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Experiences with Flood Management Practices During the 1998 Flood

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Abstract

Bangladesh currently employs a variety of flood management options such as flood control, controlled flood, flood proofing and flood forecasting. This paper discusses the experiences with these flood management options during the unprecedented flood of 1998. In the light of these experiences, this paper suggests a few courses of action, which are expected to improve the performance of these practices during such large floods in future.

THE FLOOD OF 1998

Bangladesh is a floodplain country located on the delta of three mighty rivers, the Ganges, the Brahmaputra and the Meghna. Most of the floods in Bangladesh are caused by the bank overflow from these major rivers and their tributaries and distributaries. These rivers carry enormous volume of flood water generated by heavy rainfall in upper catchments outside the boundaries of Bangladesh, which occupies only 7% of 1.72 million sq.km of total catchment area of Ganges-Brahmaputra-Meghna river system. The cause of the flood of 1998 is also the heavy rainfall in upper catchments of the Ganges and the Brahmaputra. During the 1998 flood season, trans-boundary flow contributed to 5.95 meters of water and internal rainfall contributed to 1.66 meters of water (see Table 1). Such amount of water caused flooding in more than two-third area of the country.

Table 1: Comparison of Trans-boundary Flow and Internal Rainfall During 1998 Flood

Month	Trans-boundary run-off (meters)	Internal rainfall (meters)
July	1.82	0.77
August	2.25	0.59
September	1.88	0.30
Total	5.95	1.66

Table 2 shows the water levels and duration of flood at three major rivers. As can be seen from Table 2, the 1998 flood level crossed recorded highest flood levels in the Ganges and the Lower Meghna rivers. The most damaging feature of 1998 flood was its long duration. The flood remained above mean river bank level continuously for record duration at Bahadurabad on the Brahmaputra and Hardinge Bridge on the Ganges.

Table 2: Comparison of 1998 Flood Level and Duration with Previous Record

Station and river	Highest water level (meters PWD)		Duration (days above bank level)	
	1998 flood	Previous record and year	1998 flood	1988 flood
Hardinge Bridge on Ganges	15.19	14.87 (1988)	29	27
Bahdurabad on Brahmaputra	20.37	20.61 (1988)	76	30
Chandpur on Lower Meghna	5.62	5.16 (1988)	75	87

The 1998 flood hydrograph of Lower Meghna river at Chandpur is shown in Fig. 1 and is compared with 1988 flood hydrograph. Stage-duration-frequency analysis carried out by Islam and Chowdhury (1999) indicates that at Chandpur both the highest level and the duration were unprecedented and were higher than that of 100 year return period. Salehin et al. (1999) stated that continuous inflow of very large amount of water caused abnormal tide behaviour at Chandpur. The study found no effect of spring tide, monsoon wind set up or tsunami on the 1998 flood.

The 1998 flood caused enormous damage in the country, which can be summarized after IEB (1998) as follows:

Total area affected	: 100,000 sq.km
Districts affected	: 52
Thanas affected	: 366
Number of affected people	: 30,916,351
Crop loss	: 2.2 million tons
Highways and roads damaged	: 15,927 km.
Bridges and culverts damaged	: 6,890
Embankments damaged	: 4,528 km

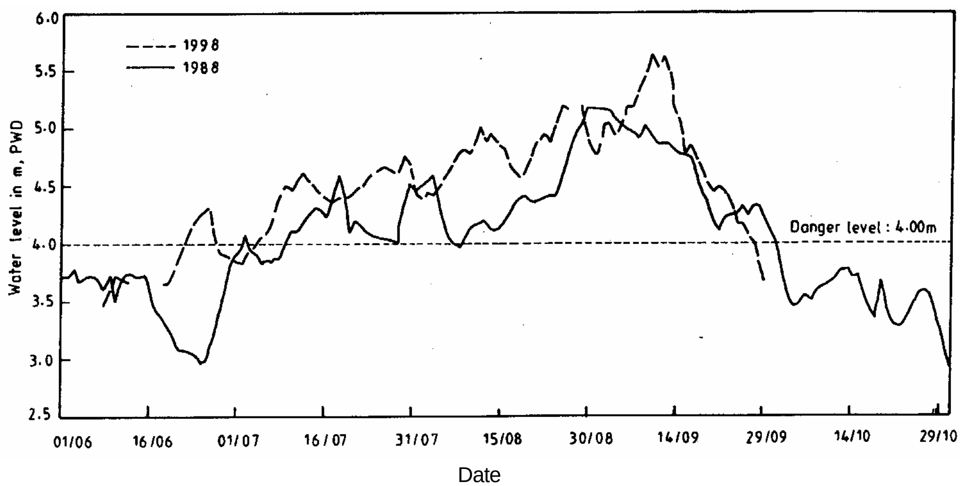

Figure 1: Water Level Hydrographs of Meghna at Chandpur

FLOODPLAIN PROCESSES

An important physiographic feature of Bangladesh is that except Chittagong region, rest of the area mainly consists of floodplain. Fig. 2 shows the areal extent of inundation each year since 1954. The areal extent of the floods in 1988 and 1998 is evidence that almost the entire country is basically a floodplain. A declining trend in the flooded area is observed in Fig. 2. This is due to construction of around 400 flood control projects over the years. Chowdhury et. al (1996) estimated that since 1964, there has been a growth of flood control coverage of 120,000 ha/year resulting in flood free area of 80,000 ha/year. Almost 60% of the potential area for flood protection is now under flood protection. Such large scale intervention in a floodplain environment is likely to produce repercussions. It is seen from Fig. 2, that despite the declining trend in flooded area, the recent floods in 1998, 1988 and 1987 are the largest recorded floods. It is also seen that year-to-year variability of flooded area has increased in recent years indicating an unstable system.

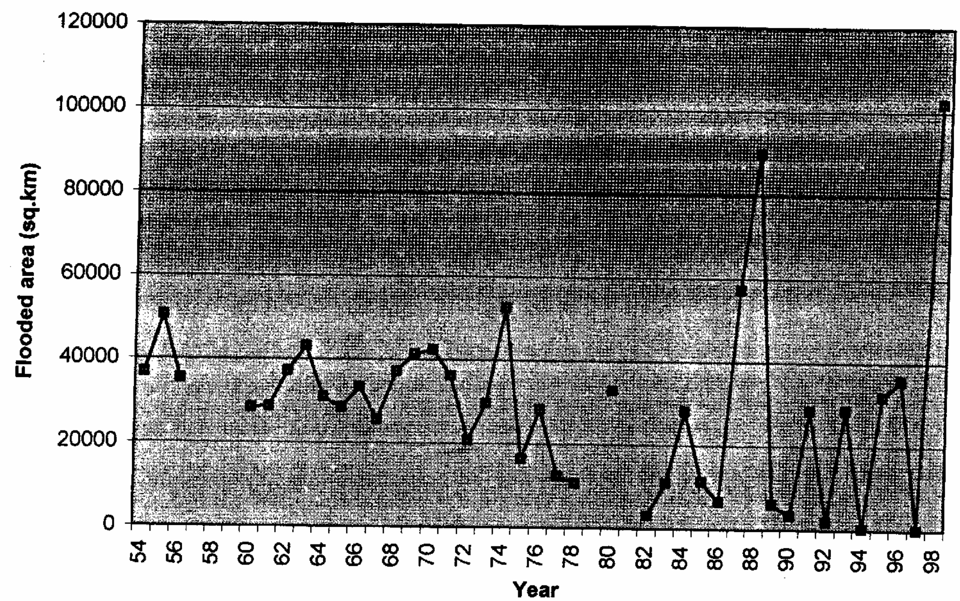

Figure 2: Extent of Inundation During Different Years

One of the reasons for poor performance of many structural interventions within the floodplain including roads, flood control projects etc. is the lack of recognition of floodplain processes and functions and their relationship with the rivers. It has been seen that population do desire some form of protection especially from large floods. Consequent land and water use interventions creates opportunities for social upliftment. However, while flood control interventions bring economic benefit to one section of the society, cause economic hardships to another section especially to those poorer sections who are dependent on many free resources of floodplain. The resultant conflict of interest in a densely populated country often compromises project performances. It has been observed that while projects affect the floodplain functions, the natural processes also affect the intended functioning of the projects. Such socio-economic and environmental interactions in the floodplain are illustrated in Fig. 3.

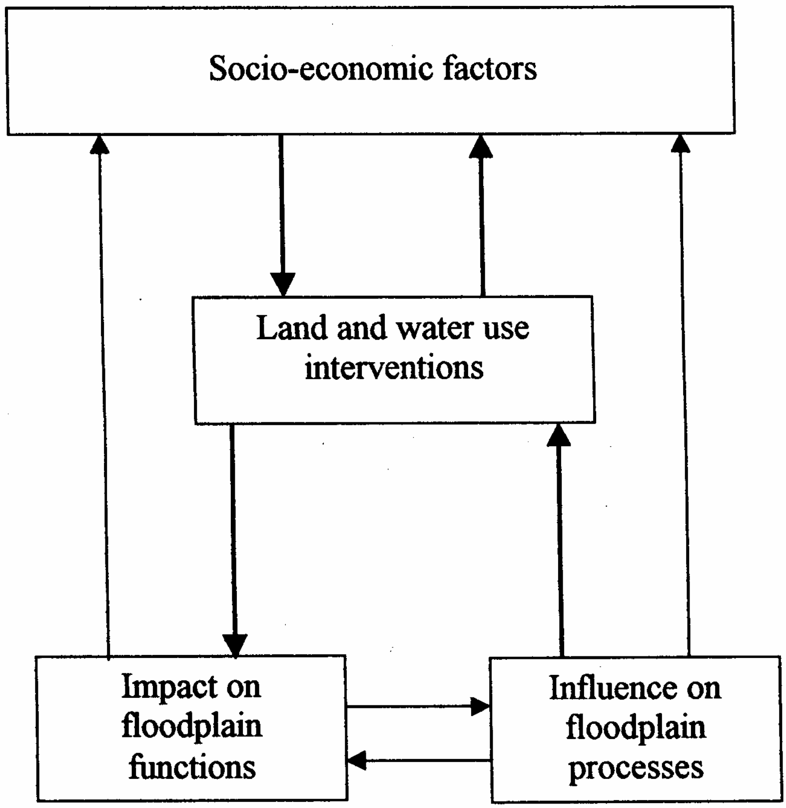

Figure 3: Schematic Diagram of Interactions in a Floodplain Environment

An important beneficial hydraulic function of floodplain is that it moderates the flood flow by acting as storage. Storage function of floodplain is also very helpful in maintaining the channels in the coastal region of Bangladesh where tide occurs twice a day. Another beneficial function of floodplain is that it augments the post-monsoon river flow by gradually releasing water from its flood storage. Rainfall and flood water over the floodplain infiltrate and recharge the unconfined aquifer. Lateral recharge also occurs from rivers at high water level. During dry season when the rivers are at low water levels, major portion of their flow comes from groundwater discharge from the upper aquifer.

While large floods such as those of 1998 and 1988 cause enormous damage to economy, normal floods have been proven to be beneficial in many ways. The river-borne sediments, which are dispersed over the floodplain, are valuable sources of soil nutrients. There is empirical evidence of bumper harvest of Boro rice after every major flood. In Bangladesh, fish is second only to rice as a source of food. Breeding, multiplication and sustenance of the inland water fish and prawn populations are intimately bound to the sequence of annual flooding. The great majority of our wildlife species are also directly or indirectly more intimately associated with the aquatic habitat. A number of globally endangered species depend upon the floodplain wetlands of Bangladesh.

FLOOD MANAGEMENT PRACTICES OF BANGLADESH

Structural Measures

Many conventional flood mitigation measures like flood control reservoirs, flood diversions or flood bypasses are not feasible inside Bangladesh because of its extreme flat topography and high population density in the floodplain. The principal structural flood management measure that has been adopted in Bangladesh is construction of embankments parallel to the riverbanks. Drainage of floodwater is facilitated by re-excavating drainage channels and constructing drainage regulators and sluices. Most of the flood control projects in our country are intended for protecting agricultural land against river flood. Such projects are designed for protection against a 20-year flood. As of 1993, there were 372 flood control and drainage projects giving protection to a total of 3.72 Mha.

In recent years, due to many adverse impacts of flood control projects on environment, most notably on fisheries, controlled flooding concept has been advocated and administered in a pilot scale in Tangail. According to this concept, flood water is not completely eliminated, but rather it is allowed to enter the project area in a controlled fashion in order to retain many benefits of normal flood while protecting the project area from abnormal floods.

Non-structural Measures

Importance of non-structural measures of flood management such as flood forecasting and flood proofing is becoming evident especially during large flood events. The Flood Forecasting and Warning Center (FFWC) of BWDB, established in 1972, is responsible for making flood forecasts and flood warning during the flood season. At present, the FFWC issues forecast of river stages for 46 stations on major and medium rivers, formulated for 24, 48 and 72 hours.

Flood proofing of homestead is a tradition of the rural settlements in Bangladesh. Rural homesteads are generally raised above usual flood level. As per Bangladesh National Building Code, any area having a potential for being flooded under at least 1m deep water due to flooding should be delineated as flood prone area (FPA). The code specifies that the lowest floor, including the basement, of any building within the FPA shall not be located below the design flood level, and the roof of one or two story buildings and the floor immediately above the design flood level for three or more story buildings shall be accessible with an exterior stair.

EVALUATION OF FLOOD CONTROL MEASURES

Agricultural Land Protection

High water level and long duration of the flood threatened many of the flood control projects. About 5,000 km of embankment was damaged. As a typical example, damages suffered by Meghna-Dhonagoda Irrigation Project (MDIP) are shown in Table 3. Damages were extensive due to long duration (more than two months) of the flood. The damages reported in Table 3 are due to typical floodplain soil characteristics and earthen nature of embankment. Risk of failure of embankment is omnipresent in the complex geo-morphological setting of the floodplain.

Table 3: Damage Assessment of MDIP by BWDB (Source: Saleh et al., 1998)

Types of damages	Seepage	Boiling	Piping due to rat hole	Sliding	
				c/s slope	r/s slope
Extent of damage	250 nos	322 nos	83 nos	3611 m	2525 m

Fortunately, large flood control projects, such as the Brahmaputra Right Embankment, the Meghna-Dhonagoda Irrigation Project and the Chandpur Irrigation Projects were not breached due to constant monitoring and timely intervention by BWDB engineers. The projects were not overtopped either, despite the fact that flood level often exceeded design flood level. Saleh et al. (1998) surmised that the additional freeboard of 3 feet (0.9 meter) saved many projects from overtopping. Indeed, Chowdhury et. al (1996) showed that due to extreme flatness of the country, the difference between 20-year flood level and 100-year flood level is less than 1 meter. Therefore, it can be stated that the existing design crest level of the embankments is able to protect the projects from 100-year floods.

However, duration of flood, which produces continuous seepage pressure on the earthen embankment, need to be made an important design consideration so that structural integrity of the earthen embankment can be maintained during long duration floods. Long duration flood also causes morphological changes in the river, which may compromise the safety of structures. MDIP was seriously threatened by river erosion during the 1998 flood.

Typical floodplain hydrology played a role in failure of some flood control projects. For example, Nagor river project failed due to public cuts by outsiders. This occurred as outsiders perceived that water level outside the project was higher due to this project. Their apprehension is not without ground. HTSL (1992) claimed that 13 projects out of 17 projects evaluated by it have given rise to higher water levels outside the projects. Harza (1991) asserted that all the eight projects that it evaluated have produced higher water levels outside. External impact of flood control projects can not be avoided especially in floodplain setting. But moderating such impacts through appropriate design modification is an important pre-condition for sustainability of projects.

The flood control projects saved considerable amount of foodgrain (MDIP alone saving more than 40,000 tons of Aman rice) which otherwise would have to be imported at the expense of scarce foreign reserve. Saving crops from such large floods can form a sounder justification for flood control projects.

Urban Protection

The importance and need of structural measures for flood control in urban areas have been underlined during 1998 flood. Flood protection for major urban areas are provided against 100-year flood while secondary towns are provided with protection from 50-year floods. During the 1998 flood, most of the western part of Dhaka City was saved from inundation by the embankment, which was built after the 1988 flood. Some part of the western Dhaka specially the diplomatic enclave and eastern Dhaka was flooded. While the agricultural flood control projects are solely managed by one agency namely BWDB, Dhaka flood protection works are managed and operated by three agencies namely, BWDB, WASA and RAJUK. Lack of coordination between these three agencies has caused flooding in the western part of Dhaka city (Chowdhury et al., 1998).

The government has decided to protect the eastern part of Dhaka City by constructing a 60-km embankment. While constructing this flood protection work, it is advisable that the planners look at the deficiencies of flood protection works in Dhaka west and take appropriate measures so that the same mistakes are not repeated. Among these deficiencies, Chowdhury et al. (1998) reported drainage congestion, lack of integrated development of urban infrastructures and formulation of appropriate land use regulation.

EVALUATION OF CONTROLLED FLOODING MEASURES

The Compartmentalization Pilot Project (CPP), Tangail was developed under Flood Action Plan (FAP-20) to promote the concept of 'controlled flooding' from both outside and inside the embankment or compartment. A compartment has been defined as an area in which effective water management, particularly through semi-controlled flooding and controlled drainage, is made possible through structural and institutional arrangements. It was envisaged in the FAP-20 that the CPP would serve three purposes: (i) flood control in order to reduce flood damages to human lives, economic assets and agricultural production; (ii) controlled flooding to capture the benefits of flooding for agriculture, fisheries and navigational purposes; and (iii) flood storage to store flood water and/or rainwater in pre-defined sub compartments to reduce flood damages elsewhere in the floodplain. Contrary to the concept of the traditional FCD/FCDI projects, where river water flooding is both unacceptable and undesirable, the compartmentalization concept recognizes the beneficial effects of river flooding on agriculture (silt deposits and nitrogen fixation) and on fishery. The CPP was commissioned in 1995 and the 1998 flood was the first major test for this pilot project.

The 1998 flood water level corresponded to a level with 27-year return period while the design level is 20-year flood level. The water level difference between inside and outside of the CPP during 1998 flood was more than 2m. As per the original concept, the embankment was to be overtopped by floodwater with all the inlet structures open, if the flood exceeded the 20-year flood. However, this could not happen, as the project people did not allow it. During the flood, the embankment was not overtopped, but there were three breaches and one public cut by outsiders. Saleh et al. (1998) expressed that 'compartmentalization concept' has not worked during the 1998 flood, but the project is deriving benefits from controlled flooding.

EVALUATION OF FLOOD PROOFING MEASURES

Properties and infrastructures have suffered substantial damage during 1998 flood, which would in turn affect the national economy profoundly. A program of flood proofing and flood preparedness can reduce vulnerability of the society to floods. Highway links of Dhaka with Chittagong, Aricha, Sylhet and Tangail were cutoff for quite a considerable time due to submergence of the highways at several places. Disruption of communication lines and essential utility services result in considerable suffering of the population. The national highways should be of adequate height so that transport is not disrupted during large floods. After the 1998 flood, it has been estimated that the Dhaka-Chittagong highway need to be raised by at least 1 meter at places to keep the highway free from submergence during such large floods. However, such costly decisions need to be made on the basis of appropriate risk based analysis.

Vital installations and other infrastructures should also be flood friendly. Food godown, domestic water supply sources and capital assets should be secured by making them flood resistant. During 1998 flood, many industries especially in Narsingdi-Narayanganj-Munshiganj belt were submerged hampering the industrial production. Daily economic and employment activities can be kept functioning by making industrial installations and business centers flood proofed.

Although Bangladesh has a building code, it is yet to be institutionalized. Due to this lacking, many houses in the floodplains have been built without due consideration to the flood risk. First floor of almost all the houses in the Balu floodplain of Dhaka city were inundated and remained submerged for almost two months during the 1998 flood causing immense suffering to the inhabitants. If the building code was institutionalized and strictly adhered to, then sufferings of the floodplain inhabitants could be considerably mitigated.

Flood control embankments, roads and other infrastructures affect the water regime in the floodplain. Construction of rural roads and highways is growing every year. Urban areas, industrial areas and rural growth centres are expanding rapidly. There should be co-ordinated planning and construction of flood control projects, roads and other water regime affecting infrastructures. A floodplain land use regulation can be formulated so that planning, design and construction of infrastructures take into consideration the flood risk, keep adequate provision for unimpeded drainage and also account for the preservation of environment.

FLOOD FORECASTING AND WARNING

Presently flood levels are forecasted at river gauging stations. During the 1998 flood, water levels at different stations were adequately forecasted. However, flood forecasting and warning process need to be made more useful and meaningful to the people. Currently no information is given about areal extent of flooding. The forecasting method should be such that it can give sufficiently advance warning for Thanas those are at the risk of flooding. It must be able to forecast the position of flood level in next two or three days at critical locations of vital infrastructures; for example, probable position of flood level with respect to the top of roads, highways and flood protection embankments. The current lead-time of 72 hours can also be increased. Chowdhury et. al (1998) have shown that flood level at Dhaka city can be predicted 4-6 days ahead.

CONCLUSIONS

The experiences during the 1998 flood in relation to various flood management practices that are currently in use in the country have been discussed in this paper. The experiences show that each of the options has scope of improvement either in planning, design or execution, which are summarized below.

Flood Control

During the 1998 flood, it has been observed that flood control measures have been able to protect large areas from inundation. The untold suffering of the people in the unprotected area will raise the call for further protection as was evident in case of eastern part of Dhaka City. Even before the 1998 flood, it was a well-known fact that people in general demand for protection against flood. The case will only be stronger after the 1998 deluge and probably there is no alternative to structural measures in ensuring protection to urban and industrial areas.

Regional hydrology play an important role in sustainability of projects. It has been seen that physical interventions by interfering with the floodplain processes have created social tension among different sections of the floodplain dwellers hampering the project performances. These experiences clearly show the need for maintaining harmony with the floodplain processes to the extent possible.

It was the unprecedented duration, not the high level of flood, that caused much more damage to the embankments. Thus duration of flood should be an important design parameter in future flood control projects. Since flood control projects saved large crop areas, saving of crops during large floods should get appropriate consideration in benefit-cost analysis at the planning stage of future projects.

Compartmentalization Pilot Project (CPP)

The CPP was severely tested during 1998 flood. It was apparent that compartmentalization concept did not work. However, controlled flooding concept has gained popularity in CPP and may be repeated in other existing and future projects to derive benefits of normal flood.

Flood Proofing

An approach needs to be adopted whereby large floods can be managed while enjoying benefits of normal flood. In managing large floods, structural approach will of-course play its due role. But non-structural measures should get serious consideration considering their cost-effectiveness and environment friendliness. Especially during large floods, non-structural measures are the best option in containing damages.

Various flood-proofing measures have to be institutionalized. Lack of institutionalization caused untold sufferings in the Dhaka East. Flood-proof measures of infrastructures should be based on risk based analysis.

Flood Forecasting

Flood forecasting need to be more user-friendly. In addition to forecasting of river water levels, flood level with respect to vulnerable areas and key linkages need to forecasted so that people can plan their activities ahead of the time.

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