Biodiversity Conservation and Management in Bangladesh: A State-of-the-Art Review Paper

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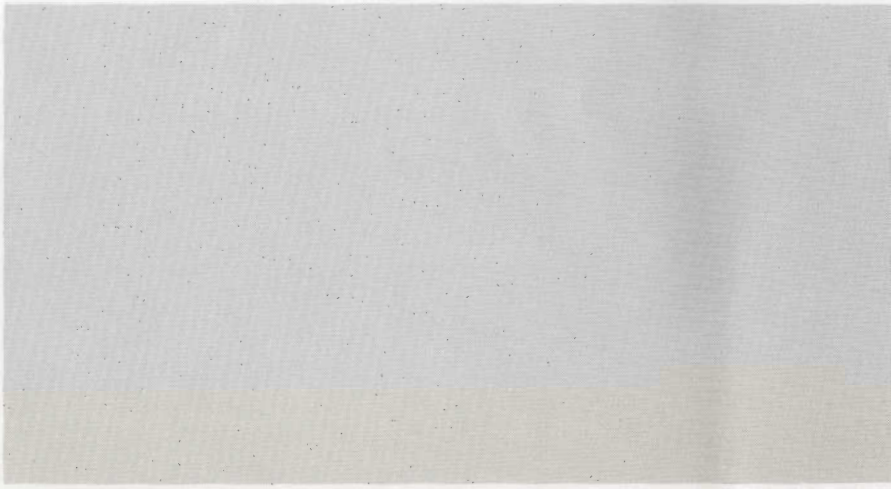

Bangladesh

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INTRODUCTION

Bangladesh lies on both sides of the Tropic of Cancer and on the 90°E meridian. The latitude ranges from 21°25' to 26°38' N and the longitude from 88°18' to 92°40'E. The total land area is about 14.4 million hectares, which include 0.92 million hectares of Estuarine floodplains, 6.78 million hectares of Meander floodplains, 1.34 million hectares of Quaternary terraces, and 1.9 million hectares of Tertiary hill areas. The remaining 3.46 million hectares are covered by inland water bodies and estuaries (Richards and Hassan 1989, Anon 1971, 1988). The geographical location of Bangladesh is shown in Figure 1.

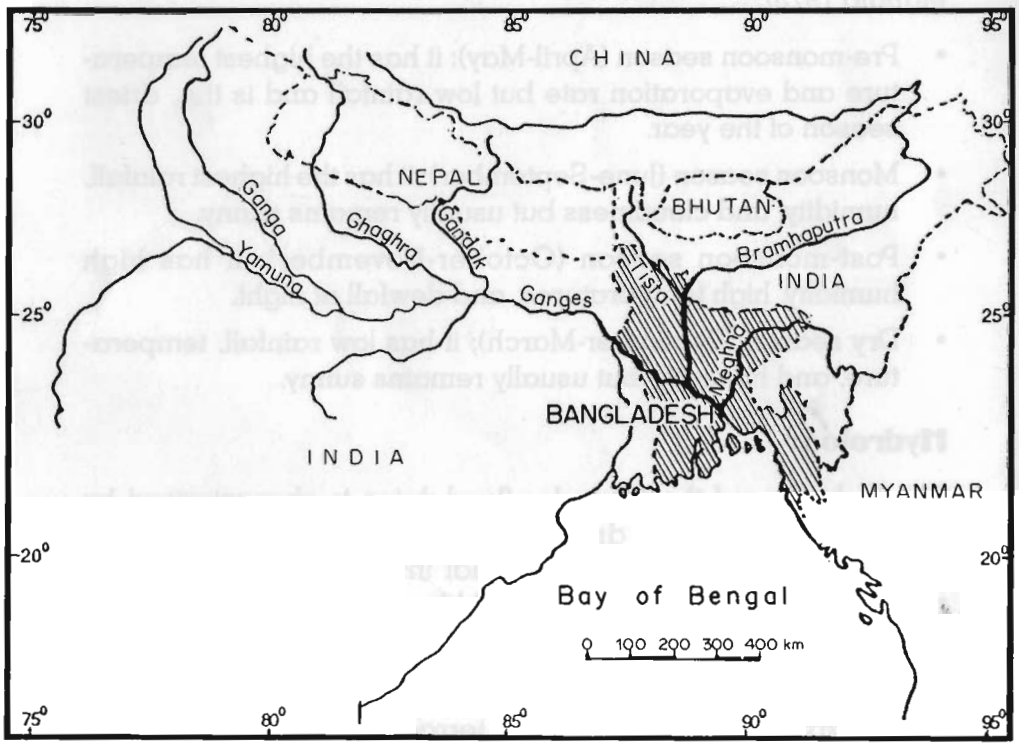


Figure 1: Geographical Location of Bangladesh

Bangladesh is a densely-populated country. Forest land occupies approximately 16 per cent of the area, of which six per cent is tree-stocked. Biodiversity in this country has been severely disturbed during the past several decades due to rapid population growth, energy deficits, resource shortages, myopic planning, poor management, and lack of motivation for biodiversity conservation. The turning point in the context of biodiversity deterioration was the war of liberation. Immediately after 1971, the deteriorating law and order situation and erosion in the sense of values permitted excessive plundering of resources. The situation further deteriorated with the impact

of the global energy crisis and food shortages during the early seventies.

The biodiversity of a region is related to the climate, hydrology, and geomorphology. These factors are briefly discussed in the following passages.

Climate

According to Thornthwaite's (1948) classification, Bangladesh has a moist, sub-humid megathermal climate with little or no moisture-deficit season. The four hydrologically different seasons recognisable in this country are given below (Anon 1971 and Manalo 1975).

- Pre-monsoon season (April-May): it has the highest temperature and evaporation rate but low rainfall and is the driest season of the year.
- Monsoon season (June-September): it has the highest rainfall, humidity, and cloudiness but usually remains sunny.
- Post-monsoon season (October-November): it has high humidity, high temperatures, and dewfall at night.
- Dry season (December-March): it has low rainfall, temperature, and humidity, but usually remains sunny.

Hydrology

The hydrology of the Meander floodplains is characterised by seasonal floods and drought, while that of the Estuarine floodplains is characterised by tidal inundation. The principal rivers are the Ganges, Jamuna, and Meghna. The tributaries and distributaries of the big rivers form a reticulated drainage pattern in the Estuarine floodplains.

The hydrology of the Quaternary terraces is regulated by high seasonal rainfall, a fluctuating groundwater table, and free surface drainage. This landscape is drained by an intricate network of valleys and creeks which ultimately converse into several local rivers. The Purnabhaba, Atrai, and Karatoa rivers flow through the northwestern part (Barind tract) and the rivers Bansi, Banar, and Dhaleswari flow through the central part (Bhawal-Madhupur tracts).

The hydrology of the Tertiary hills is regulated by high seasonal rainfall, the rock structure, and local relief. These factors are related to the surface drainage system. In addition, steepness of the hills, proximity to large water bodies (*hoars*) in the north and northeast, and proximity to the sea in the southeast contribute to the efficient discharge of rain water in this area. The main rivers

are the Karnaphuli, Sangu, Matamuhari, Banskhali, and Naf in the southeast and the Surma, Kusiara, Khowai, and Goyang in the northeast (Hassan 1982).

Geology

The Estuarine and Meander floodplain sediments are unconsolidated Recent materials which have a homogeneous texture and mineralogy. These sediments are riverine on the inland and estuarine along the coast. A long strip of piedmont material lies north-south on the western side of the Sitakunda range.

The Plio-Pleistocene terraces occur as Bhawal-Madhupur tracts in the centre and as the Barind tract in the northwestern parts. These are unconsolidated and dissected sediments.

The Mio-Pliocene hill sediments are comprised of unconsolidated and semi-consolidated silt stones, shells, and clayey sandstones which have been folded into successions of pitching anticlines and synclines. The frequent change in lithology from sandstone to shale and close dissection of the hills provide this landscape with a complex geomorphological pattern (Anon 1971, Morgan and McIntire 1959).

Physiography

In the Land Resources' Appraisal (LRA) reports (Anon 1988), 20 primary physiographic units were identified, together with 53 secondary units, and 143 tertiary units as the basis for delineating 30 agroecological zones for Bangladesh. In this paper, the agroecological zones are aggregated further into (i) Estuarine floodplains, (ii) Meander floodplains, (iii) Plio-Pleistocene terraces, (iv) Mio-Pliocene hills, and (v) Anthropogenetic land types (Figure 2).

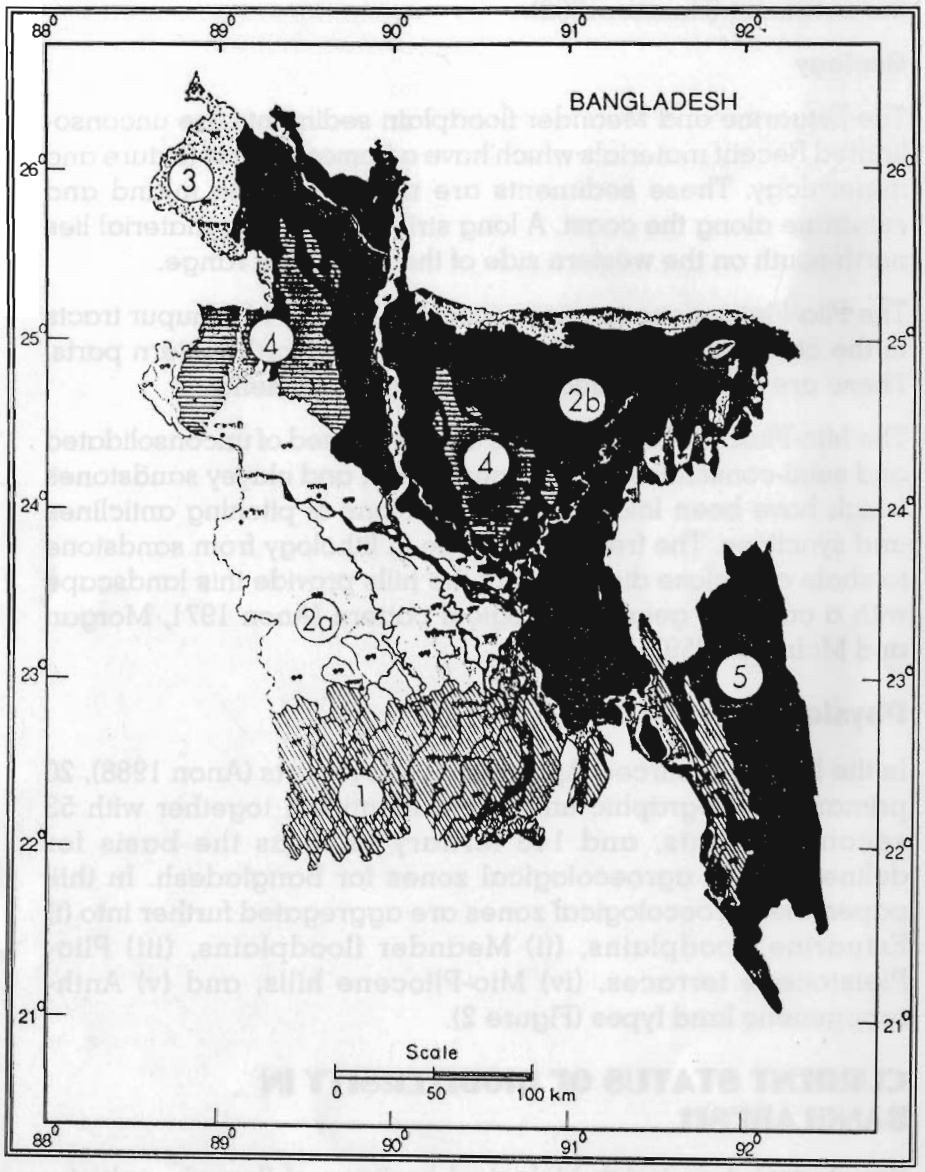
CURRENT STATUS OF BIODIVERSITY IN BANGLADESH

Bangladesh has a rich biological heritage of flowering plants, mammals, birds, reptiles, amphibians, fish, and so on.

About 5,700 species of angiosperms are available in Bangladesh, and these include 68 woody legumes, 130 fibre-yielding plants, 500 medicinal plants, and 29 orchids. Of these, as many as 2,260 species are available in the Chittagong Hill Tracts' (CHT) region.

The natural forests of Bangladesh have been facing an onslaught for years and, consequently, considerable portions have already been lost. This has resulted in the loss of wild biodiversity. The extent of biodiversity loss can only be known accurately through extensive, time-consuming laborious surveys. Currently, 27 plant

Figure 2: Aggregated Geomorphological Units



Legend

1. Estuarine floodplain
2a. Meander floodplain, Gangetic
2b. Meander floodplain, Non-Gangetic
3. Piedmont floodplain
4. Plio-Pliestocene terraces
5. Mio-pliocene hills
6. Anthropogenetic land types

species are listed as threatened or endangered. There is very little reliable information on gene pools or varieties within species. The current status of biodiversity is shown in Table 1.

Table 1: Status of Biodiversity in Bangladesh

Flora	
Angiosperms	5700
Pteredophytes	1700
Gymnosperms	3
Algae	-
Fauna	
Birds	632
Mammals	125
Reptiles	154
Amphibians	23
Fish	736

The issue of conservation and protection of biodiversity has been given low priority in Bangladesh. Although a moratorium on tree felling in natural forests was imposed in October 1989, the mechanism to enforce it has so far proved ineffective (Anon 1993).

To conserve genetic resources, viable examples of all distinct ecosystems and species must be protected within a system. A reserved area must provide long-term viability for plants, animals, and organisms within it. Assuming that a particular species can withstand the direct effects of human activities, it may still become extinct within a reserved area through interbreeding, if the individuals of the species are not enough. Therefore, reserved areas must be large enough for long-term survival of the species.

In Bangladesh, it is imperative to protect and manage the existing protected areas effectively and to expand the system by establishing new protected areas. To the extent possible, virgin forests found suitable for conservation purposes should be included in the protected area system, with emphasis on conservation of biodiversity. A comprehensive botanical and zoological survey of the protected areas should be conducted to refine management practices.

In situ conservation may still fail due to land crises brought about by the expansion of agriculture. It is, therefore, necessary to complement *in situ* conservation with *ex situ* activities. *Ex situ* measures involve conservation of germ plasm in seed stores, clonal orchards, botanical gardens, zoos, and so on. In Bangladesh, limited progress has been made with regard to *ex situ* conservation of genetic resources. The Bangladesh Forest Research Institute (BFRI) has a collection of 1,098 timber and bamboo species. There is an immediate need to strengthen the biodiversity conservation capabilities of the institutes under the National Agricultural Research System (NARS).

Description of Biodiversity at Different Levels

Conservation of genetic resources and their diversities are both matters involving insurance and investment. Both are necessary to sustain and improve productivity in agriculture, forestry, livestock, and fisheries; to prevent environmental degradation; and to reduce the causes of species' extinction.

The repository of wild gene pools can be used to enhance the quality of natural products, many of which are not economical to synthesise. This potential can be realised through a variety of techniques such as plant breeding, micro-propagation, and meristem cultivation for rapid clonal multiplication. The productivity of major crops cannot be maintained without a constant infusion of fresh genetic variability, which mostly comes from the wild relatives of modern crop plants.

Wild species also offer a diverse potential for new foods. The human diet is based upon a few crop varieties only. The narrow genetic base of introduced species may lead to disaster through fungal infection. Infection of potato and coffee crops in 1840 and 1870 in Europe and Asia, respectively, caused disaster worth millions. The 1943 Bengal famine was caused partly because of the decimation of paddy by brown spot disease. Therefore, genetic uniformity is directly related to the vulnerability of biological species to disease.

The mandate of the International Board for Plant Genetic Resources (IBPGR) is to further the study, collection, preservation, documentation, evaluation, and utilisation of genetic diversity of useful plants for human benefit (IUCN 1989). The monitory benefits arising from wild plant genetic resources can be realised from the example of the USA where 38 important agricultural and horticultural crops with commercial cultivars were improved by incorporation of wild genes (FAO 1984).

Ecosystem Diversity

On the basis of soil moisture, inundation, temperature regimes, and 20 primary physiographic units, as many as 30 agroecological zones have been identified in Bangladesh (Anon 1988). Later, the agroecological zones were aggregated further into 10 dendro-ecological regions, namely, the (i) Estaurine floodplains (ii) Meander floodplains–Gangetic, (iii) Meander floodplains–non-Gangetic, (iv) Deeply-weathered terraces, (v) Shallowly-weathered terraces, (vi) High Hills, (vii) Low hills, (viii) Terrace fans, (ix) Himalayan piedmont, and (x) Anthropogenetic land types (Richards and Hassan 1989).

The dendro-ecological regions give the most succinct picture of the development potential of forestry . The regions inundated with more then 30cm of water for all or most of the wet season are

considered unsuitable for mesophytic tree species (Richard and Hassan 1989). The 10 dendro-ecological regions can be aggregated further into (i) a seasonally intermittently flooded region, (ii) a tidally flooded coastal saline region, (iii) a non-flooded terrace region, (iv) a steeply sloping hill region, and (v) anthropogenetic land types.

Serious and widespread land degradation caused by deforestation, shifting cultivation, and encroachment in the hill region has been causing ecological hazards (Anon 1988). The hill land degradation has not only reduced the use potential in that region but also the yield of adjoining floodplains by causing flash floods, river bank erosion, breech of protective embankments, burial of fertile topsoil, and disruption of water communications.

Therefore, there is an urgent need to restore the original forest cover through proper management, biodiversity conservation, and maintenance of the entomo-flora-faunal balance of the hill regions in Bangladesh.

Biodiversity degradation in the Ganges, Brahmaputra, Tista, and Meghna catchments across the border seems likely to increase the severity and frequency of floods in Bangladesh. This has already emerged as the burning issue in cross border relations/exchange.

On-farm research in Bangladesh was introduced in 1957, but systems' research began in 1974 with trials involving rice, sugarcane-based cropping patterns, and component technologies. In 1979, a nationally coordinated Cropping Systems' Research Project was started by the Bangladesh Agricultural Research Council (BARC), with the participation of several agricultural research institutes such as the Bangladesh Agricultural University (BAU) and the Bangladesh Water Development Board (BWDB). With the farming systems' approach in 1984, the progress of the research was summarised and an integrated approach suggested. Consequently, a nationally coordinated 'Farming System Research Project' was introduced in 1985. Subsequently, a holistic approach, integrating the commodities and searching for interdependencies, was pursued.

Most of the farmers in Bangladesh are resource poor, holding 0.2 to 1.0 hectares of cultivable land per household. They produce diversified crops to meet consumption requirements. Being illiterate and poor, they are not able to use the advances in technology and are not clear in their decision-making. A schematic diagram of farming systems in Bangladesh is given in Figure. 3.

Species' Diversity

Bangladesh, being located in the humid tropical region, is rich in species' diversity. Bangladesh is unique in having such diversified

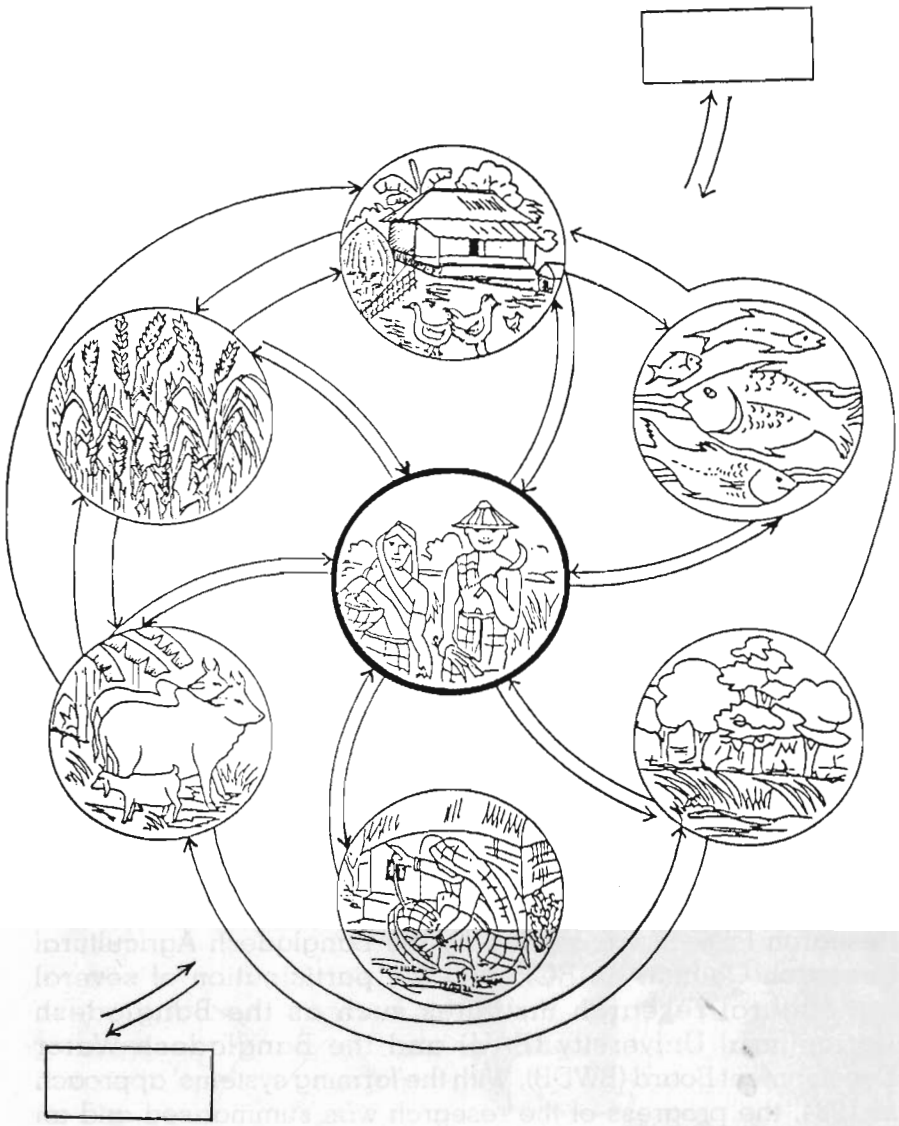


Figure 3: Farming Systems in Bangladesh

genetic resources in relation to its area. Bangladesh has about 5,700 species of angiosperms (Khan 1977, Troup 1975), of which 192 were reported to be of medicinal importance (Khan and Huq 1975). The number of medicinal plants given in a revised list issued by the Bangladesh National Herbarium (BNH) exceeded 500. But there is a steady depletion of species due to lack of management and overexploitation. Chittagong and the Chittagong Hill Tracts contained 1,559 angiosperms (Heinig 1925). Another 700 species were included in the revised list prepared by the BNH. Bamboo resources in Bangladesh, both wild and planted, include not less than eighteen taxa (Alam 1982, Banik 1994) and perhaps even more. There are at least eight species of rattan, including a newly-reported one (Alam and Basu 1988). About 130 species of fibre

resources, both wild and cultivated, were reported by Khan and Mia (1988).

Forest trees, excluding the horticultural ones, total 300 species. Comprehensive information on species' diversity is not available in Bangladesh, with the exception of a few recent studies. Species' diversity in terms of (i) chromosome numbers, (ii) morphologies, (iii) flowering and seed production habits, (iv) flowering time and flowering nature, and (v) seed morphology and viability are only available for a few agricultural species. Forest species, weeds, and medicinal and other aromatic plant species are neglected in this respect. However, the names of a few forest tree species, homestead tree species, crops, and wildlife species of Bangladesh are given in the forthcoming paragraphs (Hassan and Majumder 1990, Troup 1995).

Upland Forest Species

Chapalish (*Artocarpus chaplasha*), chandul (*Tetrameles nudiflora*), telsur (*Hopea odorata*), narikeli (*Pterigota alata*), pitraj (*Aphanamixis ploystachya*), Amoora wallichii toon (*Toona ciliata*), nageswar (*Mesua ferrea*), uriam (*Mangifera sylvatica*), Jam (*Syzygium spp*), garijan (*Dipterocarpus spp*) civit (*Swintonia floribunda*), tali (*Palaquium polyanthum*), kamdeb (*Callophyllum spp*), bandarhola (*Duabanga grandiflora*), champa (*Michelia champaca*), raktan (*Lophopetalum fimbriatum*),jarul (*Lagerstroemia speciosa*), chalmugra (*Hydnocarpus kurzii*), pitali (*Trewia nudiflora*), gamar (*Gmelina arborea*), bahera (*Terminalia bellirica*), haritaki (*Terminalia chebula*), jalpai (*Elaeocarpus robustus*), asok (*Saraca asoca*), chikrasi (*Chukrasia tabularis*), koroi (*Albizia spp*), amlaki (*Emblica officinalis*), amra (*Spondias pinnata*), assar (*microcos paniculata*), kechua (*golchidion lanceolarium*), kadam (*Anthocephalous chinensis*), shimul (*Bombax ceiba*), teak (*Tectona grandis*), sal (*Shorea robusta*), ajuli (*Dillenia pentagyna*), gadila (*Careya arborea*), jiga (*Lannea coromandelica*), sidha (*Lagerstroemia parviflora*), kaika (*Ading cordifolia*), gandhi gajari (*Miliusa velutina*), sonalu (*Cassia fistula*), and so on. The main herbacious forest species are kharga (*Phragmites karka*), nal (*Saccharum spontaneum*), sungrass (*Imperata cylindrica*), and so on. Of the 22 bamboo species, the important ones are muli (*Melocanna baccifera*), mitenga (*Bambusa tulda*), dolloo (*Neohouzeaua dullooa*), and orah (*Dendrocalamus longispathus*). The hill forests are dominated by mixed evergreen, semi-evergreen, and deciduous sal (*Shorea robusta*) forests.

Littoral Forest Species

Sundri (*Heritiera fomes*), gewa (*Exoecaria agallocha*), kakra (*Bruguiera gymnorrhiza*), passur (*Xylocarpus molluoccensis*),

dhundul (*Xylocarpus granatum*), bean (*Avicennia officinalis*), keora (*Sonneratia apetala*), ora (*Sonneratia acida*), singra (*Cynometra ramiflora*), amur (*Amoora cucullata*), goran (*Ceriops roxburghiana*), mathgoran (*Ceriops tagal*), goria (*Kanddelia rheedii*), and so on. Hargoza (*Acanthus ilicifolius*), kewa kanta (*Pandanus fascicullaltus*), tiger fern (*Acrostichum aureum*), and hantal (*Phoenix paludosa*) are the principal undergrowths (Das 1960, Troup 1975, Anon 1994a).

These species occur in the Sundarbans in the southwest, the Chakaria Sundarbans in the southeast, and in the man-made littoral forests along the entire coastal area of Bangladesh.

Homestead Tree Species

Homesteads are clustered with many varieties of fruit and other tree species and many herbs, shrubs, and creeper species. The homestead tree species are: Fruit trees: mango (*Mangifera indica*), jack fruit (*Artocarpus heterophyllus*), litchi (*Litchi chinensis*), wood apple (*Aegle marmelos*), guava (*Psidium guajava*), black berry (*Syzgium cumini*), jalpai (*Elaeocarpus floribundus*), coconut (*Cocos nucifera*), betel nut (*Areca catechu*), tal (*Borassus flabellifer*), shaddock (*Citrus grandis*), tamarind (*Tamarindus indica*), date fruit (*Ziziphus mauritiana*), phoenix palm (*Phoenix sylvestris*), lemon (*Citrus spp*), cashew nut (*Anacardium occidentalis*).

Other Trees

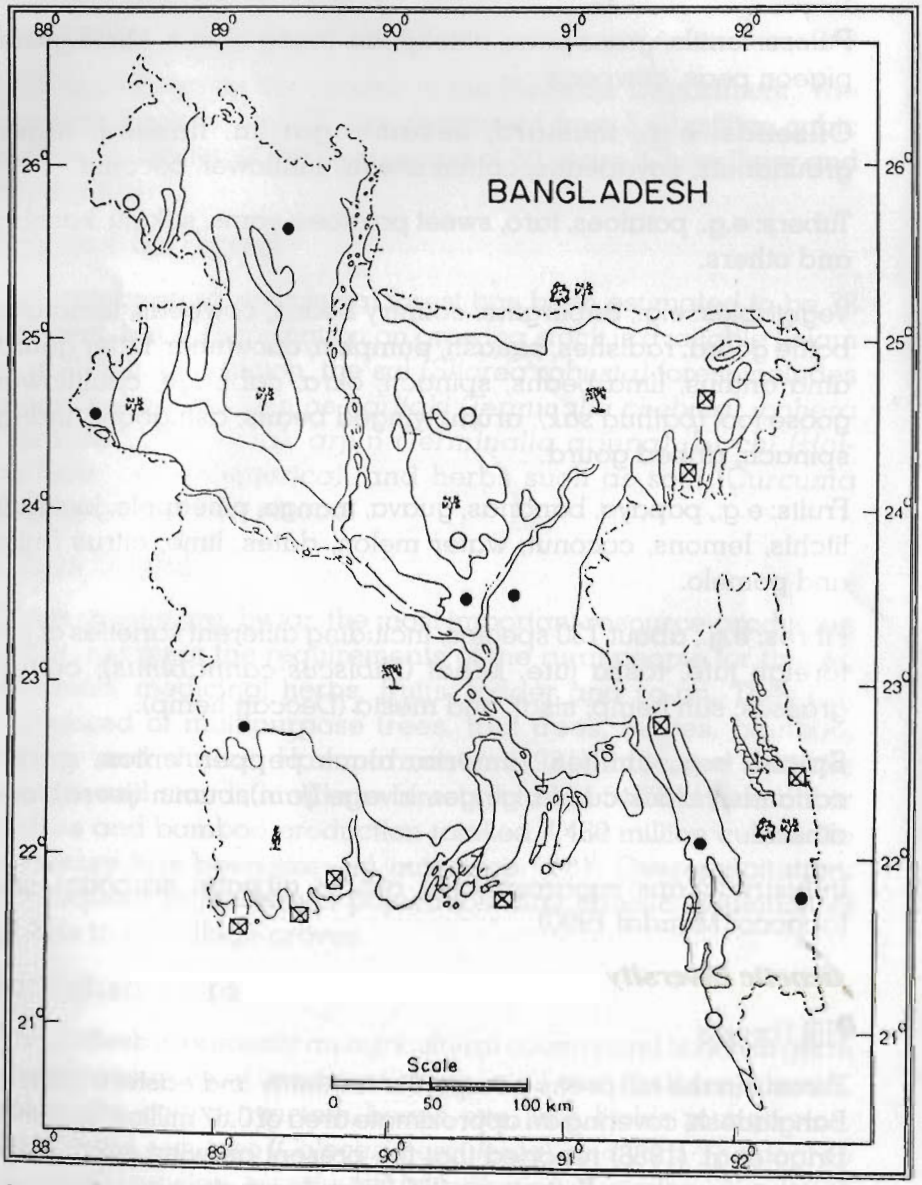
Koroi (*Albizia spp*), sal (*Shorea robusta*), shishu (*Dalberia sissoo*), bazna (*Zanthoxylum rhetsa*), mehagani (*Swietenia spp*), neem (*Azadirachta indica*), minjiri (*Cassia siamea*), jarul, champa, shimul, hijal (*Barringtonia acutangula*), bakphul (*Sesbania grandiflora*), kadam, chhatian (*Alstonia scholaris*), teak, eucalyptus, raina (*Aphanamixis polystachya*), babla (*Acacia nilotica*), ipil-ipil (*Leucaena leucocephala*), bamboo, madar (*Erythrina spp*), polash (*Butea monosperma*), bhadi (*Iannea coromandelica*), sheora (*Streblus asper*), debdaru (*Polyalthia longifolia*), and bot/pakur (*Ficus spp*) (Troup 1975, Hassan and Majumdar 1990).

Homesteads occur on different landforms of Bangladesh. Species' distribution therefore, varies slightly from one land type to another, according to the hydrological conditions. The locations of *ex situ* and *in situ* conservation sites and different forest types in Bangladesh are shown in Figure 4.

Crop Species

Crop species include cereals, pulses, oilseeds, tubers, vegetables, fruits, fibres, spices, and industrial crops (Bashar et al. 1995). A few crop species from each category are mentioned here.

Figure 4: Location of In Situ and Ex Situ Conservation Sites and Forest Types in Bangladesh.



Legend

Flora and Fauna

- ○ National Parks
- ⊠ Wildlife Sanctuaries
- △ Game Reserves
- ● Zoo Gardens
  Parks and Botanical Gardens
  (not shown)

Major Forest Types

- Mixed Forest
  (evergreen & deciduous)
- Deciduous Sal Forest
- Littoral Forest
- Swamp Forest (Fresh water)
  Homestead Forest (not shown)

Cereals: rice, boro rice, millet, wheat, maize, foxtail millet, prosomillet, barley

Pulses: lentils, grass peas, chickpeas, mung beans, black gram, pigeon peas, cowpeas

Oilseeds: e.g., mustard, sesame, garjan, linseed, niger, groundnuts, soyabeans, cotton seeds, sunflower, coconut.

Tubers: e.g., potatoes, taro, sweet potatoes, yams, sakalu, kashba, and others.

Vegetables: e.g., aubergine, country beans, cowpeas, tomatoes, bottle gourd, radishes, squash, pumpkin, cucumber, bitter gourd, amaranthus, lima beans, spinach, okra, cabbage, cauliflower, goose foot *(bathua sak)*, arum, winged beans, ash gourd, Indian spinach, ribbed gourd.

Fruits: e.g., papaya, bananas, guava, mango, pineapple, jackfruit, litchis, lemons, coconut, water melon, dates, lime, citrus fruits, and pomelo.

Fibres: e.g., about 130 species, including different varieties of jute foreign jute, tossa jute, kenaf (*Hibiscus cannabinus*); cotton; grasses; sun hemp; sisal; and mesta (Deccan hemp).

Spices: e.g., chillies, tumeric, black pepper, onion, garlic, coriander, black cumin, ginger, lovage (*jain*), cumin (*jeera*), and others.

Industrial crops: sugarcane, tea, rubber, oil palm, narcotics, and tobacco (Mandal 1990).

Genetic Diversity

Hill Forests

Forests in the hill areas occupy the northern and eastern parts of Bangladesh, covering an approximate area of 0.67 million hectares. Drigo et al. (1988) reported that the present growing stock of the forests of southern Sylhet was 920,000 cubic metres in a total area of 40,270 hectares. Chittagong and Cox Bazaar Forest Divisions cover 52,400 and 34,500 hectares of hill forest respectively, with a growing stock of 2.3 million cubic metres and 2.7 million cubic metres respectively (Demilde et al.1985a, 1985b). The Kassalong and Rainkhiang reserve forests contained appreciable amounts of timber and bamboo resources. These have shrunk considerably during the last two decades. These resources constituted 97 per cent of the national output in 1963 but came down to 51 per cent in 1983. At the same time, shifting cultivation was practised over 2,100 hectare in 1963. The area has increased to 6,000 hectares within two decades. Consequently, there has been a reduction of

productive forest from 100 per cent to 68 per cent in Kassalong and from 97 per cent to 51 per cent in Rainkhiang during this period.

Unclassified State Forests (USF)

USF land is under the control of the Revenue Department. The growing stock in the USF has decreased from 3.43 million cubic metres to almost nil within a period of 50 years (Chowdhury and Hussain 1989).

Plainland Sal Forests

The tree-covered area in sal forest has been estimated to be 32 per cent, but no information on growing stock is available (Islam et al. 1992). In addition, the sal *(Shorea robusta)* forest includes medicinal plants such as *haritaki (Terminalia chebula), bohera (Terminalia bellirica), arjun (Terminalia arjuna), kurchi (Holarrhena antidysenterica),* and herbs such as *sotti (Curcuma zedoaria),* a starch source.

Village Groves

These groves are, by far, the most important resource-producing lands and meet the requirements of the rural people for timber, fuelwood, medicinal herbs, fruits, fodder and so on. They are composed of multipurpose trees, fruit trees, fences, bamboo, rattan, and shrubs. Hammarmaster (1981) indicated that the volume and stands in village forests totalled 54.70 million cubic metres and bamboo production totalled 7,480 million culms. No inventory has been carried out since 1981. Overexploitation, consequent to increased population, has caused depletion of stands in the village groves.

Agricultural Crops

Bangladesh is primarily an agricultural country and is rich in germ plasm resources of important crops, e.g., amaranthus, banana, aubergine, cotton, hyacinth, beans, jute, lime, litchis, mango, rice, sugarcane, tea, taro (*Colocasia esculenta*), and yam. The degree of genetic erosion, because of introduction of improved varieties and depletion of cultivable land, has not yet been properly documented. The best known crop is rice. It occupies up to 80 per cent of the land area. The cultivars (estimated to number 8,000) (Haque and Mia 1989) are traditional and include fragrant, salt tolerant and deep water rice varieties. Two wild relatives of rice, i.e. *jhora dhan* (*Oryza rufipogan Griff*) and uridhan (*Porteresia coaractaka Roxb*), have restricted distribution in Bangladesh.

Mangrove Forests

These are of great economic importance as sources of timber, fish, fuelwood, and numerous minor forest products such as

golpata (nipa palm), tannin-yielding bark, and grasses and sedges for matting and fencing. The mangrove forests also provide employment for some 300,000 woodcutters, fishermen, and others who collect *golpata* (nipa palm), shale, and honey (Blower 1985). They offer a wide variety of wildlife and valuable natural products and, with wise management, can offer sustainable productivity. The dominant tree, *sundari*, providing timber and fuelwood is gradually on the decline as a result of overexploitation and traditional management. *Gewa* (sal wood) is also in great demand for the Khulna Newsprint Mill that produces 37,000 tons of newsprint per annum (Chaffey et al. 1985). Forty-eight thousand cubic metres of *gewa* were extracted from the Sunderbans in 1988/89 (Hussain et al. 1990). *Gewa* stands are decreasing due to overexploitation and ecological change caused by biotic and edaphic changes. Growing stock in the Sunderbans was 20 million cubic metres in 1963 and 13 million cubic metres in 1983. The decrease overall was by 35 per cent, with an annual decrease of 1.7 per cent.

Wildlife Resources

There are plenty of wildlife resources in Bangladesh. Primates and carnivores are becoming increasingly rare and the Royal Bengal tiger (*Panthera tigris*) is restricted to the Sunderbans. Hooved animals are diminishing in number. Several species are already on the threatened list. Some rare occurrences of elephants are now observed in the undisturbed southern hill forests. The avifaunal population is reported to include 632 bird species, of which 13 wetland and 13 other bird species are threatened. The Indian python (*Python molurus*) is reported to be vulnerable (Green 1989). In addition, Bangladesh has 735 species of fish (Anon 1995b), of which 15 are threatened. The present status of wildlife and fish in Bangladesh is shown in Table 2.

Table 2: Present Status of Wildlife and Fish in Bangladesh

	Total	Extinct	Threatened
Mammals	154	12	16
Birds	532	5	26
Reptiles	154	10	11
Amphibians	23	-	2
Fish	735	-	15

Among the 154 mammal species, 12 are extinct and 16 threatened; among the reptile species, 10 are extinct and 11 threatened; and, among the 23 amphibian species, none is extinct and two are threatened (Khan 1990, Hassan 1992). The wildlife in Bangladesh, especially in hill forests, are not in a sustainable situation.

The national economy and the livelihood of the majority in Bangladesh, who are predominantly poor, are dependent on the continued productivity and quality of renewable biological resources. Increased food production cannot be achieved and sustained without preventing environmental and biodiversity degradation. To conserve genetic resources, the national policy-makers and local communities need to coordinate their understanding of the issue and set priorities. Survey of the socioeconomic condition is, therefore, necessary (Ali 1990). For instance, the local communities can and should benefit from activities like the collection of seeds, raising of seedlings of valuable species, and plantation through rural agroforestry programmes. Distribution of the main wildlife species is shown in Figure 5.

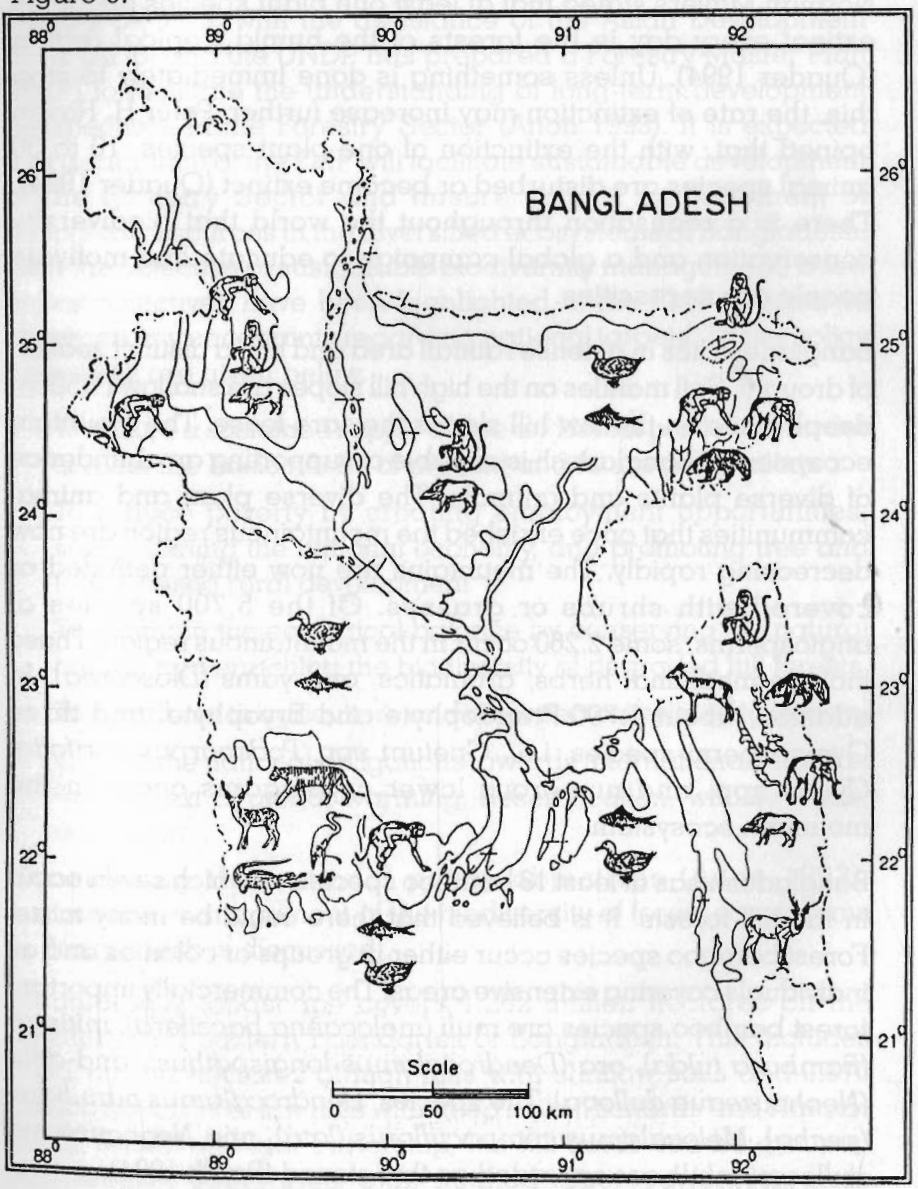


Figure 5: Distribution of Major Wildlife Species in Bangladesh

Importance of Biodiversity

Life in natural surroundings remains in equilibrium with the climatic and edaphic conditions of a region. Plant-soil-climate interdependence is a well-known feature. The animal world is dependent on plants for food and shelter. Biological diversities are closely-linked in the food chain. Therefore, the diversity of plants and animals is important for maintaining the balance of nature. Under the circumstances, if biodiversity is disturbed by anthropic disturbances, such as overexploitation, ill-planned development activities, industrialisation, use of noxious chemicals, and so on, the ecological balance is disturbed. Consequences may be disastrous to both plants and animals. Norman Mayers stated that at least one plant species becomes extinct every day in the forests of the humid tropical region (Quader 1994). Unless something is done immediately to stop this, the rate of extinction may increase further. Peter H. Raven opined that, with the extinction of one plant species, 10 to 30 animal species are disturbed or become extinct (Quader 1994). There is a realisation throughout the world that biodiversity conservation and a global campaign to educate and motivate people are necessities.

Bangladesh lies in a dense rainfall area and has a distinct season of drought. Soil mantles on the high hill slopes are shallow (<50cm deep), while on the low hill slopes they are loose. The mountain ecosystem in Bangladesh is capable of supporting an abundance of diverse plants and animals. The diverse plant and animal communities that once enriched the mountainous region are now decreasing rapidly. The mountains are now either denuded or covered with shrubs or grasses. Of the 5,700 species of angiosperms, some 2,260 occur in the mountainous region. These include medicinal herbs, aromatics, and yams *(Dioscorea)*. In addition, about 1,700 Pteridophyte and Bryophyte, and three Gymnosperm species, i.e., *Gnetum* spp, *Podocarpus nerifolia*, *Cycas* spp, and numerous lower cryptogams occur in the mountain ecosystem.

Bangladesh has at least 18 bamboo species, of which seven occur in the hill forests. It is believed that there could be many more. Forest bamboo species occur either in groups or colonies and as individuals covering extensive areas. The commercially important forest bamboo species are *muli (melocanna baccifera)*, *mitinga (Bambusa tulda)*, *ora (Dendrocalamus longispathus)*, and *dolu (Neohouzeaua dullooa)*. The species, *Dendrocalamus hamiltonii (pecha)*, *Melocalamus compactiflorus (lata)*, and *Neohouzeaua dullooa (dolul)*, are regarded as threatened (Banik 1994).

Cases of Sustainable Management of Biodiversity Resources in Mountain Areas

Overexploitation of forest resources over the past century, traditional forest management practices, effect of the liberation war, rapid population growth, shifting cultivation, and repeated calamities are largely responsible for biodiversity degradation in the mountain region. This is also true for the neighbouring countries. Because the carrying capacity of forests has continuously been under stress from the increasing demand for cultivable land, wood, and other products, the forest ecosystem is on the verge of collapse. A hard and fast decision to protect the degraded mountain ecosystem and to conserve and rebuild it should be made without delay. The Ministry of Environment and Forests (MOEF), with the assistance of the Asian Development Bank (ADB) and the UNDP, has prepared a Forestry Master Plan (FMP) to facilitate the understanding of long-term development perspectives in the Forestry Sector (Anon 1993). It is expected that adaptation of the FMP will facilitate sustainable development of the Forestry Sector and ensure proper management of biological resources in the diversified ecosystems of Bangladesh. With the objective of sustainable biodiversity management, a few policy objectives have been highlighted in the FMP in order to eliminate any uncertainty regarding national targets. These policy objectives are given below.

- To ensure a sustained supply of tree and forest products in order to meet the basic needs of present and future generations
- To reduce poverty by creating employment opportunities, strengthening the national economy, and promoting tree and forest-based rural development
- To maintain the ecological balance by conserving the natural habitat and enriching the biodiversity of degraded hill forests
- To contribute to agriculture and other sectors related to forestry
- To fulfill the national obligations towards international efforts in the context of global warming, desertification, wildlife trade, and so on

Considering the national policy objectives (Anon 1993), sustainable management of the biodiversity of forest ecosystems in Bangladesh is discussed.

Mountainous landscape covers 1.262 million hectares on the northern and eastern boundaries of Bangladesh. This includes 0.792 million hectares of high hills with shallow soils and 0.570 million hectares of low hills with deep soils (Richards and Hassan 1989). Based on legal ownership, the hill lands can be grouped into several categories, e.g., notified reserved forests, *khas*

(special) land, unclassified state forests (USF), privately-owned land, and so on. At present, the reserved forest land and parts of the *khas* and USF land are managed by the Forest Development Department through clear felling and artificial regeneration. The main parts of the USF and *khas* lands are under the Land Revenue Department and are used for shifting cultivation. The civil administration, several NGOs, and the Chittagong Hill Tracts' Development Board (CHTDB) work in the hill areas to motivate the tribal people to establish permanent settlements by providing two to three hectares of land per family. This has been raised by the Bangladesh Forest Industries' Development Institute (BFIDC) on long-term leased *khas* and USF lands. Holdings of 10 hectares or less are used for rubber, orchards, and woodlots by private entrepreneurs. In addition, there are large numbers of big and small tea estates on the low hills occurring both on the northern and eastern boundaries of Bangladesh where communication facilities are good. The poorly-drained valleys are used for paddy or other agricultural crops.

The wetland ecosystem covers the deltaic region of the Matamuhari River. This was covered with diverse littoral forest species. This natural forest is now depleted due to overexploitation, faulty management, and conflicting land uses.

About one million people, of which 0.56 million depend directly or indirectly on forestry activities and shifting cultivation, live in the eastern hill region (Anon 1992a). The hill forests also supply raw materials to the Karnaphuli Paper Mill, Karnaphuli Rayon Mill, the Forest Industries' Development Institute (FIDC), and private furniture factories. Therefore, it is imperative to adopt corrective measures to ensure sustainable biodiversity management of the hill forests. The agricultural potential of the hills is limited due to steep slopes, heavy seasonal rainfall, catastrophic erosion, and seasonal drought. Tree crop production and forestry are appropriate land uses for the hills. The hill forests, the most important watershed areas of the country, are composed of tropical evergreen and semi-evergreen species. These tropical forests, where the opulence of forest life has evolved through the ceaseless operation of a warm wet climate, are a veritable storehouse of genetic wealth and diversity. Management of these forests was introduced in the 1870s under a system of selected felling followed by natural regeneration. Subsequently, in the 1930s, clear felling and an artificial regeneration system were introduced, while the system of selection-cum-improvement felling was continued. The working plan prescriptions included a specification that natural regeneration plots of from six to ten metres in width be established around 40-hectare plantations. During World War II, the Hill Forests of Bangladesh were heavily

exploited, and thus continued even after 1947 to meet the rising demand for forest products. In the management practices of subsequent years, in which long and short rotation plantations were raised on a large-scale, the natural regeneration plots were not maintained as prescribed. With delays in revision and reformulation of management plans (working plans), the need to ensure timber yield to meet the requirements of industries and the need to regulate the area of annual plantations were addressed on an *ad hoc* basis. This led to larger areas being felled and, consequently, a larger plantation programme (Anon 1993).

The decision to undertake large-scale conservation of tropical evergreen and semi-evergreen hill forests of great biological diversity is said to have been prompted by the rationale that forests can be better protected under plantations. With the benefit of hindsight, clearly, the results did not justify the rationale, because of management problems. Sustainability principles were not applied in forest management in practice, and adequate information was not generated to establish an annual permissable felling rate. The rotation period assumed was reduced in some cases, thus artificially increasing the annual permissible felling rate. Over the years, several areas that were covered by evergreen and semi-evergreen forests degenerated into savannah forests covered by stray trees and sangrias *(Imperata* spp*)*. Annual fires cause these savannahs to expand further.

It is planned to tackle the management and conservation of mountain biodiversity through policy changes. For this purpose, a Forestry Master Plan (FMP) has been approved by the government and is being executed by the Ministry of Environment and Forests (MOEF). Several of the recommendations of the FMP to be executed within a 20-year period are given below.

- State-owned forests managed by the Forest Department will be rendered profit oriented.
- State-owned natural forests will remain as reserve forests biodiversity conservation.
- Demarcated buffer areas around the core reserved forests shall be allocated to local users and enterprises primarily for:
  - regulated multipurpose forestry practice without disturbing the conservation functions,
  - preservation of the remaining habitats, biodiversity, and enrichment and conservation of water and soil, and
  - ensuring that USF and *khas* land will be administered by local authorities to satisfy forest-based needs according to the local priorities and based on sound management principles.

- The general management principles for biodiversity conservation must be along the suggested lines.
  - The forest resources will be managed in an ecologically sustainable manner ensuring species' diversification and enhancement of environmental values.
  - Forests and plantations should be expanded for industrial wood production so that conservation targets and people's demand for forest products are satisfied.
  - The priority protection areas are the habitats that encompass representative samples of flora and fauna in core and protected areas.
  - Specific ecosystems, such as the fresh-water catchment areas which support fisheries, riverbank forests, and mangroves, will be managed for multiple use.
- Homesteads and privately-owned forests will be managed based on their owner's priorities. Technical assistance and financial support are to be provided by the government.

Factors Causing Loss of Biodiversity

In Bangladesh, forestry as well as biodiversity management have been losing ground to other forms of land use without much consideration for land potential. In the hill regions, large-scale land-use changes have caused heavy destruction of forests, rendering areas either scrubby or barren. The causes of degradation are (i) shifting cultivation, (ii) traditional management practice, (iii) encroachment, (iv) short-sighted development efforts, and (v) overexploitation. The causes are the outcome of poverty, landlessness, underdevelopment, lack of proper planning, unbalanced land tenure systems, socioeconomic instability, short-sighted urbanisation policies, and so on.

Shifting Cultivation

Shifting cultivation, locally known as *jhum*, is associated with primitive economic systems and isolated cultural communities. Shifting cultivation is characterised by a rotation of fields rather than of crops and is often accompanied by slashing and burning. In the scenario of little or no population and of minimum market pressure, shifting cultivation tended to be environmentally-sound. There were stable cases of integrated land use and good agroforestry. With fast development of the market economy and increasing pressure on land, the *jhum* areas started to show signs of degradation and retrogression due to both geophysical and socioeconomic factors.

It was noted, in the Forest Policy of 1894, that shifting cultivation denudes a large area of forest growth to place a small area under crops. It costs more to the community and can be permitted, under

due regulation, where forest tribes depend on it for their subsistence. However, there was no control or regulation of shifting cultivation, and, as a result, vast tracts were denuded, particularly in the Chittagong Hill Tracts, causing biodiversity degradation on a large-scale.

Realising the detrimental effects of shifting cultivation, the government has undertaken programmes to rehabilitate shifting cultivators. Until 1990, as many as 3,229 families had been rehabilitated on 51,000 hectares under these programmes. About 2,000 landless shifting cultivators and small farmers were settled in Chittagong Hill Tracts, by providing each family with 0.1 hectare of land for a homestead, 0.8 of a hectare for horticulture, and 1.6 hectares for rubber plantation under the Upland Settlement Scheme undertaken by the CHDB.

Encroachment

Encroachment is a serious problem, both in the sal forests and hill forests. The extent of the land encroached has not been ascertained by a proper survey. There are, however, several study reports detailing the types of encroachment in Bangladesh and the factors contributing to this (Sharafatuddin 1990). Refugees from political and ecological events, and other disasters, are responsible for encroachment. In the sal forests encroachments are caused by tenurial uncertainties. Organised encroachment is also carried out by dummy encroachers supported by powerful local land sharks. Encroachers are blessed with some kind of support, either from a powerful patron or from the administration, as a result the Forest Department (FD) alone cannot control it (FAO 1991). Efforts on the part of both the Land Department and the FD to regularise land transfers and records are needed to solve the problem.

Several social anthropologists argue that the existing system of forest land tenure and management does not provide sufficient benefits to the local community, therefore it is difficult to prevent the practice of encroachment.

Land Transfer for Development

Forest lands are transferred for the purpose of settlement, industries, fisheries, transport and communications, irrigation, energy and power, mining, tourism, educational institutions, and defence purposes. The extent of such transfers to date is about 61,000 hectares.

Overexploitation

There are reports of the loss of forest cover, including plantations, as a result of fire, grazing, large-scale removal of fuelwood, and illicit removal of wood and non-wood products, e.g., bamboo,

rattan, medicinal herbs, and so on. Estimates suggest that illegal logging is probably equal to the amount officially recorded (FAO 1986). For example, felling operations have been suspended in the sal forests since 1972 to protect the remaining area and to facilitate its natural regeneration. However, illicit felling has continued unabated.

Natural Calamities

Bangladesh is prone to various natural calamities. Its coastal area is subject to occasional cyclonic devastation and tidal surges that cause loss of plants and animals. Inland floods and north-westerly winds adversely affect biodiversity, almost on a regular basis. In addition, due to overexploitation of biological resources, desertification, especially in the northwestern region, is steadily threatening biodiversity.

CONSERVATION OF BIODIVERSITY

The term biodiversity conservation is wide ranging and includes the maintenance of essential ecological processes and life support systems, control of global warming, and reduction of greenhouse gases, affording protection to flora and fauna, conservation of genetic resources and biodiversity, management of plant and wildlife, and conservation ecosystems.

Conservation is no longer a relatively simple matter of sustaining the productivity of biological resources. Rather, it is of great importance to keep in mind global climatic and demographic changes that may ultimately affect the biodiversity of a region.

So far, only a small proportion of the biological species has been surveyed, classified, and screened for scientific and economic values. Global efforts are underway to exploit the genetic variabilities of species through the application of technological advances. Vast stocks of species are disappearing due to mere negligence and ignorance in Bangladesh. Forests, apart from their role in conservation of genetic resources and diversity, provide ecological, biological, climatic, socio-structural, and economic contributions.

The degradation of forest and biodiversity in Bangladesh has gone on at a rapid rate during the past two decades, seriously affecting the country's overall environment. This degradation should be halted before it becomes irreversible. The situation is worse in the hill forest region.

Policy measures relating to the forestry, environment, public health, and industry sectors need to be formulated and improved for the management of biodiversity conservation and environmental protection.

In Situ Conservation

Various ecosystems constitute the biodiversity of Bangladesh, i.e., (i) hill forests, (ii) plain sal forests in the plains, (iii) littoral forests, (iv) freshwater swamp vegetation, and (v) homestead groves, and they have been badly neglected. *In situ* biodiversity conservation measures are, therefore, needed. *In situ* and *ex situ* conservation sites and the main vegetation types are shown in Figure 4.

Hill Forests

Conservation measures in the hill forest ecosystem have been undertaken mainly through public sector organisations and agencies. Activities include the formulation of protective legislature, declaration of protected areas, improved management of reserved forests and USF, afforestation of denuded hills, permanent settlement of shifting cultivators, rationalisation of land tenure policies, and so on.

Plainland Sal Forests

The Bhawal-Madhupur and the Barind tracts fall into the sal forest ecosystem. High opportunity costs and location have subjected the sal forest ecosystem to heavy encroachment and illicit felling. Reforestation of denuded areas, agroforestry practices, people's participation, and declaration of protected areas, are the appropriate conservation measures.

Fresh Water Swamps

Inland perennial water bodies cover about 1.4 million hectares. In addition, about 30 million hectares of land are subjected to seasonal floods. These perennial water bodies and seasonally flooded land are the habitats for aquatic swampland species. Digging canals, constructing flood protection embankments, and intensification of agriculture have disturbed this ecosystem. The scope for restoration of the swampland ecosystem is limited. The Hoar* Development Board has been established to work for the protection of the undisturbed parts of this ecosystem.

Coastal Saline Water Swamps

Tidally-flooded coastal land covers about 0.92 million hectares in Bangladesh. Approximately, 0.7 million hectares of this land is covered by natural and man-made littoral forests. A Coastal Green Belt Project and an Integrated Sundarbans' Management Project are in operation to maintain this ecosystem.

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* *Hoars* - seasonal water bodies

Homestead Groves

Homesteads occupy about one million hectares in Bangladesh and are subjected to the most extensive land uses. Homestead groves are used for the construction of dwellings, cattle rearing and backyard woodlots, and as habitats for a wide range of biological species. The causes of degradation in this ecosystem are population pressure, poverty and unemployment, the energy crisis, and so on. Planting of multipurpose tree species (MPTS), industrial tree species, fuelwood, and fruit tree species in homestead groves is encouraged through different social forestry projects.

Trends in Biological Resource Use

The trend has been to assess the economic returns of biological resources through harvesting and tourism, totally overlooking the aspects of replacement value through sustainable development. This is total mismanagement from the point of view of sustainable productivity. As, for instance, during the British period, teak logging used to be carried out after maturity at 80 years to ensure top quality timber. Currently, the demand for raw material grows faster than the productivity of forests, as a result teak logging is carried out after 40 years, at the cost of quality.

Protected Areas

Protected areas provide the most secure means to satisfy the habitat requirements of threatened species, whereas they are only a small portion of the natural forest area. Protected areas may also provide opportunities for education, research, tourism, and associated employment. The establishment of national parks, wildlife sanctuaries, and game reserves was facilitated through the Bangladesh Wildlife (preservation) Order promulgated in March 1973 and subsequently enacted and amended in two phases as the Bangladesh Wildlife (preservation) Amendment. These three categories of protected area have been defined by the FAO (1984).

The present network of protected areas officially declared and proposed (Table 3) covers 0.8 per cent of the total land area (Green 1989).

The target recommended by the Ministry of Environment and Forests (MOEF) Task Force of five per cent of the country's area for conservation pruposes (Rahman and Akonda 1987) falls short of the accepted minimum of 10 per cent considered realistic to halt species' depletion (Miller 1984). The areas can scarcely be protected and managed due to encroachment, betel leaf and paddy cultivation, and illegal logging, and they suffer from a lack

Table 3: Protected Forest Areas and Land Use in Different Ecosystems

Legal Status	Type	Area (ha)	Vegetation/ Forest Type
Declared Areas			
Bhawal	National park	5022	Depleted sal
Himchhari	National park	1729	Mixed evergreen
Madhupur	National park	8436	Depleted sal
Ramsagar	National park	Negligible	Mixed planted
Char Kukru-Mukri	Wildlife sanctuary	40	Littoral species
Chunati	Wildlife sanctuary	7764	Mixed evergreen
Pablakhali	Wildlife sanctuary	42,087	Mixed evergreen
Rema-Kalenga	Wildlife sanctuary	1,095	Mixed evergreen
Sunderbans, east	Wildlife sanctuary	5,439	Littoral species
Sunderbans, south	Wildlife sanctuary	17,878	Littoral species
Sunderbans, west	Wildlife sanctuary	9,069	Littoral species
Teknaf	Game reserve	11,615	Littoral species
Proposed areas			
Hail *hoar*	Wildlife sanctuary	1,427	Water body
Hazarikhil	Wildlife sanctuary	2,903	Mixed evergreen
Rampahar	Wildlife sanctuary	3,026	Mixed evergreen
Protected area		1,07,430	

of personnel trained in wildlife conservation (Khan 1985; Oliver 1979). In 1976, a Wildlife Working Circle (WWC) was established under the FD with the specific responsibility for dealing with wildlife matters. The WWC was later abolished to make way for the Wildlife Advisory Board (WAB) (Blower 1985). The post of a Conservator, Wildlife Circle, was created under the FD in 1991 for management of wildlife and protected areas. This wildlife circle maintains liaison with CITES, WAB, and the Bangladesh Forest Research Institute (BFRI).

Ex Sita Conservation

Ex situ biodiversity conservation efforts are not well organised in Bangladesh. The parks, botanical gardens, and aesthetic gardens of religious, educational, public and private sector organisations, and institutions are considered *ex situ* conservation sites. These are maintained by the respective authorities.

In the agricultural sector, before the 1970s, limited efforts were made to maintain land races by plant breeders. Biodiversity conservation efforts have been institutionalised in Bangladesh since 1972. Government efforts and the institutions or organisations involved in plant genetic resources' (PGR) conservation activities are shown in Chart 1. The crop species related to different institutes are also briefly discussed.

Bangladesh Agricultural Research Institute (BARI) : cereals (other than rice), legumes, oil seeds, vegetables, spices, fruits, tubers, and other crops

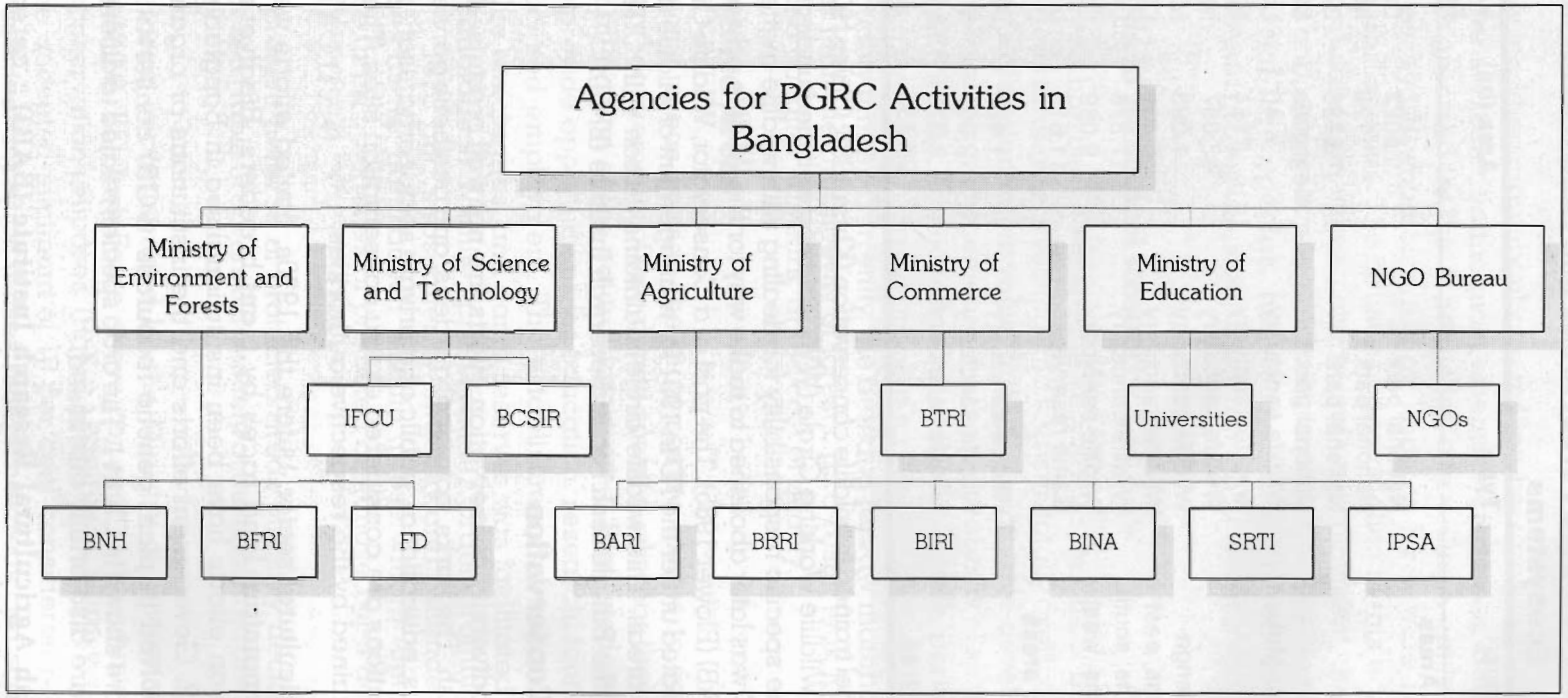

Chart 1: Institutes or Organisations involved in PGR Conservation

Bangladesh Rice Research Institute (BRRI) : rice, *Oryza sativa*, variety *indica* - traditional *indica*, *indica* breeding lines, exotic *indica*, *Oriza sativa* variety *Japonica*-exotic *Japonica*, exotic *globerrima*, wild rice

Bangladesh Jute Research Institute (BJRI) : *Corcorus* spp, *Hibiscus* spp, allied genera

Bangladesh Institute of Nuclear Agriculture (BINA) : rice (*Oryza sativa*), Jute (*Corcorus* spp), cotton, mustard, sesame, groundnuts, lentils, chickpeas, black gram, mung beans, grasspeas, tomatoes, sugarcane mutants, etc

Bangladesh Tea Research Institute (BTRI) : tea (local, exotic, and polyploids)

Sugarcane Research and Training Institutes (SRTI) : *Saccharum officinarum* and *Saccharum spontaneum*

Bangladesh Agricultural University (BAU) : rice, wheat, maize, groundnuts, lentils, dry beans, country beans, peas, faba beans, soyabeans, tomatoes, bitter gourd, sweet gourd, ribbed gourd, etc

Bangladesh Forest Research Institute (BFRI) : bamboo spp, rattan and cane, endangered and threatened tree species, medicinal, aromatic, and ornamental plant spp

In addition, BFRI places emphasis on *ex situ* and *in situ* conservation of *garjan (Dipterocarpus* spp), *chapalish (Artocarpus chaplasha)*, *civit (Swintonia floribunda)*, *telsur (Hopea orodata Roxb.)*, and *toon (Toona ciliata)*

Inventories of Flora/Fauna/Useful and Endangered Species

Inventories of biodiversity resources in Bangladesh have not been updated at the national level. The works of Prain and others (1903) quoted the presence of 5,000 species of angiosperms in Bangladesh and West Bengal (India). However, some information is available from the Bangladesh National Herbarium, Forest Department, Bangladesh Forest Research Institute, and university sources about extinct, threatened, and endangered species. Bangladesh being a small country, the species recorded as threatened, endangered, and extinct within the country's boundaries would not fall into these categories if considered on a regional basis. Therefore, transboundary studies of biodiversity resources should be undertaken and conservation measures devised.

Endangered and Threatened Fauna

Mammals

Asiatic elephants (*Elephas maximus*), serow (*Capricornis sumatraensis*), hoolock gibbons (*Hylobates gibbon*), binturong

(*Artictis binturong*), jungle cat (*Felis chaus*), barking deer (*Muntiacus muntjak*), large civet (*Viverra zibetha*), Crab-eating Macaque (*Macaca fascicularis*), great one-horned rhinocerus (*Rhinoceros unicornis*), lesser one-horned rhinocerus (*R. sondaicus*), Asiatic two-horned rhinoceros (*Didermocerus sumatraensis*), blue bull (*Boselspus tragocamelus*), wild buffalo (*Bubalus arnee*), gaur (*Bos gaurus*), banteng (*B. banteng*), swamp deer (*Cervus duvauceli*), hog deer (*Axis porcinus*), wolf (*Canis lupus*), marbled cat (*Felis marmorata*), golden cat (*F. temmincki*), slow loris (*Nyeticabus coucang*), common langur (*Presbytis entellus*), fishing cat (*Felis viverrina*), tiger (*Panthera tigris*), leopard (*P.pardus*), clouded leopard (*Neofelis nebulosa*), sambar (*Cervus unicolor*), and hispid hare (*Caprolagus hispidus*).

Reptiles and Amphibians

Grey lizard (*Varanus bengalensis*), python (*Python molurus*), king cobra (*Ophiophagus hannah*), bastomi turtle (*Trionyx nigricans*), peacock soft shell turtle (*T. hurum*), bull frog (*Rana tigrina*), marsh crocodile (*Crocodylus palustris*), salt water crocodile (*Crocodylus porosus*), gharial (*Gavialis gangeticus*), olive ridley turtle (*Lepidochelyls olivacea*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), loggerhead turtle (*Caretta caretta*), leathery turtle (*Dermochelys coriacea*), batagur turtle (*Batagur baska*), land tortoise (*Geochelone emys*), monitor lizard (*V. salvator*), yellow lizard (*V. flavescens*), clouded lizard (*V. nebulosa*), dog-faced water snake (*Cerberus hynchopa*), hook-nosed sea snake (*Enhydrina schistosa*), annulated sea snake (*Hydrophis cyanocinctus*), banded sea snake (*H. fasciatus*), estuarine sea snake (*H. obscurus*), common narrow-headed sea snake (*Microcephalophis gracilis*), and cantor's narrow-headed sea snake (*M. cantoris*).

Birds

purple heron (*Ardea purpurea*), grey heron (*A. cinerea*), black-winged kite (*Elanus caeruleus*), white-bellied eagle (*Haliaeetus leucogaster*), Pallas' fishing eagle (*H. leucoryphus*), brown fish owl (*Bubo zeylonensis*), pink-headed duck (*Rhodonessa caryophyllacea*), Burmese peafowl (*Pavo muticus*), greater adjutant (*Leptoptilos dubius*), king vulture (*Sarcogyps calvus*), Bengal florican (*Euphodotis bengalensis*), little grebe (*Podiceps ruficollis*), darter (*Anhinga rufa*), open-billed stork (*Anastomus oscitans*), lesser adjutant (*Leptoptilos javanicus*), white-necked stork (*Ciconia episcopus*), glossy ibis (*Plegadis falcinallus*), spoonbill (*Platalea leucorodia*), large whistling teak (*Dendrocygna bicolor*), white-winged wood duck (*Caririna scutulata*), comb duck (*Sarkidiornis melanotos*), grey-headed fishing eagle (*Ichthyophaga ichthyaetus*), white-backed vulture (*Gyps bengalensis*),

black partridge (*Francolinus francolinus*), rain quail (*Coturnix coromandelica*), common peafowl (*Pavo cristatus*), pheasant-tailed jacana (*Hydrophasianus chirurgus*), painted snipe (*Rostratula bengalensis*), great hornbill (*Buceros bicornis*), hill myna (*Gracula religiosa*), and paradise flycatcher (*Terpsiphone paradisi*).

Endangered and Threatened Plant Species

Ancistrocladus wallichii Planchon, *Ban-shupari (Areca triandra* Roxb.), *kadam bet (Calamus erectus* Roxb), *chhotte bet mera (Calliandra umbrosa Benth.), cycas (Cycas pectinata Griff.), modan mosta (Dehaasia kurzii King), doli garjan (Dipterocarpus grocilis Bl.), ban jalpai (Elaeocarpus ganitrus* Roxb.), *dephal (Garcinia xanthochyrus* Hook. f.), (*Gnetum scandens* Roxb.) *homalium (Homalium schlichii* Kurz), *kurud pata (Licuala peltata* Roxb.), *jangli am (Mangifera longipes* Griff.), *urium (Mangifera sylvatica* Roxb.), *monkhoma (Pajanelia longifolia* ([Wild] Schur), *ram shupari (Pinanga gracilis* Bl.), *jigra (Pithecellobium angulatum* Benth.), *bansh pata (Podocarpus neriifolia* Don) *joygga gola (Prunus ceylanica* [Wt] Miq), *chalmugra (Hydnocarpus kurzii* King), *chundul (Tetrameles nudiflora* R.Br.), *Lata am (Willughbeia edulis* Roxb.), *han sak (Xanthophyllum flavescens* Roxb.), *Boilam (Anisoptena glabra)* and *lasuagarjan (Vatica lanceifollia* [Roxb.] Bl.) (Source BFRI). The endangered and threatened floral and faunal species in Bangladesh are shown in Table 5.

Table 5: Endangered Flora and Faunal Species in Bangladesh

Floral Species	
Angiosperms	27
Faunal Species	
Mammals	12
Reptiles	10
Birds	5
Fish	15

National Action Plans and National Strategies

Different agencies, such as the Forest Department, Bangladesh Forest Research Institute, Institutes under the National Agricultural Research System (NARS), and Department of the Environment, work on National Action Plans and Strategies for sustainable management of biodiversity in Bangladesh from their own perspectives. Therefore, an agreed National Action Plan and Strategy on biodiversity conservation and management is lacking in Bangladesh. However, there is a growing national consensus regarding the fact that violation of nature must stop, and there is a mounting hope that environmental degradation can at least be halted if there is a will (Khan 1990).

Action Plans

- The widest possible range of species native to the ecosystems should be planted, with the objective of rebuilding the biodiversity of the original structure.
- Priority should be given to natural regeneration for conservation of biodiversity in natural forests.
- Anthropic interference in protected areas should be prevented, both through peoples' participation and legislation.
- Natural resources' management and biodiversity conservation components should be included in the school curriculum.
- Related institutions should be strengthened to make them capable of surveying, collecting, and assessing the flora and fauna in their habitats and their distribution range as well as for identification of rare, endangered, and threatened species.
- Peoples' participation, including that of woman and children, in biodiversity management and conservation should be encouraged.
- Reliable databases of biologically diverse resources of ecological, social, and economic value are to be developed.

However, a greater awareness and keen interest at decision-makers' level developed in Bangladesh after the Biodiversity Convention of 1992 (Bashar et al. 1995). Programmes are underway to study the implications of the Biodiversity Convention and to seek the participation of scientists, organisations, and citizens for advising policy-makers in matters related to these implications.

Steps are being taken to ratify the Biodiversity Convention in the National Parliament and to take follow-up action.

Strategies

Agricultural Sector

Food security, a self-reliant economy, employment generation, export augmentation, crop diversification, wildlife conservation, conservation of biodiversity, and sustainable development.

Forestry Sector

Sustainable development, forestry and environmental conservation, protected area system, wildlife conservation, biodiversity conservation and sustainable management, income generation from conservation activities, employment generation from forestry activities, reduction in wastage of forest products, and improvement in environmental conditions.

National Laws for Biodiversity Conservation

Forest legislation in Bangladesh dates back to 1835 with the enactment of the first Indian Forest Act. It provided protection to the forests, fire prevention, and prohibition of cultivation and grazing in forest areas. Emphasis was given to protection of Reserved Forests in the Indian Forest Act of 1927. Some of the salient features of the laws relating to forest reservation are listed below.

- After a notification is issued declaring that it has been decided to constitute any land as a reserved forest, no right shall be acquired in or over the land covered in such a notification, except by succession or under a grant of contract in writing made or entered into by some person in whom such a right was vested when the notification was issued.
- Rights in respect of which no claim has been preferred within a stipulated time, and by the existence of which no knowledge has been acquired through enquiry by the Forest Settlement Officer, shall be extinguished.
- When a right to shifting cultivation is admitted wholly or in part, its exercise might be arranged by excluding land for the purposes of the claimants or by causing certain portions of the land under settlement to be separately demarcated for the practice of shifting cultivation, subject in all cases to control, restriction, and abolition by the authority.
- An Amendment to the Forest Act of 1927 was drafted in 1987 and approved in 1989, as the Forest (Amendment) Ordinance 1989. Many of the changes, however, were related to increasing the penalties for offences defined in the Act and to compensating, in respect to fines, for inflation over the years. It made minor changes in appeal limits. It also changed references to new Acts wherever this was applicable, e.g., from the Land Acquisition Act 1894 to the Acquisition and Requisition of Immovable Properly Ordinance, 1982 (Anon 1993).

The Indian Forest Act of 1927, unlike in many countries, does not provide for wildlife management. It, however, includes, wild animals and skins, tusks, horns, bones, cocoons, honey, and all other parts and products of animals in the definition of forest products.

The Bangladesh Wildlife (preservation) (Amendment) Act of 1974 (GOB 1974) provides for the constitution of the Bangladesh Wildlife Board; control of hunting, seizing, possession, transfer, and trade of wild animals; constitution of wildlife sanctuaries, national parks, and game reserves; penalties and punishments for offences;

duties and responsibilities of government officers; and rules and regulations to be made under this law.

Currently, existing laws based on the Indian Forest Act of 1927 can be characterised as obsolete, impractical, unenforceable, and typically punitive. Therefore, there is an urgent need to reformulate laws, rules, and regulations for this sector. These laws need to be made comprehensive, consistent, and compatible with other related legislation, with emphasis on economic and environmental rules.

In the agricultural sector, Bangladesh is yet to formulate legislation to protect its plant genetic resources (PGR). The existing quarantine laws cannot be considered conducive to exchanges of PGR materials such as live plants, seeds, and other biological specimens, even though it carries out friendly and liberal exchange of PGR materials.

Gaps in the Research and Information Database on Biodiversity

Biological diversity constitutes an invaluable source for the discovery of natural resources, their identification, and authentication. These require continued research, monitoring, documentation, and development and maintenance of an information database. The research on biodiversity is conducted partly by BFRI as part of its mandate. Research activities are concentrated on management, improvement, protection of timber species, and so on and little attention is given to the management and improvement of non-timber forest products which display a wide range of biodiversity within the forest ecosystems. This statement is more true of the hill forest ecosystem (Anon 1993).

Bangladesh National Herbarium is poorly equipped to conduct research on biodiversity. This organisation conducts surveys for identification, authentication, and documentation of biodiversity resources which occur in the divergent forest ecosystem on crop lands. It has, so far, identified several wild relatives of crop plants that are in danger and has recorded the threatened species (Khan 1990).

The institutes under NARS conduct research to identify, authenticate, store, and conserve both indigenous and exotic plant genetic resources of various agricultural crops.

These institutes, in their programme, give priority to increases in yields. Recently, these institutes have realised the necessity of widening the genetic bases of crop varieties in the context of adaptability to local conditions, resistance to pest and diseases, and quality, e.g., higher protein content, likeable aroma, and so on.

As mentioned earlier, Bangladesh has a diverse faunal population, numbering about 850 species. In the National Environmental Policy (GOB 1992), it is stated that about 50 per cent of the wildlife species are rare or threatened. The hill forest ecosystem is considered to be the worst effected in this respect. Sporadic studies on wildlife have been conducted by the universities, BFRI, and the Forest Department. Systematic study and research to identify, authenticate, and document the diversity of wildlife resources is yet to begin.

Fishery resources in Bangladesh are among the richest, covering over 500 species (Fallan and Potkin 1990). The inland fish population of the country is declining due to overexploitation, use of agrochemicals, adoption of water control devices, water pollution from industrialisation, and so on. The Research Institute conducts research on yield increase, conservation of diversity, and maintenance of the foodchain in the aquatic ecosystem.

Documentation and information management of PGR activities are poor in Bangladesh. Some data are documented in the annual reports. A computerised database for germ plasm collection and biodiversity conservation has not yet been developed. None of the NARS institutes publish gene bank catalogues; information, such as passport data, evaluation data, and characterisation data, is maintained manually. The data in the gene banks fulfill official reporting purposes only.

In the absence of a proper documentation system, information/ knowledge about samples cannot be provided to users at the time the samples are supplied. In some cases, however, information about a few characteristics, gathered from the passport data and breeders' records, may accompany the samples. Most of the information on germ plasm is furnished from the germ plasm registers by the gene bank on demand from potential users.

The establishment of an internationally acceptable and regionally compatible computerised data management system for germ plasm collection and conservation can help improve documentation as well as dissemination of information, whether in the form of catalogues, newsletter, bulletins, or through other means.

In the absence of PGR networking within the country, it is difficult to make a coordinated database available. However, the gene bank at Bangladesh Jute Research Institute (BJRI), through the auspices of the International Jute Organisation (IJO), has been networking with countries such as China, India, Indonesia, Nepal, and Thailand about germ plasms of jute and allied fibre crops. The success is considered commendable and has resulted in mutual cooperation amongst the jute-producing countries.

BFRI has also very recently begun to collaborate with the Philippines, Thailand, Bhutan, Nepal, Sri Lanka, Pakistan, India, and several international agencies about the exchange of technologies and genetic materials through regional collaborative projects. This institute also collaborates with the International Neem Provenance Trial Project active in several Afro-Asian and Latin American countries.

The NARS institutes, especially BRRI, BARI, BJRI, BINA, BTRI, SRTI, and others play an important role in identifying wild relatives of cultivars, genetic improvement, introduction of exotic genes, conservation, and storage of indigenous and exotic genes in gene banks.

The universities also conduct sporadic research on various aspects of biodiversity management and conservation. The Institute of Forests, Chittagong University (IFCU), places more emphasis on biodiversity conservation research related to the hill forest ecosystem and the University of Khulna emphasises littoral forest ecosystems' research. The main research emphasis of the other university is crop-related. Bangladesh Agricultural University (BAU) plays an important role in biodiversity conservation and management research related to crops, fisheries, and livestock.

INSTITUTIONS WORKING IN BIODIVERSITY CONSERVATION AND MANAGEMENT

As mentioned in the preceding chapters, the BRFI, NARS, Bangladesh National Herbarium (BNH), the Agricultural Extension Department (DAE), Forest Department, universities, and NGOs are half-heartedly and incoherently involved in activities related to biodiversity conservation and management. In addition, many NGOs are engaged in the extension and management of crops, trees, and livestock through agroforestry, social forestry, afforestation of wasteland, and farming systems' research. It is apparent that lots of activities are going on in Bangladesh related to biodiversity conservation and management through the involvement of these institutes and organisations. These activities are compartmentalised and not consistent or coordinated. Therefore, efforts are needed to place emphasis on coordinated study of biodiversity conservation and management at national level.

Role of Public Agencies and Research Institutes

Bangladesh Forest Research Institutes and BNH conduct research to a limited extent to determine the natural distribution of native forest tree species. The main purpose of such studies is the

selection of priority species in various dendro-ecological zones (Richards and Hassan 1989). BFRI also conducts research on the introduction of high-yielding exotic tree species, non-timber economic crops, and biodiversity conservation and management in forest ecosystems.

Role of the Local Government

Local government bodies in Bangladesh include the union councils, *thana* councils, district councils, municipalities, and city corporations. The role of these bodies in biodiversity conservation and management in the past was negligible. The district councils used to plant aesthetic and shade trees along the district council roads. Currently, a greater role is being played by these bodies in national tree planting campaigns and plantation of multipurpose tree species (MPTS) along road sides and on waste and marginal lands. Multipurpose tree species and fruit trees are planted on homestead plots. In urban areas, avenue trees are planted along the road sides, around offices, and on institutional campuses, on wasteland, in recreation parks, and so on by the municipalities and city corporations. The government has undertaken *thana* and city afforestation projects under the Forest Department to collaborate with these ventures. However, local bodies are neither concerned nor very much aware of biodiversity conservation and management aspects. Rather these bodies are involved in tree-planting activities mainly for aesthetic, environmental, and economic reasons.

Role of NGOs and Indigenous Communities

It was recognised at the Eighth Forestry Congress in Jakarta (1978) that NGOs and other private associations and entrepreneurs can play an important role in forestry and biodiversity conservation and management activities. This is mainly due to the capabilities of these organisations to reach the grass roots' level and to enhance community participation in public sector activities. NGOs have gained considerable experience in working with the rural poor in development, conservation, and resource management activities. NGOs can organise groups and conduct credit programmes which can be used to finance group activities.

There are about one hundred NGOs in Bangladesh engaged in forestry and forestry-related activities. Several hundred NGOs are engaged in rural development, health, and family planning and in the agricultural sector. Amng them the Bangladesh Rural Advancement Committee (BRAC), *Proshika, Manabik Unnayan Kendra, Poush, Gono Shahajja, Sangsta, Gono Unnayan Prochesta,* and *Swanirvar* Bangladesh have successful

afforestation programmes. The NGOs in Bangladesh have been able to form groups with memberships of over a million. BRAC has organised groups with a total membership of about 600,000 of whom 65 per cent are women. BRAC has developed an elaborate social forestry management system.

In 1990 the government established an NGO Affairs' Bureau. This Bureau has simplified NGO project approval procedures. NGOs in Bangladesh can act as carriers in transferring technologies generated by different public sector organisations to the users' level.

Private investors in the forestry sector include small entrepreneurs, private corporations, and national corporations. Non-government agencies such as educational institutions, urban development authorities, youth organisations, and others support tree plantation in consideration of environmental, educational, and economic values.

ONGOING PROJECTS AND PLANNED PROGRAMMES ON BIODIVERSITY IN THE MOUNTAIN AREAS OF THE COUNTRY

Projects have been undertaken for development of the mountain areas of Chittagong and the Chittagong Hill Tracts. These projects are financed both by the government and external donors. The main executing agencies are the Forest Department, Chittagong Hill Tracts' Development Board, the Agricultural Extension Department, Bangladesh Agricultural Research Institute, Bangladesh Livestock Research Institute, Bangladesh Forest Industries Development Institute, Soil Resources' Development Institute (SRDI), and NGOs.

Twenty out of 47 externally-assisted projects implemented so far in the forestry sector were directly or indirectly related to forestry activities in mountain areas. Sponsors were the the Food and Agriculture Organisation of UNDP (FAO/UNDP), the Asian Development Bank (ADB), World Bank (WB), United States Agency for International Development (USAID), Overseas Development Agency/European/Economic Community (ODA/EEC), International Development Research Centre (IDRC), Swedish International Development Agency (SIDA), and so on (Anon 1993, Kapoor-Vijay 1992). The projects (i) Afforestation and Settlement in the USF of Chittagong Hill Tracts, (ii) Inventory of Forest Resources of Chittagong and Chittagong Hill Tracts, (iii) *Thana* Afforestation and Nursery Development, and (iv) Forestry and Energy Supply in Cox's Bazaar Division are directly related to forestry development in the mountain areas of Bangladesh. In addition, the *Jhum* Cultivation Division of the Forest Department, the

Horticultural Research Centre of BARI, the Rubber Project of BFIDC, the Jhumia Rehabilitation Project of CHDB and the Hill Farming System Research sections of BFRI, BLRI, and CHTDB are conducting, either singly or in collaboration, some activities in the mountain region.

At present, the Forest Department is implementing projects related to biodiversity conservation which also include the mountain area. These projects are (i) Reafforestation (USF) in the CHTs, (ii) *Thana* Afforestation Project, (iii) Protection and Management of Reserved Forests, and (iv) Declaration of Protected Areas.

Project activities implemented by different departments/ institutions from 1990 to1995 for the development of mountain areas are: (i) Appropriate Technologies for Pilot Project Training, (ii) Development Experiences of the CHT Workshop, (iii) Mountain Hydrology, (iv) Mountain Hydrology Network, (v) Establishment of GIS, (vi) Capability Training in GIS and Preparation of Digital Data Sets, and (vii) Strengthening of GIS Capability. Collaborating institutions are the CHTDB and Special Affairs' Division (PMO), Bangladesh Institute of Development Studies (BIDS), Department of Water Resources, Bangladesh, University of Engineering & Technology (BUET), and Jahangirnagar University (Anon 1995a) Local government bodies, the Engineering Department, the Soil Resources' Development Institute, the Institute of Forestry, and Chittagong University are also executing a project, namely, the Forest, Trees and People's Programme (FTPP) in the hill region.

The Forest Department will undertake projects to be implemented during the next 20 years. These are: (i) afforestation of catchments draining directly into the Karnaphuly hydroelectric reservoir, (ii) industrial plantation in USF and Reserve and Protected Forests, (iii) wildlife habitat development, including captive breeding of endangered and economically important species, and (iv) development of social forestry in the CHTs. This project aims to achieve the objectives of the Forestry Master Plan (Anon 1993) e.g., to develop the forestry sector as a whole and the forestry programmes of the CHTs in particular. The elements under consideration are given below.

- People's participation in forestry sector activities
- Poverty alleviation
- Creation of employment opportunities

These programmes, though directly not related to biodiversity conservation, through their implementation, will help regain the abundance of the hill forest vegetation in the CHTs as well as desirable habitats for a wide range of diverse plants, animals, and birds.

It has been mentioned earlier that forests abound in biological diversity and contain 5,000 flowering plant species, 579 bird species, and 268 animal species, including amphibians and reptiles. Five hundred fish species also occur. Biodiversity conservation offers potentially large economic benefits through harnessing a gene pool of environmentally-friendly medicinal plants.

OVERALL CONCLUSIONS AND RECOMMENDATONS

The Government of Bangladesh instituted the National Conservation Strategy (NCS) in 1987, supported by NORAD (Oslo) and assisted by the IUCN. The government appointed the Bangladesh Agricultural Research Council (BARC) the implementing agency for the NCS. A Secretariat was set up at BARC, and an interministerial committee formed to conduct multisectoral activities, including (i) land resources, (ii) genetic diversity, (iii) forestry, (iv) agriculture, (v) energy and mineral, and (vi) fisheries and water resources.

Several workshops were organised about the subject, with the objective of reaching a consensus. Experts, senior government officials from key institutes, and academicians from related fields attended the workshops. Accordingly, sectoral write-ups for inclusion in the NCS documents were discussed (Anon 1990, 1991, 1992b). In the agricultural sector, biodiversity conservation and management envisages (i) a judicious land-use policy, (ii) an inventory of PGR by expert professionals from various fields, (iii) a moratorium on tree felling for a period, (iv) identification of *in situ* conservation sites and their management measures, (v) establishment of *ex situ* conservation sites in different agroecological regions, (vi) a moratorium on export of PGRs without the decision of the National Committee, (vii) establishment of a Bureau for PGR conservation and management, (viii) ratification of the Biodiversity Convention by the national parliament, and (ix) involvement of the private sector in these activities.

The forestry sector is responsible for forestry activities and for looking after biodiversity conservation and management in Bangladesh. Strategies are (i) management of natural forests in mountain areas for conservation of genetic resources and wildlife, watershed protection, and soil and water conservation; (ii) afforestation of USF, reserve/protected forest (RE/PF) areas, and vegetation rehabilitation on degraded and denuded hills; (iii) formulation and promulgation of a new forest policy and compatible legislation; (iv) technological development in the forestry sector through adequate research support; and (v) participation of the people in forestry-related activities.

Wildlife conservation and management are among the responsibilities of the Forest Department. Several protective measures

undertaken for conservation of wildlife in the forests are i) declaration of some parts of the forest as wildlife sanctuaries, game reserves, and national parks; ii) formulation and promulgation of punitive and protective laws; and iii) preparation of a wildlife conservation and management plan for the protected areas.

Outside the forest areas, implementation of protective wildlife laws is vested primarily in the law-enforcing agencies. Hence, conservation and management of wildlife are neglected outside the forest areas due to lack of proper enforcement of laws.

The government is responsible for the management of fisheries in permanent water bodies. The fishing areas are leased annually to exploit the fish resources in the country.

Recommendations

Based on the policy objectives indicated in several consultancy reports (Anon 1993, Basher et al. 1995, Anon 1992c, Khan 1990) the following recommendations have been made. Development of capacities at grass root institutional and national levels will be the prerequisites for successful implementation of these recommendations.

- To effectively conserve, rehabilitate, replenish, expand, enhance, develop, and manage the biological resources of the country as renewable national assets, in order to meet vital needs and provide services for the benefit of all people, now and in the future.
- To protect land and watersheds against degradation by deforestation, soil erosion, shifting cultivation, landslides, floods, fire, grazing, and other natural and anthropogenetic causes, and to enhance the conservation and management function of forests and other biological resources.
- To protect wild flora and fauna, conserve ecosystems, preserve biodiversity, maintain essential ecological processes, and improve the environmental services of forests through maintenance and, where necessary, restoration of ecological balance and establishment of a nation-wide system of protected areas.
- To promote efficient and waste-free harvesting, processing, and utilisation of forest products, in order to obtain increased net benefits/profits/rents of returns on investment.
- To provide increased socioeconomic benefits to the people by contributing to the basic needs, poverty alleviation, employment creation, income generation, better living conditions, and by supporting agricultural and rural development.

- To develop and support a network of appropriate and suitably-linked institutions at different levels, consisting of the public, private, corporate, and cooperative sectors involved.
- To facilitate human resources' development in qualitative and quantitive terms, including education, training, and improvement of skills and capabilities.
- To promote and support goal-oriented biological research and improve research capabilities through adequate training, appropriate institutional restructuring, and provision of adequate incentives.
- To establish an effective forestry extension system in order to disseminate new and improved technology, research information, and knowledge for the benefit of the rural communities; to deliver improved and other inputs; and to create public awareness about the roles and contributions of biodiversity.
- To establish an adequate and effective mechanism of coordination and cooperation with other sectors in Bangladesh and also with international agencies and institutions concerned with the conservation and development of biological resources, including forestry.
- To institutionalise a system for actually reviewing and updating the biological resource situation in the country, assessing the need for changes in policies and priorities and reporting the results periodically to the appropriate national/government body.

Regional Collaboration

Bangladesh has not yet established collaboration with regional and international agencies involved in biodiversity management. It is strongly felt that a PGR centre for the South Asian Association for Regional Cooperation (SAARC) countries should be established with the objective of inviting regionally integrated PGR programmes.

The International Jute Organisation, with its headquarters in Dhaka, has contributed to the development of a Germ Plasm Division at BJRI and initiated cooperation and collaboration among the member countries of the International Jute Organisation (IJO). This linkage mechanism should be maintained and strengthened further.

Regional cooperation and collaboration on forestry-related activities are organised and coordinated through the Forestry Research Support Programme for Asia and the Pacific (FORSPA), the Forest Tree Improvement Project (FORTIP), and the newly-formed Asia Pacific Association of Forest Research Institutes

(APAFRI). Linkages with regional organisations should be strengthened further to involve the scientists, planners, and executives at different levels (Kapoor-Vijay 1992).

International Collaboration

Bangladesh is a member of the FAO Commission. Benefits derived from joining this commission have been (i) a greater awareness, on the part of from PGR workers to policy-makers, regarding the importance of biodiversity and PGR conservation, (ii) an opportunity to participate in developing regional or global action plans for PGR, and (iii) an opportunity to learn from other countries who have advanced with PGR and biodiversity conservation activities.

Other international organisations involved are the IDRC, ODA, International Rice Research Institute (IRRI), International Centre for Maize and Wheat Improvement (CIMMYT), International Potato Institute(CIP), International Centre for Agricultural Research in the Dry Areas (ICARDA), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), International Institute for Tropical Agriculture (IITA), International Plant Genetic Resources Institute (IPGRI), Danish International Development Agency (DANIDA), International Union of Forest Research Organisations (IUFRO), and FORSPA (Bashar et al. 1995, Kapoor-Vijay 1992).

An Intellectual Property Rights' (IPR) legislation is yet to be formulated in Bangladesh. This, however, requires an in-depth study. The implications of GATT/WTO accords need to be studied before formulation of the IPR legislation, legislation on exchange of genetic materials, and import and export of PGR materials. In drawing up such regulations, due recognition to farmers' or planters' right should be ensured (Bashar et al. 1995, Khan 1990, Anon 1993).

Finally, since 1971, Bangladesh has been passing through a critical phase of mismanagement of natural resources. This is mainly due to: i) erosion in values and particularly to the collapse of the social structure following the war of liberation, ii) weakness of the government authority responsible for enforcing protective laws, and iii) lack of awareness regarding conservation of biodiversity and other natural resources in their natural habitats.

For conservation and management of biodiversity, Bangladesh will need technical and financial assistance from regional and international agencies. The assistance is needed for human resource development, preparation of extension materials for mass motivation, and building of an institutional framework capable of performing the activities and maintaining the linkages

with national, regional, and international organisations. In-built mechanisms should exist within the institutional frameworks for periodic monitoring and evaluation at national, regional, and international levels.

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