


Biodiversity Conservation and Sustainable Development in Bangladesh: An overview of the present status, management problems and future prospects

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March, 2007

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Summary

Over the past few decades biodiversity has become the issue of global concern for its rapid reduction worldwide. Bangladesh is no exception. The country is exceptionally endowed with a vast variety of flora and fauna, but due to country's tremendous population pressure, rural poverty and unemployment it has been decreased alarmingly. Government has taken various initiatives to alter this situation. The present paper is based on intensive literature survey and tries to explore the country's overall biodiversity situation, biodiversity-development links, present trends and causes of depletion of biodiversity, biodiversity conservation initiatives in the country, major policy and legislation to conserve biodiversity, biodiversity research initiatives, prosperous sector of biodiversity etc. Finally the study concludes that, a separate statutory body or institution is fundamental to ensure conservation; sustainable use and equitable sharing of benefits arisen from biodiversity products and benefits in the country.

Keywords: Biodiversity; Deforestation; Hill forest; Sal forest; Mangrove forest; Wetlands.

Introduction

The term, biodiversity or biological diversity describes the biological capital held within an area. It refers, particularly, to the differences between living organisms at different level of biological organisation - gene, individual species and ecosystems. The Convention of Biological Diversity (CBD) defined biodiversity as; 'the variability among living organisms from all sources including; *inter alia*, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part'. Biodiversity encompasses multiple values and is vital for the production of food and to conserve the ecological foundations needed to sustain people's livelihood (**Box 1**).

Besides, sustainable development is; 'the development which meets the needs of the present without compromising the ability of future generations to meet their own needs'. This includes taking into account the impact of present decisions on the options of future generations. Three goals of sustainable development have been identified which includes; i) economic well being ii) social and human development and iii) environmental sustainability and regeneration (Dalal-Clayton and Bass, 2002).

Development processes and biodiversity are somehow interlinked (McNeely, 2002). Development paths involved conversion or change in indigenous land use (i.e., forest) into other productive (!) and economically profitable land use (e.g., agriculturalisation, urbanization, industrialization etc.) which in most cases negatively affect the ecosystems. Experience in Brazilian Amazon evident that, construction of a 50 km paved road inside the forest foster the deforestation rate and forest degradation thousand times higher than that of previous (Kaimowitz and Angelson, 1998).

BOX 1. The Multiple Values of Biodiversity

1. Direct use	
Subsistence	Food (meat, fish and fruits), medicine, fodder, building materials etc.
Tradable	Bushmeat (meat of wild animal), crops, timber, genetic resources etc.
2. Indirect use	
Environmental services	CO_2 & O_2 emissions, C sequestration, watershed protection etc.
Information and evolutionary	New knowledge, improved diversity & productivity
3. Non-use value	
Future options	Probable use of plant and animal products to solve a future problem (!)
Existence	Aesthetic, cultural, religious and philosophical use

Adapted and compiled from: Kozeill (2001), 22p.

Since, both biodiversity and development are the part of human life in modern era and both works to make our life safer and comfortable therefore balance should be kept in development and biodiversity conservation and priority should be given to alternative and sustainable development paths. It is now globally recognized that the global biodiversity situation is threatened million times higher than any time of its history. Over 15 million ha of natural forest are lost in the tropic every year which is more than the area of Nepal or Arkansas in the United States (FAO, 2006), again the present rate of species extinction is estimated to be between 1000 and 10,000 times the historical (pre 10,000 years BP) rate (Wilson, 1988). According to '*2004 IUCN Red List'* currently 15,589 species are threatened with extinction; 12% of world's known birds, 23% of mammals, and 32% of amphibians are also threatened (Baillie *et. al.* 2004).

Over the past few decades biodiversity became the issues of global anxiety for its rapid reduction worldwide and interestingly, most of the economically poorest countries hold the majority of the world's biodiversity (Koziell, 2001). It is also widely supposed that the poorest people of those poor countries, who depend most immediately upon local ecosystems for their livelihoods are somehow responsible for the degradation of biodiversity and will mostly affected by the consequence of this biodiversity loss (CBD, 2006; 2007). Biodiversity conservation is however essential to improve and alter this situation. Biodiversity conservation through environmental sustainability (Goal 7) is one of the prime objectives of Millennium Development Goals (**Box 2**) which strongly linked with its first objective, i.e., eradication of poverty and hunger. To date, various international treaties and conventions with intergovernmental bodies have been formed to work on biodiversity issues in national, regional and international level (**Box 3**).

BOX 2. Millennium Development Goals

GOAL 1: Eradicate extreme poverty and hunger
GOAL 2: Achieve universal primary education
GOAL 3: Promote gender equality and empower women
GOAL 4: Reduce child mortality
GOAL 5: Improve maternal health
GOAL 6: Combat HIV/AIDS, malaria and other diseases
GOAL 7: Ensure environmental sustainability
GOAL 8: Develop a Global Partnership for Development

Source: IPGRI (2006)

BOX 3. The five major biodiversity-related conventions

- CBD The objectives of the Convention on Biological Diversity (CBD) are the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits arising from commercial and other utilization of genetic resources. The agreement covers all ecosystems, species, and genetic resources.
- CITES The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) aims to ensure that international trade in specimens of wild animals and plants does not threaten their survival. Through its three appendices, the Convention accords varying degrees of protection to more than 30,000 plant and animal species.
- CMS The Convention on the Conservation of Migratory Species of Wild Animals (CMS, or the Bonn Convention) aims to conserve terrestrial, marine and avian migratory species throughout their range. Parties to the CMS work together to conserve migratory species and their habitats by providing strict protection for the most endangered migratory species, by concluding regional multilateral agreements for the conservation and management of specific species or categories of species, and by undertaking co-operative research and conservation activities.
- Ramsar The Convention on Wetlands (popularly known as the Ramsar Convention) provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The convention covers all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation in general and for the well-being of human communities.
- WHC The primary mission of the World Heritage Convention (WHC) is to identify and conserve the world's cultural and natural heritage, by drawing up a list of sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations.

Source: CBD website (URL: http://www.biodiv.org)

Biodiversity of Bangladesh: An overview

Bangladesh, the world largest deltaic region lies in the northeastern part of South Asia between $20^0 34'$ and $26^0 38'$ North latitude and $88^0 01'$ and $92^0 41'$ East longitude (Hossain, 2001). The majority of country's land is formed by river alluvium from the Ganges and the Brahmaputra and their tributaries which, consists mostly of flood plains (80%) with some hilly areas (12%), with a sub-tropical monsoon climate (Islam, 2003). Geographically, Bangladesh falls near the Indo-Burma region which is one of the ten global hot-spot areas and supposed to have 7000 endemic plant species (Mittermeier *et. al.* 1998). Due to its unique geo-physical location Bangladesh is exceptionally characterized by a rich biological diversity (Nishat *et. al.* 2002; Hossain, 2001; Barua *et. al.* 2001). An estimated 5,700 species of angiosperms alone, including 68 woody legumes, 130 fiber yielding plants, 500 medicinal plants, 29 orchids, three species of gymnosperms and 1700 pteridophytes have been recorded from Bangladesh (**Figure 1**) (Firoz *et. al.* 2004; Khan, 1977; Troup, 1975). In Bangladesh, some 2260 species of plant reported alone from the hilly regions of Chittagong, which falls between two major floristic regions of Asia (Anon, 1993).

Subsequently, the country possesses rich faunal diversity. Bangladesh has approximately 113 species of mammals, more than 628 species of birds (both passerine and non passerine), 126

species of reptiles, 22 species of amphibians, 708 species of marine and freshwater fish, 2493 species of insects, 19 species of mites, 164 species of algae (or seaweed) and 4 species of echinoderms with many others (**Figure 2**) (IUCN, 2000; Islam *et. al.* 2003).

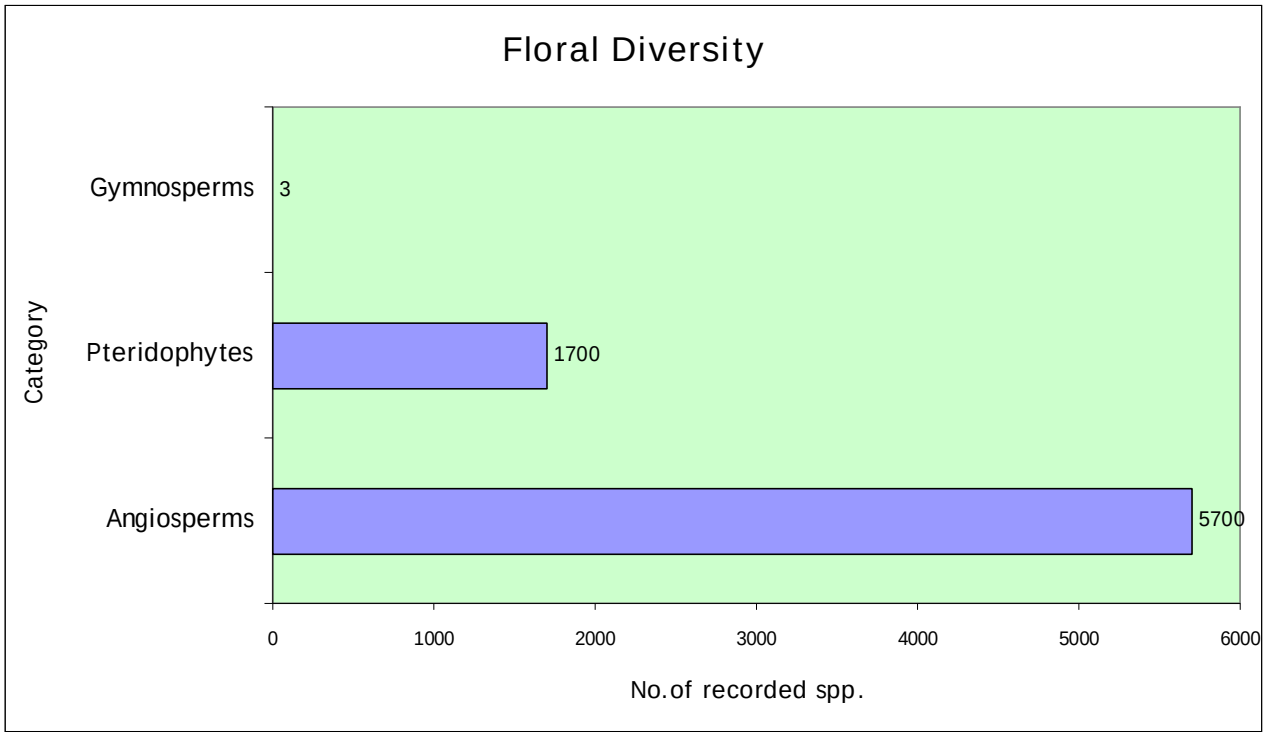


Figure 1. Floral diversity of Bangladesh

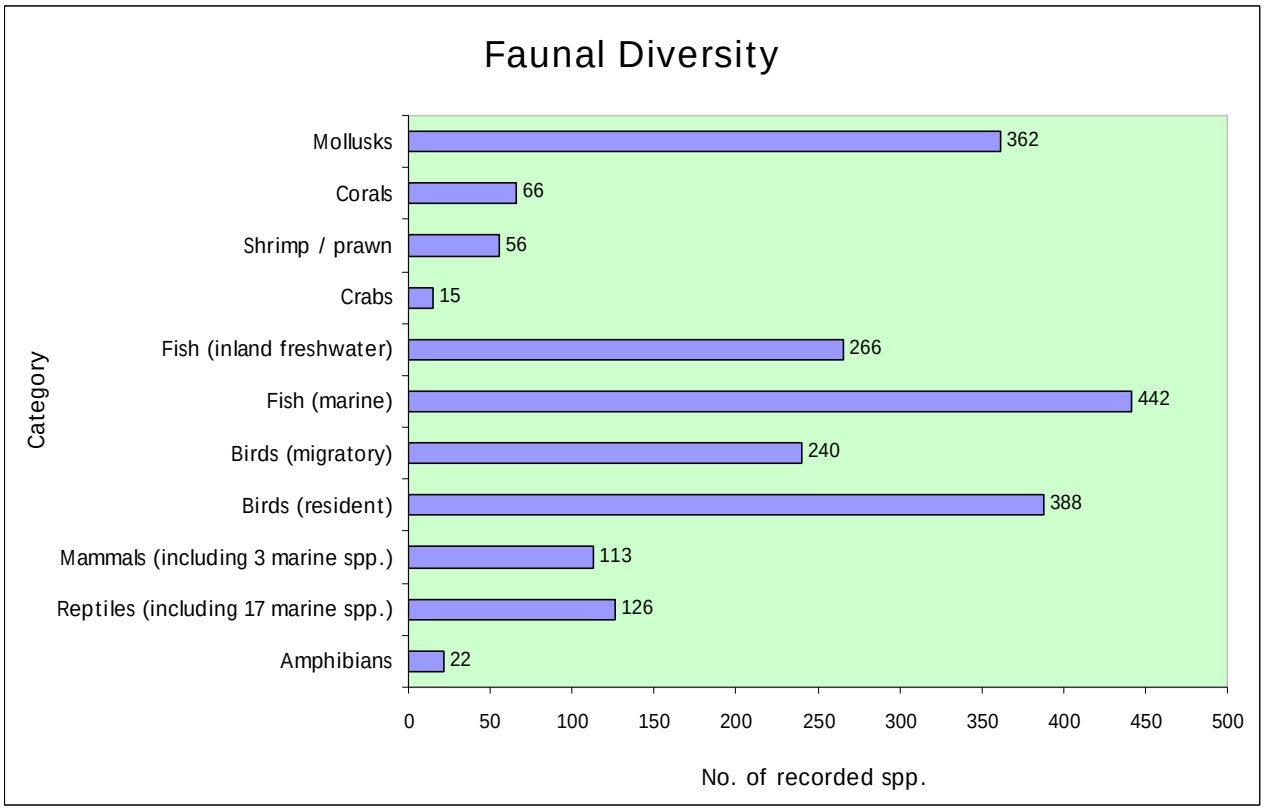


Figure 2. Faunal diversity of Bangladesh

Diminishing Bangladesh Biodiversity: past and present

Although Bangladesh is rich in biodiversity (species) but Rahman (2004) has identified 12 species of wildlife as extinct in Bangladesh (**Table 1**). Contradictorily Hussain (1992) and Asmat (2001) found 18 species of wildlife as extinct from the country. A lot of country's mammals, birds, reptiles are now under tremendous pressure for several reasons. IUCN (2000) has listed a total of 40 species of inland mammals, 41 species of birds, 58 species of reptiles and 8 species of amphibians under various degrees of risks in the country (**Table 2**). Unfortunately reliable information regarding threatened floral diversity is not available in the country. It has been assumed that already 10% flora of the country have extinct. According to a recent exercise completed by the Bangladesh National Herbarium, 106 vascular plant species face risks of various degrees of extinction in Bangladesh (Reza, 2004). Again, Dey (2006) listed 167 plant species as vulnerable or endangered in Bangladesh.

Table 1. Animal species extinct from Bangladesh at recent past

Wildlife class	Common name	Scientific name
Mammals	Great one-horned rhinoceros	*Rhinoceros unicornis*
	Javan rhinoceros	*Rhinoceros sondiacus*
	Asiatic two-horned rhinoceros	*Didermocerus sumatrensis*
	Blue bull /nilgai	*Boselaphus tragocamelus*
	Wild buffalo	*Bubalus bubalis*
	Gaur	*Bos gaurus*
	Banteng	*Bos banteng*
	Swamp deer /barosinga	*Cervus duvauceli*
	Marbled cat	*Canis lupus*
Birds	Pink headed duck	*Rhodonessa caryophyllacea*
	Common peafowl	*Pavo cristatus*
Reptiles	Marsh crocodile	*Crocodylus palustris*

Source: Rahman (2004)

Table 2. Present status of inland and resident vertebrates (species diversity) of Bangladesh

Group	Total no. of living species	Extinct	Threatened			
			Critically endangered	Endangered	Vulnerable	Total
Amphibians	22	0	0	3	5	8
Reptiles	109	1	12	24	22	58
Birds	388*	2	19	18	4	41
Mammals	110	10	21	13	6	40
Total	629	13	52	48	38	147

Source: IUCN (2000) * Excluding migratory birds

Ecosystem (habitat) diversity

Ecologically Bangladesh supports a diverse set of ecosystems. These includes sandy beaches to mangroves, flood plains, lowland forests, terraces and hills reaching far north into the eastern Himalayas – one of 25 biodiversity hot-spots globally identified. The country has the world's largest continuous mangrove forests in its south-western part; in its eastern part it has a large tract of evergreen to semi-evergreen hill forests; once very rich in biodiversity besides in north-eastern part of the country there are many wetland areas; locally called *haors* which harbors a huge number of plants, migratory birds (water fowls) and freshwater fish species. In Bangladesh, over 80% of the land is low-lying and hence waterlogged or flooded at least part of the year. Much of the land area does not generally exceed 40m ASL, making the country's

landscape the single largest flood-basin in South Asia. The entire country is biogeographically a transition between the Indo-Gangetic plains and the eastern Himalayas and in turn part of the Indo-Chinese sub region of the Oriental realm (IUCN, 2004).

There are some contradictions on the actual forests coverage of the country. Although, according to FD and some other sources (see for example, Khan *et. al.* 2007; Mukul *et. al.* 2006 and Hossain, 2005) it is nearly about 2.53 million ha representing approximately 17.5% of the country's total surface area (**Table 3**) but according to FRA- 2005 it is only about 0.871 million ha (FAO, 2006). Officially, Bangladesh Forest Department (FD) manages 1.53 million hectares of forest land of the country (Roy, 2005) (**Figure 3**). Besides, 0.73 million ha of unclassed state forests (USF) are under the control of district administration.

The natural forests of Bangladesh covers three major vegetation types occurring in three distinctly different land types, i.e., hill forest (evergreen to semi-evergreen); plain land sal forest and mangrove forest. Although, once this public forests were very wealthy but during the last few decades they have been degraded heavily due to various managerial and other problems. Brief overviews of these forests are given below;

Hill forests

Vegetation type and description: Evergreen to semi-evergreen tropical forests. Total area is 6, 70,000 ha, which is 4.7% of the country's surface area and 44% of the total forest land managed by the FD. According to latest forest inventory have a growing stock of 23.93 million m^3 of wood. The productivity of the forests declined to a range of 1.5 m^3 to 2.5 m^3 per hectare per annum from 7 m^3 to 8 m^3 twenty years ago but the forests still supply around 40% of the commercial timber production (Chowdhury, 2006). Very rich in diverse varieties of flora and fauna that supports approximately 400 evergreens to deciduous tree species.

Geographic distribution: Chittagong, Chittagong Hill Tracts (Rangamati, Bandarban and Khagrachari), Sylhet, Habiganj and Moulvibazar.

Characteristics species

- **Flora:** Shegun (*Tectona grandis*), Garjan (*Dipterocarpus* spp.), Gamar (*Gmelina arborea*), Telsur (*Hopea odorata*), Toon (*Toona ciliata*), Champa (*Michelia chamaca*), Chapalish (*Artocarpus chaplasha*), Civit (*Swintonia floribunda*), Karoi (*Albizia* spp.) etc.
- **Fauna:** Asian elephant (*Elephas maxima*), Spotted deer (*Axis axis*), Barking deer, Beer, Monkey, Langur, numerous snakes and birds.

Management problems

- Shifting cultivation or practice of *jhum* cultivation which involves forest clearance and burning of debris which ultimately causes soil erosions and nutrient loss.
- Encroachment and illicit felling.
- Lack of true political commitments and willingness
- Raise short rotation plantation with exotic and single species.
- Lack of post plantation management.
- FD's limitations
  1. Inadequate budget
  2. Lack of managerial staffs
- Management of a large tract (0.73 million ha) of forests as USF which have been managed by the district administrations and degraded or denuded seriously due to faulty and improper management techniques and skills.

Table 3. Forest types (ecosystem diversity) and areas in Bangladesh

Forest type	Location	Area (million ha)	Remarks
Hill forest			
Managed reserved forest (evergreen to semi-evergreen)	Eastern part of the country (Chittagong, Chittagong Hill Tracts and Sylhet)	0.67	Highly degraded and managed by the Forest Department.
Unclassed state forest (USF)	Chittagong Hill Tracts	0.73	Under the control of district administration and denuded mainly due to faulty management and shifting cultivation. Mainly scrub forest.
Plain land forest			
Tropical moist deciduous forest	Central and north-western region (Dhaka, Mymensingh, Tangail etc.)	0.12	Mainly *Sal* forest but now converting to exotic short rotation plantations. Managed by the Forest Department.
Mangrove			
Sundarbans	Southwest (Khulna, Satkhira)	0.57	World's largest continuous mangrove forest and including 0.17 million ha of water.
Coastal forest	Along the shoreline of twelve districts	0.10	Mangrove plantations along the shoreline of 12 districts. Managed by Forest Department.
Village forest	Homestead Forests all over the country	0.27	Diversified productive system. Fulfill majority of country's domestic timber, fuelwood and bamboo requirements.
Plantation in tea and rubber gardens	Chittagong Hill Tracts and Sylhet	0.07	Plantations of various short rotation species (mainly exotics).
Total forest		2.53	17.49 % of country's total landmass

Source: Mukul *et. al.* (2006); Hossain (2005)

Plain land *Sal* forests

Vegetation type and description: Deciduous forests. This forest comprises about 5% of the total forests in Bangladesh. Although, once the *Sal* or *Gajari* was the major species of this forests but due to poor coppicing capability and poor management practices there population is now very restricted. Majority of the area has been replanted by short rotation exotic species and some have been brought under social forestry or participatory agroforestry schemes.

Geographic distribution: Gazipur, Mymensingh, Tangail, Comilla, Rajsahi, Rangpur and Dinajpur.

Characteristics species

- **Flora:** Sal (*Shorea robusta*), Koroi (*Albizzia spp.*), Raintree (*Albizzia saman*), Sissoo (*Dalbergia sissoo*), Bohera (*Terminalia belerica*), Horitaki (*Terminalia chebula*), Kanchan (*Bauhinia acuminata*), Polash (*Butea monosperma*) etc.
- **Fauna:** Monkey (*Macaca mulatta*), Barking deer (*Muntiacus muntjac*), Spotted deer (*Axis axis*), Langur, Fishing cat, Marbled cat, Jackel (*Canis aureus*), numerous snakes and birds.

Management problems

- Conversion of forest land into agricultural fields and *jhum* practice by tribal (mainly *Garo*) and local inhabitants.
- Misunderstanding and lack of working partnership between local people and FD field staffs
- Unrecognizing indigenous people's traditional rights and poor socio-economic context in adjoining areas.
- Encroachment and illicit felling.
- Improper application of forest laws and corruptions by the FD's staffs.

Mangrove forest (Sundarbans)

Vegetation type and description: Tidal swamp forest. Considering the importance of preserving biodiversity of the Sundarbans, the UNESCO had on December 6, 1997, declared the forest as the 798th 'World Heritage Site'. It is also one of the two RAMSAR sites of the country. The forest supplies 45 percent of the country's demand for timber and fuel wood. It is also the direct source of livelihood of about 5 million people residing in its neighborhood (Manju, 2001). The forest is the largest single continuous productive mangrove forest of the world spreading over the southern part of Bangladesh and West Bengal State of India. 62% of the forests are in Bangladesh and has been protected as a Reserved Forest since 1875. Each year about 2.4 billion tons of sediment is transported through the Sundarbans, carried by the Ganga, Brahmaputra and Meghna rivers. As this immense load is deposited along the coastline, it creates 3,500 hectares of land area each year (Poffenberger, 2000). Chaffey and Sandom (1985) reported 66 plant species in Bangladesh Sundarbans among which 25 has been identified as true mangrove species while others are mangrove associates or non-obligatory mangrove species (Siddiqi, 2001). The Sundarbans mangrove forests are best known as the habitat of the Royal Bengal Tiger, with the world's largest surviving population estimated between 350 to 500.

Geographic distribution: Khulna, Satkhira and Bagerhat (natural mangroves).

Characteristics species

- **Flora:** Sundri (*Heritiera fomes*), Gewa (*Excoecaria agallocha*), Goran (*Ceriops decandra*), Keora (*Sonneratia apetala*), Golpata (*Nypa fruticans*).

- **Fauna:** Royal Bengal Tiger (*Panthera tigris*), Spotted deer (*Axis axis*), Wild boar (*Sus scrofa*), Rhesus macaque (*Macaca mulatta*), Estuarine crocodile (*Crocodylus porosus*), numerous snakes, birds (300 spp.) and fishes.

Management problems

- Over exploitation of mangrove forests (mainly NTFPs).
- Shrimp fry collection, conversion of forest to shrimp ponds and salt pans.
- Salinity intrusion due to declining fresh water flow through the tidal basin resulting from natural changes, river diversion and diversion of river water for irrigation.
- Sea level rise, environmental degradation and water pollution.
- Rise in tree mortality and top dying of *sundri* due to unidentifying reasons.
- Lack of appropriate policies for proper management and training of forest officials working on wildlife and biodiversity conservation.

Wetlands of Bangladesh

Bangladesh is a land of wetlands. More than two thirds of the country may be classified as wetlands according to the definition enunciated in the Ramsar Convention. On the basis of salinity, the wetlands of Bangladesh can be broadly classified into the inland freshwater and tidal brackish water wetlands (**Table 4**). Floodplains, *beels*, *haors* and *baors* are the parts of the inland freshwater wetlands category. The wetlands of Bangladesh support a wide variety of floral and faunal diversity, some of which are globally as well as locally endangered. However these aquatic resources have been subjected to rapid degradation due to the increasing population pressure, habitat destruction and other anthropogenic as well as natural causes. The GOB formulated the National Environment Management Action Plan (NEMAP) to reverse this degrading trend. It was a cost effective process and tries to ensure people's participation in national planning (IUCN, 2005; Choudhury, 2005).

Table 4. Types of wetlands and their estimated area during the wet season

Wetland types	Area (000 ha)
Permanent rivers and streams	480
Estuarine and mangrove swamps	610
Shallow lakes and marshes	120-290
Large water storage reservoirs	90
Small tanks and fish ponds	150-180
Shrimp ponds	90-115
Seasonally-flooded flood plains	5,770

Source: A Directory of Asian Wetlands (1989) *cit. in.* Khan (2001)

Tanguar haor and *Hakaluki haor* are the two important and major wetland systems in the country and have declared as 'ECA' by the government since 1999. These two haors are located in the greater Sylhet region which is also known as 'Haor Basin' region of the country. These two wetlands support a diverse category of flora and fauna and millions of peoples depend upon them for their subsistence and income. A brief description of these to *haors* is given below.

Tanguar haor

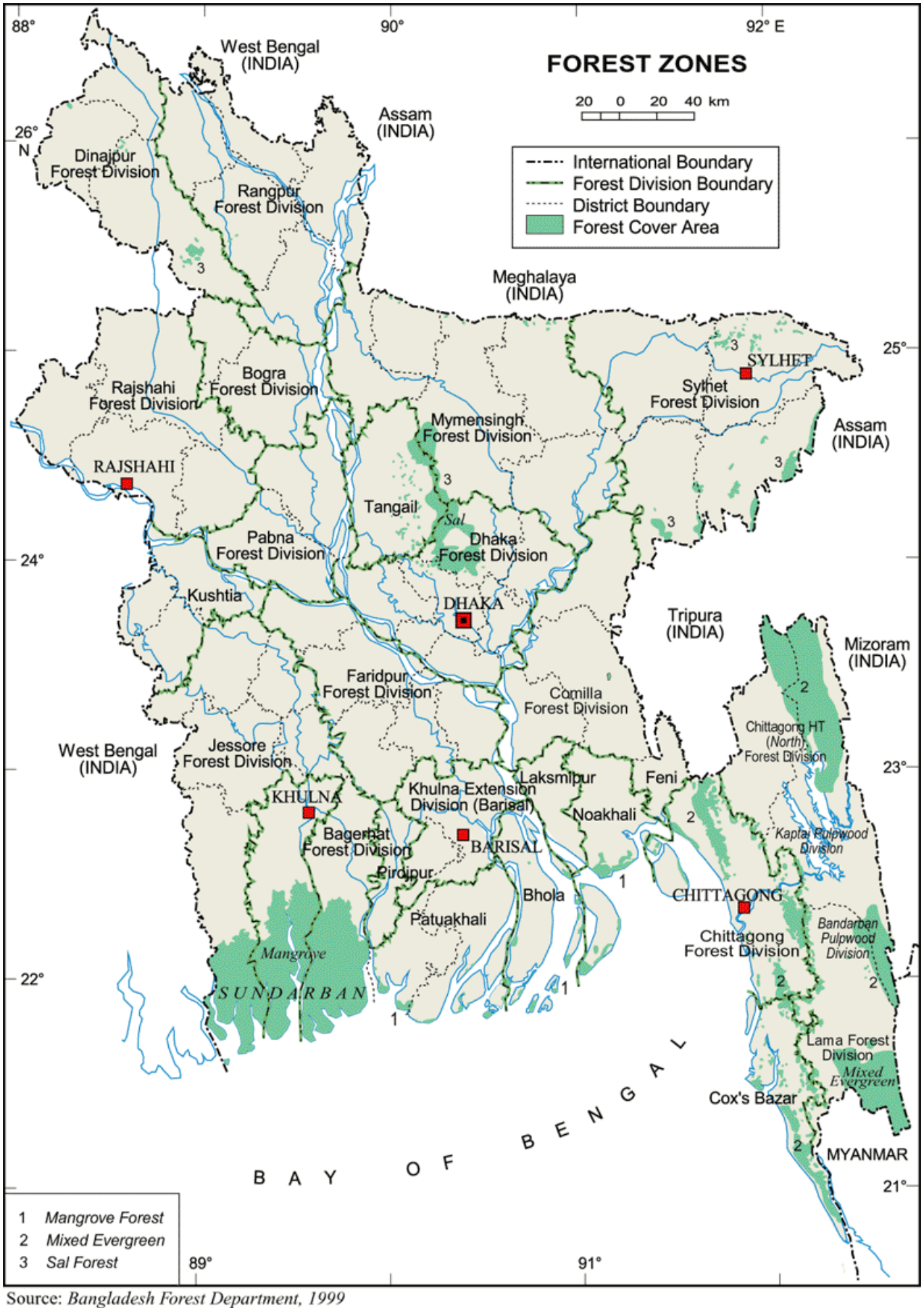
The *Tanguar haor* wetland system harboring one of the last remnants of fresh water swamp forest in Bangladesh. It lies within Sunamganj district extending over 10 *mauzas* of *Dharmapasha* and *Tahirpur upazilas* (administrative unit) of the district. The haor is close to

Indian borders and consists of 120 beels of various sizes. The area of the haor including 46 villages within it is about 100 sq km of which 2802.36 ha is wetland. The haor supports one of the most productive inland fisheries of Bangladesh and providing habitat for numerous globally (1 amphibian, 3 turtles, 2 lizards, 4 snakes, 10 birds and 6 mammals) as well as locally (55 fish, 31 birds and several wetland plat) threatened flora and fauna (Khan, 2001). In the past few decades the total environmental settings of the haor has degraded a lot. The government has taken massive plan to restore the natural environment and heritage of the haor by conserving its water, improving agriculture and fish production, and making the haor secured zone for birds and animals. Already in 1999, the GOB has declared the haor as an 'Ecologically Critical Areas'. It is as well the country's second 'Ramsar site' since July 10, 2000.

Characteristics species

- **Flora:** 120-150 plant species are expected to be occurring at Tanguar Haor; however a previous survey by Bangladesh National Herbarium (BNH) recorded only 78 plant species at the haor (Khan, 2001). These includes;
    - Eleven free-floating species, such as *Pistia stratiotes* (topapana), *Salvania natans* (tetulpana) etc.
    - Thirty eight anchored, submerged species, such as *Potamogeton crispus* (keorali), *Aponogeton echinatus* (ghechu) etc.
    - Five suspended species, such as *Utricularia aurea* (chhotojanghi), *Cerato-phyllum demersum* (also known as chhotojanghi) etc.
    - Twenty rooted species with floating leaves, such as *Nymphaea nouchali* (padma), *Trapa maximowiczii* (paniphal) etc.
    - Some 116 emergent species, such as *Phragmites kakra* (nal khagra), *Polygonum barbatum* (bishkatali) etc.
    - Five climbers, such as *Clematis cadmia, Oxystelma secamone* (dudhi lata), *Cascuta australis* (sarna lata) etc.
    - Eight swamp forest trees and shrubs, such as *Barringtonia acutangula* (hijal), *Pongamia pinnata* (koroch) etc.

- **Fauna:** Wetland ecosystems are the major habitat of birds and fishes in Bangladesh. From various sources it has been found that, Tanguar haor is characterized by,
    - Approximately 141 fish species including some exotic introduced species which represents more than half of the country's fresh water fish species (266 spp.). Among them the notables are *Air, Gang Magur, Baim, Tara Baim, Gutum, Gulsha, Tengra, Titna, Garia, Beti, Kakia* etc.
    - A total of 208 (including 98 migratory spp.) bird species representing almost 30 percent of the country's recorded avifauna. The haor also the habitat of Pallas's Fish-eagle (kura), one globally threatened bird species.
    - 34 mammals, such as otters (ud), Indian Pangolin (bon rui), Gangetic dolphin (shushuk) etc.
    - 11 amphibians and 34 reptiles (including; 6 turtles, 7 lizards and 21 snake species).
    - 12 butterfly spp.



Source: *Bangladesh Forest Department, 1999*

Figure 3. Map showing the forest of Bangladesh

Management problems

- Rural poverty in adjoining areas which leads overexploitation of fish (sometimes through current nets) and other wetland resources.
- Uses of fertilizers and pesticide in agricultural fields which degraded and threaten the aquatic ecosystems.
- Unauthorized hunting of waterfowls and other migratory birds.
- Massive introduction of invasive alien plants (e.g., *Eichhornia crassipes* (Kachuripana)) and fish (e.g., *Clarius gariepinus* (African magur), *Oreochromis mossambicus* (telapia), *Cyprinus carpio* (common carp) etc.)
- Lack of awareness and proper institutional and management framework.
- The former 'Jalmohal' leasing system.

Hakaluki haor

Hakaluki haor is the largest haor in the country with great economic and ecological significance. The haor is a complex system of more than 80 inter-connected *beels* which extends over 18,000 ha during the rainy season (IUCN, 2005). The haor is situated in the *Kulaura* upazila of *Moulvibazar* district. To the north of the *haor* is *Golapganj* upazila of Sylhet, to the west *Fenchuganj* upazila and to the east is *Barlekha* upazila. The haor is a major resting place for thousands of migratory birds in winter. The rich fish resources of Hakaluki support one of the largest inland fisheries in the country. Water from across the border comes to Hakaluki haor through *Juri, Kontiala* and *Kuiachhari* rivers and drains away through the *Kushiara* river. The haor is rich in biodiversity and has been identified by the Department of Environment as an ecologically endangered water body. The haor been also proposed for Ramsar nomination by Canadian International Development Association (CIDA) after conducting an extensive survey on the biodiversity of the haor in 1995.

Characteristics species are more or less same as ***Tanguar haor.***

Management problems

- Shrinking of the haor area due to expansion of agricultural fields, decrease in water flow etc.
- Uses of chemical fertilizers and pesticide in agricultural fields which drained by water into the haor and threaten the animal life in water.
- Overexploitation and decrease in breeding capacity of fish.
- Depletion of water plants due to widespread collection of fire wood.
- Illegal hunting of birds.
- Absence of a legal institution for preservation of biodiversity in the threatened Hakaluki haor.
- Disregard local people's wants in haor management system.

Present trends, challenges and threats to overall biodiversity of Bangladesh

Bangladesh has the highest rural population densities in the world with lowest per capita forest land (Anon, 2003; Rahman *et. al*. 2003). The contribution of the forestry sector to GDP is 3.3% at current prices and about 2% of the country's labor forces are employed in this sector (Siddiqi, 2001). Officially, although Bangladesh has nearly about 17.5% forest coverage but only 6% of them are well stocked. Besides, the annual deforestation rate in the country is 3.3% which is highest among the south-east Asian countries (Poffenberger, 2001). In recent days, although government has become anxious about biodiversity conservation but country's forest and biodiversity are still facing various challenges like other regions of the world (**Figure 4**).

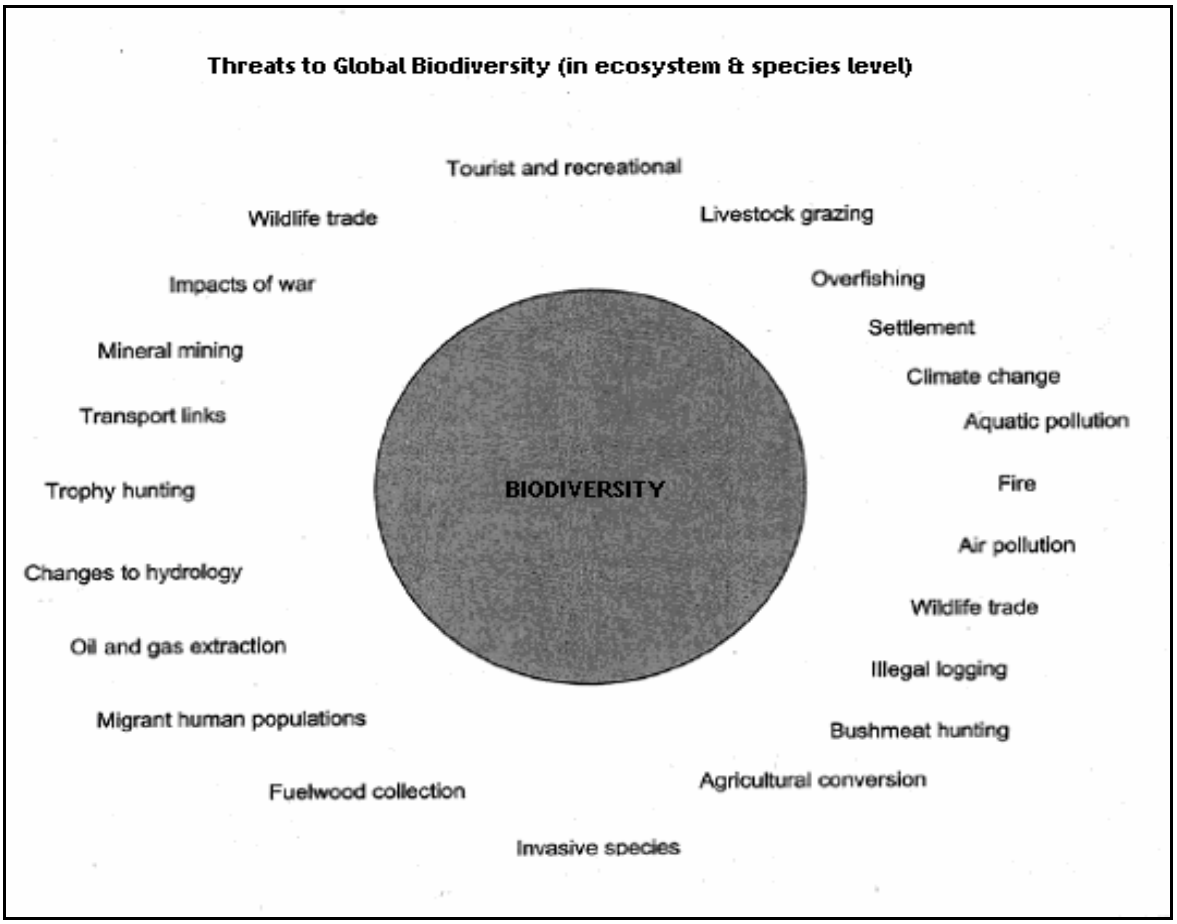


Figure 4. Threats to global biodiversity (adapted from: TBI, 2005)

Following are some major reasons behind biodiversity depletion in Bangladesh.

- **High population density, extreme poverty and unemployment:** Bangladesh is one of the world's densely populated countries with a population of more than 150 million. Majority of the people of the country are still living under poverty line and without any permanent job. Besides, more than 85% of the population of the country are living in rural areas and somehow depends upon various natural resources which often lead over exploitation of plant and animal products for their survival and income. Rural fuel consumption pattern is another important issue related to natural resource depletion in the country. Still now, most of the people in rural areas depend on fuelwood which is strongly concerned with degradation and unsustainable use of various woody and forested areas.
- **Habitat loss, degradation and fragmentation:** Biodiversity is strongly associated with intact ecosystems and natural landscapes, however transformation of land use patterns, expansion of agricultural lands, change in cropping patterns, introduction of high yielding varieties (HYV), urbanization, expansion of road networks, unplanned embankments and other manmade factors have caused immense damage of habitats in all ecosystems. The following are some underlying factors related to this issue;
    - Encroachment
    - Shifting cultivation
    - Urbanization
    - Land use change and agricultural expansions
    - Commercial shrimp cultivation in coastal mangrove areas
- **Illegal poaching:** There is a big international market (illegal!) on wild animals (and their part, e.g., teeth, bones, far, ivory etc.) for their aesthetic and medicinal value. Peoples

involved with this underworld syndicate sometimes illegally hunting/trafficking wild animals to earn some easy cash. Besides, unregulated logging, illicit felling, indiscriminate harvest of medicinal plants, Non Timber Forest Products (NTFPs), unplanned fishing, using bag nets, bottom trawling fishing, fishing in the breeding season and other factors are causing depletion of biodiversity.

- **Environmental pollution and degradation:** One of the biggest threats to biodiversity in Bangladesh is pollution of air, soil and water. Water is the greatest victim of contributed by toxic agro-chemicals (i.e., chemical fertilizers, insecticides), industrial effluents that are causing depletion aquatic resources and riparian natural resources.
- **Invasive Alien Species:** A large number of exotic (non-native) plants have been introduced into Bangladesh for agriculture, horticulture, forestry, animal husbandry and fisheries. Also some have become escapes accidentally and having adapted with local conditions proliferated profusely. Local people to different agro-ecological conditions have nurtured some of these and some have become invasive over local flora and fauna (Mukul *et. al.* 2006). Besides, replacing natural plantation with monoculture of short rotation and fast growing species have threatens the existence of local fauna as they have not adapted with this species.
- **Absence of proper institutional arrangements, frameworks and monitoring:** Lack of adequate institutional or administrative frame works and suitable policies, weak implementation of existing policies, lack of integration of sectoral activities are other major threats to biodiversity in Bangladesh. Beside these, week institutional capacities and lack of trained manpower in all disciplines dealing with biodiversity, poor coordination and cross-sectoral integration, weak national information system and inadequate knowledge on ecosystem structure and function are vital reason for biodiversity loss in the country. Monitoring is particularly important in understanding the fate of ecosystems, habitats and rare and endangered species.
- **Global climate change and sea level rise:** Bangladesh is supposed to be affected mostly due to global climate change which will ultimately lead to sea level rises in near future. It has been roughly estimated that about one third of the country's land will go under water. Already, salinity intrusion and decreasing fresh water flow in the mangroves of Sundarbans cause massive vegetation change in the area. It has been supposed that top dying of *Sundri* and other mangrove species is also happen due to this change (Khan, 2003). Biodiversity may also be vulnerable due to variation in the length and period of climatic events.
- **Lack of true political commitments and willingness:** Unfortunately, no political parties of the country been not included any forestry and biodiversity issue in their political campaign and these issues have also overlooked or weakly recognized or poorly emphasize when they are in power. In same cases political persons have been found responsible to illegal forest activities (i.e., encroachment) and environmental degradation.
- **Lack of people's awareness:** Lack of biodiversity related information and knowledge automatically leads to gaps in awareness. Gaps in awareness have been identified at various levels. To start with, most people do not even know that there are so many species of organisms in Bangladesh. Even the educated do not know that there are laws that ban hunting and trade in wild animals, there are laws that protect certain species and ecosystems and that there are laws that are meant to control environmental pollution. Different categories of Protected Areas exist in the country. However, many including the policy makers are not aware of the different management systems that the Protected Areas are placed under.

Biodiversity conservation initiatives in Bangladesh

Bangladesh has signed the five major conventions and agreements related to biodiversity conservation (i.e., CBD, CITES, CMS, RAMSAR, WHC) (Brown and Durst, 2003). As a signatory party of these conventions the government has undertaken various initiatives to conserve the biodiversity in both ecosystem and species level. Again as a CBD-COP the country is bound to adopt the Ecosystem Approach to conserve biodiversity (**Box 4**).

BOX 4. The Ecosystem Approach

The Ecosystem Approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complex knowledge or understanding of their functioning. Ecosystem processes are often non-linear and the outcome of such processes often shows time-lags. The following 12 principles of the ecosystem approach are complementary and interlinked:

Principle 1: The objectives of management of land, water and living resources are a matter of societal choice.

Principle 2: Management should be decentralized to the lowest appropriate level.

Principle 3: Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.

Principle 4: Recognizing potential gains from management, there is usually a need to understand and manage the ecosystems in an economic context. Any such ecosystems-management programme should: (a) reduce those market distortions that adversely affect biological diversity; (b) align incentives to promote biodiversity conservation and sustainable use; (c) internalize costs and benefits in the given ecosystem to the extent possible.

Principle 5: Conservation of ecosystem structure and functioning, in order to maintain ecosystem and services, should be a priority target of the ecosystem approach.

Principle 6: Ecosystem must be managed within the limits of their functioning.

Principle 7: The ecosystem approach should be undertaken at the appropriate spatial and temporal scales.

Principle 8: Recognizing the varying temporal scales and lag-effects that characterize ecosystem processes, objectives for the ecosystem management should be set for the long term.

Principle 9: Management must recognize that change is inevitable.

Principle 10: The ecosystem approach should seek the appropriate balance between, and integration of, conservation and use of biological diversity.

Principle 11: The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.

Principle 12: The ecosystem approach should involve all relevant sectors of society and scientific discipline.

Source: (CBD, Decision V/6, 2002) *cit. in.* Scialabba and Hattam (2006)

Hereafter various initiatives taken by the government to conserve biodiversity in two different ways (i.e., *ex-situ* conservation and *in-situ* conservation) is briefly discussed.

In situ conservation

In situ conservation is carried out in the following areas: nature reserves, protected areas (i.e., national parks, wildlife sanctuaries and game reserves), world heritage sites and Ramsar sites etc. According to FRA-2005 about 20.9% forests (out of 8.71 million ha) of the country are primarily managed for conservation purpose (FAO, 2006). There are some eco-parks and safari parks in the country where both *ex situ* and *in situ* conservation measures have been practiced.

- **Nature Reserves –** The objectives of a nature reserve are to protect communities and species and to maintain natural processes in order to have ecologically representative examples of the natural environment. However, in Bangladesh there are no nature reserves. The country has one world heritage site (Sundarbans) and two Ramsar sites (i.e., Sundarban and Tanguar Haor) which has globally recognized for their unique ecological settings and conservation importance and presently conserved and managed by the government. Besides, the government has declared some Ecologically Critical Areas (ECA) which has been notified as ECA after severe ecological destruction (**Box 5**).

BOX 5. Ecologically Critical Area

Ecologically Critical Area (ECA) is; ecologically defined areas or ecosystems affected adversely by the changes brought through human activities. The Director General of the Department of Environment have the provision for declarations of ECA in certain cases where ecosystem is considered to be threatened to reach a critical state. If the government is satisfied that due to degradation of environment, the ecosystem of any area has reached or is threatened to reach a critical state, the government may by notification in the official gazette declare such areas as ECA. The government shall specify, through the notification provided in sub-clause (1) or by separate notification, which of the operations or processes cannot be initiated or continued in the Ecologically Critical Area.

The following are the eight ECA's declared by Department of Environment (DoE), to date;

- Cox's Bazar-Teknaf Sea Beach
- St Martin's Island
- Sonadia Island
- Hakaluki Haor
- Taqnguar Haor
- Marjat Baor
- Gulshan Lake
- Strip of 10 km. outside the Sundarbans Reserved Forest

Source: Islam (2005); Kothari *et. al.* (2000)

- **Protected Areas -** Protected Areas are, "areas especially dedicated to the protection and maintenance of biological diversity and associated cultural resources, and managed through legal or other effective means" (IUCN, 1994). Globally the number of protected areas has been increasing significantly over the last few decades and currently about 12% of all forests are officially protected for conservation values (Scherr *et. al.* 2004; Mulongoy and Chape, 2004). In

Bangladesh three types of PA (i.e., national parks, wildlife sanctuaries and game reserves) have been defined under Bangladesh Wildlife Preservation Act, 1974. Presently there are 10 national parks, 7 wildlife sanctuaries and 1 game reserve in the country which covers less than two percent of total landmass and less than ten percent total forests of the country (Mukul *et. al.* 2006; **Box 6**).

BOX 6. Protected Areas of Bangladesh

Protected Areas: With the objective of conserving biodiversity (flora as well as fauna) and the natural environment within various forest types, the following three types of protected area under different IUCN protected area management category are defined in the Bangladesh Wildlife Preservation Act, 1974:

- *Wildlife Sanctuary:* an area maintained as an undisturbed breeding ground for wild fauna and where the habitat is protected for the continued well-being of the resident or migratory fauna.
- *National Park:* a comparatively large area of natural beauty to which the members of the public have access for recreation, education and research, and in which the wildlife is protected.
- *Game Reserve:* normally comprises a relatively isolated area meant for protection of wildlife in general and to increase the population of specified species.

The followings are the PAs (for *in situ* conservation) declared to date under different forest types of Bangladesh;

List of protected areas of Bangladesh

Sl.	Protected Areas	Forest types	Location	Area (ha)	Established (Extended)
A.	*NATIONAL PARKS* (IUCN category V)				
01.	Modhupur NP	Sal forest	Tangail	8,436	1962(1982)
02.	Bhawal NP	Sal forest	Gazipur	5,022	1974 (1982)
03.	Himchari NP	Hill forest	Cox's Bazar	1,729	1980
04.	Lawachara NP	Hill forest	Maulvibazar	1,250	1996
05.	Kaptai NP	Hill forest	Rangamati	5,464	1999
06.	Ramsagar NP	Sal forest	Dinajpur	27.75	2001
07.	Nijhum Dweep NP	Coastal mangrove	Noakhali	16,352.23	2001
08.	Medha Kachapia NP	Hill forest	Cox's Bazar	395.92	2004
09.	Satchari NP	Hill forest	Habiganj	242.82	2005
10.	Khadimnagar NP	Hill forest	Sylhet	679	2006
B.	*WILD LIFE SANCTUARIES* (IUCN category IV)				
11.	Sundarban (East) WS	Natural mangrove	Bagerhat	31,226.94	1960 (1996)
12.	Pablakhali WS	Hill forest	Rangamati	42,087	1962 (1983)
13.	Char Kukri Mukri WS	Coastal mangrove	Bhola	40	1981
14.	Chunati WS	Hill forest	Chittagong	7,761	1986
15.	Rema-Kalenga WS	Hill forest	Habiganj	1,795.54	1996
16.	Sundarban (South) WS	Natural mangrove	Khulna	36,970.45	1996
17.	Sundarban (West) WS	Natural mangrove	Satkhira	71,502.13	1996
C.	*GAME RESERVE*				
18.	Teknaf GR	Hill forest	Cox's Bazar	11 615	1983

Source: Mukul (2007); Mukul *et. al.* (2006); NSP (2006)

- **Eco parks and Safari park-** Government has established and declared several eco parks and one safari park to conserve biodiversity and genetic materials for research and other purpose. Both *in situ* and *ex situ* conservation strategies have been adopted here to maintain and keep biodiversity in sound condition. Table 5 lists the name and location of eco-parks and safari park in Bangladesh.

Table 5. Eco-Parks and Safari Park (both *in situ* and *ex situ*) of Bangladesh

Sl.	Eco-Parks / Safari Park	Forest types	Location	Area (ha)	Established
01.	Banskhali eco-park	Hill forest	Chittagong	1,200	2003
02.	Madhob-Kunda eco-park	Hill forest	Maulvibazar	253	2000
03.	Kua-Kata eco-park	Coastal mangrove	Patuakhali	5,661	2006
04.	Sita-Kunda eco park	Hill forest	Chittagong	403	2000
05.	Madhu-Tila eco park	Sal forest	Sherpur	100	1999
06.	Dulhazra safari park	Hill forest	Cox's Bazar	900	1997

Ex situ conservation

In contrast to *in situ* conservation, *ex situ* conservation includes any practices that conserve biodiversity (or genetic materials) outside the natural habitat of the parent population. In Bangladesh these types of effort are mainly limited to Bangladesh Forest Research Institute (BFRI) and it includes the followings (Islam, 2004);

- **Botanical gardens-**
  - Mirpur Botanical Garden: area 85 ha, with 255 tree species (total 28,200 plants), 310 shrub species (8,400 plants), 385 herb species (10,400 plants). The total number of families of trees, herbs and shrubs is 114.
  - Baldha Garden: area 1.15 ha with 18,000 trees, herbs and shrubs from 820 species and 92 families.

- **Preservation Plots-** BFRI has established five preservation plots at different hill forest areas and 27 at the Sundarbans (mangrove) forest.

- **Clone Banks:** The BFRI has established two clonal banks, one at Hyako, Chittagong (4 ha) and another at Ukhia, Cox's Bazar (4 ha). Seven tree species (*Tectona grandis, Gmelina arborea, Bombax ceiba, Dipterocarpus turbinatus, Syzygium grande, Swietenia mahagoni* and *Paraserianthes falcataria*) are preserved in these two locations.

- **BFRI Arboretum's-**
  - One bambusetum (1.5 ha) has been established at the BFRI campus. This arboretum contains 27 bamboo species including 6 exotic species.
  - One arboretum of medicinal plants (1 ha) has also been established at the BFRI campus with a collection of 40 species.
  - One cane arboretum (0.5 ha) with seven species.
  - Three arboreta of tree species have been established at the BFRI-HQ with 56 species, Keochia Forest Research Station with 56 species and Charaljani Silviculture Research Station with 52 species.

Major policy, legislation and activities relating to biodiversity conservation in Bangladesh

There are several legislative policies and initiatives that provide provisions for regulating, harvesting and protecting plants and animals in Bangladesh (Ali and Ahmed, 2001; Kothari *et. al.* 2000). Those are;

National Conservation Strategy (NCS)
The need for a National Conservation Strategy was first emerged in September 1986. Its primary goal was to provide a national strategy for conservation of all concerned sectors. It provides specific strategies for sustainable use of natural resources as well as sustainable development in 18 different sectors. The National Conservation Strategy Implementation Project I (1994–1999) was a five-year project implemented by the Ministry of Environment and Forest (MoEF), with financial and technical support from NORAD and IUCN. Through this NCS Phase 1, one major programme was implemented in four distinct ecosystems—tropical and mangrove forest areas, *St. Martin's Island*, *Tanguar Haor* and *Barind Tract*. The main objective of all these activities is conservation of biodiversity.

National Environment Management Action Plan (NEMAP)
The MoEF prepared the NEMAP, which is based on a comprehensive participatory planning process ranging from grassroots up to national level. Inputs were provided from local communities, government agencies, non-governmental organizations, professional groups, academics, parliamentarians, lawyers and journalists. Together, this cross section of concerned stakeholders identified key institutional, sectoral, location-specific and long-term issues and actions. The NEMAP thus constitutes a synthesis of perceptions of the government, NGO's and the people on environmental problems and the actions required to address them. The NEMAP provides the policy framework of, and action plan for environmental development in combinations with a set of broad sectoral guidelines that emphasis, *inter alia*, the following:

1) Maintenance of the ecological balance and overall progress and development of the country through protection and improvement of the environment.
2) Protection of the country against natural disasters.
3) Identification and control of all types of activities related to the pollution and degradation to the environment.
4) Undertaking environmentally sound development programmes in all sectors.
5) Sustainable long term and environmentally congenial utilization of all natural resources.
6) Activities in association with all environmental-related national and environmental initiatives.

Sustainable Environment Management Programme (SEMP)
The Sustainable Environment Management Programme supported by the UNDP and implemented by MoEF for a five year periods (1998-2002) was the response evolved from the concerns, needs and actions identified through the National Environment Management Action Plan (NEMAP) process. It focuses on community-based resource management in wetlands. In the NEMAP several major priority areas of environmental concern were identified, and the SEMP has been designed to address these priorities. The programme consists of 26 components on five major themes, and is implemented by 22 organizations from the government, non-government organizations (NGOs) and private sector. The community-based "Haor and Floodplain Resource Management Project" is being implemented by the IUCN with the Ministry of Environment and Forest, in two well-defined degraded areas of haor and floodplain ecosystems. The major focus of the programme is to involve community people in the planning and implementation of activities for the management of natural resources that maintain biodiversity and human well-being.

The Bangladesh Environment Conservation Act, 1995 and Environment Conservation Rules 1997: The Bangladesh Environment Conservation Act of 1995 was enacted for environmental conservation, environmental standard development and environmental pollution control and mitigation. ECA 1995 is currently the main legislative framework relating to environmental protection in Bangladesh. The Environment Conservation Rules, 1997 (ECR 1997), are the first set of rules which have been promulgated under the ECA 1995. The major aspects covered by ECR 1997 are the National Environmental Quality Standard; requirements and procedures to get environmental clearance; requirement of Initial Environmental Examination and Environmental Impact Assessment for any project. However, the major application of ECA 1995 was to declaration of Ecologically Critical Areas (ECA).

National Biodiversity Strategy and Action Plan (NBSAP)

As a signatory party of CBD Bangladesh has prepared a NBSAP with 24 different conservation components which has been implemented and executed by different government and non-governmental conservation organizations (**Box 7**).

BOX 7. National Biodiversity Strategy and action Plan (NBSAP) of Bangladesh

Implementing and planning agency: Ministry of Environment and Forests (MoEF)

Donors: GEF/UNDP

Objectives of the Bangladesh NBSAP:

- Formulate strategies and action plans for conservation and sustainable use of country's biological diversity.
- Identify the current pressure on the biological resources, and options and priority actions for the conservation and sustainable use of national biodiversity by the stakeholders.
- Complement and build on the NCS (National Conservation Strategy) as well as the NEMAP (National Environmental Management Action Plan) and other sectoral plans, through participatory processes involving representativeness from different sectors of the society.
- Raise community awareness of the sustainable use of biodiversity.

The Bangladesh NBSAP identified a total of 24 conservation related components subdivided under 13 major priority areas, which includes:

1. Biodiversity documentation and valuation.
2. Conservation of ecosystems, species and genetic pool.
3. Restoration of ecosystems and recuperation of endangered species.
4. Biosafety procedures and standards to deal with AIS and GMO.
5. Equitable sharing of biodiversity conservation costs and benefits.
6. Awareness raising and capacity building.
7. Recuperation of the traditional knowledge and the protection of the intellectual property rights.
8. Establishment of an implementing mechanism for the Bangladesh NBSAP (National Biodiversity Board and supporting mechanisms).
9. Establishment of participatory mechanisms leading to biodiversity conservation.
10. Review and completion of biodiversity related legislation and creation of a specific branch in the Judiciary.
11. Establishment of an open and transparent monitoring and reporting.
12. Development of a sustainable funding system for biodiversity conservation.
13. Linking biodiversity conservation to climate change, livelihood and poverty.

Source: Firoz *et. al.* (2004); IUCN (2004)

Nishorgo Support Project (NSP)
This pilot protected area management programme is a Forest Department's Project and has been financed by USAID under a Strategic Objective Grant Agreement. This is a five year project (2005-2010) and has been primarily implemented in five PAs of the country (i.e., *Lawachara National Park, Rema-Kalenga Wildlife Sanctuary, Satchari National Park, Chunati Wildlife Sanctuary* and *Teknaf Game Reserve*) (Roy, 2005). The overall objective of this project is conservation of biodiversity within the PAs. The project has worked to achieve six separate but closely related objectives in support of this overall objective, as stated below:

- Develop a functional model for formalized collaboration in the management of Protected Areas.
- Create alternative income generation opportunities for key local stakeholders in and around PAs.
- Develop policies conductive to improved PA management and build constituencies to further these policy goals.
- Strengthen the institutional system and capacity of the FD and key stakeholders so that improvements under the project can be made permanent.
- Build or reinforce the infrastructure within PAs that will enable better management, and provide limited visitor services.
- Design and implement a program of habitat management and restoration for PAs.

Bangladesh Wildlife (Preservation) (Amendment) Act, 1974
The Bangladesh Wildlife (Preservation) Order, 1973 was promulgated under Presidential Order No. 23 in 1973 and was subsequently enacted and amended as the Bangladesh Wildlife (Preservation) (Amendment) Act, 1974. The law provides for the preservation, conservation and management of wildlife in Bangladesh. According to the Act the term wildlife or 'wild animals' means 'any vertebrate creature, other than humans beings and animals of usually domesticated species or fish, and include the eggs of birds and reptiles' only. The law itself is not sufficient to provide legal protections to the significant aquatic biodiversity component of the ecosystem. For example, by this definition, the important components of the coral species in the St. Martin's Island, and also fishes and mollusks, remain outside the legal protection of this Act.

Bangladesh Forest Act, 1978 and Subsequent Amendments
The law provides protection of and development of forests. The government may assign a reserved forest to any forestland or wasteland, or any land suitable for afforestation, which is the property of the government, over which the government is entitles. Subsequently, the Forest Law has been amended and updated foe a number of times in response to changing needs. The Forest Act, 1972, the Forest (Amendment) Act 1990 and the amendment in 2000 may be mentioned in this regard. These are contributing quite a lot to the conservation of biodiversity, although not enough, and much more remains to be done.

Forest Policy and Forestry Sector Master Plan
The GOB first formulated the National Forest Policy in 1979. But as the situation began to change with demand for forestry products and consequent depletion of forest resources and degradation of the overall environment, the Government had to update it and formulate a revised policy which is known as the Forest Policy 1994.

The biodiversity issue has been given increased importance in the latest policy. The policy stated that attempts will be made to bring about 20% of the country's land under the afforestation programmes of the government and the private sector by 2015. In order to achieve self-reliance in forest products and maintenance of ecological balance, the government will work hand in hand with the NGO's and people's participation will be encouraged.

The policy further stated that the priority protection areas are the habitats that encompass representative samples of flora and fauna in the core areas of National Parks, Wildlife Sanctuaries and Game Reserves. Attempts will also be made to increase the extent of these protected areas by 10% of the reserved forest area by 2015. To achieve the objectives and targets as stated in the policy, the government has also formulated the Forestry Sector Master Plan (1995-2015). The financial requirements to implement the plan have been estimated to be about Tk. 80,000 million.

Biodiversity related research initiatives in Bangladesh

The Government of Bangladesh has undertaken and implemented several biodiversity related programmes and projects, under the financial assistance of various international donor countries and organizations. Some of the noteworthy ones are described below (Rahman, 2004):

Coastal and Wetland Biodiversity Management
Bangladesh has completed a Pre-Investment Feasibility (PRIF) study in the "Coastal and Wetland Biodiversity Management Project" funded by the Global Environmental Facility (GEF). It was a preparatory initiative to develop a project proposal to implement a reserve, and a multiple-use management programme for the protection, sustainable management, and integration of at least three-priority biodiversity sites in Bangladesh. The primary focus was to integrate conservation and development, in order to protect and manage the priority areas in a sustainable way. The duration of the project was 15 December 1997 to 31 December 1999. The Project Brief and the outcome of the said PRIF study project have already been approved by the Project Steering Committee, and subsequently accepted by the GEF. The product of the follow-up project entitled "Coastal and Wetland Biodiversity Management in Cox's Bazar and Hakaluki Haor (BGD1991G31)" has also been prepared, and approved by the GEF council for funding. This project is under process of execution by the Government of Bangladesh.

Integrated Coastal Zone Management (ICZM)
In December 2000 the Minister of Water Resources announced the Government's intention to develop an ICZM policy. Among other objectives, the ICZM policy will attempt to rationalize and coordinate more effectively a number of environment and development initiatives taking place in the coastal zone. A number of donors, including the World Bank and the Netherlands Government, will be supporting the development of the policy over the coming years.

Management of Aquatic Ecosystem through Community Husbandry (MACH)
The natural resources in the floodplains and wetlands throughout Bangladesh are in decline. Thus, to conserve these resources the Government of Bangladesh and the United States of America have jointly developed a programme called MACH. An agreement to implement this programme was signed in May 1998. Its goal is to ensure the sustainable productivity of all wetland resources such as water, fish, plant and wildlife over an entire wetland ecosystem.

Sundarbans Biodiversity Conservation Programme
The Asian Development Bank funded the project "Biodiversity Conservation in the Sundarbans Reserved Forest." The objective of the project was to establish a effective system for the participatory and sustainable management of the ecosystem of the Sundarbans Reserved Forest. The scope of the project included biodiversity conservation, sustainable resource management, community development, participatory resources management programme, development of

ecotourism infrastructure, and establishing a new multi-sectoral management agency that will work for an integrated conservation and development approach.

Biodiversity survey in different protected areas

A biological survey study was conducted in 13 protected areas by the Bangladesh Centre for Advanced Studies, in collaboration with the Forest Department. The survey was conducted to assess the biological resources available in the designated areas. The potential value of each protected area was evaluated through determination of the species present, the relative abundance of the species and the species diversity. The critical habitats in each of the protected areas were identified for protecting the threatened species, and also for developing protective area management plans.

Conservation and management of medicinal plants

A project on the conservation and management of biodiversity of medicinal plants for their sustainable utilization will be executed in Rangamati Hill district. This project is in the process of final approval by the GEF. The specific objectives of the project are:

- Development of an inventory of medicinal plants in the project area;
- Documentation of traditional uses by the local people;
- Conservation of medicinal plants and their ecosystem;
- Capacity building of concerned agencies in the sustainable use of the medicinal plants.

Towards sustainability: future potentials of biodiversity conservation in Bangladesh

The followings are some prosperous sector in the field of biodiversity in Bangladesh that can contribute both in development and conservation of biodiversity in the country,

Eco-tourism: Nature or forest-based tourism is a key category of eco-tourism, one of the fastest growing sectors in the world (Landell-Mills and Porras, 2002). However in Bangladesh this promising sector is poorly utilized. From a source it has been found that, less than 10,000 foreign visitors entered in the country in 1992, domestic tourism on the other hand appear to be a strongly flourishing sector of the market (Vantomme *et. al.* 2002). Government should develop infrastructural and other facilities to attract national and international tourist in various attractive sites of Sylhet, CHTs, Cox's Bazar and Sundarbans.

Payment for environmental services (PES): The concepts of payments for environmental services (PES) have emerged in recent years as a potential tool for achieving ecosystem conservation and improving the livelihoods environmental-service providers and consumers (Robertson and Wunder, 2005). In Bangladesh forests have been provided various environmental services like; watershed protection, protection from tidal surges and cyclones, air purification, carbon sequestration, erosion control etc. Government can check the feasibility of payments schemes (e.g., tax) for these environmental services.

Carbon trading: Bangladesh forests still absorbs more carbon than the total carbon produced in the country. As a signatory party of 'Kyoto Protocol' the country can ask for compensation from the developed countries for this extra carbon absorbed by country's forest.

Non-timber forest products and conservation: Non-timber forest products (NTFP) includes include fruits, firewood, bamboo, rattans, medicinal plants, spices etc. other than commercial timber. It is now widely believed that, the collection and use of NTFPs is ecologically less destructive than timber harvesting and have encouraged the belief that more intensive management of forests for such products could contribute to both development and conservation objectives (Arnold and Ruiz Pérez, 2001). In Bangladesh many people living in and adjacent to

forest are customarily depends on various forest practices which sometimes found harmful to forests, now commercialisation and development of NTFP-based small scale industries in these regions may act as an incentive to forest conservation.

Homegardens and biodiversity conservation: The homegardens of Bangladesh are a diversified agroforestry productive system. They are very rich in floral diversity and still fulfill the majority of country's domestic fuel, bamboo and timber needs. These forests are a major habitat of various birds; reptiles; even few mammals in the country and can contribute to biodiversity conservation.

Conclusion

As peoples of Bangladesh, depends chiefly on various natural resources for centuries, it is essential to demonstrate the linkages between biodiversity/ecosystem services, livelihoods and socio-economic structure. Another requirement is to delineate and restore country's unique habitats (including existing protected areas) and adopt measures to ensure that these areas are conserved. An essential way of achieving this objective is through collaborative management regimes which has already found effective in some regions of the country. The involvement of local communities in preventing over-exploitation and poaching is essential to long-term conservation. Finally a separate national body or institution is fundamental to ensure conservation; sustainable use and equitable sharing of benefits arisen from biodiversity.

Acknowledgement

The paper is mainly based on secondary information except few case study experiences. I am thankful to various authors of Center for International Forestry Research (CIFOR); Non-Timber Forest Products Exchange Programme (NTFP-EP) for South and South-East Asia and IUCN who have made my work easy by providing some of their instructive literatures earlier. Organizational support of CBD through Mrs. Michael Harrison, CIFOR through Ms. Taranita Rizka and TROPENBOS through Ms. Joke Mahulete was also appreciable.

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PHOTOGRAPH DETAILS

Front cover (clockwise)

1. Flower of *Melastoma malabathricum* (tea indicator)
2. A red jungle fowl (*Gallus gallus*) in Satchari National Park (SNP)
3. A fern tree (*Filicuum decipiens*) in Rema-Kalenga Wildlife Sanctuary
4. Wild beauty of SNP
5. An NTFP market in Noakhali sadar
6. Women waiting to sell woodfuel in *Teliapara* collected from SNP
7. Rattan products market in Sylhet town
8. A Tripura women weaving their traditional cloths

Back cover (clockwise)

1. Rhesus macaque (*Macaca mulatta*) in the holy shrine of Hz. Chasnee Per (R.) in Sylhet town
2. A lake in the hill of Bandarban district
3. Betel vine (*Piper betel*) cultivated by the Khasia tribe in Lawachara National Park
4. A colorful blood sucker (*Calotes. versicolor*) in Khadimnagar National Park
5. Tribal women selling their cloths and fruits in the entry of a stream at Bandarban
6. A children collecting fallen leaves from SUST campus for domestic cooking
7. Cycle fuel (!) market at Chunarughat upazila (brought from Rema-Kalenga WS)
8. A boat under construction in Sunamgong

A lonely tree standing in the periphery of Satchari National Park, Habiganj