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Water management in Bangladesh: an analytical review

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Abstract

Water management in Bangladesh is a critical issue owing to growing demand and increasing conflict between alternative uses. Demand for water is growing rapidly in agriculture mainly from irrigation for cereal production, the urban and industrial sector, fishery, inland navigation and salinity control. The supply of clean and uncontaminated water has fallen far short of demand owing to inadequate flows in the Ganges, pollution caused by the disposal of effluents and chemicals, salinity intrusion in the coastal area and arsenic contamination. Further, the availability of freshwater is highly seasonal depending on the presence and duration of the monsoon. The incidence of both flood and drought in a yearly cycle profoundly affects river morphology. This paper identifies various geographic, socioeconomic and environmental factors that shape the water management issues of Bangladesh. The paper mainly concerns the status and trend of these issues.

Keywords: Bangladesh; Surface water; Transboundary issues; Water management; Water resources

1. Introduction

Water is a natural resource of immense importance in Bangladesh. Rivers, wetlands and the seasonal floods are the lifeblood of this country. However the availability of fresh water is highly seasonal since the region's weather is mainly governed by a monsoon climate. This seasonality is reflected in its abundance during the monsoon *vis-à-vis* its scarcity in early summer. Floods sometimes cause havoc, although usually they are beneficial for groundwater recharge, soil fertility, moisture and renewal of fish stocks. Floods cause further aggravation with increasing water coming through the cross boundary rivers during the monsoon. There are 57 cross-boundary rivers, of which 54 are shared with India and the remaining three with Myanmar. Bangladesh is the common lower riparian of all these transboundary rivers.

The objective of this paper is to highlight various geographic, socioeconomic and environmental factors that shape the water management landscape of Bangladesh deserving special attention. Part 2

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describes the physical context including annual rainfall, hydromorphology, land types and the use of water in socioeconomic activities. Part 3 discusses the importance of water in biodiversity and environmental sustainability. Part 4 highlights the national development priorities and the relevance of the water sector therein. In part 5, water management issues are discussed against the backdrop of the relevant physical, socioeconomic and national dynamics developed in parts 2, 3 and 4. Part 6 explains the policy implications of the institutional network in place, taking care of different facets of water management issues. Apart from domestic management, this section emphasizes the international dimension of water management. It also takes into account a set of future exogenous factors like population growth and climate change and how these might affect the whole scenario. The paper is concluded in section 7.

2. Physical context

Bangladesh's topography is formed by three of the largest river systems in the world. It occupies the greater part of the Bengal Basin which was slowly built up by alluvial deposits carried from the adjoining mountains of the Himalayas by the Ganges–Brahmaputra river system. It is a riverine country with 230 tributaries and distributaries. The Ganges–Brahmaputra–Meghna river systems drain a total area of about 1.72 million km^2 (Ahmad *et al.*, 2001) in India, China, Nepal, Bhutan and Bangladesh, henceforth the name Ganges–Brahmaputra–Meghna (GBM) river basin. A lower riparian located at the lowermost reaches of the three large rivers, Bangladesh itself makes up only 7–8% of the watershed (Ahmad *et al.*, 2001).

As a result of tectonic movement there are depression areas called *haors* (low-lying natural depressions). There are other water bodies called *baors* (oxbow lakes)[1], *beels* (deeper sections of low-lying depressions) and ponds. The annual renewable surface water is estimated to be 1,160 billion m^3 (Ahmad *et al.*, 2001). About 93% of the surface water of the river systems comes from outside the country (Ahmad *et al.*, 2001). This gives rise to an element of uncertainty in the quantity of water available from the surface water system. The groundwater aquifers are another important source of water and are hydraulically connected to the major waterways. Heavy rainfall and annual inundation replenish the groundwater during the monsoon. In 1991 the Master Planning Organization (MPO) made three estimates: potential recharge (72,100 million m^3), usable recharge (54,100 million m^3) and available recharge (21,100 million m^3)[2].

Withdrawal of surface water in the upstream reduces the groundwater level in Bangladesh (Khuda, 2001). It also increases the salinity of the shallow aquifers in the coastal region. A tidal regime works here as one-third of Bangladesh is influenced by the tides of the Bay of Bengal. The region is marked by a vast network of river systems, interaction of huge quantities of fresh water that are discharged by the river systems and a saline waterfront penetrating inland from the sea. In addition to the coastal plains, there are a number of small islands that are subject to strong wind and tidal interactions throughout the year. Most of the combined flow of the GBM system is discharged through the low-lying area of the

[1] Oxbow lakes are created in abandoned channels of rivers.

[2] Potential recharge was defined as the annual volume of surface water that could reach the aquifer. Usable recharge was defined as 75% of the potential recharge.

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central coastline. Heavy sediment inputs from the rivers result in a morphologically dynamic coastal zone. An influx of brackish water occurs during high spring tides when the water is saline during the dry season. The coastal areas are highly prone to cyclone-induced storm surges that bring about the most catastrophic damage here.

2.1. Annual rainfall

The average annual rainfall varies from 1,200 mm in the extreme west to over 5,000 mm in the northeast (World Bank, 2000). Four seasons are identified on the basis of rainfall patterns. About 80% of the total rainfall occurs during the monsoon from June to September. In the post-monsoon (October–November) and winter period (December–February), only 10% of the annual rainfall is available (World Bank, 2000). Rainfall is extremely unreliable in the subsequent pre-monsoon period (March–May). On an average there is about 10% of the annual rainfall in this period (World Bank, 2000). Therefore there is a seasonal lack of water depending on the presence and the duration of the monsoon (see Table 1).

2.2. Hydromorphology

The combined discharge of water from the GBM rivers is second only to that of the river Amazon. These rivers discharge 1.5 million m^3 of water per second during the peak period (Hasan & Mulamoottil, 1994). In the low season, the runoff is only about 61,000 m^3 per second (Hasan & Mulamoottil, 1994). The ratio of peak to low season flow is approximately 25:1. Almost 85% of the

Table 1. Average rainfalls in mm in some selected districts of Bangladesh.

	Districts			
Months	Rajshahi	Khulna	Cox's Bazar	Sylhet
Jan	21.7	8.5	8.6	15.9
Feb	9.7	20.1	11.7	41.5
Mar	29.2	47.3	22.5	93.9
Apr	29.2	93.5	96.4	320.9
May	111.3	180.5	278.4	592.4
Jun	244.3	351.8	824.8	1,005.3
Jul	361.0	398.7	1,089.9	771.0
Aug	253.6	283.1	755.4	685.3
Sep	212.0	272.5	392.7	469.1
Oct	114.1	162.7	298.6	237.8
Nov	14.4	30.8	60.7	29.5
Dec	1.4	1.7	13.4	6.5
Year	1,420.2	1,837.7	3,899.2	4,401.6

Source: Climate data from www.worldclimate.com. The choice of the districts is arbitrary. According to annual rainfall the country is divided into seven hydrological regions. Rajshahi and Khulna are in the Ganges basin and in the Western part of Bangladesh which is drought prone and receives least average rainfall in the country. Rajshahi is also in the northern region of the country. Khulna is also in the south west region which suffers from salinity intrusion from the sea. Cox's Bazar is in the South East Hill basin and experiences heavy rainfall owing to its location on the Bay of Bengal. Sylhet is in the Meghna basin and is in the north east region which receives the highest average rainfall in the country.

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mean dry season stream flow is found in the GBM Rivers (World Bank, 2000). In terms of water availability, March is a critical month. The Brahmaputra accounts for 67% of the flow measured within the country, whereas the share of the Ganges is only 13% (Hasan & Mulamoottil, 1994). The Meghna contributes only 2% of the total measured discharge in Bangladesh during March. The ratio between the discharges of the dry and monsoon seasons for the Ganges River is 1:6 (World Bank, 2000). The geological characteristics and the precipitation patterns vary widely in the catchments area, as described below[3].

The river Brahmaputra–Jamuna originates in Tibet on the northern slope of the Himalayas. The total catchments area is 570,000 km^2, 7% of which lies in Bangladesh. The river starts rising in March/April caused by snowmelt in the Himalayas and attains its peak in the beginning of July and mid-September owing to heavy monsoon rain. Minimum flow usually occurs during the end of February and the beginning of March. The average annual sediment discharge of the river is 590 million tons, of which 200 million tons consist of sand and the rest is of silt and clay. Bank material of the river Jamuna consists of loosely packed silt and fine sand and is highly prone to erosion. An EGIS (Environment and GIS Support Project) study of the Brahmaputra–Jamuna River in 1997 found that the average width of the river has increased by about 130 m per year since 1973 and appears to have been slowly widening since it adopted its current course in the early 1800s. Both riverbanks are retreating and eroding the floodplain.

The Ganges drains the southern slope of the Himalayas. It travels about 2,200 km before meeting the Jamuna draining about 1,000,000 km^2, of which 5% lies in Bangladesh. Annual average rainfall within the catchments is 1,200 mm. It starts rising at the end of June or the beginning of July and attains its peak level at the end of August or the beginning of September. The minimum flow of the Ganges is dependent on the execution of water sharing agreement between India and Bangladesh since the commencement of the Farakka Barrage[4]. Water availability upstream of the Farakka Barrage declines sharply during the dry season owing to water use for irrigation and other purposes. Usually the minimum flow occurs in April/May.

The river Meghna rises in the Manipur hills in India. The total length of the river is about 900 km of which 400 km is in Bangladesh. The total catchments area is 77,000 km^2, about half of which lies in Bangladesh. The river drains an area where the annual average rainfall is very high. The Meghna is a rain-fed river and reaches its peak in August. The lower part of the river is under high tidal influence and consequential backwater effect.

2.3. Land types

Bangladesh consists mainly of floodplains, except terraces in the *Madhupur, Barind* tract and hills in Sylhet and Chittagong Hill tracts. Floodplains constitute about 80% of the total land area while terraces (slightly uplifted fault blocks) and hills account for about 8% and 12%, respectively (Hasan & Mulamoottil, 1994). The altitude normally does not exceed 11 m above the sea level except in the hilly areas of Chittagong and Sylhet (Hasan & Mulamoottil, 1994) (see Table 2).

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[3] This section is adapted from Alam & Koudstaal (2000).

[4] India constructed a barrage at Farakka only 18 km from Bangladesh border to direct water from the Ganges into the river Bhagirathi–Hoogly in India. India continued to withdraw water at Farakka to the full capacity during the 1976 dry season.

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Table 2. Flood regime land types of Bangladesh.

Land type	Description	Flood depth	Area (ha)	Area (%)
F0	Non flood	Not flooded	5,235,800	39.7
F1	Shallow flood	30 to 90 cm	3,857,900	29.2
F2	Medium flood	90 to 180 cm	1,905,400	14.4
F3	Deep flood	180 to 300 cm	1,194,200	9.0
F4	Very deep flood	Over 300 cm	221,500	1.7

Source: Bangladesh Agricultural Research Council (BARC) and Water Resources Planning Organisation (WARPO). The depths of different flood phases have generally and conveniently become known as land types. Land type F0 is not flooded and is considered to be highland. F1 is categorized as medium highland normally flooded up to about 90 cm deep during the flood season. F2, F3 and F4 are normally known as medium lowland, lowland and very low land, respectively. F4 remains under water for more than 9 months in a year. However this classification is not as rigid as these might suggest. Flood levels in an area vary by a metre or so between different years and may also attain peak levels for only a few days during a particular time of the year.

2.4. Water usage in socio-economic activities

An increasing demand for both surface and groundwater comes from irrigation in the months. It accounts for 58.6% of total demand for water. However, in setting priorities for allocating water during critical periods, the National Water Policy gives this sector a relatively low priority and sets the following order: domestic and municipal uses, non-consumptive uses (e.g. navigation, fisheries and wildlife), river regime sustenance and other consumptive and non-consumptive uses including irrigation, industry, environment, salinity management and recreation (WARPO, 1999). Fisheries, navigation and environment sectors demand 40.7% while demand for household and industrial use is 0.7%. Therefore the following are the major water using sectors:

2.4.1. Agriculture. Agriculture comprises 22% of GDP and employs about two-thirds of the country's labour force (Government of Bangladesh, 2005). Agriculture is the major water-using sector for surface and groundwater irrigation with rice cultivation being the single most important activity in the economy. The crop calendar is based on the temporal distribution of rainfall and temperature throughout the year. Three cropping seasons are pre-monsoon, monsoon and winter or dry season. *Aus* is the pre-monsoon variety while *Aman* is the rain-fed monsoon (wet season) rice and *boro* is (irrigated) dry season rice. *Aman* is the leading rice crop occupying about 56% of the total rice cultivated area followed by *boro* (27) and *aus* (WARPO, 1999; Ahmad *et al.*, 2001). A remarkable feature of the rice growth pattern is the rising share of irrigated HYV (high yielding variety) *boro* rice.

Aus is no longer an important crop as *boro* became the crucial crop after the introduction of HYVs. This implies that the demand for water from agriculture will further increase in the coming years. A large portion of the increased demand for water is expected to come from irrigation expansion. Currently, 7.6 million ha of the total cultivable land of 9.03 million ha used in agriculture are suitable for irrigation and about 4.5 million ha are irrigated (World Bank, 2006). The private sector provides about 90% of this irrigation which comes mainly from groundwater. The irrigated area would reach 6.9 million ha by 2020 (World Bank, 1998).

2.4.2. Fisheries. Bangladesh is endowed with one of the largest and richest inland fisheries in South Asia. Fish is the major source of protein as it yields almost 65% of animal protein in an average

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Bangladeshi diet (World Bank, 2006). Fisheries provide employment for about 9% of the total labour force and account for 6% of total GDP (World Bank, 2006). There are two types of fisheries: capture and culture. The sources of inland capture fisheries are rivers and estuaries, *Kaptai* Lake, Sundarbans mangrove forests, floodplains, *haors*, *baors* and *beels*. Culture fishing takes place in closed water bodies like shrimp farms, saltwater enclosures as well as ponds and tanks.

Fisheries in the coastal zone range from fully inland freshwater fishery, shrimp and brackish water fishery to marine fishery in the Bay of Bengal. Shrimp farming[5] has become the principal activity in coastal brackish aquaculture as it is one of the fastest growing export industries in Bangladesh. Inland aquaculture produces an estimated 850,000 million tons of fish annually (World Bank, 2006). In 2002 coastal aquaculture produced 95,000 million tons, inland capture fisheries 750,000 million tons and coastal/marine capture fisheries 590,000 million tons. Open access has contributed to over-exploitation in capture fishery. Water requirements for fisheries comprise the requirements for estuarine and floodplain capture fishery, freshwater aquaculture and brackish water shrimp production.

2.4.3. Navigation. Transport accounts for about 8% of GDP and water transport accounts for about 15% of total transport GDP (World Bank, 2006). About 30% of all national freight and 14% of the passengers use inland waterways (World Bank, 2006). Traditional, small, privately owned country boats carry a large part of the rural water traffic. There are about 850,000 country boats with a carrying capacity of 3 million metric tonne (World Bank, 2000) which are 20 times the capacity of trucks in Bangladesh. It is noteworthy that transportation of bulk goods by boats is less expensive than road transportation. It is most cost effective in the southwest part of the country (World Bank, 2006). Further roads and highways are inadequate in remote areas and, particularly during the monsoon in low-lying areas; many roads are in poor states of repair.

Bangladesh Inland Water Transport Authority (BIWTA) prepared a long list of navigation routes and estimated required draft or water depth for some of the navigation routes (Master Plan Organization, 1986). While many of the routes are not navigable throughout the year, some 8,000 km are currently navigable by larger mechanized vessels during the wet season and this is reduced to about 3,800 km in the dry season (World Bank, 2006).

2.4.4. Industry. According to an estimate of the MPO (1991), water demand for the domestic and industrial sectors constitutes less than 1% of the total demand. The water requirement for the domestic and industrial sectors is minimal because of low industrialization. However, the water situation in Dhaka (the capital) requires special attention. The rate of population growth in Dhaka is the highest in the world and is projected to create a demand of 700 million m^3 of water against a supply of 300 million $m^3$of water per annum (World Bank, 2006). Of the total current supply, groundwater constitutes 98% of the supply and the remaining 2% comes from surface water.

In industry, water is used mainly as an input in the production process and for cooling machines. In the paper and pulp industries, newsprint mills use water directly as an input. Some industries are connected to the municipal supplies through the urban distribution network and others are connected directly to surface or ground water sources.

[5] There are two types of shrimp farming: freshwater and brackish water.

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3. Importance of water in biodiversity and environmental sustainability

In a total area of 147,570 km^2. Bangladesh harbours a great diversity of flora and fauna that vary with different climatic regimes, different water availability, land type and so on. A broad range of ecosystems including tropical evergreen rainforests, moist deciduous forests, mangrove forests, riparian and coastal wetlands and the littoral, sub-littoral and benthic communities of the Indian Ocean is found here (IUCN, 2000). Bangladesh has more fish species that can be found in the whole continent of Europe. Seasonally over 60% of Bangladesh can be classified as wetlands (World Bank, 2006). Wetlands serve the hydrological functions of maintaining the subsurface water table through recharge of aquifers and act as a buffer against flood. Wetlands are economically important as these are the nurseries and the habitats of many types of migratory fish. Together with neighbouring India, Bangladesh supports the largest remaining mangrove forest in the world—the Sundarban. It is home to several important and rare species of flora and fauna that depend on wetlands[6]. The Sundarban has an important function in shoreline protection from storms and cyclones. The natural ecosystem of this forest is threatened by lack of freshwater in the north and intrusion of saline water from the south.

4. Development priorities and relevance of the water sector

The Government of Bangladesh (2005) Poverty Reduction Strategy Paper (PRSP) emphasizes the importance of water resources management. Some of the important development goals according to this report (Government of Bangladesh, 2005) are:

4.1. Poverty alleviation through accelerated economic growth

In order to raise income and meet basic human needs poverty alleviation through accelerated economic growth is the basic theme. The current PRSP report targets an increased GDP growth at an average rate of 7% per year. The report also estimates that agriculture will have to grow at 4–4.5% per annum in order to achieve this growth rate in GDP. Sustainable growth of a heavily water-dependent economy is intricately related to a holistic approach to water management. A major development objective is to boost agricultural productivity through increased irrigation coverage, increased cropping intensity and improved water and farm management practices.

4.2. Food security

Achieving food security is another major development objective that is heavily dependent on irrigation expansion. The average daily per capita calorie intake hardly exceeds 2,000 kcal, compared to the desired value of 2,400 kcal. The attainment of food production beyond the self-sufficiency level and a higher production of diversified high-valued export foods constitute one significant goal. Rice and wheat production increased from 11.47 million tons in the mid-1970s to 27 million tons in 2002/3

[6] Many of these species are globally threatened such as the Asian Elephant, the Royal Bengal Tiger, *Gharial* (crocodile), the Ganges River Dolphin and the Hoolock Gibbon.

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(Government of Bangladesh, 2005). Food security is a temporal as well as a structural issue since floods and droughts disrupt food production and distribution.

4.3. Employment generation

The country is facing the challenge of creating employment for nearly 1 million people entering the labour force every year with an employment-GDP elasticity of 0.34 (Government of Bangladesh, 2005). The labour force is growing at almost twice the rate of population growth. The capacity of crop agriculture, currently the major employment sector, will soon diminish given the scarcity of land.

4.4. Fisheries

The GOB (Government of Bangladesh, 2005) PRSP report plans to finalize the National Fisheries Policy to enhance fisheries production to meet the demand for animal protein and boost economic growth by exporting fish and fisheries products. The policy highlights the need to conserve fish habitats particularly in the development of water management infrastructure. It clearly points to a determination to prevent further drainage of standing water bodies for agricultural development and to promote fisheries development in all water bodies.

4.5. Improvement of quality of life

Only around half of the population has access to basic health care. The major causes of illness are poor sanitation and nutrition. The largest single disease is diarrhoea, which is responsible for death of many children under one year of age. The government has committed itself to achieve 100% coverage of water and sanitation for all by 2010. At present, safe drinking coverage is 74% while sanitation is only 33% (Government of Bangladesh, 2005). The objective is to improve public health by reducing waterborne diseases and contamination of surface and groundwater. A recent health threat to the population is arsenic poisoning caused by widespread water contamination. The government is undertaking massive programs for the availability of arsenic-free water.

4.6. Protection and preservation of the environment

Most of the country's environmental resources are linked to the water ecosystem. Successive governments have developed a detailed policy framework. These include the National Environment Policy (1992), the National Environment Action Plan (1992), the National Agriculture Policy (1994), the National Forest Policy (1994), the National Energy Policy (1996), the Forestry Master Plan (1993–2012), the Environment Conservation Act (1995), the National Policy for Safe Water Supply and Sanitation (1998), the National Fisheries Policy (1998), the Draft National Conservation Strategy, the National Water Policy (1999), the Sustainable Environment Management Program (SEMP) and the National Arsenic Mitigation Policy (2004). Further, the National Environment Management Action Plan (NEMAP, 1995) has been prepared with a wide participation of stakeholders. It should be emphasized that realization of most of these objectives is heavily dependent on successful water management practice.

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5. Water management issues: problems and prospects

Water management is a critical issue owing to the growing demand and increasing conflict between alternative uses. Demand for water is growing rapidly in agriculture, the urban and industrial sectors, fishery, inland navigation and salinity control. The supply of clean uncontaminated water has fallen far short of demand owing to inadequate flows in the Ganges, pollution caused by the disposal of effluents, salinity intrusion in the coastal area and arsenic contamination. On the demand side, irrigation has received higher priority than the supply of safe drinking water. On the supply side, the use of groundwater has received more emphasis than surface water. The result is mass scale arsenic contamination. These various demand and supply issues affecting water management are taken up here.

5.1. Flood and drainage congestion

During the monsoon, water is slow to drain and banks overflow. Flood damage from the GBM rivers is catastrophic and after the peak season water congestion continues to impede drainage. Development of FCDI (flood control drainage irrigation) projects in the last 57 years by the Bangladesh Water Development Board (BWDB) is part of water management. Since the floods of 1954 and 1955, flood control and drainage projects have played an important role in water resource management[7].

Most flood control and drainage projects prior to 1988 were justified in terms of increased crop cereal production but undermine the need for water by industry, fisheries, inland navigation and environment. Construction of flood-control embankments impedes natural water flows, threatening wetland and fishery resources. Some intensive irrigation projects have neglected drainage leading to water logging. Bangladesh needs a flood management that combines both structural and non-structural measures. FCDI projects should be multi-purposed and part of an integrated water resource management scheme that takes into account navigation, fisheries and environmental concerns. Embankments must be designed for controlled flooding of major rivers such as the Ganges and Meghna and other small rivers. The problems of sedimentation and subsidence must be considered during the construction of embankments and polders. Non-structural measures include upgrading methods of flood forecasting and warning, flood proofing and disaster management and floodplain zoning.

5.2. Dry season shortage of water

The issue of balancing water supply and demand during the dry season[8] is a critical one. Water extraction upstream of Bangladesh greatly reduces dry season water flow. This is the season of greatest demand for groundwater for irrigation. Western regions are particularly vulnerable to droughts[9]. From December through to May when rainfall is low droughts occur owing to: (i) a cumulative effect of dry days and (ii) higher temperatures ($>40^{\circ}C$ in March/May). This drought affects all the winter crops, such

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[7] In fact, they account for about half of the funds spent on water development since 1962 (World Bank, 1998). According to an estimate of the BWDB, about US$1732 million were spent on the FCDI projects in the period between 1944 and 1999.

[8] The dry season in Bangladesh, normally lasts from November to April, is characterized by a drastic reduction in the discharge of major rivers, drying of water channels, falling water tables and salinity encroachment, particularly in the southwest.

[9] In the context of Bangladesh, a drought is defined as a period when soil moisture is less than what is required for satisfactory crop growth.

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as HYV *boro*, *aus*, wheat, pulses and potatoes especially where irrigation possibilities are limited. In the *Rabi* season, 1.2 million ha of cropland faces droughts of various magnitudes. Apart from loss in agriculture, droughts[10] have significant effects on land degradation, livestock population, employment and health.

One can consider the viability of augmenting dry-season flow in the southwest regions (SWR). The 1996 water treaty with India is supposed to give Bangladesh a minimum of 991.09 m^3 per second, or 50% of the water available at Farakka, if the Ganges' total flow is less than 1,982.18 m^3 per second during the dry season. This should increase the availability of surface water in the dry season and create a new water balance. In order to augment surface water utilization, the BWDB and the Water Resources Planning Organization (WARPO) have already finalized a feasibility study which includes a detailed engineering design for constructing a Ganges Barrage (Government of Bangladesh, 2005). But India is also exploring the idea of transferring water from surplus to deficit basins. Therefore it is imperative that Bangladesh makes an agreement with India on all other transboundary rivers for mutual benefits.

5.3. Groundwater availability and quality

Since the availability of surface water is not uniform seasonally or spatially, use of tube wells to raise shallow groundwater was encouraged to support intensive irrigation and provide safe drinking water in rural and urban areas. Almost 95% of drinking water and 68.5% of irrigation water are derived from groundwater sources (World Bank, 2000; Ahmad *et al.*, 2001). Groundwater abstraction represents 35% of total annual water withdrawal (World Bank, 2006). Overexploitation of groundwater in agriculture together with its massive use by households, municipalities and industries is depleting this resource quickly. It is lowering the water table and increasing saline intrusion. The water table in many areas has fallen below the suction level of the tube wells. In Dhaka the groundwater table has gone down by 20 m in the last decade (World Bank, 1998). The fall in the water table increases the salinity of the shallow aquifers in the coastal region. It also leads to subsidence of land. An additional problem is wide-scale arsenic contamination of shallow groundwater tables.

5.4. Arsenic contamination

High levels of naturally occurring inorganic arsenic are detected in 59 of the 64 districts in Bangladesh. The highest level of contamination is found in the large basins of the Rivers Padma (local name of the Ganges), Atrai, Brahmaputra and Meghna in the northern and the north eastern part (Khuda, 2001). Another area of high concentration of arsenic is in the southern and the south western parts. The World Health Organization has specified 0.01 $mg\,l^{-1}$ as the maximum permissible level of arsenic concentration in potable water. Bangladesh accepts a higher level of 0.05 $mg\,l^{-1}$ of water. However, water samples collected from different parts of the country contained arsenic in the range 0.1–0.3 $mg\,l^{-1}$. It is estimated that 35 million people are affected in both rural and urban areas (World Bank, 2006). The National Institute of Preventive and Social Medicine (NIPSOM) has identified arsenic-related diseases in 37 districts. If farmers continue to depend on shallow tube wells, the rate of

[10] Very severe droughts hit the country in 1951, 1961, 1975, 1979, 1981, 1982, 1984, 1989, 1992, 1994 and 1995.

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groundwater abstraction will increase, leading to increased arsenic abstraction with possible impacts on crops (World Bank, 1998).

The solution lies in the treatment of tube wells or in collecting water from alternative sources such as surface or rainwater. Key areas of research are the implications for food safety of irrigating with arsenic-contaminated water, prediction of whether contamination will change over time and cost effective solutions for immediate mitigation and long-term solutions. The extent of arsenic contamination in water extracted by deep tube wells also needs to be researched further.

5.5. Land erosion and accretion

Rivers in Bangladesh are morphologically highly dynamic. Rivers erode part of their banks owing to current and wave action during flood and post-flood periods. The GBM, *Teesta* and *Surma-Kusiyara* rivers flow within well-defined meander belts on extensive floodplains where erosion is widespread (World Bank, 2000). In lower delta areas, tidal currents and storm surges from the sea cause riverbank erosion. Riverbank erosion is responsible for a huge loss of fertile agricultural land and homestead. Satellite image studies of the GBM rivers show that an area of 106,300 ha was lost owing to erosion between 1982 and 1992, while the accretion amounted to only about 19,300 ha. Most of the net loss of 87,000 ha was agricultural land. A huge population of 728,439 was displaced owing to the erosion (Alam & Koudstaal, 2000).

Riverbank protection and river training works are required in rapidly eroding areas like the banks of the Brahmaputra and Meghna to save valuable land and also to safeguard the existing water management infrastructure. But engineering works on major rivers are expensive and can be subject to high risk. However, in order to control erosion of major rivers and protect large and small towns, the government has undertaken a Jamuna–Meghna Erosion Mitigation Project (Government of Bangladesh, 2005). Because of increasing pressure on land, accretion is an important issue for Bangladesh[11].

5.6. Floodplain fertilization

In recent years the amount of sediment in the Ganges and Brahmaputra has increased with a higher proportion of sand and lower proportion of the organic matter that is important for floodplain fertilization. The probable reason is gully erosion, intensified by the removal of the vegetative cover in the upper catchments in India and China. Sediment load has become a serious quality parameter for this purpose.

5.7. Sedimentation

Bangladesh is located on an active sedimentary basin and the intricate network of alluvial rivers carries an average quantity of 0.5–2.8 billion tons (World Bank, 1998) annual discharge and sediment load from the mountains to the Bay of Bengal. Major sources of the sediments are in the upstream areas

[11] At present this land is owned by the state. Newly accreted land along the coast may take up to 15 years to develop full production potential, whereas land lost to erosion is in most cases valuable agricultural land. Therefore an improvement of land tenure arrangements needs more attention. A coherent land policy with appropriate support services is essential to avoid illegal settlements before the soils have developed their full productive capacity.

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in India, China, Nepal and Bhutan. Forest clearing in the Himalayan watershed, in the hills of Tripura and Meghalya affects downstream erosion and sedimentation. Part of the load deposited gradually changes topography and seriously reduces the carrying capacity and navigability of drainage channels. In the post-monsoon period, when river discharge decreases rapidly, huge sediment loads are deposited in channels and low-lying areas (Master Plan Organization, 1986). Progressive silting and decrease in channel depth increase flood vulnerability. The solution lies in selective dredging of channels and selective excavation of silted channels. Dredging and desiltation will be particularly effective when they are combined with measures that reduce maintenance dredging. Dredging is expensive and is often not an option. At the local level, community participation in drain re-excavation should be encouraged.

5.8. Navigation

Over the years, water depth in many navigation routes has fallen owing to lack of water in the dry season. Also silting of the delta and the floodplain of the GBM rivers is seriously curbing surface water supply in many parts and disrupting navigational routes. Many regional rivers such as the river *Gorai* (a tributary of the Ganges flowing through the SWR) have lost their connection with their perennial water source in the dry season (Ahmed, 2000). Dams and diversions for irrigation also affect inland navigation. Navigation has become hazardous owing to inadequate dredging. This is hampering port facilities, *Mongla* port functioning. The main issues are allocation of stream flows to maintain navigation depths and control of activities restricting or impairing navigation. The government is keen to maintain rivers through comprehensive development and management of the local and main river systems.

5.9. Surface water quality

This is a serious concern owing to the runoff effects of chemical fertilizers, pesticides, untreated domestic sewage and industrial effluent. The rivers are frequently used as dumps. Certain industries, like tanneries, pulp and paper mills, textile, dyeing, petroleum refineries and other chemical industries, pollute water by discharging untreated effluent. These pollutants are causing serious damage to both freshwater and marine ecosystems including the Sundarban. However, industrial effluent is not a major problem yet because there is very little industrialization in comparison with highly industrialized countries. Pollution of closed water bodies caused by human waste is a major problem. Faecal contamination in urban areas, village ponds and small streams needs immediate attention. Ganges water is heavily polluted. The problem is further aggravated by lean season flows to dilute the pollutants. Poor water quality not only affects country's human population but also its entire aquatic environment. The government is considering a nationwide program to reduce pollution emission and rehabilitate water bodies which consists of various regulatory and non-regulatory measures.

5.10. Salinity intrusion

This occurs through both surface and groundwater aquifers. The effect of saline water intrusion is highly seasonal. Saline intrusion is at its minimum during the monsoon when the GBM Rivers discharge about 80% of the annual fresh water flow (World Bank, 2000). In winter months the saline front begins to penetrate inland and the affected areas rise sharply from 10% in the monsoon to over 40% (World

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Bank, 2000)[12]. Environmental degradation caused by the intrusion of saline water is a major problem in the SWR. The reduced flow of the Ganges during the dry season causes intrusion of surface water salinity from the Bay of Bengal since the northward current of water towards land becomes stronger than the southbound river flow owing to lack of water in the river system. The process has been exacerbated by the diversion of the Ganges' water at the Farakka Barrage in India. Since 1975 this reduction has caused the salinity front and tidal limits to move northward, eliminating surface water potential for significant land areas in the southwest, south-central and southeast regions.

The northeast region of the Sundarban is suffering from salinity intrusion. It is affecting fresh groundwater for human and industrial consumption in addition to irrigation of *aus* crops. The Khulna Newsprint Mill and *Goalpara* power station have suffered serious set backs owing to lack of fresh water during the dry season. It necessitates freshwater being imported by barge from further inland for various processing purposes. As a consequence, no new heavy industry has developed in recent years despite increasing infrastructure facilities (sea-ports, etc) in the coastal districts. Thus salinity in surface and groundwater in the SWR has become a serious constraint on industrial growth. It is threatening the economic viability of an area over 25,000 km^2 dependent on the Ganges. The government has taken a number of steps such as afforestation of the foreshore to protect against tidal surges. An Integrated Coastal Zone Management Program is underway to take care of many pressing problems unique to this region. A similar program to increase future inflow of fresh water through the Gorai river system to the Sundarban is under study.

5.11. Watershed management

Upland watersheds in India, Nepal, China and Bhutan are source areas for surface and groundwater recharge in Bangladesh. Downstream agriculture and urban development in Bangladesh are directly dependent on water supply from these countries. Forestry plays an essential role in watershed management. Land degradation and deforestation in the upland and hilly areas of India and Nepal contributes towards increased soil erosion and impacts on the river systems of Bangladesh as sediment loads increase. Basin planning provides the most rational basis for development of water resources of the rivers entering the Bangladesh border (Halcrow, 2001). However it will take considerable effort and time for Bangladesh to enter into agreements with other co-riparian countries in order to realize basin-wide planning in terms of sharing international rivers, watershed management, data exchange, resource planning and long-term water resources management under various circumstances.

5.12. Waterborne diseases

Polluted water is the main cause of many waterborne diseases like diarrhoea, jaundice and typhoid. Water pollution causes four out of five illnesses and 230,000 deaths annually (World Bank, 1998). Water is polluted from arsenic contamination, untreated sewage, runoff effects of chemical fertilizer and pesticides. During floods, inundation of hand pumps and latrines increases the incidence of waterborne diseases. Waterborne diseases caused by the floods of 1988 and 1998 resulted in a large number of

[12] The coastal areas of Bangladesh face three types of saltwater intrusion in streams, groundwater and soil. Salinity is also experienced severely around the single purpose flood control embankments.

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casualties. With a rapid growth of population and urbanization it is getting ever more difficult to provide clean water and appropriate sanitation.

5.13. Fish habitat

Availability of water bodies and connectivity of migratory routes are crucial for fisheries. Construction of FCDI projects to prevent or regulate floods in paddy fields has severely restricted the ability of migratory fishes to move across different water bodies. This has heightened tension between farmers and fishermen. A major water management issue is the great damage done to capture fisheries by past interventions. Migration routes are also being affected owing to salinity and therefore less habitat during the dry season. These factors have reduced fish (*Hilsha*) productivity and species diversity in many areas. Fish hatchlings from the Ganges and the *Padma* (combined Ganges and Brahmaputra rivers) migrate to the southwest region through the *Gorai* and *Arial Khan* rivers. Fresh water migratory fish hatchlings[13] face a survival problem in the SWR because of increased salinity. With declining number of hatchlings in the dry season the overall fish production in the floodplains declines significantly.

In order to safeguard natural fish habitats it is necessary to maintain the link between static (perennial depressions) and dynamic (flood-inundated plain) water bodies for fish migration by maintaining the required level of water in static water bodies during the dry season and ensuring minimum amounts of water in dynamic water bodies for fish expansion during the wet season. The government is considering construction of fish passes to provide adequate hydraulic connections between the floodplains and the main river system[14].

5.14. Biodiversity and ecosystem status

The wetland habitats and ecosystems have lost connections with water bodies like rivers and canals owing to silting and land filling for agriculture and homestead use. The northeast region of the Sundarban is suffering from lack of freshwater availability. Wetlands are subject to continuous pressure from the expansion of the dry season *boro* rice in the *Haor* regions of Sylhet and Mymensingh. This degradation has brought about a loss of biodiversity, reduction in fish habitat and an increase in flood proneness of certain floodplains. The country has a tiny island in the south eastern area where coral reefs are located. However existing environmental conditions near the coral island are poor owing to frequent spillage of bulge water from sea going vessels, increasing turbidity of coastal water because of deforestation and land erosion in Chittagong Hill tracts and exploitation of coral by local traders. Without immediate and adequate conservation activities the already endangered coral islands are likely to suffer further degradation.

Brackish water shrimp farming, one of the fastest growing export industries in Bangladesh, has intensified in recent years giving rise to a monoculture with negative environmental consequences. Major shrimp culture activities are located in Satkhira, Khulna and Bagerhat districts in the SWR and in Cox's Bazar[15] in the southeast. Shrimp farming has also created a social conflict in land use with

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[13] Migratory fresh water fish hatchlings cannot survive even in moderately saline (2,000 mmhos cm^{-1}) water (EGIS-Il fisheries expert).

[14] Fish passes are constructed more as mitigation measures where migration of fish is hampered by interventions like embankments.

[15] Salt producing pans and relevant industries are primarily located in Cox's Bazar.

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rice farming in the coastal zone. Since it brings substantial foreign exchange, poor rice farmers in shrimp growing areas are forced to move and become landless. As shrimp farming becomes increasingly lucrative, mangroves are cleared to accommodate it. Reduction of forest biodiversity has negatively affected food, fodder, medicine and shelter for poor people. Even though the whole population suffers owing to environmental degradation, the poor are the hardest hit since they are directly dependent on the land and water for a living. Therefore they are most affected by a collapse in the local ecosystem[16].

5.15. Trade-off between agriculture and fishery

Fish is important for nutrition, poverty alleviation and rural economics in Bangladesh. According to a government estimate, 1 million people fish full time and another 11 million rural households are engaged in this activity on a part time basis (World Bank, 2006). Agriculture and fisheries have traditionally been complementary activities in the floodplains, but increasing population and intensification of agriculture have brought these sectors into conflict. *Beels* have been drained to provide land for dry-season cropping and water for irrigation. River embankments have been built to protect dry- and wet-season crops from flooding. This intervention has damaged natural fish habitats and migration routes. Preservation of natural fisheries must be weighed against irrigation development and flood control and drainage, as the latter has already affected river and open area capture fisheries in many places.

5.16. Industry and agriculture trade-off

Although at present agriculture consumes the major part of water resources, demand from municipalities and industries is increasing. Currently, municipal water supply is mainly derived from groundwater sources, but overexploitation has denuded aquifers and there is a critical shortage of groundwater in large metropolitan areas like Dhaka. The country's industrial concentration is also around Dhaka and rising industrial demand for water is likely to become a problem in the near future. It is possible that the constrained water supply for domestic and industrial usage will require a cutback in groundwater irrigation in many areas. The cost of irrigation is bound to rise, requiring a shift away from water-intensive crops such as rice.

6. Implications for policy and institutions

As water is needed in all areas of society there is a need for effective institutions and a legal framework to take care of the issues described above. The overall management of water resources is shared between state water agencies, users of water including the public, NGOs and other government agencies in agriculture, industry, commerce, water and sewage, public health, municipalities, inland water transport, fisheries, forestry and the environment.

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[16] Interested readers are referred to Dasgupta & Mäler (1993).

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6.1. Institutional network

The Ministry of Water Resources is responsible for flood management, irrigation, drainage control, erosion protection, land reclamation, integrated management of coastal polders, river flow augmentation, water sharing from transboundary rivers and wetland conservation through participation of local people and coordinated programs with all the ministries dependent on water resources. Major public organizations under the Ministry of Water Resources are WARPO, BWDB and River Research Institute (RRI). Organizations in other sectors that have interlinkages with this sector are the Department of Public Health Engineering (DPHE), the Local Government Engineering Department (LGED), the Water and Sewerage Authority (WASA), the Department of Fisheries (DOF), BIWTA, the Roads and Highways Department (R&H), the Department of Environment (DoE) and respective municipal authorities.

The National Water Resources Council (NWRC) is the highest national body for the formulation of water policy. It coordinates different water agencies and makes recommendations on all water policy issues to the cabinet. The National Water Policy formulated in 1999, has guidelines for agriculture, fisheries, industry, navigation, environment, basin-wide planning, water rights and allocations, public and private investment, water supply and sanitation. The policy underscores the broad principles of water resource development and its rational utilization. It emphasizes both public and private actions and highlights the importance of conjunctive use of ground and surface water.

WARPO is a principal agency of the Government of Bangladesh under the Ministry of Water Resources. It has a mandate to ensure coordination of all relevant ministries through the NWRC and to plan all aspects of water development including major and minor irrigation, navigation, fisheries and domestic water supply. It is responsible for three main assignments:

- Preparation of the National Water Management Plan (NWMP) for the period to 2025 according to the National Water Policy formulated in January 1999[17].
- Establishing and updating the National Water Resources Database (NWRD).
- Acting as a clearing-house for all water sector projects undertaken by any agency involved in the water sector.

BWDB carries responsibility for the planning and execution of over 400 projects, ranging from flood control, drainage and irrigation to coastal protection and erosion control. Major investments in the water sector are made by the Ministry of Water through the BWDB and by the Ministry of Local Government and Rural Development through its LGED. As WARPO is responsible for national and regional level plans BWDB is supposed to develop projects fulfilling the requirements of their plans. BWDB is also a major collector of water resources information and as such it is a major partner of WARPO in sustaining the NWRD.

DPHE facilitates rural and urban water supply. DPHE is also responsible for arsenic problems and planning. BIWTA is mainly responsible for maintenance of river channels for waterway navigation during the monsoon and the dry season. Of these the Hydrography and Planning Departments are most relevant to WARPO. The Hydrography Department publishes annual tide tables. The Joint

[17] The National Water Management Plan (NWMP) has been approved by the government.

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Rivers Commission (JRC) is responsible for 57 identified border rivers and has data on cross-boundary water resources. Many of these are classified according to the ongoing negotiations with the co-riparians.

All water sector projects need to conform to DoE rules and guidelines. It endorsed a set of EIA guidelines operated by the Ministry of Water Resources. Most of the Ministry's projects are subject to DoE scrutiny when they are submitted to the Planning Commission. WARPO and DoE share overlapping responsibilities like setting standards, monitoring compliance, data acquisition and storage. In principle WARPO, NWRC, the Ministry of Environment and Forestry and DoE all have to some extent overlapping roles. Special attention is needed to ensure cooperation between these institutions. At WARPO's level a close link with DoE is of mutual advantage particularly in the area of standards and guidelines development for the water sector[18].

Quite often it is found that structures built to control floods in one area have aggravated the problems in others and hampered agriculture, fishing and navigation activities. Given the differential needs of the various water management issues, improved coordination of the activities of these institutes will yield better designed projects and large economies of scale.

6.2. International dimension of water management

Bangladesh shares 57 rivers with India and Myanmar. Since Bangladesh receives the residual flow after upstream utilization, dry season water shortage is always a critical issue in water sharing negotiations with India (Ahmad *et al.*, 2001). Interregional government efforts to tackle the problems of the Ganges began with the signing of the Ganges Water Treaty between India and Bangladesh on December 12, 1996. Under this treaty, India is likely to give Bangladesh a minimum of 991.09 m^3 per second, or 50% of the water available at Farakka, if the Ganges' total flow is less than 1,982.18 m^3 per second during the dry season. A number of agreements were signed between India and Bangladesh on the Ganges including this treaty. However, these agreements have the limited purpose of sharing the waters during the dry season only from January to May every year. The seasonal variation in the Ganges flow can result in catastrophic floods in the rainy season and acute water scarcity, as well as severe drought conditions during the dry season.

The series of agreements concluded between 1975 and 1996 did not address problems of flood control and environmental degradation. Water sharing is a bilateral issue between Bangladesh and India, while augmentation has to be done through multilateral cooperation of the co-basin countries: Bangladesh, India and Nepal. None of these committees included a neutral third party from outside the region. India has a long-standing policy of adhering to bilateral negotiations because it can best address its own needs *vis-à-vis* each of its neighbours separately. As a consequence the Ganges–Brahmaputra river system has never been managed to its full potential. Further, the recent Indian plan for a river linking project and *Tipaimukhi* dam will inflict severe ecological and socioeconomic damage on Bangladesh.

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[18] The other important organizations are research institutions like RRI, the Surface Water Modeling Centre (SWMC) and the Environment and GIS Support Project for Water Sector Planning (CEGIS). RRI is a research and data generation unit for hydraulic and river studies. SWMC is developed as an excellent centre for water modelling and mapping under the Flood Action Plans (FAP). CEGIS is involved in various environmental, socioeconomic and institutional studies relating to the water resources sector in Bangladesh.

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Table 3. Population growth and annual per capita water availability.

Year	Population (million)	Annual per capita water availability (m^3)
1991	111	12,162
2000	131	10,305
2010	150	9,000
2020	170	7,941
2025	176	7,670

Source: Ahmad *et al.* (2001).

6.3. Future exogenous parameters

There are some relevant exogenous factors that may affect the whole water management situation in an ambiguous way. These are population growth or demographic transition, climate change and the international environment. Despite steadily declining fertility, the population is expected to exceed 176 million by 2025 when the population density will rise to about 1,200 persons per km^2. Population pressure on natural resources including water resources has led to overexploitation (see Table 3).

The issue of demographic trend is important for estimating the future demand for water directly in case of water supply and sanitation and indirectly in terms of food production requirements and demand for irrigation. The impact of global climate change[19] is to increase the overall uncertainty within which water planners operate. According to a World Bank (2000) report on climate change in Bangladesh, future changes in climate caused by global warming will complicate water resources management beyond the present climate variability. The sea level along the Bangladesh coast is rising at about 3 mm each year and the sea surface temperature is showing a rising trend.

Bangladesh is particularly vulnerable to climate change in its coastal zone, which covers about 30% of the country. Northward penetration of the salinity front would result in salinity-induced succession problems in the Sundarban. Any rise in the sea level propagates upstream into the river system. In Bangladesh this effect will be more pronounced because of the morphologically dynamic rivers, which will adapt their bed levels in a relatively short time period. This whole process will lead to decreased river gradients, increased flood risks and increased drainage congestion. One of the key effects of drainage congestion is an increase in the period of inundation and expansion of wetland areas. There may be some benefits for fisheries, *boro* production and so on. However, it may hamper agricultural productivity and also threaten human health by increasing the potential for waterborne diseases and holding back food production.

In terms of precipitation, most of the general circulation models (GCM) show the possibility of increasing monsoon precipitation and decreasing dry season precipitation. Increased salinity levels will reduce fresh water availability for irrigation for agriculture. Since the temperature would rise and there is a strong possibility that winter precipitation will decrease, it is likely that the moisture content of the topsoil would reduce substantially leading to severe drought conditions in the winter months. Thus a greater incidence of droughts in the western and north western areas will reduce the areas suitable for rice production. In addition, increased coastal morphological dynamics will contribute to the existing

[19] This section is heavily drawn from the 2000 World Bank Report titled, *Bangladesh: Climate Change and Sustainable Development*.

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problem of loss of valuable agricultural land caused by erosion in the coastal zone where agricultural activities are likely to be in conflict with industrial development.

Climate change-induced alterations in temperature would affect the timing and rate of snow melt in the upper Himalayas. GBM river systems would begin to swell early, while increased precipitation in the monsoon would generate additional volumes of runoff. Problems concerning drainage congestion will aggravate further with increasing volumes of water coming through the cross-boundary rivers during the monsoon. During the winter period, flows in the GBM rivers might decrease because of lower rainfall and higher surface evaporation. In the long term there will be increased competition for water among the co riparian countries stimulated by the effects of climate change. This might lead to further low water flow in the transboundary rivers of Bangladesh during the winter months. Therefore, it is in Bangladesh's particular interest as the lower riparian to understand how this wider perspective may affect its internal management of water resources.

7. Conclusions

Water is both scarce and abundant in Bangladesh. Flood and drainage congestion become a huge water management issue during the monsoon when heavy rainfall coincides with peak river flows. During the winter there is a critical shortage of water, hampering irrigation, fishing and navigation activities. Dry season shortage of water also affects wildlife and biodiversity dependent on water ecosystems. The incidence of both flood and drought in a yearly cycle profoundly affects river morphology. Continuous and severe riverbank erosion accounts for a massive land loss every year. Availability of freshwater in Bangladesh is highly seasonal depending on the presence and duration of the monsoon. March is a critical month in terms of water availability when rainfall and river discharges are low. An increasing demand for both surface and groundwater comes from irrigation in the dry months. At present, irrigation and fisheries compete for water. Salinity intrusion is also highly seasonal. Environmental degradation caused by the intrusion of saline water is a major problem in the SWR. Recently high levels of arsenic have been detected in groundwater.

Bangladesh is a downstream country and upstream intervention by India significantly affects surface water availability during the dry period. Given that groundwater is subject to increased abstraction and arsenic contamination, the country has to rely more on surface water not only for fishery, navigation, salinity control and protection of biodiversity but also for household use and agriculture. Under these circumstances an adequate supply of water in the river systems will largely depend on continued cooperation with India and other basin countries in the region. On the demand side, economic efficiency of water use in irrigation must be improved and economic incentives should be designed for less water-intensive crops. In this regard water pricing will play an important role in reflecting the true opportunity cost of water for its various users. It is imperative that future research focuses on efficiency of water use for various crops and stakeholders across different regions of the country.

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