2.1 COUNTRY PROFILE

Bangladesh is a developing country in South Asia located between 20°34′ to 26°38′ north latitude and 88°01′ to 92°42′ east longitude, with an area of 147,570 sq km. It has a population of about 128 million, with a very low per capita Gross National Product (GNP) of US$ 370 (WB, 2000). It has a border on the west, north, and east with India, on the southeast with Myanmar, and the Bay of Bengal is to the south.

Geologically, Bangladesh is a part of the Bengal Basin, one of the largest geosynclinals in the world. The Basin is bordered on the north by the steep Tertiary Himalayas; on the northeast and east by the late Tertiary Shillong Plateau, the Tripura hills of lesser elevation, and the Naga-Lusai folded belt; and in the west by the moderately high, ancient Chotanagpur plateau. The southern fringe of the basin is not distinct, but geophysical evidence indicates it is open towards the Bay of Bengal for a considerable distance. The formation and growth of the Bengal Basin is directly related to the origin and morphology of the Indo-Gangetic trough, which itself is overlaid and filled by sediments thousands of metres thick (Rahman, 1994).

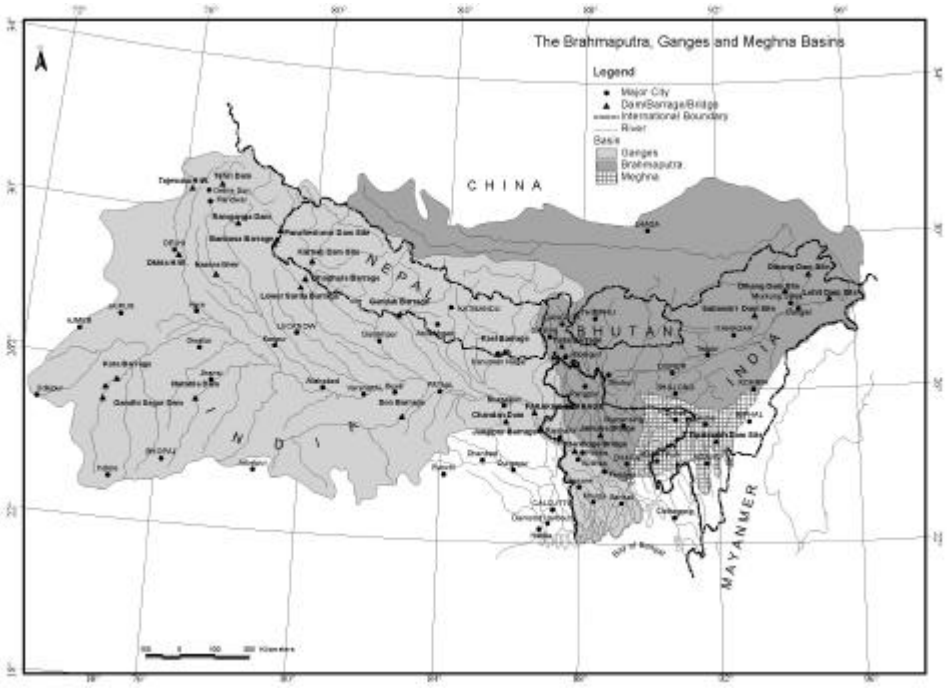
The broad geological features of the Bengal Basin and its prominent tectonic elements are Indian platform, Bengal foredeep, Arakan Yoma folded system, and the Sub-Himalayan Foredeep. Other features are Rangpur Saddle, Dinajpur slope, Bogra slope, Hinge Zone, Barisal High, and Troughs of Sylhet, Faridpur and Hatiya, etc.

The floor of the Bengal Basin consists of quaternary sediments deposited by the *Ganges*, the *Brahmaputra*, and the *Meghna* rivers, known together as the GBM river system, and their numerous tributaries and distributaries. The sediments are washed down from highlands on three sides of the Basin, particularly from the Himalayas, where the slopes are steeper and the rocks less consolidated. Over 92 per cent of the annual runoff generated in the GBM catchment area flows through Bangladesh, although it comprises only about 7 per cent of the total catchment (Coleman, 1969).

The flat topography of the Basin, and the occurrence of recurring floods that cause rivers to change course have complicated the river morphology pattern.

The whole country consists of mainly low and flat land, except for the hilly regions in the northeast and southeast. A network of rivers, with their tributaries and distributaries, crisscross the country.

Figure 2.1.1 Geographical Location of Bangladesh



Source: WARPO Database

Physiographically the country can be divided into hills, uplifted land blocks, and the majority alluvial plains with very low mean elevation above sea level (Rashid 1991). Figure 2.1.1 shows the geographical location of Bangladesh in the context of the GBM river system.

The physical environment of Bangladesh is diverse, and there is a mix of both traditional and modern methods of land use, all very closely adapted to the heterogeneous conditions. This complexity of environment and utilization patterns has important implications for the vulnerability and depletion of the natural resource base. Moreover, neither the physical environment nor technologies remain static. For example, rapid and frequent natural changes are taking place in the river systems, and they are also subject to

the influence of various human interventions. Thus, there are dynamic changes taking place in the hydrological system all the time. These in turn influence land use patterns.

Bangladesh has a comparatively low natural resource base, but a high growth rate of population, with almost half of the population below fifteen years of age. Most of the people are among the poorest in the world, and depend mainly on the natural resource base for their livelihood. But now the resource base is under serious threat, as many natural resources are either being over-exploited or used sub-optimally. Besides the effects of anthropogenic stresses, the low 'land-man' ratio in the country is often further threatened by natural hazards. Thus, for the survival of Bangladesh's dense population, it is essential to have environmental planning and management that conserves and sustains the ecosystems that support their livelihoods.

The high population density, low economic growth, lack of institutional infrastructure, an intensive dependence on agriculture and agricultural products, geographical settings, and various other factors, all contribute to make the country weak in its economic development and quality of life. Table 2.1.1 is a summary of the social, economic, and environmental indicators in Bangladesh from 1981 to 1995.

Table 2.1.1 National Statistics

Indicators	1981	1991	1995
Population (million)	89.9	111.45	119.8
Land Area (square kilometres)	144,000	147,570	147,570
-- Forest (percentage)	15.00	12.80	12.74
-- Agriculture (percentage)	60.52	55.08	52.06
-- Cultivable Wasteland (percentage)	1.62	3.93	4.28
-- Current Fallow Land	3.39	6.49	2.68
GDP in 1989-90 constant price (US$ in million)		26500	32060
GDP in terms of PPP (1990 US$) in billion	NA	NA	125.15
-- Industrial GDP (percentage)		22.14	24.18
-- Services GDP (percentage)		49.45	50.98
-- Agriculture GDP (percentage)		28.13	24.83
GDP per capita (1995 US$)		241	336
PPP per capita of GNP (1995 US	NA	NA	1380
Urban Population as % of Total Population	15.20	17.20	22.00
Population below poverty level	73%	47%	45.8%
Life Expectancy at Birth (years)	55	56	58
Literacy Rate	23.8	32.4	37.2

Source: Population Census 1981, 1991 and Statistical Year Book 1996 of Bangladesh Bureau of Statistics, Draft Fifth Five Year Plan, World Development Report, 1997 of World Bank, Key World Energy Statistics, International Energy Agency, Paris

Figure 2.1.2 Administrative Unit of Bangladesh

Source: WARPO/EGIS National Database

Agriculture, manufacturing industries, and various services such as transport, trade, and housing-related are the major economic sectors of the country. Detailed major sector shares of GDP for the year 1989-90 and 1994-95, at constant (1989-90) prices and current prices, are presented in Table 2.1.2. While there is some debate regarding the direct contribution of agriculture to the national income, two facts remain undisputed. Firstly, there is a decreasing trend in its share. Secondly, despite this, it is still of paramount importance, because of the dependence of most other sectors or activities on it - either for processing its products, or servicing the sector. Therefore, the economy of the country crucially depends upon a high and stable level of agricultural production. Agriculture critically depends upon weather conditions, and is subject to the inherent variability of weather and climate in Bangladesh. Consequently, manufacturing and service sector outputs also become variable. A

Table 2.1.2. Major Sectors Share of GDP

Sector	GDP at current Prices		GDP at constant prices (1989-90)	
	1989-90	1994-95	1989-90	1994-95
Agriculture	25.62	20.32	25.62	21.31
Transport	10.78	12.66	10.78	11.39
Manufacturing	11.44	12.88	11.44	13.62
Trade	16.27	16.80	16.27	17.42
Construction	8.98	8.95	8.98	9.00

Source: BBS, 1997

significant exception to this is the ready-made garments manufacturing industry, which now comprises a significant income sector for Bangladesh.

Economic development of the ever-growing population of Bangladesh is one of the main objectives of planning activities of the Government of Bangladesh (GoB). The GoB has identified poverty alleviation as the principal objective of human resource development, and that it can be achieved through enhanced investment in education to improve human resource potential. However, it is increasingly being recognized in Bangladesh, as in other parts of the world, that for long-term development to be meaningful and sustainable, environmental concerns and planning should be integrated into all development activities. Specific environmental actions are also required for a better future.

Achieving environmentally sound development has emerged as the greatest challenge for the dominant development paradigms all over the world. For a developing country like Bangladesh it has become a formidable task, with its inherent resource constraints, geomorphologic instabilities, political instabilities, weak institutional infrastructure, and paucity of well-established modalities for establishing a framework for sustainable environmental development.

This chapter highlights the present environmental conditions and trends of natural resources and development in Bangladesh, in the context of its physical resources, ecological resources, and quality of life of human resources, i.e., the economic context of the country. It serves as a compilation of relevant background information regarding the key components of the environmental resource base analyzed in the following chapter.

2.2 STATE OF ENVIRONMENTAL RESOURCES

The primary sources of environmental resources in the country can be considered to be the existing natural and human resources. The condition and well being of these two resources are strongly inter-linked. Development primarily depends on the richness and quality of the natural resource base, but in Bangladesh this is very low compared to the density of population, and their demands. In the following section of the report, the environmental resources of the country have been summarized and described under two broad headings, i.e., natural physical, and natural biotic, which reflect the quality of life.

2.2.1 Natural Physical Resources

2.2.1.1 Land and Physiography

Broadly the physiography of Bangladesh can be grouped into three major units: hill soils (12 per cent), old alluvial soils (8 per cent), and recent alluvial soils (80 per cent). The hill soils occupy the Himalayan ranges, Chittagong hills, and the low hills and hillocks of Sylhet, and are derived from tertiary rocks and unconsolidated tertiary and Pleistocene sediments. Old alluvial soils are seen in the tracts of the Madhupur and Barind. The soils of these two tracts have been formed on the old alluvium of the Pleistocene epoch, and are typically reddish to brownish in colour. In addition to these two major Pleistocene terraces, another two minor terraces with old alluvial soil flank the basin, one is east of the Rajmahal Hill system, and the other is to the west of the folded Tripura Hills (Rashid, 1991).

Recent alluvial soils are found in the *Gangetic* alluvium, *Teesta* silt, *Brahmaputra* alluvium, and coastal saline tracts. The deposits of the Ganges and many of its tributaries have formed *Gangetic* alluvium. These soils are rich in calcium, magnesium, potassium, and calcium carbonate. The soils in the *Brahmaputra* alluvium tract include samples of all the fully inundated areas in the region of active rivers. The broad physiographic units of the country are depicted in Figure 2.1.3.

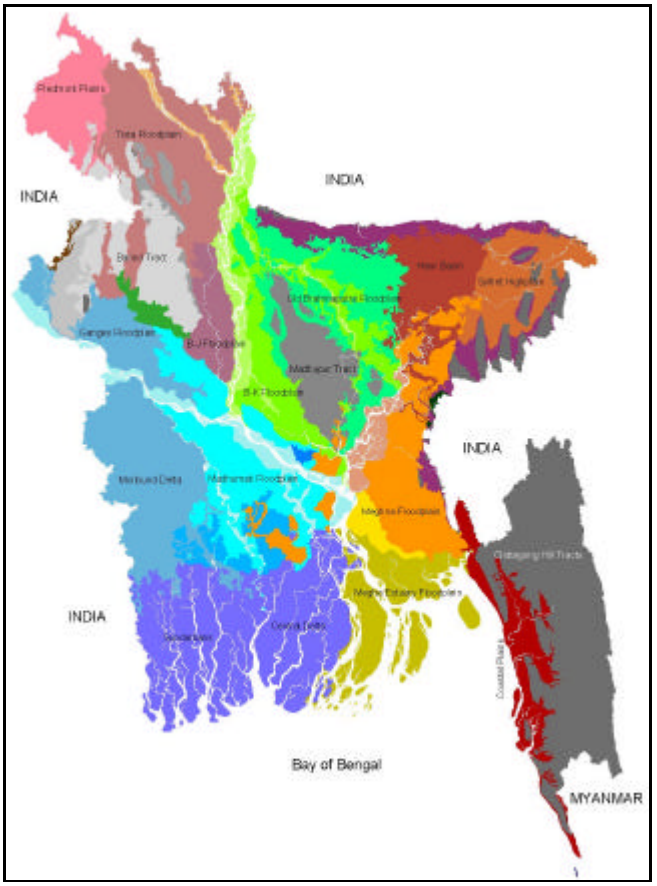
The coastal saline tract is a part of the active flood plain, but is subject to flooding with saline water at

high tides. This tract includes the southern parts of the old districts of Khulna, Barisal, and Patuakhali, and the islands and coastal areas of Noakhali and Chittagong regions. The soils of the coastal districts have some localized variations, both areally and stratigraphically, but consist primarily of fine sands, silts, silty sands, sandy silts, and clayey silts.

A few large depressions, locally known as *beels*, are seen on the delta. The *beels* are usually scars and ox-bow lakes, or back-lands of old riverbeds, but tectonic subsidence is also regarded as one of the causes of the origin of the basins. These major *beels* are mainly found in the *haor* area of Sylhet-Mymensingh. Besides that, there is the Chalan *beel* situated in Rajshahi-Pabna, and Chanda *beel* in the Gopalganj, Faridpur.

The topography of Bangladesh is extremely flat, with local relief ranging between 1 and 2 meters. At least 20 per cent of the area of the country consists of low-lying tidal plains, with elevations of less than 3 meters above sea level. Due to the flat terrain, rivers have extremely low gradients, e.g., 4-5 cm/km for the *Ganges*, 6-10 cm/km for the *Brahmaputra*, and 3 cm/km for the *Meghna* (Rashid and Pramanik 1990).

Figure 2.1.3 Broad Physiography of Bangladesh



Source: WARPO/EGIS Database

As an active delta of three of the world's major rivers, suitable conditions prevail for agricultural activities in Bangladesh. Agriculture is of paramount importance to the country. Most of the land area is occupied by agriculture, forest, and habitat. Less than 1 per cent of the land area is used for industry, and other miscellaneous social needs (Table 2.1.3). Four-fifths of the population depends directly or indirectly upon agriculture. Nearly half of the National Product is from agriculture in Bangladesh.

Table 2.1.3 Bangladesh Land Area Classification, 1990

Landuse Category	Million (ha)	Percent
Agriculture	9.25	64.2
State Forest		
Classified	1.49	10.3
Unclassified	0.73	5.1
Private forest		
Village	0.27	1.9
Tea/Rubber Garden	0.07	0.5
Sub-total (forests)	2.56	17.8
Urban	1.16	8.1
Water	0.94	6.5
Other	0.49	3.4
Sub-total	2.59	18.0
Total	**14.40**	**100.0**

Source: Forestry Master Plan, 1995

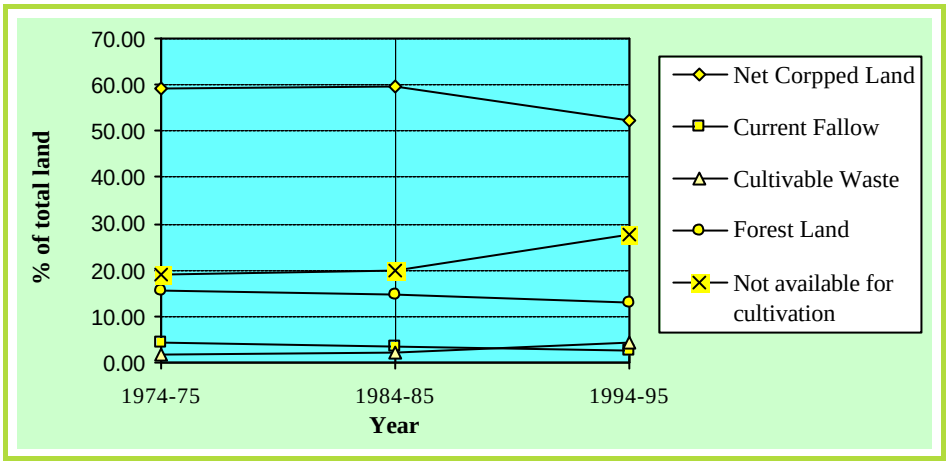
Land use is generally classified into five categories, i.e., cultivated, forest, cultivable waste, current fallow, and not available for cultivation. With the growing population, and their expanding needs in various sectors, land use patterns have changed as shown in Figure 2.1.4, and the "area not available for cultivation" is increasing, which includes land that is mainly urban, rural settlements, and industrial land. On the other hand, the net cropped land, and forestland is shrinking. Almost half of the existing forestland is under different types of non-forest land use now, e.g., shifting agriculture, illegal occupation, unproductive areas, etc.

The major environmental issues relating to land resources span various sectors of the economy, because almost all areas including agriculture, water, forests, habitat, industry, and horticulture, compete for the use of land.

2.2.1.2 Hydrology

Bangladesh is the largest delta in the world formed by the *Ganges*, the *Brahmaputra*, and the *Meghna* river system. This delta is characterized by flat terrain interlaced with the intricate system of rivers and tidal channels, which carry an enormous quantity of sediment-laden water downstream. The three major rivers have a huge catchment area of 1,554,000 sq. km, spreading over five countries, namely, Bhutan, Nepal, China, India, and Bangladesh. There are about 700 rivers, canals, and streams in Bangladesh, with a total length of approximately 22,155 km, which occupies a riverine area of about 9,384 sq. km (BBS 1979, 1998).

Figure 2.1.4 Changes of Land Use from 1975 to 1995



Source: BBS, 1998

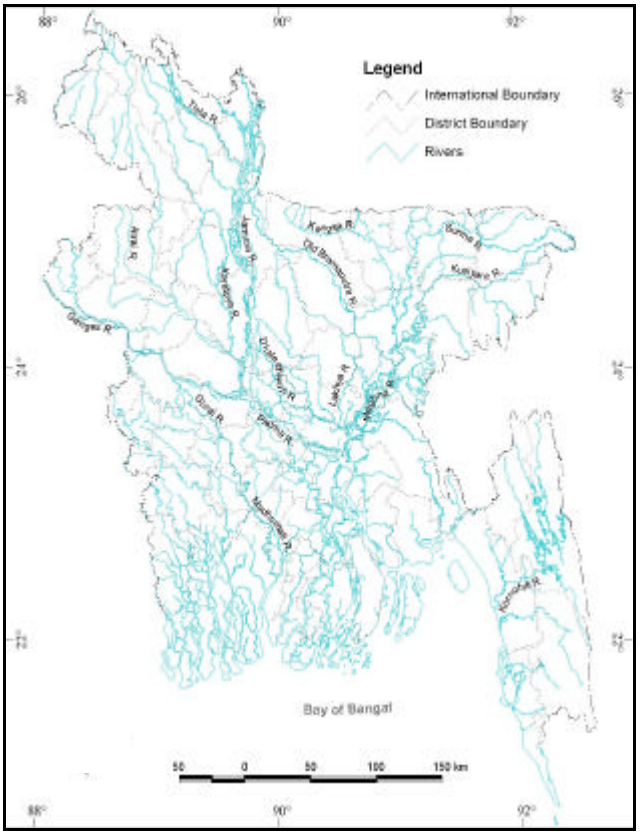
The main river system occupying the delta is formed by the *Ganges* and the *Brahmaputra*, which once they enter Bangladesh are known as the *Padma* and the *Jamuna*, respectively. The *Jamuna* joins the *Padma* near Aricha, and flows up to Chandpur where it joins the *Meghna* and the combined flow is called the *Meghna*. It comprises a large estuary, known as the *Meghna* estuary, at the northeastern apex of the Bay of Bengal.

The *Ganges*, primarily a meandering stream, is about 2,600 km long, and flows parallel to the Himalayan range. It is fed mainly by rivers rising in the southern slopes of the Himalayas and enters Bangladesh at the western extremity of Rajshahi region. The *Brahmaputra* arises in Tibet, and flows in an easterly direction north of the Himalayan range before turning south through the mountains; then it flows west down the Assam valley for a distance of about 700 km, and enters Bangladesh as a wide-braided river, in the region near Majhiali in Rangpur. The meandering *Meghna* river drains the Sylhet Basin and parts of the adjacent Shillong Plateau, and Tripura Hills. The river system of the country is presented in the Figure 2.1.5

The rivers flowing from the hills situated in the southeast of Bangladesh, namely *Feni*, *Karnaphuli*, *Sangu*, *Matamuhuri* and *Knaaf* flow into the Bay of Bengal. The most important river in this region is the *Karnaphuli*, which is also the longest, 274 km.

Thus, a vast amount of water flows through Bangladesh. The rivers of Bangladesh also carry huge amounts of sediment, an estimated 2.4 billion m.tons/year (Milliman and Meade,

Figure 2.1.5 River Systems of Bangladesh



Source: WARPO/EGIS National Database

1983). These sediments are subjected to coastal dynamic processes, generated mainly by river flow, tide, and wind actions. The ultimate result may be additional new land in some places due to accretion, forming islands called *chars*, and loss of land in some other places due to erosion.

Bangladesh is also richly endowed with numerous perennial and seasonal waterbodies known locally as *haors*, *beels*, *baors*, *khals*, *pukurs* and *dighies*. Rivers, canals, *beels*, lakes, and *haors* are open wetlands, while *baors*, *dighis*, ponds, and ditches constitute closed ones. The *haors* are depressions located between two or more rivers, and function as small internal drainage basins. Within the lowest points of the *haor*, there are one or more *beels*, which are lake-like deep depressions retaining water permanently or for a greater part of the year. The *beels* are usually connected to the adjacent rivers by one or more drainage channels, locally termed as *khals*. The *baors* are oxbow lakes from the old meandering bends of rivers that got cut off from the main stream. *Pukurs* and *dighies* refer to ponds of various sizes. To these may be added the vast estuarine systems and mangrove swamps of the south and southeast regions, as well as innumerable man-made water bodies of various sizes.

2.2.1.3 Atmosphere and Climate

The climate of Bangladesh is characterized by high temperatures, excessive humidity, and fairly marked seasonal variations of precipitation. Though more than half the area of Bangladesh is situated north of the Tropics, the effect of the Himalayan mountain chain makes the climate more or less tropical throughout the year. The climate is controlled primarily by summer and winter winds, and partly by pre-monsoon and post-monsoon circulation. The Southwest Monsoon originates over the Indian Ocean, and carries warm, moist, and unstable air. The easterly Trade Winds are also warm, but relatively drier. The Northeast Monsoon comes from the Siberian Desert, retaining most of its pristine cold, and blows over the country, usually in gusts, during dry winter months.

Temperature

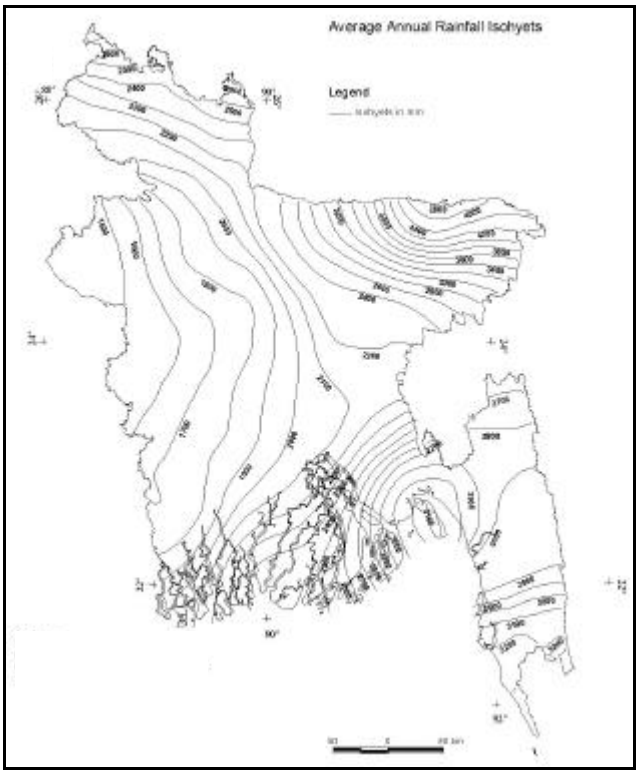
The country has an almost uniformly humid, warm, tropical climate, throughout the country. Traditionally the Bengali year consists of six seasons, namely, Grisho (Summer), Borsha (Rain), Shorot (Autumn), Hemonto (Late Autumn), Sheet (Winter), and Boshonto (Spring). This division based on the harvest cycle is quite reasonable, although there is really no spring or autumn in the sense understood at higher latitudes.

On the basis of temperature (and rainfall), there are three main recognizable seasons as follows:

1) The hot *summer season* from March to June is characterized by high temperatures - 5 to 10 days with more than 40°C maximum in the west, highest rate of evaporation, and erratic but heavy rainfall. The maximum temperatures in the year are reached between the last week of March and the end of April, when average maximum annual temperatures range from 24°C to 34.8°C in different parts of the country. Average minimum annual temperatures range from 11.1°C to 26.4°C.

2) From June to October is the hot and humid *monsoon season* with temperatures ranging from 20°C to 36°C, and heavy rainfall - about two-thirds of the mean annual rainfall. In June there is a marked fall in temperature, because of the monsoon rains. The mean maximum temperature over most of Bangladesh is

Figure 2.1.6 Average Annual Rainfall (Isohyets)



Source: NWRD-Based on daily Rainfall Data from BWDB and BMD for the period from 1966 to 1995

about 31°C, and the mean minimum is 6 degrees less.

3) The relatively cooler and drier *winter* extends from November to March, when temperatures range from 8°C to 15°C, and minimum temperatures can fall below 5°C in the north, though frost is extremely rare. The temperatures fall gradually throughout November and December, and in the last week of December, northern areas of the Northern Region record a maximum of 9°C, and in the Sylhet Hills the mean minimum temperature is 8°C.

In February and March, the temperatures rise again quite sharply. In the west the rise is steep, for example at Rajshahi the temperature goes from 25°C to 32°C. The rise is fastest from the first week of April, when the mean maximum goes up 6°C in Rajshahi, 5°C in Dinajpur, and 4°C in Jessore. In the east, the summers are milder, and the rise in that period is 2°C in Noakhali, 1°C in Chittagong, and very little in Cox's Bazar and Sylhet districts. In Cox's Bazar, the mean maximum rises from 27°C at the end of January to 31°C in the first week of April.

Rainfall

As mentioned briefly above, there are three main periods of rainfall corresponding to the seasons described, each with its distinct source of precipitation. These are:

1) The *pre-monsoon thunderstorms* known as the Nor'westers (North-westerlies) begin about the 10th of March. The Nor'westers arise due to a variety of reasons, the main ones being the steady flow of cool dry air above 1800 meters altitude from the northwest (Anti-Trades), a warm, moist current below 1800 metres from the south, intense evapo-transpiration in the Bengal basin and Assam, and katabatic winds from the surrounding mountains.

2) The heavy *summer rains* known as the Monsoons start from the end of May and continue till mid-October. The main rainy period begins with the coming of the moisture-laden Southwest Trades, popularly known as the Monsoons, which are drawn to the Indian sub-continent by the intense heat, and consequent low pressure over Punjab (in Pakistan and India) and the Upper Ganges Valley. This gives rise to a "tropical cell", with convection currents of massive proportions. These winds blow across the North Indian Ocean, and reach the Malabar Coast of India two weeks before they come up the Bay of Bengal to Bangladesh. One arm of these vast trades moves up the Ganges valley, and brings in rains. It is the orographic rains caused by the striking of this east-flowing air mass against the Arakan Yomas, Meghalaya Plateau, and the Himalayas that forms the major part of the rainfall in Bangladesh.

During the monsoon months the mean cloudiness is from eight to nine-tenths. The total rainfall in these five months varies in different parts of the country. It is 122 cm in the northwestern part at Rajshahi, 149 cm at Narayanganj in the central part, 338 cm in the coastal areas like Cox's Bazar, and over 500 cm in the northeastern part in North Sylhet - across the border from Cherapunji and Mawsyriem, two of the rainiest places in the world (Rashid, 1991).

In most places the maximum rainfall is recorded in June, though July and August record nearly as much. There is a slight difference in rainfall rates in different parts of Bangladesh during the heavy rainfall period. Dinajpur and the northwest of North Bengal, Kushtia, Satkhira, and Noakhali get their maximum rainfall in July. Many places, such as Comillla, Brahmanbaria, Bogra, and Srimangal have a slight tendency to record "double-maxima" in July and in September.

After the 14th October, the monsoon rainfall drops off rapidly. In the western half of the country and in Central Bengal, the rains normally come to an end between the 20th and 25th of October, whereas in the east and southeast, they do not end till about the 10th of November. The rain is very little after this period until the middle of January. At that time, the mean cloudiness is only one to two-tenth.

3) The *western depression of winter rains* occurs mainly from 20th January to 25th February, when it rains from 1 cm to 4 cm.

The mean annual rainfall varies widely within the country according to geographical location, ranging from 1,200 mm in the extreme west to 5,800 mm in the east and northeast. The average annual rainfall is only 273 cm at Chittagong, while Cox's Bazar gets 500 cm or more of rainfall. Nakhyongchhari gets 295 cm annual rain, and to the northeast at Lama

Bazaar it is 300 cm. Further north, Kaptai receives 282 cm, 257 cm at Rangamati, 198 cm at Barkal, and 259 cm at Mainimukh. The rainfall increases northwards, even though the hills are lower, because of the proximity of the Meghalaya Plateau and the Naga Hills. Along the coast the rainfall increases rapidly north of Chittagong, but decreases after the southern-most spurs of the Tippera Hills are passed. In the Surma valley and neighboring hills, the rainfall is very high. In the foothills of South Sylhet, Rashidpur gets 249 cm, Srimangal 253 cm, Patrakhola 216 cm, Kurmah 262 cm, Shamshernagar 269 cm, and near the foot of the abrupt Meghalaya Plateau at Sunamjanj it is 533 cm, and at Lalakhal it is 650 cm - the highest rainfall station in Bangladesh (Rashid, 1991).

In recent years the weather pattern has been erratic, with a reduction of the cool, dry season (Rashid, 1991). This could be a temporary phenomenon, or it may be the beginning of long-term changes due to global warming caused by greenhouse gases. Possible connections with *El Nino* have only now begun to attract attention as a major possible influence on climatic patterns in the Subcontinent.

Fog, Mist, Dew, and Haor-frost

Fog and mist are common features of the weather from November to March. At the beginning and end of this period, mist usually develops at sunset and remains till sunrise, but not fog. In December and January, there is fog on many nights, which may persist even up to noon. Heavy long-lasting fog usually forms in these two months over the *Brahmaputra-Jamuna* River in Sylhet district, and in the Hill Tracts. Dewfall is also very heavy in these two months. Dew possibly accounts for two centimeters or more of precipitation in the wetter areas. Frost may also form in winter on the highest ranges of the Hill Tract districts. Sometimes there are cold air masses from the upper Ganges Valley that lower the night temperatures sufficiently for *haor*-frost to form.

Winds

From November to February, the general directions of the winds are from the northeast in the Northern Region, the northwest over the rest of Western Bangladesh, and from the north in the eastern part. From March to May, the winds are from the west or southwest in the western half, but south-southeast in the eastern half. Occasional Nor'westers change the wind direction of course, and bring relief from the dull heat. From June to September, the winds are not all from the south, much being from the southeast, and even the east. In October the winds are very variable, but there is a definite strengthening of the northern winds, at the expense of those from the southeast. The Inter-Tropical Convergence Zone is in the north of Bangladesh during the four monsoon months, and thus it is a pronounced field of air mass convergence.

2.2.2 Natural Biotic Resources

Terrestrial and aquatic ecological resources play an important role in national development. They serve as rich sources of food and fuel for the population, as well as habitat for the country's biodiversity. Forests provide a wide range of habitat for wildlife, and the wetland ecosystem provides habitat for aquatic species.

2.2.2.1 Terrestrial Ecology

Forests are both environmentally and economically important natural resources in the terrestrial ecosystem. The total land under forest in Bangladesh is about 2.56 million ha, which includes officially classified and unclassified state lands, and forestlands accounted for by village forests and tea or rubber gardens. Although a significant part of the existing forest area is designated as State Forest, most of this land is actually barren of tree vegetation (FMP, 1995). In Bangladesh natural forest areas constitute almost 31 per cent, and forest plantation 13 per cent of forest areas. Only 5 per cent of existing forestlands are designated as protected areas. In terms of per capita forestland, Bangladesh ranks amongst the lowest in the world, with about 0.02 ha per person.

The forests of Bangladesh have been disappearing at an accelerating rate. The good to medium density forest of the Chittagong Forest Division had shrunk from approximately 30,000 ha in 1985 to 20,000 ha in 1992. In Cox's Bazar, natural forest cover dropped from 31,300 ha in 1985, to about 24,300 ha in 1992. In Sylhet only about 6,000 ha, i.e., 15 per cent of the actual forest area had remained in its original state in 1987. In Sundarbans, 78 per cent of the forest had canopy closure of 75 per cent or more in 1961, which was reduced to 65 per cent in 1984. As of 1989 only about 17 per cent of the total legitimate Sal forest area remained across central and northwest Bangladesh (FMP, 1995).

Up to the mid-1980s it was thought that Bangladesh had a deforestation rate of 8,000 ha annually. A recent estimation has shown that there was a loss of 37,600 ha annual forest-cover area over the period 1980-1990, which is a reduction of 3.3 per cent annually. The Forestry Master Plan has mentioned that the status quo scenario will result in the remaining forest largely disappearing over the period of the Plan, except the Sundarbans, which might be spared because of remoteness and poor accessibility.

The major causes of deforestation are industrialization, rapid urbanization, and high population pressure on existing forestland, both for settlement and shifting cultivation. Other causes include encroachment, grazing, fire, uncontrolled and wasteful commercial logging, illegal felling, fuel wood collection, and official transfer of forestland to other sectors, i.e., for settlement, agriculture, and industries. In this way, almost half of the existing forestland is under different types of non-forest use.

In recent years, an estimated number of 109.92 million trees have been planted in the urban areas and as strip plantations along the roads, highways, railways, and embankments. These refer to plantations not classified under GoB-managed (*Khas* land) forest (ALGAS, 1998).

Natural Hill Forests

Hill Forests are the most important major category of woodlands in the country, and comprise more than half the State Forests. They are important from an economic and environmental point of view. The growth rate of Natural Hill Forest is 0.5 to 1.5 m^3/ha/ year. A brief description of the Hill Forests is given below.

Dipterocarp Forests: These forests cover a large part of the wooded area, and consist of mixtures of many tropical evergreen and tropical deciduous trees, occurring in association with bamboo jungles. Though no singletree type is uniformly present or clearly defined over a large tract, in the top storey Garjan (*Dipterocarpus turbinatus*) is the predominant species, and Civit (*Swintonia floribunda*), Narikel (*Sterculia alata*), and Chandal (*Tetrameles nudiflora*) occur in mixture. In the middle storey the important species are Kamdeb (*Anthocephalus chinensis*), Chapalish (*Artocurpus chaplasha*), Nageswar (*Mesna nagesarium*), Pitrajm (*Aphanamixis polystachya*), Jam (*Syzygium sp.*), Bandarhola (*Dhabanga grandifolia*), Champa (*Micheliachampach*) and Toon (*Toona ciliata*). Common tree species in the lower storey are Jam (*Syzygium sp.*), Jarul (*Lagerstromia speciosa*) and Gamar (*Gmelina arboria*). Ecologically this type of forest could be classified into four further sub-sections, i) Tropical Wet Evergreen, ii) Tropical Mixed Evergreen, iii) Tropical Moist Deciduous, and, iv) Tropical Open Deciduous forests.

Savannas: Savannas cover large parts of the Unclassified State Forest of greater Chittagong Hill Tracts, stretching into the Reserve Forests in many places. The vegetation consists of tall grasses (sun grass) with average heights of 1.25 meters, and scattered trees.

Bamboo Forests: Bamboo occurs in abundance, particularly in greater Chittagong Hill Tracts and Sylhet. There are four commercially important bamboo species, namely, Muli (*Melocanna baccifera*), Mitenga (*Bambusa tulda*), Daloo (*Neohouzeana dullon*) and Orah (*Dendrocalamus longispathus*). Muli is the predominant species.

Fresh Water Swamp Forests: These forests occur in low-lying areas of Northern Sylhet. The main species are Hijal (*Barringtonia acutangula*), Jarul (*Lagerstromia speciosa*), and Pitali (*Trewia polycarpa*).

Natural Inland Sal Forest

The Inland Sal Forest is ecologically a Tropical Moist Deciduous Forest in nature. The main species is Sal (*Shorea robusta*), and associated species are Palas (*Butea monosperma*), Haldu (*Adina cordifolia*), Koroi (*Albizia* spp), Bahera (*Terminalia belerica*), Kurchi (*Holarhena antidysentrica*), Haritaki (*Terninalia chebula*), Kusum (*Schleichera oleosa*), Sonalu (*Cassia fistula*), Chaplash (*Artocarpus chaplasha*), and Udal (*Sterculia* sp.). More than 66 per cent of the Sal Forest is denuded or in the possession of encroachers. The growth rate of Sal trees is lower than trees in the Natural Hill Forests.

Littoral Mangrove Forests

The Sundarbans is the major mangrove forest of Bangladesh, lying at the southern extremity of the *Ganges* River Delta, bordering on the Bay of Bengal. The growth rate of this forest is also lower than the natural Hill Forests. Within the mangrove forests there are three distinct belts. *Heritiera fomes*

and *Excoecaria ageallocha* are the dominant species in the slightly saline, and moderately saline zone. In the strongly saline zone, the forest consists mainly of *Excoecaria ageallocha* and *Ceriops decandra* (Goran).

Plantation in Hills

Before 1980, most Hill Forest plantations were Teak and associated species, mainly Jarul and Gamar. Occasionally there were Garjan, Dakijam, and Mahogany. Teak and associated trees are long-rotation crop products for timber. Gamar, Eucalyptus, and Mangium are medium-rotation plantation, for poles, pillar logs, and pulpwood. Short-rotation species are Melucaana, Acacia, and Eucalyptus. The estimated average annual growth is 2.5 and 10 m^3/ha/year for long rotation and short rotation plantations, respectively. For long rotation plantation, the trees are subjected to thinning for years to maintain good timber production.

Inland Sal Plantation

In the early 1950's and 1960's the Bangladesh Forest Department (BFD) raised Sal plantations over large areas. Over the course of the years most of these plantations have disappeared, leaving only a few patches. Later in the 1970's, BFD raised plantations of moderately fast-growing indigenous species on recovered encroached lands. Most of these did not survive either. Then in the 1980's, plantations of eucalyptus and acacia met with the same fate, except some plantations in Rangpur, Dinajpur and Rajshahi division. Under the 'Thana Banayan Plantation Program', enrichment and agro forestry plantation have started again in the Sal forest areas.

Coastal Plantation

In the 1960's Coastal Bangladesh experienced severe cyclone and tidal bores. To protect lives and property from future disasters, the Forest Department started planting trees on the outside of the protective coastal embankments. Now there are about 142,835 ha of coastal plantation.

2.2.2.2 Aquatic Ecology (Freshwater and Coastal Wetland)

For the purpose of the Ramsar Convention as adopted in Ramsar, Iran in 1971, wetlands are defined as areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters. Globally, wetlands are amongst the most fertile and productive ecosystems.

Wetlands are invaluable components of the environment and biodiversity in Bangladesh. Bangladesh possesses enormous wetland areas, among which the principal ones are rivers and streams, freshwater lakes and marshes, including *haors*, *baors*, and *beels*, water storage reservoirs, fish ponds, flooded cultivated fields, and estuarine systems with extensive mangrove swamps. The coastal and inland wetlands encompass the vast floodplains and delta system of the *Ganges*, *Meghna* and *Brahmaputra* rivers. The total area of the wetlands in the country has been variously estimated at seven to eight million hectares, or about 50 per cent of the total land surface.

The biological productivity of these aquatic habitats depends mainly on the activities of plankton, macrophytes, and fauna at the bottom. The chlorophyll-bearing plants are the primary producers initiating the food chain of the aquatic ecosystem. The vegetation thus contributes to the biological cycling and mobilization of chemical elements, which allows the ecosystem to directly support a wealth of fisheries. Aquatic vegetation beds act as spawning grounds and shelter for juveniles of a large variety of fishes and prawns.

The wetlands in Bangladesh are increasingly being recognized as habitat and escape cover for a large variety of wildlife, and a safe nesting site for avifauna. The marsh vegetation associated with wetlands also forms important breeding areas for a wide variety of waterfowl, and roosting places for a large number of resident and migratory birds.

The nutrient products of wetlands in Bangladesh are carried by rivers and floodwater, and benefit the systems downstream. The grazing systems in these regions support cattle that recycle nutrients, enrich soil, and are used as draft animals. The plant diversity provides refuge for predators of pests, e.g., snakes, frogs, and certain fish species, and this helps agriculture in general. Bangladesh does not possess adequate finances and infrastructure for sewage systems on a large scale, but this function is naturally and effectively performed by the wetlands, which serve as a filtering system through recycling of toxic pollutants.

It is the dynamic interaction of terrestrial and aquatic systems in the wetlands with people that makes them so environmentally valuable. They provide a wide range of staple food plants, lush grazing lands, and fuel. Their resources play a significant role in human economic activities like extraction of reeds, and harvesting of food plants and those with medicinal importance. Besides their scenic beauty, which can support the development of tourism, they protect the coastline from erosion, and act as barriers against storm surges.

Disappearing wetlands

The wetlands of Bangladesh are being drastically affected by the impacts of the burgeoning human population. In the *Ganges-Brahmaputra* floodplain alone, approximately 2.1 million ha of wetland have been lost to flood control, drainage and irrigation development. Severe erosion in the catchments areas is causing increased siltation, and having major impacts on the key wetland areas.

Wetlands are being continuously lost or degraded primarily because of various recent developments, such as shrimp culture, which reflect a lack of community awareness of wetland functions and values. Indigenous protective management systems have given way to short-term benefits for a few vested groups. The exploitation of the *haor* wetland ecosystem began due to ever-expanding agrarian settlements, and they are being reclaimed as agricultural land for production of rice. The *beels* are being drained, and embankments built to save crops from flash floods. Apart from these changes in land use patterns, there has also been a decline in fish and migratory birds. Swamp forests that were once extensively distributed, are now on the verge of extermination.

2.2.2.3 Biodiversity

The terrestrial and aquatic areas of the country support a large number of diverse biological populations, both plant and animal. The biodiversity depends on the type and quality of habitat, and level of interference of the human population and development activities. Notwithstanding insufficient baseline information on biological resources, it is believed that development practices have caused a significant depletion of terrestrial and aquatic species diversity. Over-exploitation of some very common species in an unwise manner has led to their being reduced to a vulnerable status; for example, the Freshwater Crocodile is now threatened.

Mangrove forests form a unique environment of floral-faunal assemblages. Leaf litter undergoing decomposition provides particulate and dissolved organic matter to the estuarine ecosystem, and this complex detritus-based food web supports a number of marine and brackish water organisms.

The Sundarbans support a very rich and diverse fish fauna of 400 species, 270 species of birds, and over 300 species of plants. It is an important staging and wintering area for migratory shore birds, gulls, and terns. They comprise the largest remaining tract of habitat for the Royal Bengal Tiger *(Panthera tigris)*. St. Martin's Island is an important nesting area for marine turtles, and a wintering ground for migratory shore birds.

There is an abundance of waterfowl and wetland-dependant birds in the *Haor* Basin. A total of 125 species of waterfowl are known to occur, of which 53 are resident breeding species or breeding summer visitors. During the NERP field program, 284 species of birds were recorded in the Northeast region, of which 89 are true waterfowl. Birds largely or wholly dependent on wetland ecosystems are 30 species, whereas other birds observed in wetlands or adjacent floodplains and dry land are 42 and 123 species, respectively. Despite massive habitat losses, the *Haor* Basin remains an internationally important wintering area for migratory waterfowl, principally ducks and shorebirds. Coastal wetlands support an even larger number of migratory birds, including some highly endangered species.

2.2.2.4 Endangered Species

The adverse effects of recent developments can easily be discerned in the dwindling populations of natural fauna in the wetlands. The Sundarbans now provide the only natural habitat to ensure long time survival in the wild of the world's largest genetically viable population of the Royal Bengal Tiger *(Panthera tigris)*. But the globally endangered Estuarine Crocodile *(Crocodylus porosus)*, which was recorded up to 1950 in Chakaria Sundarbans, has now disappeared from this greatly degenerated and disturbed habitat.

Among the 150 recorded waterfowl in the wetlands of Bangladesh, over 70 are now nearly extinct. The

Grey-leg Goose *(Anser anser)*, Brahminy Duck *(Tadorna ferruginea)*, and Mukra or Comb Duck *(Sarkidiornis melanotos)* have disappeared, while the white winged Wood Duck is almost on the verge of extinction.

The Marsh Crocodile or Mugger *(Crocodylus palustris)* is now represented in Bangladesh by only a few individuals in the large private marsh adjoining a saint's grave at Bagerhat. Another allied species, Gharial *(Gavialis gangeticus)*, is also nearly extinct with an estimated total population of 8-10 individuals. In the wetlands of the *Haor* Basin, seven species of mammals and reptiles are highly endangered. These are the Common Otter *(Lutra lutra)*, Smooth-coated Otter *(Lutra perspicillata)*, Fishing Cat *(Felis viverrina)*, Black Pond Turtle *(Geoclemys hamiltoni)*, Black Monitor Lizard *(Varanus bengalensis)*, Rock Python *(Pytholon molurus)* and Monocellate Cobra *(Naja naja kauthia)*.

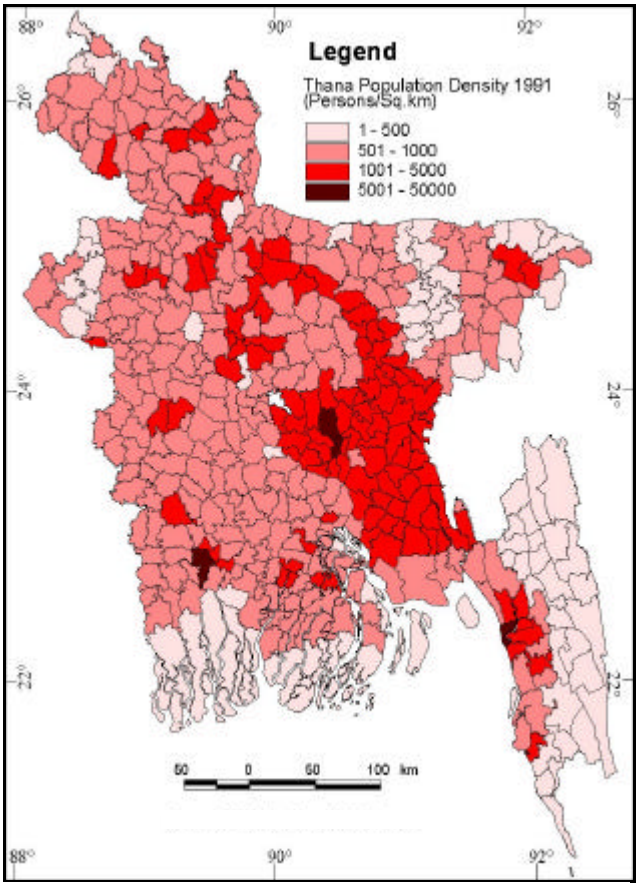
At least four plant species confined to wetland habitats are tentatively listed as threatened. In the *Haor* Basin, Makhna *(Euryale ferox)* is over-exploited for its edible seeds, and the wild rose of Bengal *(Rosa involucrata)* is being depleted at an alarming rate on account of loss of habitat.

2.3 QUALITY OF LIFE

2.3.1 Population Growth

Bangladesh has a population of over 120 million, and with more than 830 persons per sq km is the most densely populated country in the world. Population growth is identified as perhaps the most serious problem inhibiting the sustainable use of resources. Increases in development or productivity are eroded by population growth. At present over 50 per cent of the population in Bangladesh is below 15 years of age. Hence in the next 10 years, there will be a dramatic rise in demand for employment, but opportunities in agriculture appear to be limited, and other sectors are not creating sufficient new jobs. The urban population was 13 million in 1981, and is expected to reach 41 million in 2000. The demand for land is enormous, because of the population density, and a very low land-man ratio intensifies the competition for the very limited land resources for different uses. Conversion of the vast population to a productive human resource remains the greatest development challenge.

Figure 2.1.7 Population Distribution 1991



Source: GIS Division, BCAS

2.3.2 Poverty and Malnutrition

It is estimated that more than 40 per cent of the population regularly consume less than the absolute critical minimum of 1800 kilo calories per day. These 50 million people are amongst the poorest in the world by any standard of development. Furthermore, it has been estimated that the numbers of absolute poor have risen significantly. The poverty of these deprived people is deep rooted, pervasive, and multi-faceted, relating not just to the absence of reliable incomes and productive assets, but also to food, safe water, sanitation, education, shelter, inequities, injustice, and lack of power. These deprived people are also extremely vulnerable to disaster and disease. The challenges posed by this massive poverty are enormous for a country with accelerating environmental degradation of an over-populated land base.

The Human Development Indicators for Bangladesh are also staggeringly low. Bangladesh has an adult literacy rate of 37 per cent, life expectancy of 52.2 years, mortality rate of 109, maternal mortality rate of 650 (in 1986), and a morbidity rate of 18 per cent for

females, and 15 per cent for males. The forecast is that by the year 2001, a quarter of the population will live in urban areas. Urban slum dwellers now account for some 15 per cent of the population, and this is still growing by 6 per cent per annum.

2.4 MAJOR ENVIRONMENTAL CONCERNS

Bangladesh is confronted with a host of environmental issues and problems owing to both natural and human factors. The concerns relate to programs and activities in various sectors, and are of variable nature and intensity. The main environmental issues that are addressed through different policy and planning documents, like the National Environment Management Action Plan (NEMAP), the Fifth Five Year Plan (1997-2002), Environmental Policy, etc., are described briefly below.

2.4.1 Agricultural Resource Base

Over 60 per cent of the total land area in Bangladesh is cultivated. This is one of the highest percentages in Asia. Agriculture represented slightly less than half of the GDP in 1986, and the average annual rate of growth in agricultural production was about 2.7 per cent from 1980-86, which was barely enough to keep pace with population growth. Food consumption affect more than half of the population. In 1992 for the first time the country was self-sufficient in rice, the main staple diet, largely due to a disaster-free year. In the year 2000, the country has produced over 25 million tons of cereals and thus has attained self sufficiently in grain production. Sustainability of this level of production is however a big question. Export volumes are relatively small, and not well diversified.

The vast majority of the population depends on agriculture and natural resources for a large part of their food and income. As a result, agricultural resources in Bangladesh are under severe pressure and environmental strain already. The mechanization of agriculture, and emphasis on high-yielding varieties to grow more food, has resulted in the loss of many traditional varieties of rice and other crops. In addition, the practice of mono cropping has caused serious deterioration of soil characteristics, and a decline in productivity. There are also competing demands on land for non-agricultural uses. Thus, a more dynamic agricultural sector, better use of natural resources, and increased concern for environment are essential. An emphasis on the preservation of biodiversity is necessary to sustain and improve agriculture, forestry, livestock, and fisheries production systems. The indigenous flora, fauna, and ecosystems are important in order to keep future options open, as they form a buffer against harmful environmental changes, and as raw material for scientific and industrial innovations.

2.4.2 Biomass

In Bangladesh biomass plays an important and complex role, especially in the rural areas where about 80 per cent of the people live. At present, there is an acute crisis of biomass fuel, which constitutes 73 per cent of total energy consumption, and the per capita supply is declining. The problem is not merely the supply of wood for fuel or food. There is an increased use of crop residues and dung as fuel, which is depriving the soil of valuable nutrients and organic matter.

2.4.3 Chemical Fertilizers and Pesticides

Modernization of agriculture has led to extensive use of fertilizers and pesticides. Although production of food grain and some other crops has increased significantly, but, as a result of indiscriminate use of these chemicals the quality of the land has suffered. In addition, farmers spraying pesticides because of ignorance often suffer from heart and skin diseases. Cows, goats, and other domestic animals eating pesticide-affected grasses also suffer from the health impacts. Fish populations in the rivers and other water bodies have drastically decreased due to water pollution by chemicals, including fertilizers and pesticides. Application of both fertilizers and pesticides are still very low in Bangladesh, compared to developed countries. Judicious use of these chemicals is essential.

2.4.4 Pollution

The growth of industries in the country has generally been unplanned, without careful consideration of environmental protection issues. There are many industries in residential areas, causing air and water pollution through smoke emission and dumping of untreated effluents. Industrial wastes have polluted the water of the rivers *Buriganga*, *Sitalakhya*, *Karnaphuli*, and others. Effluents from tanneries are extremely

harmful to human beings, since they contain high concentrations of chromium compounds. About 250 tannery units clustered in the Hazaribagh area within Dhaka city are causing serious environmental pollution, and are a health hazard that makes the area unsuitable for human habitation.

2.4.5 Deforestation

Bangladesh has a classified natural forest area of about 10 per cent of the total land area, but only 6-8 per cent of this has good canopy cover, which is far below the desired level. About 50 per cent of the destruction of forests has taken place during the last 20 years, affecting topsoil and causing land erosion. Social forestry and backyard plantations have not yet been able to compensate for such deforestation.

2.4.6 Wetlands and Fisheries

Bangladesh has a high proportion of wetland areas, which of late have been declining. They are significant sources of sweet-water fish, and many other natural resources. The decline in fish production has been attributed to a general deterioration of the wetlands, characterized by silting up of bed levels, water logging, as well as water pollution.

2.4.7 Mangrove Ecosystem

The Sundarbans, located in the southwestern part of Bangladesh, is the largest single expanse of mangrove forest in the world. It is a dynamic, fragile, and complex ecosystem, with a delicate balance of land and water. It is a good habitat for offshore fisheries, offers natural coastal protection, highly valuable forest resources, and tourism and recreational possibilities. But a gradual degradation of environment in the Sundarbans has been taking place due to rapid deforestation, top-drying of trees, saline water intrusion, killing of wildlife, inadequate reforestation, and lack of efficient conservation programs.

2.4.8 Salinity

Diversion of the *Ganges* water upstream through construction of a barrage by India has drastically reduced the downstream flow of its distributaries. Consequently, saline seawater enters the mainland through the rivers. This has adverse effects on agriculture, and sweet-water shrimp cultivation, and also on availability of potable water for domestic and other uses. The situation worsens during the dry season, when salinity penetrates further and deeper into the mainland.

2.4.9 Health and Sanitation

The present sanitation conditions are quite unsatisfactory, particularly in rural areas. Only 36.9 per cent of the population has acceptable sanitary systems for safe disposal of excreta. Raw sewage contamination of water systems in Bangladesh is the major factor in transmission and spread of various communicable waterborne diseases, including diarrhea, cholera, typhoid, etc. Industrial wastes, indiscriminate defecation practices, and unhygienic disposal of human waste often pollute surface water, which is an important source of water for human use, including drinking. The coliform count of most surface water resources is beyond the acceptable standard for any domestic use. The high infant mortality in Bangladesh is attributed to the high prevalence of various waterborne diseases, and unhygienic sanitation practices.

2.4.10 Urbanization

Serious problems of environmental degradation are resulting from unplanned urbanization in Bangladesh. The present pattern of urbanization is leading to various problems like land use alterations; inadequate shelter, water, sanitation, and other facilities in slums and other urban poor areas; degradation of community ambient environment; little control of industrial waste emissions; and environmental pollution due to inadequate management of human and domestic wastes.

The capital city of Dhaka is among the fastest growing cities in the world, with an average population growth of 6 per cent per annum. The environmental problems of Dhaka have become a major concern to all strata of society, including the government, NGOs, and scientists, as well as the country's development partners and aid agencies. The World Bank and the Asian Development Bank have sponsored a number of studies and public consultations on environmental issues in Dhaka city. Apart from air pollution, household solid waste poses a serious threat to the city's environment. According to an estimate, 700-800 tons of household and commercial solid wastes are produced in the dry season, and 900-1100 tons during the monsoon season. The wastes are dumped

untreated in nearby low-lying areas and water bodies, where they pollute surface water and generate a foul odor. The hazardous medical wastes from a large number of clinics and hospital are believed to go through the same type of untreated disposal.

2.4.11 Water Pollution

Although Bangladesh is relatively backward and in an early stage of industrialization, the congested location of industrial units and some commercial activities can be identified as environmental hazards, causing severe local water pollution. The tanneries at Hazaribagh in Dhaka city, the textile and dying units at Narayanganj and Gazipur near Dhaka, and the commercial shrimp culture in the coastal regions of Khulna and Chittagong are some of the environmental "hotspots" that have been identified in the country.

More recently, arsenic contamination of the groundwater has emerged as a serious problem threatening public health. In the past decades, groundwater was considered a source of safe drinking water, and was promoted through the installation of thousands of tube wells in rural areas throughout the country. During this period there was remarkable success in providing pure drinking water, free from pathogenic microorganisms, and a concomitant improvement in public health. Then a few years ago, arsenic contamination of groundwater was detected in 44 of the country's 64 districts. Although the real causes of arsenic contamination are yet to be identified, the government has launched a US $50 million project with assistance from donors, and coordinated by the World Bank, for on-site mitigation of arsenic contamination, and the creation of a National Arsenic Mitigation Information Centre (NAMIC).

2.4.12 Global Warming and Climate Change

There is firm scientific evidence that the concentration of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide, in the earth's atmosphere is increasing, largely due to human activities. The consequences will be progressive global warming and climate change. The outlook for any particular country is still not fully clear, because of large uncertainties regarding the rate and magnitude of warming. However, preliminary studies in the past few years have yielded scenarios of Bangladesh's probable vulnerability to climate change.

It is expected that Bangladesh may get warmer and wetter owing to global warming. Higher precipitation may increase the area and depth of flooding, which will require additional measures for protection and adaptation. Other probable impacts include, disruption of the monsoon rhythm, prolonged drought, and increased frequency of cyclones. The most serious consequence of climate change for Bangladesh will be a rise in sea level along the Bay of Bengal coast, causing submergence of 10 to 20 per cent of the land (including the Sundarbans), as well as saline intrusion in the rivers. Although climate change is a long-term process, the implications for Bangladesh are vital for further policy planning.

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