3.2.1 INTRODUCTION

Water is the most vital element among the natural resources, and is crucial for the survival of all living organisms. The environment, economic growth and development of Bangladesh are all highly influenced by water - its regional and seasonal availability, and the quality of surface and groundwater. Spatial and seasonal availability of surface and groundwater is highly responsive to the monsoon climate and physiography of the country. Availability also depends on upstream withdrawal for consumptive and non-consumptive uses. In terms of quality, the surface water of the country is unprotected from untreated industrial effluents and municipal wastewater, runoff pollution from chemical fertilizers and pesticides, and oil and lube spillage in the coastal area from the operation of sea and river ports. Water quality also depends on effluent types and discharge quantity from different type of industries, types of agrochemicals used in agriculture, and seasonal water flow and dilution capability by the river system.

Bangladesh is the lower riparian of three major river systems, the *Ganges-Padma*, the *Brahmaputra-Jamuna* and the *Meghna* (GBM), and constitutes about 8 per cent of the combined catchment area. Over 92 per cent of the annual runoff generated in the GBM catchment areas flows through Bangladesh (Coleman, 1969). The combined flow of the *Ganges* and *Brahmaputra* typically vary between less than 5000 m^3/s in the driest period (March-April) to 80,000-140,000 m^3/s in late August to early September (WARPO, 2000b).

The contribution of local rainfall to the annual surface runoff is about 25 per cent, with significant seasonal variation. Annual rainfall and evapotranspiration of the country show that there is a substantial excess of rainfall everywhere in the monsoon season. From the annual overall averages, dependable rainfall exceeds evapotranspiration by over 10 per cent in most parts of the country, except in the Northwest (NW) and Southwest (SW) regions. In the NW region, rainfall and evapotranspiration are almost equal, but in the SW the overall deficit is about 10 per cent. From November to May, evapotranspiration exceeds rainfall all over the country, except in the Northeast (NE) region (WARPO, 1999b).

The concerns over water quality relate not just to the water itself, but also to the danger of diffusion of toxic substances into other ecosystems. The aquatic environment for living organisms can be affected and bioaccumulation of harmful substances in the water-dependent food chain can occur. A variation of inland surface water quality is noticed due to seasonal variation of river flow, operation of industrial units and use of agrochemicals. Overall, inland surface water quality in the monsoon season is within tolerable limit with respect to the standard set by the Department of Environment (DoE). However, quality degrades in the dry season. The salinity intrusion in the Southwest region and pollution problems in industrial areas are significant. In particular, water quality around Dhaka is so poor that water from the surrounding rivers can no longer be considered as a source of water supply for human consumption.

The largest use of water is made for irrigation. Besides agriculture, some other uses are for domestic and municipal water supply, industry, fishery, forestry and navigation. In addition, water is of fundamental importance for ecology and the wider environment. Water stress occurs when the demand for water exceeds the amount available during a certain period or when poor quality restricts its use. This frequently occurs in areas with low rainfall and high population density or in areas where agricultural land or industrial activities are intense. Even where sufficient long-term freshwater resources do exist, seasonal or annual variations in the availability of freshwater may at times cause water quality degradation (EEA, 1999).

The Water Pollution and Scarcity section of the report deals with inland surface and groundwater quality, pollution problems, salinity attributed to low water flow and coastal water pollution. Other water-related environmental problems have been discussed in detail in other sections. For example, droughts and floods have been discussed under the Natural Disaster section. The Biodiversity section addresses the implications of shrinking dry season water area. Riverbank erosion and the consequences of gradual silt deposition in the floodplain are discussed under Land Degradation.

3.2.2 PRESSURES

For water resource analysis and planning, water demands have been categorized into consumptive and non-consumptive uses. Consumptive demands are those where water is lost from the resource pool and non-consumptive demands are those where used water is returned to the resource pool, and can be re-used (WARPO, 1999b). The consumptive use of water is increasing due to the growth of different economic sectors - agriculture in particular.

The increasing urbanization and industrialization of Bangladesh have negative implications for water quality. The pollution from industrial and urban waste effluents, and from agrochemicals in some water bodies and rivers have reached alarming levels. The long-term effects of this water contamination by organic and inorganic substances, many of them toxic, are incalculable. The marine and aquatic ecosystems are affected, and the chemicals that enter the food chain have public health implications.

Water quality in the coastal area of Bangladesh is degraded by the intrusion of saline water that has occurred due to lean flow in the dry season. This affects agriculture significantly, as well as other consumptive uses of the water.

A common phenomenon in the lower riparian countries is that of enough water in monsoon, but water scarcity during the dry season. It is also common in Bangladesh for areas that were once inundated facing water scarcity in the dry season. Dry season water availability depends on water use for irrigation, dry season rainfall and withdrawal or diversion of water upstream. It has implications for navigation, and the wetland ecosystem and its productivity.

Excess water in the monsoon causes floods and riverbank erosion, which result in loss of land and people being left homeless. This is discussed in detail in the Land Degradation and Natural Disaster sections. Although there is an abundance of water in the monsoon, often the water quality is compromised during floods, and this translates into a type of water scarcity when good potable water becomes difficult to obtain.

The inter-linkage of pressures, state, impacts and various policy responses to address water related environmental problems have been presented in Table 3.2.1. Detailed analyses of various policies and

Table 3.2.1 Inter-linkage of pressures, state, impacts, and various responses related to water

Pressures	State	Impacts	Policy Responses
Pollution • Industrial effluent • Agrochemical • Fecal Pollution • Ship breaking and lube oil discharge • Oil and lube spillage during normal refueling of ships at sea and river ports • Low water flow in the river system in dry season	• Decreasing inland water quality in dry season • Decreasing coastal water quality • Salinity intrusion in surface and groundwater • Soil salinity increase • No primary or secondary measurement is available on discharge quantity	• Pressure on urban water source • Fish fingerling mortality, migration and quality of fish • Degradation of fish habitat • Yield reduction (soil fertility loss) • Increase in risk from waterborne diseases • Affecting marine aquatic life	• Environmental Conservation Act and Regulation • Setup environmental quality standard • Industrial EIA and effluent treatment plants to reduce pollutants load • Polluters pay principle • National Water Policy: EIA for water development projects and increase surface water flow in dry season
Scarcity (dry season) • Upstream withdrawal for consumptive and non-consumptive use • Low rainfall • Gradual siltation in river bed and floodplain • Dry season irrigation • Flood	• Decline river water level and discharge • Low water flow • Shrinking dry season water area • Decline/fluctuation of groundwater • Less access to safe drinking water	• Decline in aquatic resources production • Navigation problem • Increase conflict among different users and sectors • Domestic uses • Increase pressure on groundwater • Quality of water decline	• National Water Policy: Dredging and water harvesting, regional cooperation, augmentation of dry season flow and use of surface water for irrigation
Abundance of Water (Monsoon season) • Geographical location and setting (92 per cent runoff flows through Bangladesh, which is 7 percent of the catchment area) • Monsoon Climate (78 per cent rainfall occurs in the monsoon)	• Increase flooding • Increase water related hazards • Increase river bank erosion • Increasing river bank shifting	• Crop yield reduction and damage • Disruption of livelihood system • Damage of homestead and towns • Population displacement	• National Water Policy: Structural and non-structural mitigation (early warning and flood proofing) • Planned development among different sectors need

Source: SoE Study Team

programs to address degradation of water quality and scarcity are presented in section 3.2.4.

3.2.2.1 Causes of Water Pollution

The major causes of degradation of inland water quality are related to land based activities, when adequate regulatory measures are not incorporated and the stakeholders do not show proper concern. The underlying driving forces for this are poverty, an unhealthy national economy, lack of institutional strength, and lack of awareness and education. Pollutants that enter the marine and coastal environment originate on land in the form of runoff from municipal, industrial and agricultural wastes, and from commercial seafaring activities.

A view of industries, situated on the river banks

Industrial effluent

In Bangladesh, industrial units are mostly located along the banks of the rivers. There are obvious reasons for this such as provision of transportation for incoming raw materials and outgoing finished products. Unfortunately as a consequence, industrial units drain effluents directly into the rivers without any consideration of the environmental degradation.

region, which comprises about 49 per cent of the total sector. About 33 per cent of the industries in the NC region are textiles, apparels and tanneries, of which Dhaka district accounts for almost half and Narayanganj about 32 per cent. About 65 per cent of the total chemicals, plastics and petroleum industries are also located in the NC region, and concentrated in and around Dhaka, Narayanganj and Gazipur districts (WARPO, 2000a). Region-wise numbers of industrial establishments and most polluting industries are shown in Table 3.2.2.

The organic pollutants are both biodegradable and non-biodegradable in nature. The biodegradable

Table 3.2.2. Region-wise Number of Industrial Establishments and Polluting Industries

Region	No. of Establishments	Textiles, apparels & tanneries	Paper, paper products & printing	Chemicals, plastics & petroleum	Non-metallic minerals manufactures
North West	4,403	545	113	181	360
North Central	12,133	4,093	707	1,242	733
North East	1,117	55	20	47	132
South East	2,518	346	68	83	549
South West	849	72	39	42	199
South Central	1,408	128	29	77	157
South East	2,506	475	102	231	229
Total	24,934	5,714	1,078	1,903	2,359

Source: WAROP, 2000a

The most problematic industries for the water sector are textiles, tanneries, pulp and paper mills, fertilizer, industrial chemical production and refineries. A complex mixture of hazardous chemicals, both organic and inorganic, is discharged into the water bodies from all these industries usually without treatment.

The highest numbers of industrial establishments in the country are located in the North Central (NC)

organic components degrade water quality during decomposition by depleting dissolved oxygen. The non-biodegradable organic components persist in the water system for a long time and pass into the food chain (Ahmed and Reazuddin, 2000). Inorganic pollutants are mostly metallic salts, and basic and acidic compounds. These inorganic components undergo different chemical and biochemical interactions in the river system, and deteriorate water quality.

Agrochemical

The main suspected sources of agricultural runoff pollution are from the use of fertilizers and agrochemicals, including herbicides and pesticides. Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP) and Gypsum are the major chemical fertilizers used in Bangladesh. The total amount of fertilizers used annually is about 2 million tons. With the increase of irrigated areas and cultivation of HYV rice, there was an increase of about 20 per cent fertilizer use in 1990. But the present growth in use has decreased and fluctuates from plus minus 5 to 10 per cent. In 1995, the use of nitrogenous fertilizer accounted for about 88 per cent of the total fertilizer use, which was about 67 per cent in 1991. The share of the market held by domestic production of Urea, TSP and Gypsum is currently about 90 per cent (BBS, 1979, 1985, 1990, 1994, 1998).

Pesticide use was introduced in Bangladesh in 1957. Since 1981, the area covered by plant protection measures has actually decreased, though the trends have been erratic. Insecticide is commonly used for pest control, which accounts for about 90 per cent of the total consumed pesticide (BBS, 1985, 1998). The trends of irrigated land, and the use of chemical fertilizers and pesticides from 1991 to 1995 are presented in Figure 3.1.1 in the Land Degradation section.

Fecal Pollution

Bangladesh has the highest rural population densities in the world, and with an exception in some areas, the overall density is very high. Most of the rural areas have densities around 1,000 people per km², and over one third of the *thanas* exceed this. The main problem poses in respect to water is the lack of sanitation facilities in the rural areas and inadequate facilities for urban wastewater treatment. There is one sewage treatment plant in the whole country, serving only a part of Dhaka. A major program for provision of sewerage is needed to arrest the increasing fecal pollution of open watercourses around all urban areas in Bangladesh, particularly Dhaka. Outside the urban areas, there is a problem with designing adequately sealed latrine systems at the household level, which can cope with the annual flooding and prevent fecal pollution of the water supply. Poor management of wellhead areas may be the most significant source of fecal contamination rather than direct aquifer pollution.

Oil and Lube Spillage

Chittagong and Mongla are the two seaports of the country, and on an average deal with 1500 to 1600 vessels and 12,000 to 13,000 cargos annually (BBS, 1998). These ports, however, do not have facilities to receive and treat bilge and ballast water, and thus ships throw wastewater into the territorial waters of Bangladesh. Oil and lube spillage also happens during refueling of vessels and cargo handling. In addition, there are innumerable mechanized trawlers and boats engaged in fishing in the Bay of Bengal. The operators of these vessels dump waste, including burnt oil, into the water, because of their ignorance about its adverse effect on environment.

As the seaports and the harbors of Bangladesh are located near shallow water, large oil tankers carrying crude and refined oil cannot enter them. Therefore, oil spills also take place in outer anchorage during the transfer of crude and refined oil from large oil tankers to small tankers. There have already been several environmental disasters due to heavy spillage from oil tankers in outer anchorage and along coastal areas. In late 1989, a Greek-owned Cypriot flagship charted to bring crude oil for the Bangladesh Petroleum Corporation caused about 3,000 tons of oil slicks along the Chittagong Cox's Bazar coast. The vessel developed a hole through which crude oil oozed out, but authorities only detected it as the vessel rose higher as it was unloaded at outer anchorage. A huge oil slick was also detected around the Khulna coast in 1992, which was dumped from a foreign ship. But the authorities concerned failed to identify the vessel responsible for this (Majumder, 1999).

Lube oil and heavy metals enter the coastal area water from the ship-breaking industries in Chittagong, and several accidents have occurred. However, there is no assessment available on the amount of lube oil discharged from ship-breaking industries. Concern over this pollution in the coastal area is emerging, and actions to prevent it are in the initial stage. Enforcement of ECA and ECR, with institutional strengthening, is essential to address this problem.

Low Flow in Dry season

A certain level of stream flow is required to maintain navigability, the wetland habitat and ecosystem, and equilibrium between freshwater and saline water mixing zones. Generally, reduction of water flow causes saline water intrusion into the river system. Saline water intrusion is aggravated in the coastal area of the country in dry season, when water flow from the river system becomes lean. Over the past two decades, the lowest water level data of the major rivers showed a declining tendency in the dry season (BBS, 1985, 1992, 1998). However, scientific research is required to establish whether decreasing water level has a direct linkage or not with salinity increase in the coastal area.

3.2.2.2 Causes of Scarcity

Generally, water scarcity is a dry season phenomenon when the availability becomes less than the demand or the quality of the water restricts its use. Dry season water resources are comprised of the runoff and trans-boundary river inflow, together with water contained in surface water bodies and groundwater. Scarcity is also dependent on the amount of soil moisture available at the beginning of the season. Trans-boundary inflow in the dry season has decreased due to upstream development, and withdrawal of water for irrigation and other purposes. Groundwater is the major source of irrigation in Bangladesh, and there has been a tremendous increase in suction mode irrigation. The following section presents a brief description of the causes of water scarcity in dry season.

Upstream Withdrawal and Diversion of Flow

As a lower riparian country, Bangladesh has 57 trans-boundary rivers, of which 54 are shared with India and 3 with Myanmar. The upper riparian countries have adopted innumerable development schemes in the upstream regions of these rivers. Apart from big barrages and other river based constructions near the border of the country, there is construction of spurs and weirs going on in other minor rivers such as *Dhalai* and *Kachamara*, a blockage on the *Sonai* river, barrage over the *Khowai* and *Gumati*, and many other structures on a number of rivers (Nazem and Kabir 1986). A significant amount of dry season stream flow is withdrawn and diverted upstream both inside the country and outside by neighboring countries, for irrigation and navigation. Withdrawal of water inside the country is done mainly for irrigation.

Dry Season Rainfall

The National Water Management Plan Project has considered the dry season to be from November to May, when rainfall is scanty, irregular and erratic. There is hardly any rainfall, except for the pre-monsoon months of April and May. Over this seven-month period, only 22 per cent of rainfall occurs, and evapotranspiration is four times higher than the rainfall (WARPO, 1999b). The maximum deficit of water is in the southwest and northwest regions of the country. Dry season rainfall plays a very important role for irrigating HYV *Boro* and reduces pressure on groundwater extraction for irrigation.

Gradual Siltation in River Bed and Floodplain

The three major rivers, the *Ganges*, the *Brahmaputra* and the *Meghna*, with their innumerable tributaries and distributaries used to carry about 2.0 to 2.4 billion tons of sediment every year into the country (Colemen, 1969, Milliman and Meade, 1983). But the recent estimate is somewhere between 1.2 to 2.0 billion tons. This indicates that there is a decrease in sediment load in the river system. Only about 5 per cent of the sediments are deposited in the riverbed and floodplain, and the rest are discharged into the Bay of Bengal (Hossain 1992).

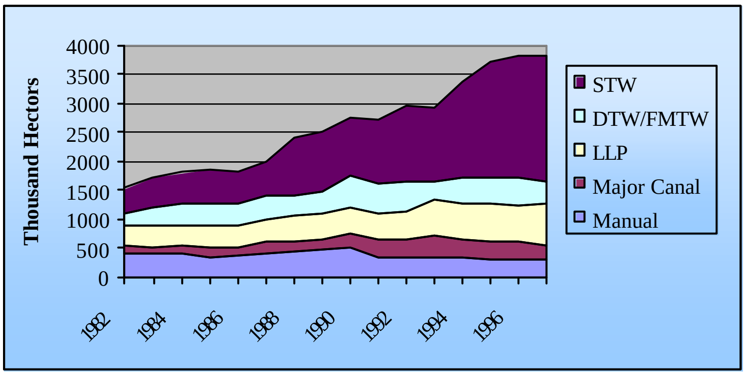
Besides the regional geography, irrational use of forestland and other natural resources in areas up and downstream of the rivers for human activities lead to an increased sediment load in the river system (Islam, 1986). In the dry season, the in-stream sedimentation rate is increased due to an interruption of natural water flow. This creates strips of raised land, called *"Char"*, inside the river channels, which reduce the navigability.

Deposition of sandy materials on agricultural land is frequent in the lower regions of the piedmont areas of north Netrokona, and the valleys of Sylhet and Chittagong Hill tracts. It happens because of the deforestation of the hills in the upper catchment areas. During the monsoon season, heavy rainfalls occurs in the upper hill areas and causes flash floods in the lower plains. With the runoff the water carries sandy sediments that spread over the floodplain. This shrinks the water holding capacity of the low-lying areas. For example, siltation in the *Kaptai* Reservoir has increased from 1 mm to 1.2 mm per year due to deforestation and improper agricultural activities in surrounding hilly areas over the last decade (Hossain, 2000a). The impacts of gradual siltation of the land and the reduction of soil fertility are discussed in the Land Degradation chapter.

Withdrawal of Wetland Water

Withdrawal of water from wetland *haor*, *baor* and *beel* for irrigating agricultural lands, as well as for fishing, is a very common practice. Different agencies at different places all over the country have noticed the impacts of this ill-judged practice. The noteworthy impacts of such water use are the declining trend in production of aquatic species, and destruction of habitat for other wetland dependent species. The government of Bangladesh, among others, has initiated a new approach of "Community-Based Management of Aquatic Ecosystems" on a pilot scale to restore aquatic habitats and improve the quality of life of the local community.

Figure 3.2.1 Irrigated area in dry season by different technology



Source: WARPO, 1999b, Topic Paper 7

Dry Season Irrigation

Agriculture consumes the highest amount of water among the consumptive uses, in particular irrigating HYV crops. Over the last three decades, much effort has been put into intensification of agriculture by promoting dry season cropping through irrigation. Future demands of water for this will depend on the government policy for irrigated crop development.

A view of wetlands in dry season

Groundwater is an alternative source of water in dry season. A recent study shows the trends in groundwater use for irrigation and annual level of natural recharge. It shows that the groundwater aquifer is recharged annually through rainfall and flooding, and replenishes every year; except underneath Dhaka city, where an imbalance between recharge and groundwater extraction have been established (WARPO, 1999b). However, it is important to note that due to excess withdrawal of groundwater, water contamination such as arsenic pollution is on the rise. Thus, further use of groundwater does need re-evaluation.

The overall present trend of irrigated areas shows a steady rise (Figure 3.2.1), although a leveling off may be found in some areas. The trend may indicate that suction mode irrigation development has reached its limit in these areas, other non-resource factors may also influence the figures. These include land availability, the conflict between overlapping crops (e.g., transplanted *Aman* and wheat), the cost of growing *Boro* on permeable soils, and social and economic factors such as land ownership.

Climate variability and change is also an emerging issue that requires further assessment with respect to water resource management. As part of its program on climate change, the Government of Bangladesh has done an initial assessment incorporating the climate change scenario. Research and development on low water demanding and drought-tolerant crop varieties are also necessary.

Floods

Monsoon is characterized by excessive rainfall and surface runoff, which is mostly generated outside the geographical boundary of Bangladesh. About 78 per cent of the total rainfall occurs in the five months starting from June to October (WARPO, 1999b). The combined effect of surface runoff and monsoon rainfall makes the country vulnerable to flooding, which causes other water-related problems. Of major concern during floods is access to drinking water and its purity. The higher total and fecal coliform levels in the surface water at such times leads to a high incidence of diarrheal diseases, particularly surrounding the urban areas. Study results show that the surface water quality of Dhaka City during the 1998 flood was highly polluted and crossed the safe threshold limit set by the Department of Environment (Yusuf, 1998).

3.2.3 STATE AND IMPACTS

There are several government departments in Bangladesh dealing with water pollution and scarcity problems. Among them, the Department of Environment (DoE) deals with pollution issues. The Ministry of Water Resources, Ministry of Communication and Ministry of Agriculture, through its different branches, deals with scarcity.

DoE has been collecting data on surface water quality since 1980, at 11 points spread amongst five rivers of the country, i.e., *Buriganga*, *Sitalakhya*, *Balu*, the *Jamuna*, and the *Meghna*. Most of these points are located either towards the borders of the country or adjacent to known sources of pollution problems. A further 36 sites were added in 1991, of which only 14 sites are located in Dhaka and Chittagong Divisions. The relevant divisional offices of the DoE are collecting data on the remaining 22 points. Some sites are designated as Global Environmental Monitoring System (GEMS) points, the results of which are forwarded to Nairobi, Kenya, as part of an international commitment of the Government of Bangladesh. At present, DoE is monitoring water quality data at 69 stations, the details of which are presented in Table 3.2.3.

Various key parameters and indicators of water quality are monitored by the DoE. These include physiochemical characteristics of water, like the pH, dissolved oxygen (DO), biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), suspended solids (SS), total coliforms, heavy metals, electrical conductivity (EC), chloride, turbidity, total alkalinity and temperature.

The Bangladesh Water Development Board (BWDB) collects data on suspended sediments and surface water salinity. Data on surface water and groundwater salinity of the coastal area of the country are collected by the Soil Resources Development Institute (SRDI), and are available from 1990 to 1997.

The main source of data for groundwater quality is the Department of Public Health Engineering (DPHE), particularly for domestic water supply. Since the late 1980's, DPHE has undertaken routine monitoring of basic water quality parameters at production wells in different district centers. In Dhaka and Chittagong, Water Supply and Sewerage Authority (WASA) periodically monitors production wells. Since 1965, the monitoring programs of the Bangladesh Water Development Board include 19 parameters for 115 tubewells. Sampling work was also carried out under the Bangladesh Agricultural Development Corporation (BADC) Deep Tubewell Programs, covering the period 1977 to 1992, followed by the National Minor Irrigation Development Project (NMIDP). The recently completed, Groundwater Studies for Arsenic Contamination in Bangladesh, summarized the groundwater situation in the country, and in addition to arsenic levels, gives a wider analysis.

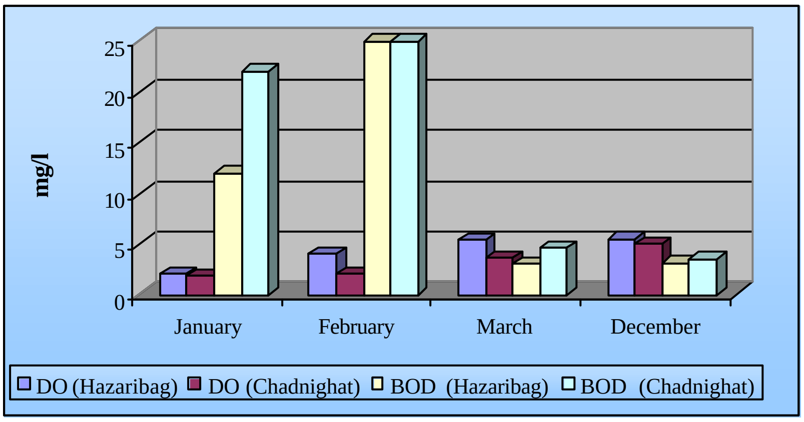
Table 3.2.3 Designated Stations for Water Quality Monitoring by DoE

Division	Name of the River	Number of Stations
Dhaka	Balu River	1
	The Brahmaputra River	5
	Buriganga	15
	Jamuna	2
	Meghna	2
	Sitalakhya	3
	Turag	1
	Dolasoria	1
	Kaligonga	1
	......	1
Chittagong	Dakatia River	1
	Halda	4
	Karnaphuli	1
	Kushiara River	1
	The Meghna River	1
	Surma River	4
	Kaptai Lake	1
Rajshahi	The Jamuna River	1
	Isamoti River	1
	Korotoya River	2
	The Padma	2
	Tangs River	1
	Tista River	3
Khulna	Bagherhat River	1
	Balesher River	1
	Bhoirab River	7
	Beel Dakatia	1
	Doratana River	1
	Gabkhan River	1
	Kakshialy River	2
	Kirtankhola River	1
	Kumar River	2
	Madhumati River	1
	The Padma	2
	Pashur River	1
	Rupsha	3
	Shugandha River	1
Total		69

Source: Rahman, October, 2000

Different industrial units, particularly pulp and paper mills, and fertilizer factories monitor surface water quality in the dry season, in order to maintain industrial production. In addition, a few other projects have collected data on inland and coastal water quality to cover their study objectives. Data on coastal water pollution and its sources are very scanty and unpublished. The Ministry of Defense and the Marine Science Institute of Chittagong University have some unpublished data on coastal and marine water quality of the country.

Figure 3.2.2 Water Quality of Buriganga, 1998



Source: Department of Environment, 2000

3.2.3.1 State and Impacts of Water Pollution

Longitudinal analysis of surface water quality data is difficult due to the absence of consistent data at the same monitoring points. In addition, the seasonality of flow in the watercourses from the main rivers constitutes a significant constraint to their ability to dilute and disperse effluent discharged into them. This becomes complicated further by the fact that some of the discharges are themselves seasonal in nature. Issues of concern regarding water quality data on the depths from where the samples were taken, and the state of the tide at that time in those areas. However, there is little debate that there are "hot spots" of water pollution due to industrial effluents around the major cities, i.e., Dhaka, Chittagong, Khulna and Bogra.

Inland Surface Water Pollution

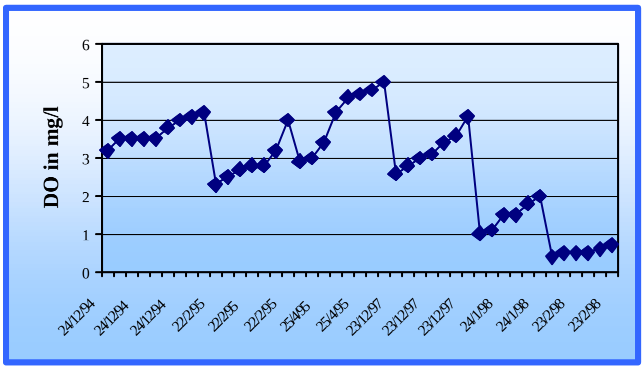
The overall inland surface water quality in the monsoon season is within tolerable limits, with a few exceptions, including the rivers *Buriganga*, *Balu*, *Shitalakhya*, *Karnaphuli*, and *Rupsha*. However, concerns over surface water quality are gradually emerging due to the dispersed locations of polluting industries, and the adverse effect on surrounding land and aquatic ecosystems, as well as subsequent impacts on the livelihood system of the local community. The extreme examples of this type of effect are near Dhaka at Konabari and Savar, where industrial effluents are discharged into nearby land and water bodies without any treatment.

Among the polluted areas, the worst problems are in the River *Buriganga* situated to the south of Dhaka, where the most significant source of pollution appears to be from tanneries in the Hazaribagh area. In the dry season, the dissolved oxygen level becomes very low or non-existent and the river becomes toxic (WARPO, 1999a). Water quality data at two stations of the river *Buriganga* in 1998, Hazaribag and Chadnighat, showed that DO and BOD exceeded the tolerable limits in the months of January, February, March and December, with the worst situation prevailing in the months of January and February (Figure 3.2.2). The seasonal variation of water quality in the *Buriganga* is linked with seasonal variation of water flow and the operation of tanneries. The recent construction of the nearby flood protection embankment, whilst concentrating the effluent near the works, may have the possible advantage of restricting the wider dispersion of this very heavy pollution.

The second most polluted river is the *Shitalakhya*, flowing from the east of Dhaka. The major polluters of the river are Ghorashal Urea Fertilizer Factory and an oil terminal situated on the bank of the river. Industrial units at Narayanganj and Demra are also sources of the pollution. Monitoring data of the DoE demonstrated that the concentration of dissolved oxygen in the river *Shitalakhya* beside the fertilizer factory varies between 2.1 to 2.9 mg/l during low tide (DOE, 1993). Monitoring data of the Surface Water Modelling Centre (SWMC) on the same river, showed a degrading trend for water quality in the dry season. The lowest level of DO was observed at the end of February 1998, when the concentration became less than one (Figure 3.2.3).

Water of the river *Balu* is badly contaminated by urban and industrial wastes from Tongi and the effluent flowing out through the *Begubari Khal*, most of which emanates from the Tejgaon industrial area in Dhaka. In the rivers *Balu* and *Turag*, water quality in the dry season becomes worse, with DO concentrations becoming almost zero (Saad, 2000).

Figure 3.2.3 Concentration of Dissolve Oxygen in the River *Shitalakhya* in different time of day and year



Source: SWMC

In terms of data from point sources on other rivers, there is a specific problem with the Jamuna Fertilizer Factory in the dry season. The low flow channel, which serves as both the source of processing water and recipient of wastewater, also increases the pollution level in the river. The discharge point has moved some 10 km away from the factory site, due to the complex erosion and accretion patterns.

One study was undertaken the year 2000 in Kaliakoir by the Bangladesh Centre for Advanced Studies (BCAS), for a project named "Management of Aquatic Ecosystem through Community Husbandry (MACH)". A number of textile and leather industries discharge their industrial effluents into a nearby small water body, *Mokesh Beel*. The study analyzed both water and sediments of the study area. The results showed that levels of COD, TSS and DO in the water exceeded standard limits. It also showed that the total chromium concentration in sediments and wastewaters near the discharge points of the local tannery and textile industries is very high. The concentrations of zinc, lead and cadmium were also found to be higher than the national standards (BCAS, 2000).

Groundwater Pollution

Groundwater has different uses, but the standard for its quality was set nationally. Groundwater was treated as the best source of safe drinking water, before arsenic contamination was reported. However, 54 per cent of hand pumped tubewells were found to have fecal contamination, due to poor wellhead design, faulty construction and management, but the aquifers themselves were not polluted (Hoque, 1998).

Arsenic

High levels of arsenic in groundwater can cause serious human health problems if imbibed for a long time (from 5 to 15 years); including skin ailments, damage to internal organs, skin and lung cancers, and eventual death. The recent major studies carried out on arsenic reveal that among 30,000 tubewells studied, 2,000 of them exceeded the national standard of 0.05 mg/l for drinking purposes (the WHO guideline is 0.01 mg/l).

The problem is acute in tubewells abstracting groundwater from 10 m to 100 m depths in the Southeast, South Central (the northern part only), and Southwest regions. To a lesser extent, the eastern part of the Northeast region, and the very southern fringe of the North Central and Northwest along the river Ganges are affected. The most seriously affected districts are Chandpur, and those around it. It was estimated that more than 20 million people drink water exceeding the national standard for arsenic levels.

The presence of arsenic is a naturally occurring phenomenon, but prolonged use of the water can be very harmful when the levels cross the standard limit. Contrary to earlier reports by the press, the available evidence strongly argues against the idea that arsenic contamination originates either from the use of synthetic chemicals, such as wood preservatives, or insecticides.

Arsenic contamination has considerably serious implications for groundwater abstraction in affected areas. This impinges on domestic water supply, since groundwater is the preferred source, because compared to surface water it is less likely to be fecally polluted. Already thousands of cases of arsenic poisoning have been recorded among local people, and some deaths have been reported. Clinical studies are being carried out by the Dhaka Community Hospital.

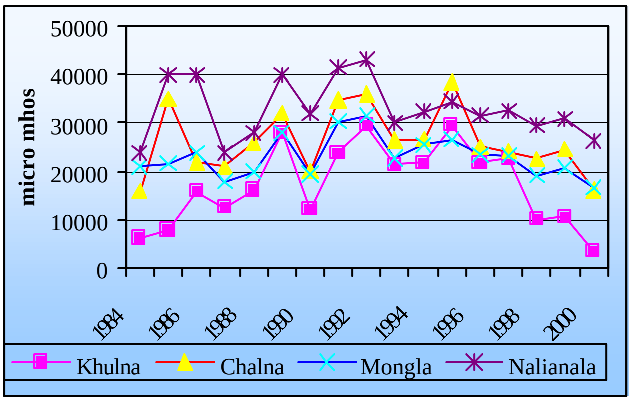
In agriculture, there are also serious implications from the possible transfer of arsenic into the food chain through crops that are under irrigation with arsenic-contaminated water, and then consumed by humans. There is little evidence of arsenic contamination in rice grains through irrigation with arsenic contaminated water. However, boiling rice in arsenic-affected water does lead to its contamination, which causes serious problems. The crops most likely to absorb arsenic from irrigation are leafy vegetables, and possibly coconuts, and melons. These crops pass arsenic into the food chain.

The effects of arsenic on pond-reared fishes are now under study. Livestock that drinks arsenic-contaminated water should also be under study, because humans consume these animals and their products. The infiltration of arsenic-affected water in the soil also needs to be studied, along with possibility of infiltration into shallow aquifers.

Source: WARPO, 2000b

Iron concentration in the groundwater in many parts of the country, particularly the central parts, is much higher than the WHO and national recommended limits, but there are no known human health implications. There are high natural occurrences of manganese (above the WHO guidelines for drinking water), particularly in the west, central and northern parts of the country. 30 per cent of wells have high manganese levels, and

Figure 3.2.4 Trend of Highest Salinity Concentration



Source: BBS and SWMC

this is harmful for human health (WARPO, 1999a). Concern also exists regarding the concentrations of manganese, boron, phosphorus phosphate, and nitrate from agrochemical residues in groundwater, some of which have already crossed the threshold limits, making it unfit for human consumption.

Coastal Water Pollution

The coastal morphology of the country is very dynamic, with a zone of freshwater and saline seawater interaction. There are two main problems existing in the coastal water bodies, namely, water pollution in the marine zone and salinity in the estuary. The magnitude of these problems depends on seasonal freshwater flow from river systems, pollution load through runoff from land based activities,

Table 3.2.4 Dissolved metal concentrations in water along Chittagong and Cox's Bazar Coasts

Parameter	Mean (ppm)	Max (ppm)	Min (ppm)
Fe	0.43	1.02	0.00
Pb	0.35	0.60	0.04
Cd	0.06	0.10	0.03
Cu	0.04	0.08	0.01
Zn	0.08	0.18	0.02
Mn	0.04	0.41	0.00

Source: Chowdhury et. al., 1994

operation of seaports and other sea-based activities (Hossain, 2000b).

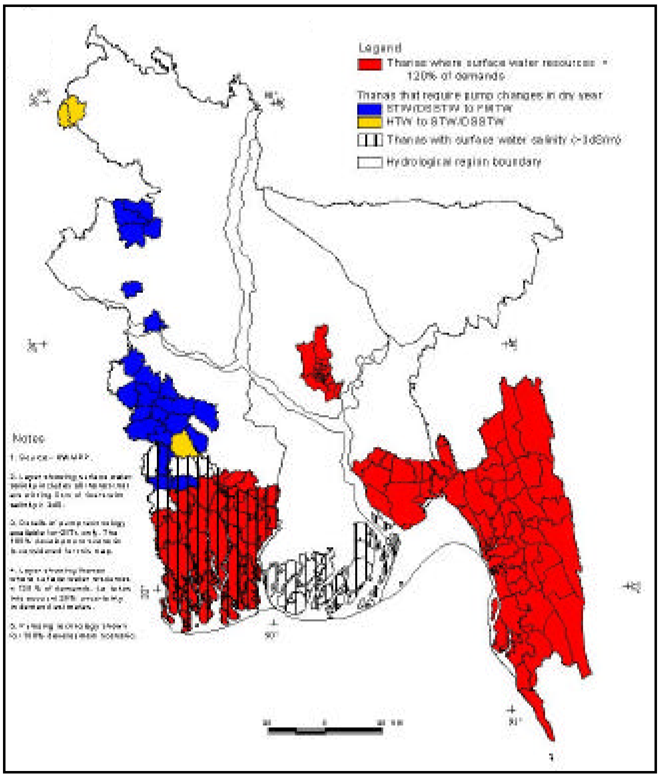
A preliminary assessment of water and sediment pollution load along the coasts of Chittagong and Cox's Bazar showed that the dissolved concentrations of metallic and non-metallic elements in water are higher towards the sea. Conversely, the metallic and non-metallic concentrations in the case of sediments are higher towards land. This is mostly due to land-based activities and untreated effluents from urban centers. The lead concentration has crossed the acceptable level (0.2 ppm) in most areas, except *Bakkhali*, lower *Kumira*, and upper and lower *Karnaphuli* (Chowdhury *et. al.*, 1994). Details of dissolved concentrations of metals in water samples are presented in Table 3.2.4.

The DoE has conducted a survey on ship-breaking industries and seawater quality on the coasts. The survey results showed that about 50 ship-breaking industries are operating in the Chittagong region, discharging effluents that are polluting both the land and water environments. Concentration of DO varies from 5.6 to 5.8 mg/l and the BOD varies from 2.2 to 2.5 mg/l (DoE, 1997).

There is a seasonally moveable salinity interface in the estuaries, with the threshold limit for agriculture (2dS/m) moving inland in May in the southern part of Bhola and other southern islands. There are also salinity issues in the Southwest region, attributed to reduced dry season flows into the area from the *Ganges* system. During the 1990s dry season, salinity levels in the Khulna area rose, for which one of the likely causes was postulated to be the decrease in dry season surface flow from the *Ganges* (DHV, 1998). The highest salinity concentrations of four selected stations in the coastal rivers from 1984 to 2000 are presented in Figure 3.2.4. It shows an increasing trend up to 1996 in Nalianala, followed by Chalna, Mongla and Khulna. The situation has improved slightly after the signing of the "Ganges Water Sharing Treaty" in 1996.

The major groundwater salinity problem lies in the coastal areas of the country. This causes a constraint on its use, but there are some localized freshwater sources close to the coast. Upstream abstractions of groundwater reduce the ability of freshwater to hold back salinity intrusion, and this is reported to be a major concern in the Khulna area and other parts of the southern half of the Southwest region (WARPO, 1999a). Fresh groundwater in most coastal areas has to be abstracted from a depth of over 150 m, up to 450 m. This can be relatively expensive to develop and operate. Although this does restrict the use of the deep

Figure 3.2.5 Water Scarcity Zones



Sources: WARPO, 1999b

aquifer for irrigation, compared to shallow aquifers it has the benefit of being free from arsenic. There are also residual salinity problems in Comilla, Brahmanbaria and Chandpur caused by old deposits, from the time when the areas were under a marine ecosystem.

3.2.3.2 State and Impacts of Water Scarcity

The situation common in the country is that of an abundance of water in the monsoon and less water in the river system in the dry season. The impacts of scarcity of water in terms of quantity, as well as its quality, are immense, having effects on its demand for consumptive and non-consumptive use.

The significant environmental indicators for available inland water are lowering of water level and discharge in the major rivers. The fluctuation and lowering of groundwater levels are used for monitoring the situation. Dry season water flow, obviously depends on upstream water withdrawals, and therefore has cross-sectoral impacts. Lean water flow in the river systems has impacts on inland water navigation, aquatic resources, salt-water intrusion, pressure on groundwater and pollution dilution. Salinity and its impacts have been discussed earlier under Land Degradation, and the issue of aquatic resources and biodiversity has been discussed in the Biodiversity chapter.

Surface water scarcity is observed in the Sundarbans, Chittagong, Noakhali and Dhaka regions, where the ecological and environmental demands for surface water are higher than the supply. Figure 3.2.5 shows the spatial distribution of areas having water scarcity problems.

River Water Level

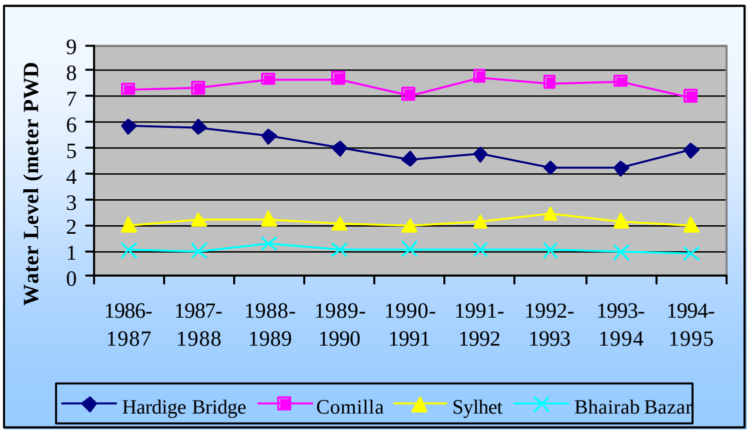
Over the last few decades the major river water levels in the dry season have shown a declining trend. As a result, there is practically no water flow in small tributaries and distributaries that do play an important role in agriculture, fisheries and biodiversity. The lean flow of the major rivers also play a critical role in saline water intrusion into the river system, navigation problems in the rivers, and puts pressure on groundwater for irrigation. All these ultimately results in yield reduction in coastal agriculture and industries, decline in the quality of coastal ecosystems, particularly the Sundarbans ecosystem, and decline in the groundwater table. Figure 3.2.6 presents the trend of lowest water levels of the *Ganges-Padma* and the *Meghna*, at Hardinge Bridge and Bhairabbazar, respectively.

One of the major impacts of the lowering in dry season river water flow is increasing surface water salinity in coastal areas and salt-water intrusion. Salinity plays a limiting role in crop agriculture and industrial production in the coastal areas of Bangladesh. The available literature on impacts of salinity on different crops suggests that the soil salinity reduces productivity of rice during its germination, vegetative (early) growth and reproductive stages (Bhumbla *et. al.*, 1968; Rai, 1977a; Rai, 1977b; Ayers and Westcot, 1976; Das *et. al.*, 1971; BRRI, 1983; BARC, 1981-82 and BARC, 1982-83). The Land Degradation section deals in detail with salinity impact on crop agriculture in the coastal regions of Bangladesh.

Groundwater Level

WARPO recently analyzed the groundwater resources of the country under the "National Water

Figure 3.2.6 Trend of Lowest Water Level



Source: BBS, 1990, 1992, 1994, 1998

Management Plan Project". The study showed that the groundwater table of the country has been lowered over the last ten years (WARPO, 1999b). The analysis was conducted using data from the groundwater monitoring wells distributed all over the country. It was also found that natural inflow of groundwater to streams and other surface water bodies has reduced with increased use of pumping for irrigation.

The fluctuation of groundwater has been observed all over the country, and the highest levels of fluctuation are in the north central, northeast and southeast regions of the country.

The spatial distribution in a normal year of maximum depth to groundwater showed that in the northwestern part of the country the groundwater is at relatively less in depth, whereas the north central region has a deeper groundwater table. Spatial distribution of depth to groundwater in a normal year is presented in Figure 3.2.7.

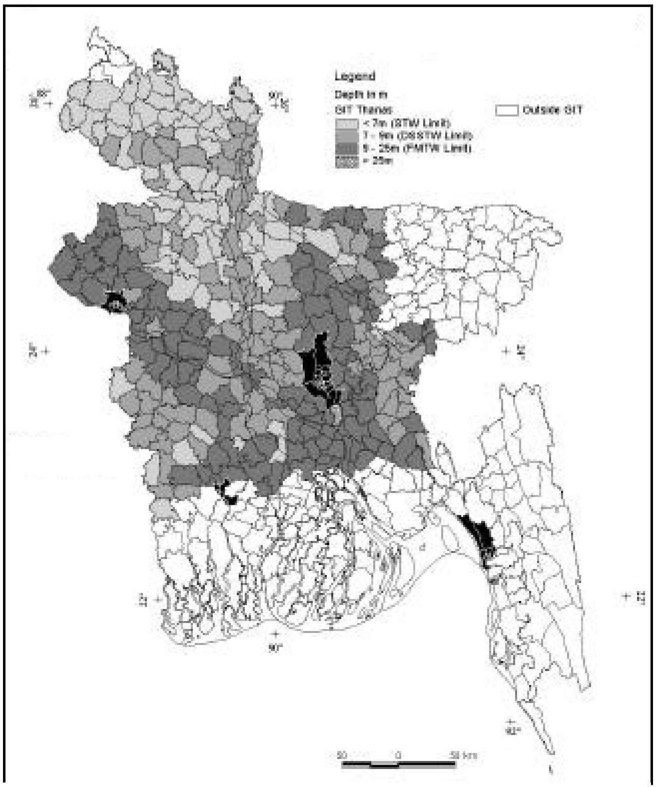
3.2.4 RESPONSES

The need for a human response to problems associated with water date back to the early history of civilization and development. Most of the responses were based upon water scarcity and abundance as constraints to development. Thus, many of the initial bureaucratic acts and rules pertaining to water in the region of Bangladesh were to meet sectoral demands and needs, for example, the Irrigation Act in 1876, and the Agricultural and Sanitary Improvement Act, 1929. The importance of comprehensive water development and management, with mostly supply-side management, was recognized after the flood havoc of 1954 and 1955, and its implementation was accelerated after the country got independence.

Water quality issues of the country (along with other environmental issues) were emphasized in the Bangladesh Environment Policy, 1992, and more detail was outlined in the Environment Conservation Act, 1995 and Environment Conservation Rules of 1997. The National Water Policy, 1999, also emphasized water pollution, and supply and demand side management. Nowadays, it is well recognized that it is not the acts, laws and rules addressing water pollution and management of water resources that are inadequate, but rather their enforcement. The following section will highlight major institutions involved in water management and its quality, along with their policies. It will also give an analysis of policy and program gaps, and the future course of actions that are required to attain the policy objectives and goals.

In 1983, the government initiated a National Water Plan (NWP) preparation exercise, which was completed in 1986 and was updated in 1991. After the

Figure 3.2.7 Maximum Depth to Groundwater



Sources: WARPO, 1999b

two consecutive devastating floods of 1987 and 1988, a five-year Flood Action Plan (FAP) project was launched, with an emphasis on flood mitigation measures. It was gradually recognized that the FAP studies should pay attention to integrated water resources management, and not just the problem associated with flood. In March 1998, the National Water Management Plan (NWMP) project was launched and its completion is expected by November 2001. The project will develop a water management plan up to the year 2025.

The massive general development effort of the government has led to the creation of a number of agencies responsible for water development in the country. A National Water Council has been formed, which consists of ministers and nominated members of parliament, headed by the Prime Minister. This committee is the highest decision-making authority for policy regarding water resources development in the country.

The Ministry of Water Resources is the principal government organization responsible for formulation of national plans for water resource development. Water Resources Planning Organization (WARPO) and with multidisciplinary professionals from other organizations, such as the Ministry of Agriculture, Inland Water Transport Authority (IWTA), DPHE, WASA under the Local Government and Rural Development (LGRD), Ministry of Environment and Forest (MoEF), and Ministry of Fisheries and Livestock (MoFL).

The Bangladesh Water Development Board (BWDB) was established in 1972, from the division of the former East Pakistan Water and Power Development Authority (EPWAPDA) into the two separate Water Development and Power Development Boards. It is under the Ministry of Water Resources, and is the organization responsible for implementation; operation and maintenance of water related projects. This includes surface water irrigation, drainage, flood control, erosion control, town protection and river training throughout the country.

3.2.4.1 Institutions

Department of Environment (DoE)

The primary institution for environmental management is the Department of Environment (DoE), under the Ministry of Environment and Forest (MoEF). The DoE is the authority with the mandate to regulate and enforce environmental management, and the setting and enforcement of environmental regulations, including the pollution control of water resources.

Its key duties related to the water pollution include:

- Pollution control, including monitoring effluent sources and ensuring mitigation of environmental pollution;
- Setting Water Quality Standards (WQS) for particular uses of water and for discharge to water bodies;
- Defining Environmental Impact Assessment (EIA) procedures and issuing environmental clearance permits - the latter being legal requirements before proposed projects can proceed to implementation;
- Providing advice or taking direct action to prevent degradation of the environment;
- Declaring Environmentally Critical Areas (ECAs) where the ecosystem has been degraded to a critical state. ECA status confers protection on land and water resources through a series of environmental regulations.

Water Resources Planning Organization (WARPO)

Under the National Water Policy (NWPo), the National Water Resources Council (NWRC) forms the apex coordinating body for water resources management. WARPO is the mandated planning agency for water resources management and acts as the Secretariat of the Executive Committee of NWRC (ECNWRC). As the Secretariat of ECNWRC, WARPO has the responsibility to advise on policy, planning and regulatory matters concerning water resources, and related land and environmental management. It is also emphasized in the NWPo that the activity of WARPO should be complementary to the role of DoE, and active cooperation between the two organizations needs to be strengthened. The involvement of WARPO in pre-screening EIAs for water sector projects, in advance of submission to DoE for final clearance, would relieve part of the burden on DoE. In addition to its contribution in such clearing-house activities, the WARPO Environmental Section is being prepared to play an active role in raising environmental standards as a whole in the water sector. To this end, WARPO is expected to progressively undertake the following functions:

- Participation in the development of the NWMP, and subsequent updates to ensure fulfillment of NWPo environmental objectives;
- In collaboration with DoE and other line agencies, develop environmental standards and guidelines relevant to the water sector, in conformity with the NWPo, and the various laws and regulations;
- Monitoring the efficacy of water sector standards and guidelines in achieving the aims and objectives of the NWPo and NWMP, and as necessary recommending improvements;
- Raising environmental awareness of water-related issues through relevant agencies to wider civil society;
- Advice on environmental impacts of the portfolio of projects included in other government departments with an interest in environmental management of water resources, such as the Department of Fisheries (DoF), under the Ministry of Fisheries and Livestock (MoFL), and the Forest Department (FD). The DoF has field-based staff down to *thana* level, and with the Ministry of Lands (MoL) is at present responsible for the management of public water bodies. However, this is changing, as shown by the recent (August 2000) transfer of responsibility for water bodies larger than 20 acres from MoL to MoFL for a ten-year (renewable) period.

There are also many important non-government organizations (NGOs) in Bangladesh with environmental interests. These include: the International Union for the Conservation of Nature (IUCN), National EIA Association, International Centre for Living Aquatic Resources Management (ICLARM), Bangladesh Centre for Advanced Studies (BCAS), Surface Water Modelling Centre (SWMC), Environment and GIS Support for Water Sector Planning Project (EGIS), Local Government Engineering Department (LGED) and the Bangladesh Environmental Lawyers Association (BELA). ICLARM has specific wetland management programs for the country. BCAS has provided assistance to the MoEF and prepared National Environment Management Action Plan (NEMAP). Apart from being a significant lobbying body, BELA has also provided assistance with drafting environmental legislation, and is beginning to place public-interest litigation on environmental cases before court. The Coalition of Environmental NGOs (CEN) is the lobbying organization for national NGOs with regard to environmental matters. In addition, there are single-issue NGOs, some of whom have area-based operations, and specific environmental interests which relate to the water sector. As an example of such an organization is the Coastal Area Resource Development and Management Association (CARDMA).

3.2.4.2 Major Policy Responses

National Environment Policy, 1992

The National Environment Policy was drawn up in 1992 based on the IUCN concept of sustainable development, which was an outcome of the National Conservation Strategy.

The objectives of the NEP are to:

i) Maintain ecological balance and overall development through protection and improvement of the environment;

ii) Protect the country against natural disasters;

iii) Identify and regulate activities which pollute and degrade the environment;

iv) Ensure development that is environmentally sound for all sectors;

v) Ensure sustainable, long-term, and environmentally sound use of all national resources;

vi) Actively remain associated with all international environmental initiatives to the maximum possible extent.

The 1995 NEMAP aimed to institutionalize both the Policy and the NCS into a strategy that could be implemented. NEMAP was based on a national consultative process to identify the main environmental issues in the country, including those that relate to water pollution and scarcity.

National Water Policy, 1999

With over 50 clauses of relevance to the environment, the 1999 National Water Policy (NWPo,) forms a comprehensive framework for ensuring activities in the water resources sector are fully environment friendly. Its many environmental concerns and specific demands recognize that most of the country's environmental resources are linked to water. Compliance with the Policy will ensure that the development and management of the nation's water resources include protection, restoration, preservation of natural habitats and their dependent bio-diversity, and water quality - with specific provisions for wetlands, mangrove and other forests, and endangered species. The Policy also prescribes water resource management practices that avoid, or at least minimize, environmental degradation. Specific provisions include:

- Protection, restoration and enhancement of the water resources;
- Protection of water quality, including strengthening of the regulations concerning agro-chemicals and industrial effluent monitoring;
- Facilitation of potable water and sanitation provision;
- Provisions for fish and fisheries;
- Participation of local communities is a requirement for all water sector development as a subject to an environmental assessment procedure and for the planning and management process.

In addition, the Government of Bangladesh has signed several international conventions that have implications for environmental aspects of water resources planning. The major conventions are: Agenda 21, the 1992 Rio Convention on Climate Change and Biological Diversity, the 1971 Ramsar Convention on Wetlands, the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) and the 1954 International Convention for Prevention of Pollution of the Sea by Oil. Under the last, permitted discharge amounts and locations from ships are specified. Bangladesh has also ratified the Marine Pollution Conventions (MARPOL). These conventions regulate handling of domestic and (bilge) oil waste from ships, and receptor facilities in harbors, as well as domestic and waste oil handling from oil platforms.

3.2.4.3 Legal and Regulatory Framework

As a response to the National Environment Policy, 1992, the following critical pieces of environmental legislation have been set as the framework for environmental management of the country:

i) The 1995 Environmental Conservation Act

ii) The Environmental Conservation Rules of 1997

iii) The 1997 EIA Guidelines for Industries

iv) The 1999 Environmental Court Act

The Environmental Conservation Act and Rules

The 1995 law is an enabling act, which gives the MoEF the power to draw up rules and guidelines for managing the environment. The law also designates the DoE as the responsible body for enforcing the EIA procedures outlined in the 1997 Rules, along with the legal procedures to be followed for implementing the EIA process. The rules also designate four classes of possible interventions by degree of expected environmental impact. The Environmental Conservation Rules also contain national environmental standards, including those for water quality standards for different sectors and purposes.

The EIA Guidelines for Industry

Despite its title, the EIA Guidelines for Industries covers significant water sector interventions, including flood control embankments, polders, dykes, water supply and sewage treatment, as well as roads and bridges. All these water sector interventions fall under the 'Red' category, with the exception of bridges less than 100 m long, and feeder and local roads. This requires the most stringent EIA process to be followed for proposed project construction, re-construction and extension.

The responsibility for following the environmental assessment procedure lies with the project proponent or developer. The procedures are different, depending upon the categorization of the proposed intervention. The two most stringent classes, Orange/Amber B and Red, are required to have an Initial Environmental Examination (IEE), with an Environmental Management Plan (EMP). The red classification requires an additional full EIA to be undertaken. Once the DoE approves these documents, then a Site Clearance Certificate is issued - provided the developer has obtained a 'No Objection Certificate' from the local authority.

Environmental Quality Standards

The National Environmental Quality Standards are given in the Environmental Conservation Rules of 1997. These set a range of water quality criteria and limits depending upon the intended uses, including use for human drinking water, livestock drinking, fisheries, recreation, irrigated agriculture and industry. Discharge standards are also specified by sources, including public sewage outfalls, irrigation water and specific types of industrial discharges by size. The overriding problem of environmental standards in Bangladesh is the difficulty in enforcing them.

Moreover, the regulations are essentially 'end-of-pipe' standards, or just abstractions. Although there is an Ambient Water Standard, it covers none of the many chemical pollutants known to be discharged. There is no effective regulation that takes into account the ability of rivers to dilute and disperse effluent, especially in times of low flow, and under complex cumulative discharge patterns. These cumulative impacts are crucially important for the natural aquatic environment.

EIA Guidelines for the Water Resources Sector

The environmental component of the Flood Action Plan, FAP 16, drew up a set of EIA Guidelines, which were approved by the MoEF and DoE for use in the water resources sector; and they were adopted by FPCO and WARPO in 1992.

In addition to the water resources EIA Guidelines, FAP 16 drafted a manual in 1995 for carrying out EIA. The manual was intended to assist people not familiar with EIA work, and to give more detail on the use of the Guidelines for a wide range of water sector projects. Under SEMP, the DoE has recently started drafting 18 sets of sectoral EIA Guidelines. WARPO and DoE are at present collaborating on new guidelines for the Water Resources Sector, which in time ought to replace the water resource sections of the Industry Guidelines.

3.2.5 GAPS AND FUTURE CONCERNS

Notwithstanding the large number of rules and regulations to protect water from industrial effluents and other pollution, and the policies for enabling the environment through dry season augmentation of water, there is a lack of institutional capability to enforce them, and there are few action programs. There is also a lack of skills and expertise for taking appropriate action

Table 3.2.5 Policy, legal and regulatory framework, and actions programs to address the water pollution and scarcity

Pressures	Policy, Legal and Regulatory Framework	Program Undertaken	Probable Options to Address the Problem
Industrial Effluent	Industrial Policy, Environmental Conservation Act and Regulation, Guidelines for Industrial EIA	There is very limited action program. Need institutional strengthening, and enforcement of laws and regulations	Installation of Treatment Plant, Land Zoning, Enforcement of ECA and ECR
Agrochemical	Agricultural Policy. Government has regulatory body, with some departmental rules to oversee import of agrochemicals and their use. However, legal and regulatory framework is not present	Need wider dissemination of knowledge regarding balanced use of agrochemicals. Need legal and regulatory framework for banning import of hazardous agrochemicals	Awareness Campaign, Proper use of Agrochemicals and Introduction of IPNS
Fecal Pollution	Safe water supply, and sanitation policy	Both government and non-government organizations are working in water supply and sanitation. Municipal wastewater treatment needs more attention as very limited measures have been done	Safe Sanitation System and awareness raising
Ship-breaking and lube oil discharge at sea	Bangladesh signed the UN Convention on the Law of the Sea in 1982. Environmental Conservation Act and Regulation	There is very limited action program. Need institutional strengthening, and enforcement of laws and regulations.	Enforcement of ECA and ECR, West reception and treatment facilities at port
Low water flow in the river system in dry season	National Water Policy. Ganges Water Treaty	Augmentation of dry season water flow, consumptive use of surface and groundwater for irrigation. Ganges Barrage	Strengthening of regional cooperation, implementation of Ganges Barrage project
Upstream withdrawal for consumptive and non-consumptive use	Ganges Water Treaty. National Water Policy: Dredging and water harvesting, regional cooperation, augmentation of dry season flow, and use of surface water for irrigation	Regional cooperation and need institutional strengthening and financial support. Awareness-raising for consumptive use of surface and groundwater for irrigation	Strengthening of regional cooperation

Source: SoE Study Team

during project design and implementation, to ensure that environmental concerns should be properly addressed. The most important issue is the apparent overlap in the mandates of the Ministry of Environment and Forest (MoEF), WARPO and NWRC in developing policies regarding water resources development and management. However, over the last decade progress has been made, particularly in identifying environmental issues and potential solutions. An analysis is presented in Table 3.2.5 of policy, legal, and regulatory frameworks, and action programs to address water pollution problems.

Future concerns prevail regarding the implementation of national policies, due to lack of institutional capability and awareness to properly address the policy objectives and goals. Earlier analysis of climate change scenarios show that water scarcity in the dry season would be aggravated, and low water flow in the river system would allow further saline water intrusion into it. Therefore, climate change and its impact on water pollution and scarcity need further integrated analysis. An analysis is presented in Table 3.2.6 on possible future concerns and implications of various national polices on water-related environmental issues and required actions.

Table 3.2.6 Future Concerns regarding other National Polices and Water-related Environmental Issues

National Policy and Key Water-related Environmental Issues	Future Concerns/Implication	Need to Address the Issues
Agriculture (1999): Increased food crop production for food security; environmentally-friendly, sustainable agriculture; strengthening of agro-forestry; research, e.g. on fish and rice; introduction of improved HYVs	Possible land use competition and increased water pollution due to unbalanced use of agrochemicals, though the policy document emphasizes more balanced use of agrochemicals	Strengthening of existing dissemination activities about balanced use of agrochemicals. This should be based on agro-ecological units and soil requirement
Energy (1995): Expansion of generating capacity	Chemical and heat pollution of water.	Enforcement of environmental laws and regulations
Fisheries and Livestock (1998): Conservation of fish habitats, including fish sanctuaries; integrated fish/shrimp/ rice production; banning agro-chemicals; promotion of culture fisheries; banning complete dewatering of water bodies; conservation of fish and other biodiversity; sustainable coastal fish/shrimp production; fisheries committees at all levels	Possible land use competition and population pressures to meet demand, particularly between HYV *Boro* and overexploitation of aquatic resources	Harmonization of Agriculture, Fisheries and Livestock Polices. Awareness-raising at community level and develop appropriate land use and cropping pattern
Forestry (1994): Wildlife protection and biodiversity conservation; afforestation; prevention of adverse impacts on mangroves and other ecosystems; integrating of trees and traditional land uses, expansion of forest area	Land use competition, and raising conflict among the sectors.	Harmonization and coordination among different ministries and departments. Awareness-raising among the different stakeholders
Industry (1999): Raising industrial share of GDP from 10% to 25% in 10 years; encouragement of private enterprise; environmentally sustainable development, conforming to law; ISO 14000 certification encouraged	Increased production/dispersal could increase severity and spread of population problem	Institutional strengthening to enforce environmental rules and regulations. Coordination between DoE and Ministry of Industry is needed
Land: Agricultural land zoning; provisions for leasing of inland open waters; coastal greenbelt creation; participatory forestry on roads	This will support pollution reduction and enrich water environment	Institutional strengthening and coordination is required
Safe Drinking Water Supply and Sanitation (1998): Increased and sustainable basic water supply and sanitation; mitigation of arsenic problems; storm water drainage in urban areas; community participation and social awareness	Surface water quality and groundwater arsenic mitigation are major concern for future	Institutional strengthening, coordination, awareness raising, and ensure community participation
Wetlands (Draft, 1998) Wetlands conservation, sustainable development, and biodiversity conservation; wetlands survey and database maintenance of wetland functions; people's participation in development decisions	Conforms and overlaps with Water Policy; careful definition of wetlands required	Institutional strengthening, coordination, awareness-raising, and ensure community participation

Source: SoE Study Team

3.2.6 OPTIONS AND ACTIONS FOR POLLUTION MANAGEMENT

The Environmental Conservation Acts and Rules, and National Water Policy have adequate clauses related to industrial pollution. This includes water quality protection, institutions to prevent pollution, effluent discharge monitoring, zoning regulations for new industries and strengthening of the regulatory system for agrochemical pollution control.

Under Bangladesh Environment Management Program (BEMP) and Sustainable Environment Management Program (SEMP), the DoE is currently working towards improved water quality monitoring, and estimation of pollution loads in the rivers and watercourses, along with institutional strengthening. The initiatives include preparation of Guidelines for EIA applicable to several sectors, including flood control and drainage. The associated institutional strengthening is also underway. The focus of these initiatives is on ambient water quality monitoring and regulation of proposed new industries. However, there are few initiatives to address the immediate problems, for clean-up programs for the serious industrial pollution caused by existing industries. The DoE have not yet set any guidelines for these in any detail or detail clear time-bound targets. Clear measures for ensuring compliance with the environmental laws and regulations, including enforcement, are lacking. Without clean-up action in and around the main cities, water quality will continue to worsen in the foreseeable future, constituting a major threat to millions of lives and livelihoods, especially of the very poor.

The absolute numbers of polluting industries that have to be dealt with as over 1000 in Dhaka and

Table 3.2.7 A brief description of water quality management options with anticipated outcome and actors

Option	Outcome of the Option	Actors
Land zoning of industries: *Export Processing Zone, Industrial Park etc.*	Support collective treatment of wastes. Reduce pollution load in water ecosystem system	Ministry of Land, Ministry of Industry, Ministry of Environment and Forest and Department of Environment. Private sector and business community
Enforcement: *ECA, ECR, WQS, EIA and environmental audit.*	Help to build institutional capability to deal with rules and regulation. Reduce pollution load and other environmental impacts of industries and other development projects	Ministry of Environment and Forest, Department of Environment, Ministry of Industry, Ministry of Water Resources. Media campaign, NGO actions and campaign on particular issues
Clean-up and Rehabilitation of Pollution Hot-spots: *Dhaka, Chittagong, Khulna etc,*	Make the water available once again for different use and restore habitat for fishes, and other economic activities (e.g. potable water supplies). For example, for Dhaka this would then obviate the need to seek relatively costly unpolluted potable water sources at great distances from the city	Ministry of Environment and Forest, Department of Environment, Ministry of Industry, Ministry of Water Resources. Media campaign, NGO actions and campaign on specific site. Involvement of local community in the clean-up program
Strengthening of Water Quality Monitoring Program: *Nationwide*	Comprehensive water quality data including discharge ('end-of-pipe') and/or identifying the sources of specific pollutants found in receiving waters, water flow in the river course, tidal influence etc	Ministry of Environment and Forest, Department of Environment, Ministry of Industry, Ministry of Water Resources
Maintenance of Dilution and Dispersion Flows in Rivers: *Dry season water flow*	Dilution and dispersion of pollutants in river system will reduce pollution load and concentration	Ministry of Water Resource, Ministry of Environment and Forest, Department of Environment
Sediment Control and Reduction in the Main Rivers	Reduce sediment load in the major river system and subsequently less sedimentation will be found the floodplain	Internationally coordinated action is required to reduce soil erosion in the upper catchments. Activities can be canalized through Joint River Commission, Ministry of Water Resource
Waste reception and treatment facilities in ports: *Chittagong and*	Enable port to receive bilge and ballast water for treatment. Reduce pollution load in the coastal area	Ministry of Shipping and Port Authority
Strengthening of Coast Guard Ships	Enable to detect oil and lube oil spillage	Ministry of Shipping and Port Authority
Study of Bio-accumulation	Enable to detect accumulation of harmful substances in aquatic species and its health hazards	Fisheries Department of Fisheries, Department of Environment, Ministry of Health
Study on Agrochemicals Residues in Water	Enable to detect residues of agrochemicals in water ecosystem	Department Environment, Department of Agriculture

Source: SoE Study Team

over 600 in Chittagong alone. It is suggested that no realistic strengthening and expansion of the DoE will be able to cope directly with all the problems. Therefore, an essential component of any pollution clean-up strategy must be through mobilization of other organizations and the public in generag, including public-private partnership approaches. The supporting measures must allow concerned groups or even ordinary citizens to have legal access to redress water pollution problems.

The following options may be put forward to address the requirements of the National Environment Policy and National Water Policy. A brief description of water quality management options, which could be considered separately or in a combined manner, with their anticipated outcomes, and possible actors, is presented in Table 3.2.7.

To address water pollution and scarcity problems through undertaking various options mentioned above needs institutional coordination, strengthening, and strategies for obtaining research and study funds from the international donor community.

3.2.7 CONCLUSION

Water resources need to be managed both qualitatively and quantitatively due to their importance for economic development, and the physical and social environments. Particularly in Bangladesh, where water is intricately linked with the lives of people and economy, its value has increased with competing demand. Therefore, economic efficiency of water use is a major policy consideration. Frequent floods and droughts in Bangladesh impose tremendous variability, and make it difficult to manage development based on prices and the market mechanism. The Government of Bangladesh is facing a number of growing problems, because it cannot address water issues in a comprehensive manner. Separate ministries and departments are in charge of pollution control, surface irrigation, groundwater irrigation, fisheries, public health, environment, municipal water supply, power and navigation, and each acting independently. The interdependency among sub-sectors and uses should be recognized and comprehensive planning, taking the interest of all users into account, should be used to reduce the conflicts in the system.

MoEF and DoE are burdened with the tasks of (a) setting standards, (b) evaluating and giving clearance to impact assessments, and (c) enforcing environmental rules and regulations. These are major tasks, and although institutional strengthening of DoE is underway to help develop its capacity to fulfill its mandate. The task would become easier if other agencies fulfilled their own environmental duties and responsibilities effectively. The role of civil society as a whole would be made significant by their meaningful participation in environmental issues, and help in tackling the problems, through public-interest litigation.

Major agencies with activities in the water sector, such as BWDB, LGED and DWASA, have environmental guidelines for developing and implementing their projects. However, there is a lack of relevant skills in these organizations. LGED has established an environmental cell, but BWDB has not done it yet where usually working on outsourcing EIA work for larger projects. A general training on environmental awareness, and empowerment to take action would contribute greatly to raise environmental standards.

Current legal frameworks require all implementing agencies to conform to environmental rules and standards, but without a strong support from DoE and proper resources, the quality of the EIAs undertaken cannot be assured. In addition, future climate change issues have emerged that particularly the national water sector has included in planning for development and management of water resources.

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