Present Status of Studies on Hydrological Aspects in Bangladesh

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Abstract

This paper reviews the activities of hydrological concern undertaken by various organisations in Bangladesh. The paper describes the hydrogeological setting of Bangladesh in the context of the Hindu Kush-Himalayan system. Hydrological regimes and the impacts of deforestation are discussed. It is found that the forest cover in Bangladesh has been reduced significantly, and this has brought about noticeable changes in river morphology; namely, through the supply of excess water and sediment. Emphasis is given to establishing a linkage between upland hydrology in mountain areas and floodplain hydrology in delta areas, in order to better understand and more sustainably develop the water resources of both regions. Results of studies on the impact of deforestation on sedimentation are also discussed.

Introduction

Bangladesh is an agro-based, flood-prone country in terms of its socioeconomic and geographical conditions. It has within its geographical boundaries the confluences of four major rivers: the Ganges, the Brahmaputra, the Meghna, and the Teesta. Most of the country is a floodplain formed by the sediment carried and deposited by these rivers. These river systems, originating from outside Bangladesh's territory (more specifically from the Himalayan Range) traverse China, India, Nepal, and Bangladesh, and drain an area of approximately 1.7 million sq.km. A large volume of discharge and sediment load obtained from the erosion of basins of the rivers is discharged into the Bay of Bengal through Bangladesh, which has an area of only 0.144 million sq.km., i.e., about 8.5 per cent of the total basin area of the river systems.

It has been estimated that the quantity of sediments carried by the river systems through Bangladesh varies from 1.1 billion to 1.6 billion tons annually (Hossain 1992). A small part of this sediment load is carried to the deeper zone of the Bay of Bengal, the rest being deposited on floodplains and in riverbeds. The huge water and sediment discharge brings about significant morphological changes not only in the river systems but also in the topography and ecology of Bangladesh. Therefore, an understanding of the hydrological processes and systems in upstream areas is vital for an understanding of the responses downstream. The river systems that flow through Bangladesh and their basins are shown in Figure 1.

It may be seen from Figure 1 that, although the three major rivers have different origins and traverse a number of countries following different routes, they ultima-

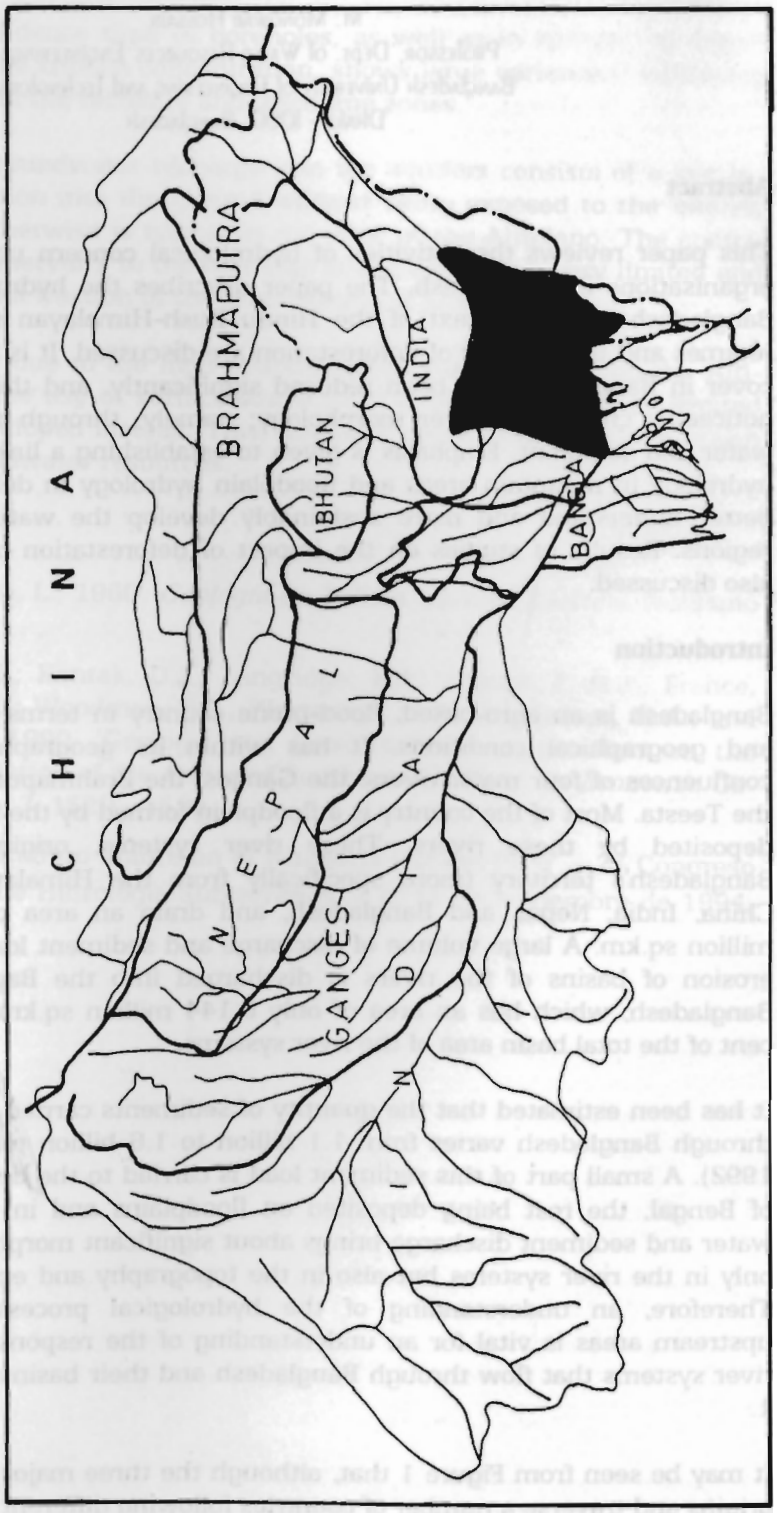

Figure 1: The Ganges, The Brahmapurta, and The Meghna River Basin

tely meet in the central part of Bangladesh. As a result, an enormous quantity of water and sediment obtained from the catchment erosion of these river systems is drained into the Bay of Bengal through the heart of Bangladesh. The rainfall within the country and the huge quantity of regional water coming from without cause serious flooding in Bangladesh and untold suffering and economic loss to the people and the nation. It may be worthwhile to point out that the lives and deaths of the 120 million people of Bangladesh are historically linked to the flood flows and also lean flows (drought) of the three major, transborder river systems. Therefore a proper understanding and management of the flood flows and drought flows of these river systems are very vital for the sustainable development of Bangladesh, and for this one needs to keep in mind that these systems originate in the Himalayan region and receive their major discharge and sediment loads from upstream catchments.

Location and Physical Characteristics of Bangladesh

Bangladesh, a sub-tropical monsoonal country, lies in the Indo-Ganges plain of South Asia. It is bordered by India in the west, north, and north-east, the Bay of Bengal in the south, and Myanmar in the south-east. It is bounded between 20?38' and 26?38' north latitude and 88?01' and 92?41' east longitude.

Consisting mainly of alluvial land with a flat topography, except for a range of hills in the south-east, the Bengal plain is considered to be the largest delta in the world. The country is criss-crossed by the innumerable tributaries of three major rivers; namely, the Ganges, the Brahmaputra, and the Meghna. It experiences major natural disasters, including excessive rainfall (causing floods), droughts, and cyclones.

Typically, there are three seasons: the hot or summer season (March to June), the warm and humid monsoon season (July to October), and the cold, dry season (November to February). The average annual rainfall varies from 1,500mm to 5,000mm. With 120 million people, Bangladesh is the most densely-populated country in the world (833 persons/sq.km.) except for city states.

Present Land Cover

Once encapsuled within dense forests, Bangladesh is now almost void of forest vegetation. The remaining forests are situated mostly in far-flung areas along the eastern, south-eastern, and south-western border. A small tract of evergreen and semi-evergreen forest in the Chittagong area, deciduous forest ('sal forest') in the central part of the country, and mangrove forest in the Sundarban represent the major forest types. The mangrove forest in the Sundarban is the largest tract of mangrove forest in the world.

A number of often conflicting estimates are available on the total acreage of forest cover in Bangladesh. The official figure for Bangladesh was about 20,160sq.km. (14%) in 1989 (Bangladesh Bureau of Statistics 1993). One recent estimate by the IUCN (after Chowdhury 1993) indicates that the country has about six per cent of its area covered with forest.

The principal cause of deforestation is the expansion of agricultural land, following clear-cutting of forested areas by the ever-growing population. However, shifting cultivation is the main reason for deforestation in the hilly regions (UNFP/GRID 1993).

Agriculture, the economic mainstay of the country, has laid claim to almost all cultivable land. Multiple cropping is being practised, with rice and jute as the two principal crops. *Aus* (deep-water rice) and a*man* (broadcast and transplanted) are the two major rice varieties.

Hilly Regions

The hilly regions of Bangladesh are comprised of the areas of Chittagong and the Chittagong Hill Tracts, the Lalmai Range in Comilla district, the hills of north-eastern Sylhet district, and those along the narrow frontier strip of Sylhet and Mymensingh districts.

The highest peaks in the hilly areas of Bangladesh are in Chittagong and the Chittagong Hill Tracts, and they are 30 in number (Khan 1991). Towards the east, the ranges become higher and the slopes steeper up to the highest hill range in the east, marking the boundary between Bangladesh, Myanmar, and India. The highest of these peaks vary from about 400 to 1,000m above mean sea level. Hill ranges of north-eastern Sylhet district and hills along narrow frontiers are lower in height and usually less than 350m. These hills do not form continuous ranges but constitute a chain of circular and elongated hillocks separated by recent alluvial valleys.

The stratigraphic and tectonic development of the frontier hills differs greatly from that of the eastern hilly region. The hilly regions occupy about 25,000sq.km., i.e., about 18 per cent of the total area of Bangladesh. A physiographic map of Bangladesh is given in Figure 2.

Hydrological Features

The hydrology of the area is influenced by the topography, drainage network (i.e., the river systems), and the rainfall pattern. The topographic features of Bangladesh may be broadly classified as floodplains, delta, table land, and hilly regions. The mean annual rainfall in Bangladesh is about 2,800mm. The heavy rains generally last from June to October. Cyclonic storms, along with heavy rains, also occur during the pre-monsoon (April-May) and post-monsoon (October-November) periods. A typical rainfall isohyet during a rainy season month is shown in Figure 3. Some of the salient characteristics of the major river basins are shown in Table 1.

Hydrological Regions

Bangladesh has been divided into five hydrological regions for the assessment of water resources' availability and the planning of water resources' development as an outcome of the Flood Action Plan (WARPO 1994), as follows:

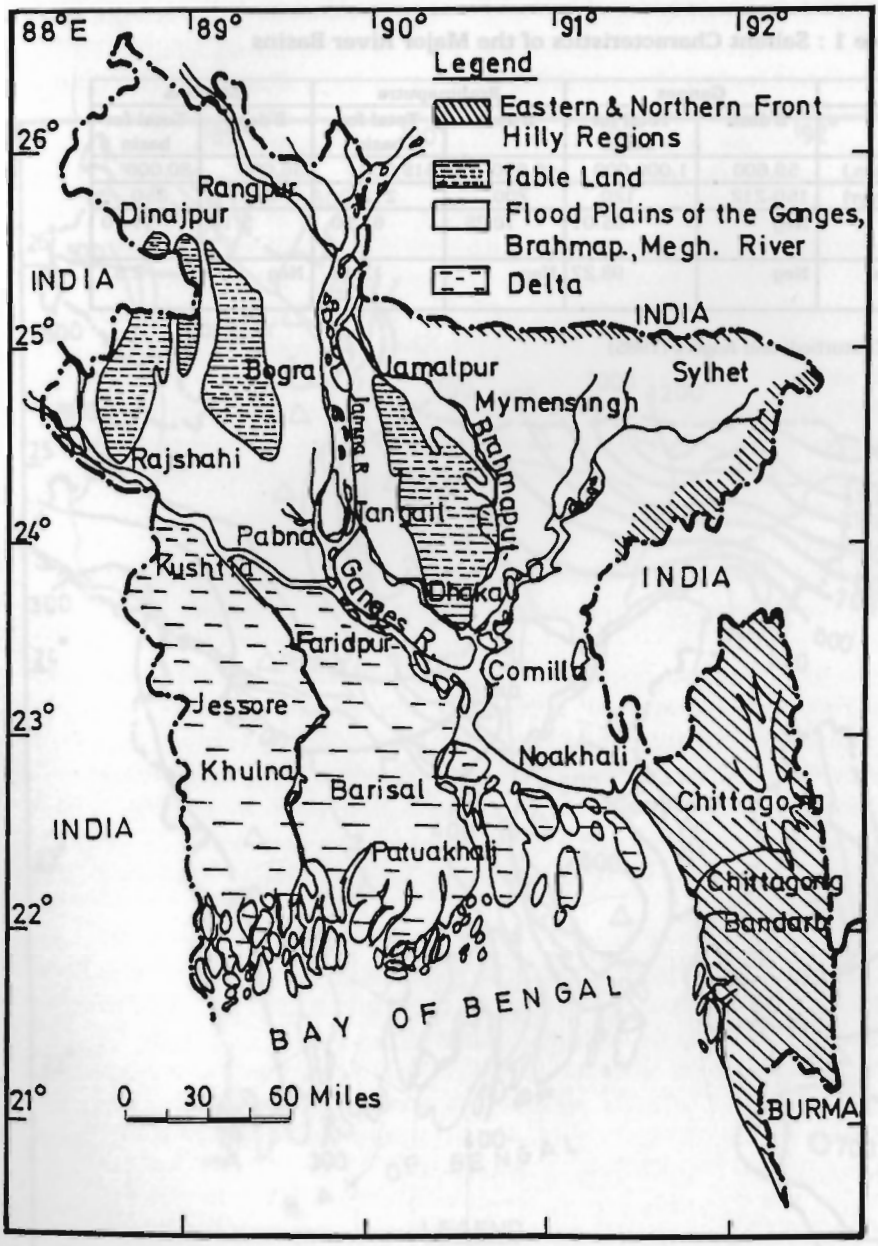

Figure 2: Physiographic Map of Bangladesh

Table 1 : Salient Characteristics of the Major River Basins

Description	Ganges		Brahmaputra		Meghna	
	B'desh	Total for basin	B'desh	Total for basin	B'desh	Total for basin
Catchment area (sq.km.)	59,600	1,000,000	46,650	615,000	36,000	80,000
Mean annual ppt (cm/yr)	150-212	120	200	212	240	350
Total annual runoff (mhm)	Neg	55.01	10.25	61.50	5.10	11.10
Hydropower Potential (mkw)	Neg	98.27	Neg	13.43	Neg	2.5

Neg = Negligible
Source: UN (1996), Chaturbedi and Rogers (1985)

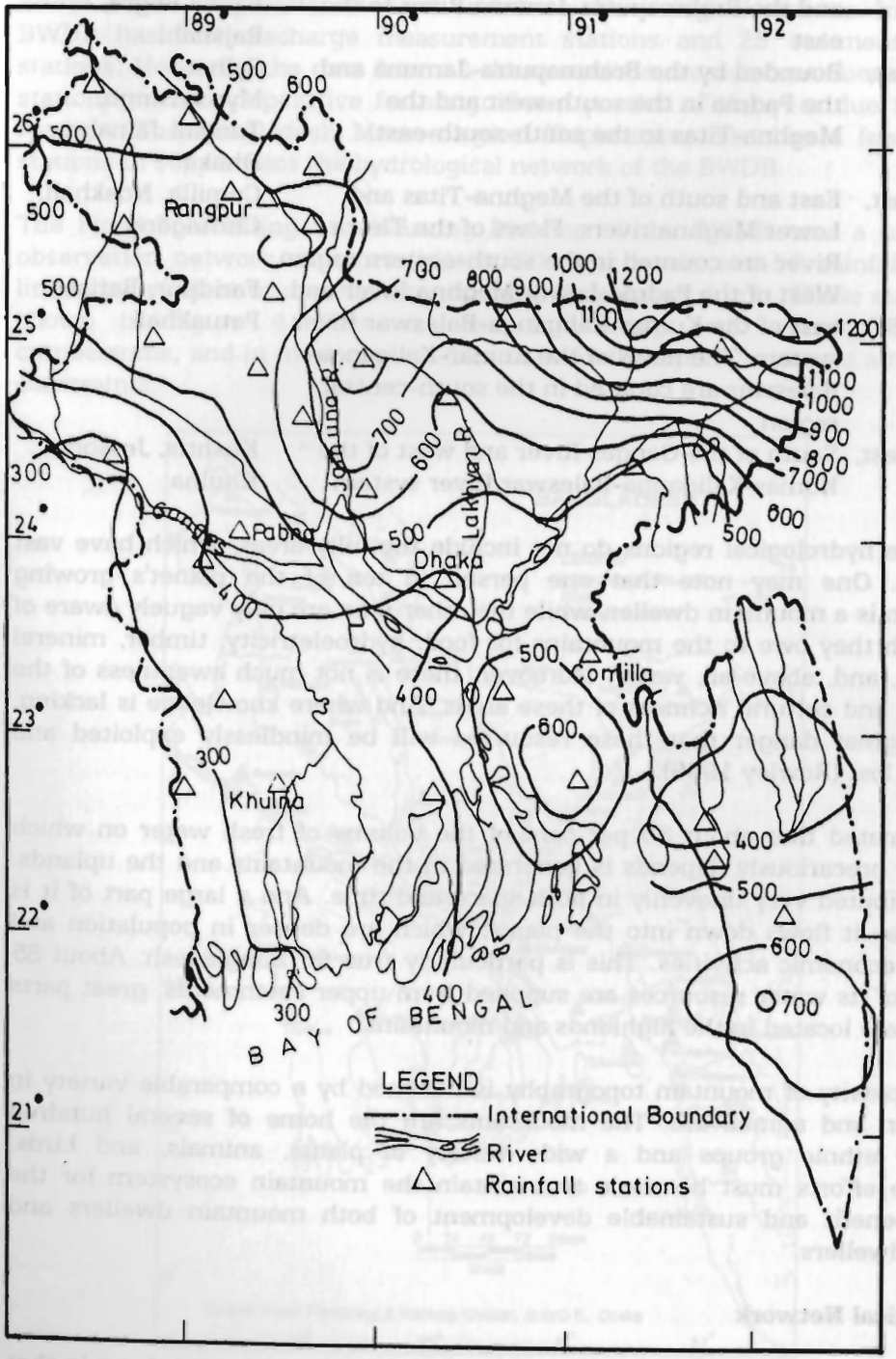

Figure 3: Rainfall Isohyets for August, 1995

Region	Hydrological Area	Regionwise greater Districts
North-west, NW:	Bounded by the Ganges River to the south and the Brahmaputra-Jamuna River to the east	Rangpur, Dinajpur, Pabna Bogra, Rajshahi
North-east, NE:	Bounded by the Brahmaputra-Jamuna and the Padma in the south-west and the Meghna-Titas to the south-south-east	Sylhet, Mymensingh, Tangail Jamalpur, Dhaka
South-east, SE:	East and south of the Meghna-Titas and Lower Meghna rivers. Flows of the Tiesta River are counted in the south-eastern region	Comilla, Noakhali, Chittagong
South-central, SC:	West of the Padma-Lower Meghna River and east of the Kumar-Kaliganga-Baleswar River system. The flows of the Kumar-Kaliganga-Baleswar are counted in the south-central region	Faridpur, Barisal, Patuakhali
South-west, SW:	South of the Ganges River and west of the Kumar-Kaliganga-Baleswar River system	Kushtia, Jessore, Khulna

The above hydrological regions do not include the hilly areas, which have vast resources. One may note that one person in ten of the planet's growing population is a mountain dweller, while the other nine are only vaguely aware of how much they owe to the mountains for food, hydroeletricity, timber, mineral resources, and, above all, water. Moreover, there is not much awareness of the biological and cultural richness of these areas. And where knowledge is lacking, there is great danger that these resources will be mindlessly exploited and tragically lost (Rowley 1996).

It is estimated that about 80 per cent of the volume of fresh water on which humanity precariously depends is generated in the mountains and the uplands. It is distributed very unevenly in both space and time. And a large part of it is used up as it flows down into the plains, which are denser in population and richer in economic activities. This is particularly true for Bangladesh. About 85 per cent of its water resources are supplied from upper catchments, great parts of which are located in the highlands and mountains.

The complexity of mountain topography is matched by a comparable variety in vegetation and animal life. The mountains are the home of several hundred tribes or ethnic groups and a wide variety of plants, animals, and birds. Therefore efforts must be made to maintain the mountain ecosystem for the overall benefit and sustainable development of both mountain dwellers and lowland dwellers.

Hydrological Network

There are about 600 rivers in Bangladesh, of which 54 are regional rivers in that they originate outside Bangladesh. These regional rivers are, in fact, the main rivers in the country.

The hydrological network of Bangladesh is maintained by the Bangladesh Water Development Board (BWDB). The BWDB has 342 water-level gauge stations, of which 28 are automatic. And of the 271 rainfall stations, 25 are automatic. There are 39 evaporation stations and three climatological stations. In addition, BWDB has 109 discharge measurement stations and 25 sediment gauging stations. However, the data from all these stations are not continuous, as some stations remain inoperative for a significant portion of the year due to various reasons. The Bangladesh Meteorological Department also has a few weather stations to supplement the hydrological network of the BWDB.

The Flood Forecasting and Warning Division of the BWDB uses a nationwide observation network of approximately 50 river levels and 50 rainfall stations linked by wireless transceivers to the central operations' unit. These stations are shown in Figure 4. However, this forecasting and warning system is cumbersome, and in most cases it fails to fulfill its objectives due to a number of constraints.

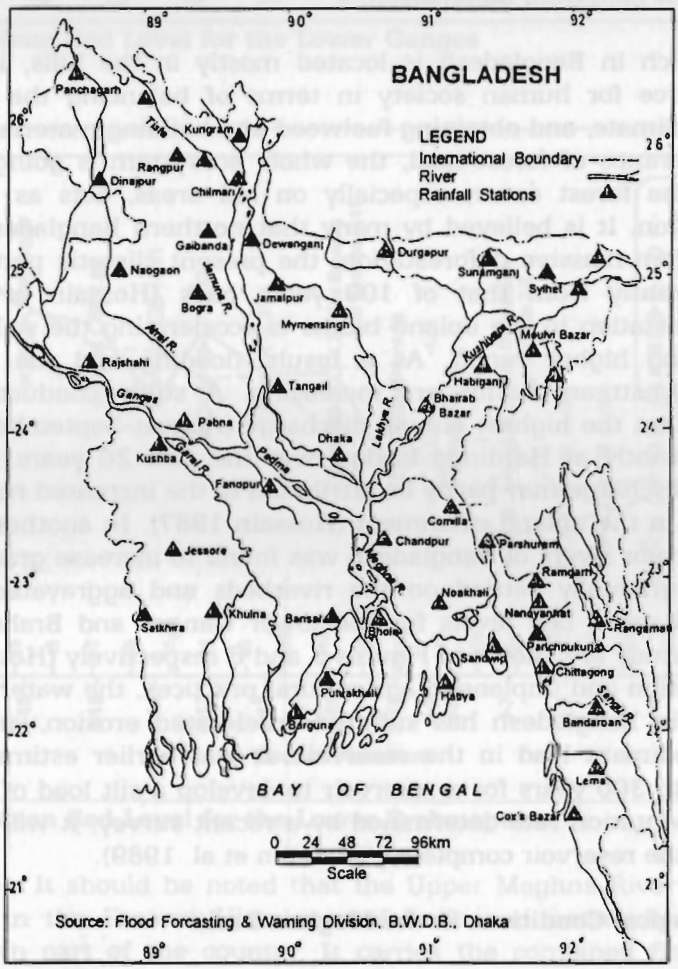

Figure 4: Map Showing the Rainfall Stations of Bangladesh Used by Flood Forecasting and Warning Division, BWDB

Deforestation and Hydrology

Deforestation is a growing worldwide problem, a problem that affects downstream countries if these countries share regional river basins, as Bangladesh does. The causes of deforestation have been studied by many individuals and organisations that serve developing countries. These causes are mainly trade in tropical timber, agricultural expansion by destroying forest covers, and population pressure. The main causes of deforestation in Bangladesh are similar to those of other countries of the Himalayan region, but with some differences. Of the total forest cover, only a part is maintained by the Department of Forests. In the Chittagong Hill Tracts, forest areas are being cleared for fuelwood by tribal people. Recent development work launched by the government in the hill tracts has contributed significantly to deforestation. A big threat to the forest land of northern Bangladesh is the planting of tobacco and the drying of it, which requires the felling of a large number of trees for the purpose of heat generation. Similarly, brick burning and shrimp cultivation are taking away forest land from Bangladesh.

Forest land, which in Bangladesh is located mostly in the hills, is the most important resource for human society in terms of balancing the ecosystem, moderating the climate, and obtaining fuelwood and building materials. With the gradual disappearance of forest land, the whole ecosystem is going through a crucial stage. The forest cover, especially on hill areas, acts as a protector against soil erosion. It is believed by many that northern Bangladesh is facing desertification from massive deforestation, the present climatic pattern having changed significantly from that of 100 years back (Hossain et al. 1989). Continued deforestation in the upland basins is accelerating the soil erosion as well as producing higher runoff. As a result, flooding and the siltation of riverbeds in downstream basins are increasing. A study conducted on this problem shows that the highest annual discharge (August-September flow) has increased significantly at Hardinge Bridge over the past 20 years. This major change in flood discharge may partly be attributed to the increased runoff caused by deforestation in the upland catchment (Hossain 1987). In another study, the silt load in the major rivers of Bangladesh was found to increase gradually. This heavy silt load gradually settled on the riverbeds and aggravated the flood problem. Typical mean bed levels for the lower Ganges and Brahmaputra as observed in the study are shown in Figures 5 and 6 respectively (Hossain 1991). Due to deforestation and unplanned agricultural practices, the watershed of the Karnafuli River in Bangladesh has suffered accelerated erosion, and this has increased the sediment load in the reservoir. It was earlier estimated that it would take 270 to 300 years for a reservoir to develop a silt load of 1,000ppm. Under the sedimentation rate determined by a recent survey, it will take about 170 years to fill the reservoir completely (Hossain et al. 1989).

Hydro-meteorological Conditions in the Meghna Basin

The hydrological and meteorological conditions prevailing in the floodplain area are closely related to the conditions in the mountain ranges. This topic has been studied to some extent in the Upper Meghna basin in Bangladesh by Hossain and

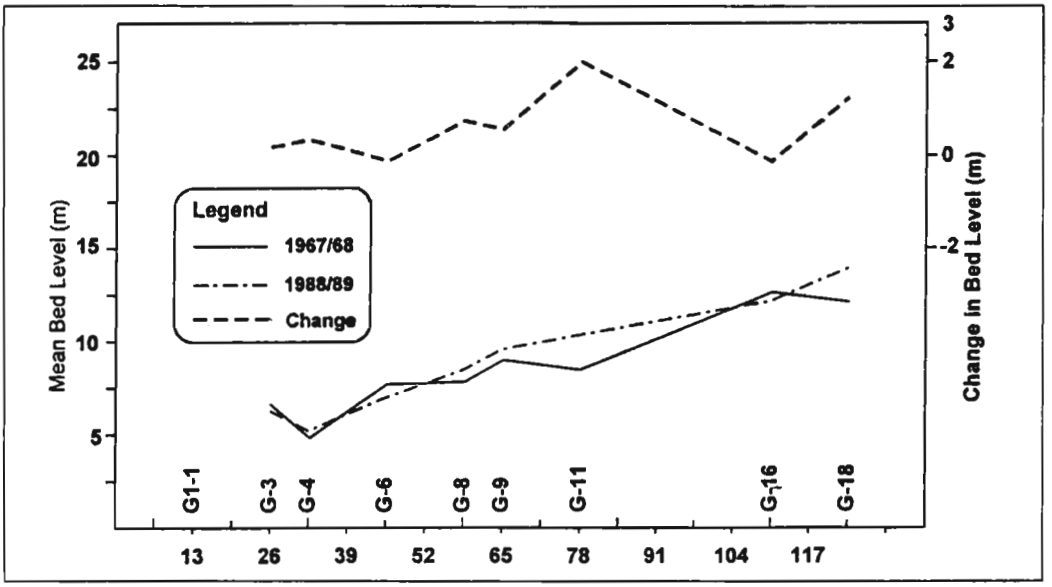

Figure 5: Mean Bed Level for the Lower Ganges

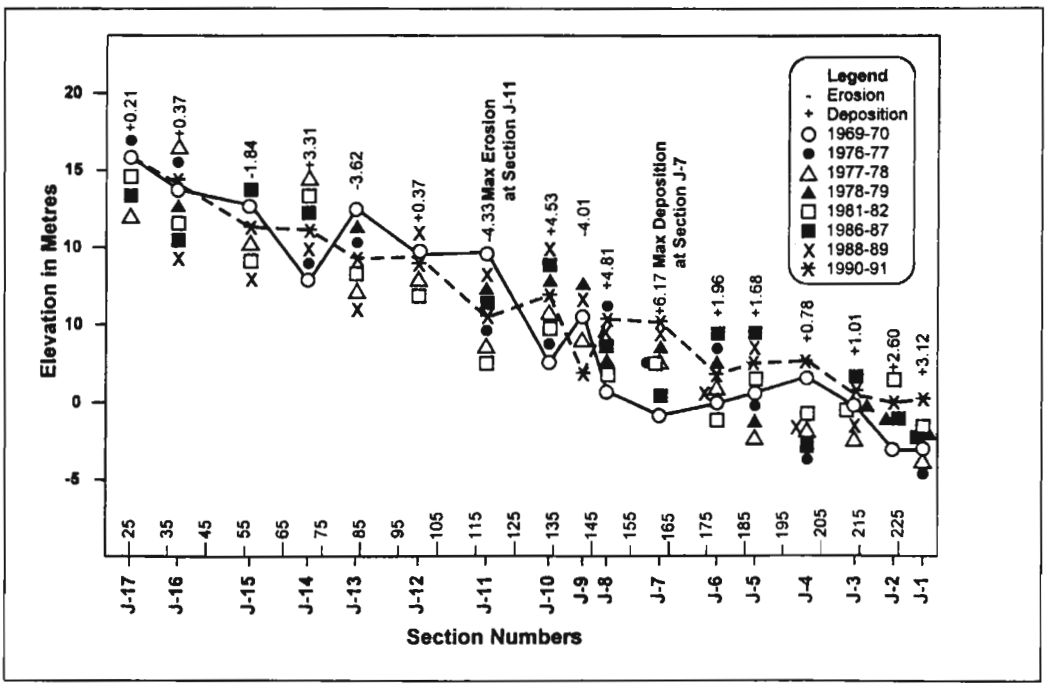

Figure 6: Mean Bed Level for the Lower Brahmaputra

Alam (1995). It should be noted that the Upper Meghna River originates from Meghalaya in the Eastern Himalayas of India and enters Bangladesh in the north-eastern part of the country. It carries the combined flow of the rivers Baulai, Surma, and Kushiyara, along with a large number of small streams. The basin thus covers both highlands and plains. Hossain and Alam (1995) related rainfall data of three stations located in the basin, viz., Sylhet, Sunamganj, and

Chatak, with the discharge and water levels in the Meghna River at a nearby station using the data for the period from 1980 to 1990. They found that the rainfall peaks are closely related to the peaks of the hydrograph, but with a time lag, which is logical. Similarly, the variation of sediment transport in the Meghna was compared with rainfall intensity in the basin. No definite trend could be established in this case, but indications of some correlation between sediment transport and rainfall intensity were found. If more studies are undertaken to correlate hydro-meteorological conditions in adjacent mountain catchments and floodplain catchments, more valid conclusions regarding the interdependence of various hydro-meteorological factors could definitely be reached.

Concluding Remarks

Hydrological phenomena in the floodplains of Bangladesh, especially in the basins of its major river systems, have been given quite significant attention. Such phenomena in the highlands, especially in hilly areas, have not been given due attention, but, at present, awareness is increasing and attention is being turned gradually in that direction. An understanding of the upland hydrology and its ecosystem is very vital for the overall planning and management of the downstream catchment and its water resources. Increased efforts must be taken to understand the highland hydrology in Bangladesh. Regional exchange of data and information can play a key role in this respect.

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