Controlling Flood through Best Management Practices

Formulating solutions to flooding problems requires a comprehensive understanding of the geologic settings of the region, and a better knowledge of hydrodynamic processes that are active in watersheds. Only solutions that take into account the underlying long-term factors contributing to flooding problems can prevail.....Structural solutions, such as the building of embankments along the rivers and polders in coastal regions in Bangladesh, will not solve the flooding problems, but will result in many adverse environmental, hydrologic, economic, ecological, and geologic consequences.

by Md Khalequzzaman

At the present time 130 million people of Bangladesh are facing a series of environmental problems. The people are repeatedly confronted by natural and human-made catastrophes such as flooding, surface and groundwater pollution, droughts, cyclones, riverbank erosion, air pollution, wetland loss, tornadoes, and coastal erosion. While some of these environmental degradations and calamities are not directly related to human activities and land-use practices (such as tornadoes, and cyclones), others are related to human interactions with the nature. Flooding is one environmental problem that is directly related to human activities. The magnitude and intensity of flooding are very much dependent on land-use practices in the watershed of each river or stream. Bangladesh is faced with yet another flood this year. Finding solutions to the flooding problem is an imperative. It is important to understand the processes that influence flooding in Bangladesh, before any solution to the flooding problem is prescribed.

Riverine floods occur when the amount of runoff originating in a watershed (the area that collects and directs the surface runoff into the rivers, streams and lakes that drain it) exceeds the carrying capacity of natural and constructed drainage system. Flooding can occur due to river overflow or surface runoff. There are two types of floods which occur in Bangladesh: annual floods (*barsha*) that inundate up to 20 per cent of the land area; and low frequency floods of high magnitude that inundate more than 35 per cent of the area (*bonnya*). While the annual floods are essential and desirable for overall growth of the Bangladesh delta and the economy, the major floods such as those that occurred in 1954, 1955, 1974, 1984, 1987, 1988, 1993, 1998, 1999, and occurring in 2000 are destructive and cause serious threat to lives and economy. We need to analyze possible underlying causes of recent unusual and frequent floods in Bangladesh in the light of hydrodynamic processes that operate in the watershed and the land use practices that take place in this region.

Few Observations

Documentation of floods in terms of flood depth, area affected, damage to crops, damage to infrastructures, number of people affected, and overall monetary damage started in 1953. Other major recorded floods prior to 1953 took place in 1787, 1917, and 1943. Based on the historic records, it is obvious that the frequency, magnitude, and duration of floods have increased substantially during the last few decades. For example, all major floods covering more than 30 per cent of the country (total area of Bangladesh is 144,000 km^2) occurred after 1974. Four floods of such great magnitude (1974, 1987, 1988, and 1998) took place during the last 25 years, averaging one in every six years. According to some researchers, the floods of 1980 and 1984 also covered an area more than 30 per cent, making the number of such floods to be six since 1974 (i.e. one in every four years). In addition, the total area covered by major floods has been steadily increasing since 1974, with an exception of 1984 floods. The land area affected by major floods has increased from 35 per cent in 1974 to 68 per cent in 1998. Variations in data pose a problem in analyzing the findings. However, all sources of data show a general trend of increased flooding propensity.

Control Measures and the Outcome

Flood control measures in Bangladesh are mainly limited to building of earthen embankments, polders, and drainage. A total of 5,695 km of embankments, including 3,433 km in the coastal areas, 1695 flood control/regulating structures, and 4,310 km of drainage canals have been constructed by the Bangladesh Water Development Board during the last several decades. Embankments and polders have reduced floodplain storage capacity during floods, leading to an increase in water levels and discharges in many rivers. Earthen embankments can easily breach and can be damaged by riverbank erosion. Most of the embankments in Bangladesh have experienced breaching and erosion more than once since their completion. Embankments have created a false sense of security among residents living within embanked areas. Breaching of the Gumti embankment at Etbarpur during the 1999 flood caused substantial damage to the environment and property. The effectiveness of embankments is being questioned in other countries as well. Flood control embankments along the Mississippi River are constructed using superior engineering designs and are maintained regularly by the US Army Corps of Engineers. During the floods of 1973, 1984, and 1993 these embankments and other embankments maintained by state governments in Illinois breached at many places and proved to be ineffective as flood control measures. During the 1993 flood, some 1,082 of 1,576 levees on the Upper Mississippi and Missouri River basins were either overtopped or failed.

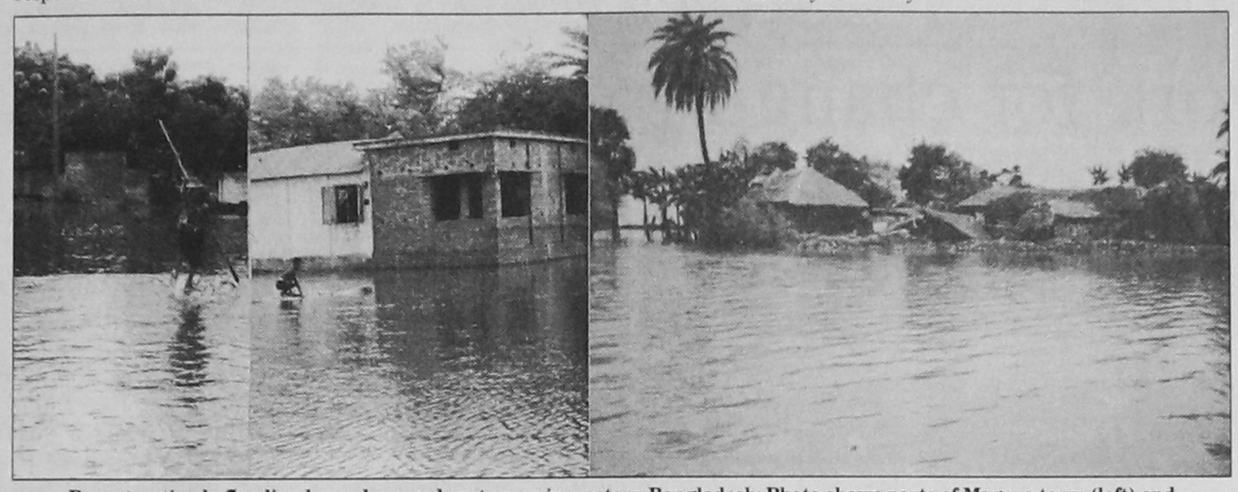
Following the1988 flood the Government of Bangladesh has adopted a World Bank sponsored flood action plan (FAP) that calls for the construction of hundreds of kilometers of tall embankments along the great rivers of the Bangladesh delta, enormous drains, and compartments on the flood plains. The feasibility of the FAP has been criticized by numerous researchers on the basis of technical, economical, environmental, socio-political, and ecological grounds. The Dhaka Integrated Flood Protection Embankment-cum-Eastern Bypass Road Multipurpose Project, which is a component of the FAP, is underway at a calculated initial coast of 24,758.21 million taka. The effectiveness of such embankments as flood control measure is debatable at best.

Despite flood control measures already administered by the Government of Bangladesh, the total amount of damage to economy, crops, and infrastructures due to floods has steadily increased during the period between 1954 and 1998. According to one study, overall damage to the economy ranged from $600 million dollars in 1974 to $1,200 million dollars in 1988; and crop damage has varied between 0.6 million tons in 1953 and 3.2 million tons in 1988. Another study done in 1992 estimated the economic loss to increase from 1,500 million taka in 1954 to 4,000 million taka in 1988, with a maximum of 20,000 million taka in 1974. Those studies determined that the total damage to the economy had increased from1,200 million taka in 1954 to 100,000 million taka in 1998. Furthermore, the number of deaths had increased from 112 in 1954 to 2,379 in 1988. Although the numbers vary somewhat, it is very clear that flood control measures did not make a significant impact in terms of reducing the flooding propensity and total damage caused by floods.

The magnitude and duration of floods have changed during the last few decades. The duration of 1998 flood was over 70 days. A prolonged flooding condition prevailed throughout much of the monsoon season in 1999. This begs the questions, "why, despite all the flood control measures taken and the money spent, is the flooding propensity in Bangladesh increasing, and what can be done to reduce such damage in the future? The answers to these questions lie in understanding the long-term factors contributing to increased frequency and duration of floods. Once the causes of the problem are determined, then preventive measures can be taken to reduce future damage caused by floods.

Factors Contributing to Propensity

Likelihood of flooding in an area can vary greatly with a change in the: (a) amount of runoff that results from rain in a watershed, (b) water carrying capacity of a drainage basin, and (c) change in land elevations with respect to riverbeds and sea level.



Recent untimely flooding has submerged vast areas in western Bangladesh: Photo shows parts of Magura town (left) and Darshanpara union of Paba upazila in Rajshahi district (right)

An increase in runoff component of the hydrologic cycle in a watershed, a decrease in water carrying capacity of a drainage system, and a decrease in land elevations will increase flooding propensity in an area. Therefore, the flooding problem and the solutions to such problems can (or should) be analyzed in the context of these three fundamental parameters: runoff, water carrying capacity, and land elevation changes. What is needed is analysis of land use practices in watersheds during the last few decades that have the potentials to impact hydrodynamic behaviours of rivers, affecting three vital parameters mentioned above.

Unplanned urbanization: Rapid population growth creates extra pressure on the land of already overcrowded Bangladesh. Agricultural lands give way to housing developments and roads. This rapid development and urbanization has almost undoubtedly must have aggravated the flooding problem in Bangladesh. Urban population has increased from 1.81 million (4.33% of total population) in 1951 to 25.2 million in 1990. The current urban population is more than 30 million (25% of total population), and is projected to exceed 58 million (36% of total population), by the year 2010.

Unplanned urbanization can adversely impact flooding situation in a watershed. Prior to urbanization there exists a greater lag time between intense rainfall and peak stream flow. After urbanization the lag time is shortened, peak flow is greatly increased, and the total run-off is compressed into a shorter time interval, creating favourable conditions for intense flooding. For example, in a city that is totally served by storm drains, and where 60 per cent of the land surface is covered by roads and buildings (like Dhaka City), floods are almost six times more numerous than they were before urbanization.

Following urbanization, it is necessary to adjust drainage capacity in the watershed to take into account the "basin development factor (BDF)" in order to accommodate the extra runoff that results due to urbanization. The amount of adjustment in the carrying capacity of natural streams following urbanization depends on the degree of BDF. For an increase in the amount of impervious surface by 10 per cent in a watershed, a 23 per cent increase in the drainage capacity by dredging or deepening of streams is required. Dhaka City is located in the watersheds of Buriganga and Sitalakhya Rivers.

A significant increase in the amount of impervious surface in these watersheds has taken place due to expansion of the Dhaka Metropolitan area over the last few decades. However, no attempts have been taken to increase the carrying capacity of these rivers to accommodate for the BDF. On the contrary, many of the rivers including Buriganga are being filled up by people. The illegal encroachment onto the rivers is contributing to the reduction in water carrying capacity during floods. Moreover, the internal drainage system consisting of tributaries to Buriganga and Sitalakhya Rivers has been diminished due to unplanned land use practices. For instance, it is apparent from topographic maps that Dhanmondi Lake and Baridhara Lake are remnants of tributaries to Bugiganga-Sitalakha Rivers. Also, filling up of Dholaikhal channel has reduced the runoff capacity from Dhaka City. The lack of an efficient storm sewer system in Dhaka City also contributes to the reduction of water carrying capacity, causing water logging throughout the monsoon season. According to reports published in national newspapers, Dhaka City has experienced serious water logging problems during the wet months of July to October in 1999, and during July to September in 2000.

Riverbed aggradation: Riverbed aggradation is most pronounced for the Ganges and its distributaries. From the border with India to the point where the Ganges meets the Brahmaputra River, the riverbed has aggraded as much as 5-7 meters in recent years. The average width of the Ganges has decreased from 1.27 km in 1973 to 1.01 km in 1985. Riverbed aggradation is so pronounced in Bangladesh that changes in riverbed level can be observed during one's lifetime. For example, the Old Brahmaputra River was navigable for steamers only about 30 years ago, and is presently an abandoned channel. This situation is true for many other distributaries of the Ganges and Meghna Rivers, such as the Madhumati, Bhairab, Chitra, Gorai, Ghorautra Rivers, etc. Riverbed aggradation reduces the water carrying capacity of rivers, causing floods due to bank overflow. This recent increase in riverbed levels has undoubtedly contributed to the increased flooding propensity in Bangladesh.

Soil erosion: Ploughing makes the land surface more susceptible to soil erosion. Surface run-off can easily wash away the topsoil from cultivated lands. This surface erosion reduces land elevation, which in turn increases flooding intensity in an area. According to the Report of the Task Forces (RTF) on Bangladesh Development Strategies for the 1990s, soil erosion is a serious problem in many parts of Bangladesh. Hilly areas in Sylhet, Chittagong, and Chittagong Hill Tract districts are more susceptible to soil erosion. About 55 per cent of Chittagong Hill Tract area is highly susceptible to soil erosion. Heavy monsoon showers remove the surface soil through runoff. Eroded sediments are deposited on the riverbeds, reducing the water carrying capacity and increasing flooding propensity in a watershed. Soil erosion also reduces land elevations and increases elevations of riverbeds, contributing to increased flood depths. The land elevations in other parts of Bangladesh must have reduced over time due to soil erosion. Aside from this, the tilling on the mountain slopes of the Himalayas is thought to be responsible for massive soil erosion in Nepal , which eventually causes rapid riverbed aggradation in Bangladesh. Moreover, construction sites in cities can contribute to soil erosion if silt fences or sediment retention ponds are not employed properly. In Bangladesh, no such measures are in practice at construction sites.

Deforestationin the upstream region:A rapid increase in population in the Indian Subcontinent over the course of the 20th century has resulted in an acceleration of deforestation in the hills of Nepal to meet the increasing demands for food and fuel wood. Deforestation of steep slopes is assumed to lead to accelerated soil erosion and landslides during monsoon precipitation, which in turn is believed to contribute to devastating floods in the downstream regions, such as in Bangladesh. Deforestation within Bangladesh also contributes to the soil erosion. The amount of forest cover in Bangladesh was reduced from 15.6 per cent in 1973 to 14.6 per cent in 1985-86, and eventually to13.4 per cent in 1987. A minimum of 25 per cent forest cover is suggested for a healthy ecosystem. The amount of forest cover in Bangladesh at the present time believed to be less than 10 per cent.

Local relative sea-level rise: The ultimate destination of all rivers is the ocean. The land elevations are measured with respect to the sea level in an area. Therefore, any change in the sea level causes land elevations to change as well. At the present time the sea level is rising globally. If the sea-level rises in an area at rates faster than the rates of land aggradation due to sedimentation, then land elevations decrease over time. Any decrease in land elevations can cause increased inundation by rivers overflowing at bankful stage. The rate of local relative sea-level rise is 7 mm/year in the coastal areas of Bangladesh. According to a study, the local relative sea level at Chittagong Port has increased by as much as 25 cm between 1944 and 1964. The relative sea level in the Bay of Bengal is predicted to rise 83 to 153 cm by the year 2050. An increase in the sea level raises the base level of rivers, which in turn reduces the gradients of river flow. As a consequence, the amount of river discharge decreases, creating a backwater effect further inland. The backwater effect caused by sea-level rise can result in more flooding of lands from "piled up" river water inland. This certainly seems to be one of the contributing factors for the increased flooding intensity in Bangladesh.

Inadequate sediment accumulation: A delta can prograde if sediment accumulation rates are greater than the rates of local relative sea-level rise. Limited data show that the average sediment accumulation rates in the coastal areas of Bangladesh is 5-6 mm/year for the last few hundred years, which is not enough to keep pace with the rising sea level at 7mm/year. As a result, land elevations must have been decreasing over time in Bangladesh, resulting in more flooding inundation.

Subsidence and compaction of sediments: Sediments on a delta plain are rich in decomposed organic matters, and are subject to compaction due to dewatering and sediment weights. Most deltas subside due to the weight sediments, and due to overdraft of groundwater to meet the demand of increased population. Subsidence and compaction reduce land elevations with respect to sea level. No direct measurements of subsidence or compaction are known for Bangladesh. However, the groundwater table in Dhaka City has had a considerable lowering by as much as nine to 12 meters over the last three decades. Experience in other countries indicate that at least nine meters of permanent lowering of groundwater table causes 30 cm of land subsidence. Therefore, it is likely that land elevations in many parts of Dhaka City have been lowered by up to 30 cm, contributing to increased flood depth.

Best Management Practices

Flooding is a natural phenomenon, which cannot be prevented. Complete flood control is not in the interests of most Bangladeshi farmers. The flood control measures and policies should be directed to mitigation of flood damage, rather than flood prevention. Resources should be allocated to help people adopt a 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 will be necessary to achieve sustainable economic development and to reduce any environmental degradation. In addition, implementation of an improved real-time flood and drought control warning system can reduce the damage caused by floods.

A greater understanding of the processes that contribute to increased flooding propensity, however, can help us mitigate the adverse effects on human lives, the environment, and the economy. To mitigate flooding propensity in Bangladesh, both the government and the people will have to shift their paradigms, as well as will have to adopt best management practices (BMPs) in agriculture, forestry, landuse planning, water resources management, and urbanization. The BMPs pertaining to flood control are those activities that will help reduce the run-off, will increase the carrying capacity of drainage system, and will increase land elevations with respect to sea level or riverbeds. Examples of BMPs to reduce flooding in Bangladesh should include the following features and activities: dredging of rivers, re-excavation of abandoned channels-ponds-lakes, dispersion of dredged sediments to increase village platforms and road elevations, conservation tillage, establishment of vegetated buffer zone along rivers, putting silt fences around construction sites, building sediment retention ponds in construction sites, removal of polders in the coastal areas to enhance sedimentation on delta plain, efficient storm sewer systems in cities, planned urbanization, watershed-scale land use zoning maps, reforestation, good governance, integrated regional water resources development plans that include participation from India, Nepal, and Bhutan.

Conclusions

Formulating solutions to flooding problems requires a comprehensive understanding of the geologic settings of the region, and a better knowledge of hydrodynamic processes that are active in watersheds. Only solutions that take into account the underlying long-term factors contributing to flooding problems can prevail. Such contributing factors are: unplanned urbanization, soil erosion, local relative sea-level rise, inadequate sediment accumulation, subsidence and compaction of sediments, riverbed aggradation, and deforestation.

Structural solutions, such as the building of embankments along the rivers and polders in coastal regions in Bangladesh, will not solve the flooding problems, but will result in many adverse environmental, hydrologic, economic, ecological, and geologic consequences. Solutions to flooding problems can be achieved by adopting and exercising watershed-scale best management practices in agriculture, construction, forestry, governance, river and water resources management, urbanization, flood forecasting, and regional cooperation.

Since Bangladesh is a small part of a larger hydrodynamic system that comprises several countries in the region, mutual understanding and cooperation among the co-riparian countries will be necessary to formulate any long-term and permanent solutions to the flooding problems.

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