and animal rearing. Marginalized people, *char* dwellers, poor minorities living in different parts of the country are the worst victims of floods due to their limited coping capacity. Proper rehabilitation and post-flood reconstruction for them need to be prioritized and appropriate policy should be devised for their protection. The scope of social safety net programmes should be increased to benefit people from it. One crucial aspect that has been severely neglected in country's flood management is the psychological impact of flood on victims. Despite precautions taken, flood always inflicts deep psychological trauma on victims. Therefore, victims' assistance, rescue and rehabilitation should systematically

⁴³ Carla Stanke, Virginia Murray, Richard Amlôt, Jo Nurse and Richard Williams, "The Effects of Flooding on Mental Health: Outcomes and Recommendations from a Review of the Literature", *Plos Currents*, Vol. 1, May 2012.

include mental and psychological support administered by skilled personnel, whose activity should extend throughout several months after the event for their proper recovery and rehabilitation.

4.12 *Knowledge Based Management*

Information and knowledge are two integral parts of SFM. Lack of those regarding the risk of flood, at community, policymaking and administrative level is a major challenge for Bangladesh. Furthermore, people are not fully aware of the growing impact of climate change on the nature of the country's flood intensity and frequency. Therefore, there is a limited urge among them to adopt new measures to mitigate its impact. In addition, lack of long-term vision among the concerned authority is impeding the sustainability of various flood management measures. Active role of local level disaster management committees in flood management is also questionable due to their dearth of adequate knowledge regarding various plans, policies and regulations of government. In Bangladesh, investment in research and innovation is only 0.6 per cent of the country's total GDP. This is not sufficient. It limits the scope of finding sustainable solutions to various flood related problems.

Recommendations: It is very important for people to have a better understanding of what to do and how to cope with flood risks for curbing flood related damage in the long run. Efforts should be made to inform communities about the risk of flooding; which means recognizing flood as a natural phenomenon, have proper understanding and preparedness about it, not to fear or underestimate it and most importantly, consider it appropriately when adopting long-term mitigation measures. Knowledge is recognized as the most efficient mechanism in reducing fatalities associated with extreme weather events.⁴⁴ Therefore, knowledge about risk must be passed on through appropriate tools like flood hazard mapping, flood zoning, and other information by concerned authorities, both from government and non-governmental spheres to raise public awareness, especially among rural and backward communities. Knowing about flood risk should include all important parameters, such as types of flooding and its probability, flood velocity and intensity, and the extent of impact to enlighten people about the gravity of the phenomena. This knowledge must be imparted convincingly to all actors. Media can be an effective tool for educating people on flood risk management. Local media and news agencies should initiate broadcasting educational programmes and information regarding flood preparedness in local language so that those can be easily understood by the target groups. In addition, in the context of Bangladesh, knowledge generation through scientific research and innovation is indispensable to cope with the changing

⁴⁴ Achim Steiner, "The Adaptation Imperative", *Project Syndicate*, 08 January 2015, available at <https://www.project-syndicate.org/commentary/climate-change-conference-lima-by-achim-steiner-2015-01>, accessed on 10 December 2017.

nature of floods. Such research should include scientific modelling, data sharing and forecasting. Considering the continual change in the Bengal delta as well as the “drivers” of the flooding system (genesis of floods, cause and scale of socio-economic and ecological impacts), multidisciplinary research on flood management is necessary for institutional capacity building and to create a local knowledge base that can support the whole gamut of activities. Research should also be conducted to find out and collect indigenous coping mechanisms of flood so that they can be preserved and mainstreamed. Invention of various flood tolerant crop varieties is another important aspect of research. Efforts should be made to grow new crops and rice varieties that can be harvested within shorter period. Investment in research and innovation need to be increased by manifold and adequate funds need to be mobilized for agricultural research institutes like Bangladesh Agricultural Research Institute (BARI), Bangladesh Rice Research Institute (BRRRI), Bangladesh Rice Knowledge Bank (BRKB), etc., to assist quality research for sustainable agricultural solutions to flooding problems.

5. Conclusion

Bangladesh is a small country with a huge population. Unplanned human settlement and development works have already taken enormous toll on its environment which goes on unabated, worsening disaster related damages, including floods. During any major flood, this dismal scenario becomes noticeably more disturbing. Limited resources make evacuation and relief much tougher as large numbers of people have to be accommodated and provided for with such limited ability. Chaos and mismanagement leave rescue and relief operations in disarray. The greater challenge has to face when it comes to rehabilitation of flood victims caused by the same limitations and lack of long-term vision. Moreover, as there is little or no space to be effectively used as water outlets, persistent water-logging in many places makes rehabilitation even tougher. Building flood-resilient community is still a far cry hampering sustainability of flood management in Bangladesh.

Since systematic efforts to manage floods began in Bangladesh in the 1960s, most were related to structural interventions, ignoring country’s geophysical location, deltaic and hydrodynamic features. Though structural solutions, such as building embankments along rivers and polders in coastal regions provide protection from floodwater for short period, but total reliance on it is not sustainable in the long run. Besides, they have many adverse environmental, hydrologic, economic, ecological, and geological impacts, thus further worsening flood situation in the country. A growing concern is anthropogenic augmentation of floods by unplanned urbanization, mismanaged development, encroachment into wetlands, deforestation, lack of good governance, etc. In recent times, global warming and climate change are severely threatening Bangladesh, raising flood frequency and intensity.

Sustainable solutions to floods can be attained by adopting multi-faceted, multipronged approach that aims to work with all stakeholders keeping environmental costs minimal, introducing flood and water resource management best practices, like effective floodplain management and embracing opening-up approach, catchment based RBM, integrated water resource management covering all aspects related to land, water and environment, etc. All structural measures to control and navigate floodwater must take geological and hydrological characteristics of the country into account, its socio-economic and environmental impacts before implementation. Various non-structural measures like effective flood forecasting and early warning, knowledge based management and raising public awareness, scientific research and innovation for flood coping mechanism are some of the crucial SFM initiatives that need to be prioritized and implemented. In formulating a flood management plan, decision makers at all levels (local, regional, national and international), stakeholders and civil society should be involved, especially active participation of the worst sufferers of flood, i.e., the poor and marginalized, need to be made sure. As Bangladesh is a small part of the larger hydrological system situated at the lowest part of GBM basin, mutual understanding and cooperation among co-riparians are mandatory to formulate any long-term and sustainable solution to flooding. Strong diplomatic efforts need to be pursued in this regard.

Bangladesh has recently graduated from low-income economy to lower-middle-income economy and envisaging becoming a developed nation. Its economy and development activities will increase in accordance with that vision in the future. But socio-economic progress does not offer immunity to natural disasters and Bangladesh remains vulnerable to these, worsening mostly by manmade causes, making more people and their livelihood vulnerable to floods. Therefore, to achieve SFM, it is crucial to acknowledge the country's deltaic features, which require navigable and free flowing rivers with all water bodies and wetlands being conserved, proper understanding of country's geological settings and hydrodynamics while preparing strategies, plans and policies. With days passing by, floods and other natural disasters will take more toll on its citizens and development works. Without attaining SFM, Bangladesh will not be able to keep its wheel of economic growth in motion for long and secure all its development works from the devastation of disasters, thus, accomplishing its long-term vision of becoming a developed nation.