

Status of forest genetic resources conservation and management in Bangladesh

Sk. Sirajul Islam

Director, Bangladesh Forest Research Institute, Chittagong, Bangladesh

Introduction

Bangladesh is located between latitudes 20° 34' to 26° 38' N and longitudes 88° 01' to 92° 41' E. The country consists mostly of flood plains (80%) with some hilly areas (12%), with a sub-tropical monsoon climate. In winter, temperature ranges from a minimum of 7°C to 13°C to a maximum of 23°C to 32°C. In summer, the temperature varies from 36°C to 41°C. The mean annual rainfall ranges from 143 to 434 cm (BBS 1994). The population stood at 131.6 million in 2001.

Forest resources

Bangladesh has a total area of 14.39 million ha, of which 9.12 million ha is cultivated, 2.14 million ha public forests, 0.27 million ha village groves, and 1.64 million ha constantly under water. The remaining land area (1.22 million ha) is occupied by tea gardens, uncultivable areas, rural and urban houses and ponds (Kibria *et al.* 2000). The area of government and village forests is about 16% of the total land area. However only 0.93 million ha (6.5%) is under tree cover, which is about 40% of the forests controlled by the government. The remaining 60% includes denuded lands (grassland, scrubland and encroached areas). About 24 000 ha of forest is lost annually as a result of homestead development, urbanization and deforestation (Anon 1992).

The mangrove forests composed of two major components, *viz.*, the Sundarbans and the Coastal Afforestation. The Sundarbans forest is spread over 0.58 million ha in the south-western region (Ali 1989), with an annual depletion rate of about 1.7%. A large-scale coastal afforestation programme has been undertaken since 1966, covering about 170 000 ha. The hill forests cover an area of 0.67 million ha. The growing stock has been estimated to be about 28 million m³ or 100 m³ ha⁻¹ (Anon 1992). Annual depletion of the growing stock stands at 1.65%. The estimated average annual forest growth is 2.5 m³ ha⁻¹. The forest cover of 0.12 million ha mainly consisting of *Shorea robusta* (sal) is located in the central and northern part of the country. The area under tree cover in this region has been estimated to be 32%. A large portion of this forestland has been encroached. About 0.02 million ha of plantations have been established. The unclassified state forests include 0.73 million ha of hilly land located at the southeast corner of the country. The village forest area is 0.27 million ha (TFYP 1985). The growing stock of the woodlots and bamboo resources have been estimated to be 54.7 million m³ and 7480 million culms respectively.

The contribution of forestry to the national Gross Domestic Product (GDP) at current prices has been estimated to be 3.28% (BBS 1994). The supply of various forest products such as timber, poles, fuelwood, bamboo, etc. cannot meet the present demand. Village forest areas, being one-tenth of the national forest area, supply 70% of sawlogs, 90% of fuelwood and 90% of bamboo consumption of the country (Douglas 1982). The annual per capita consumption of timber and fuelwood was estimated to be 0.01 m³ and 0.08 m³, respectively, based on a population of 90 million as at 1980 (Byron 1984). The figure would be less if the present forest production and population were considered. The gap between demand and supply has been increasing with the increase in population. This gap may be narrowed through the establishment of plantations of fast growing trees in the denuded forest areas, wastelands as well as homestead areas.

Status of forest genetic resources

Bangladesh, located in the humid tropical region is rich in species diversity and is unique in the diversity of genetic resources compared to its land area. It has about 5700 species of angiosperms and four species of gymnosperms (Khan 1977; Troup 1975) of which some 2260 species are reported from the Chittagong region (Anon 1992). The major forest tree species of the country are shown in Appendix 1.

Khan (1996) reported that there are about 86 timber species, 130 species yielding fibre and 29 medicinal plant species available in the country. The Bangladesh National Herbarium (BNH) prepared a list of 500 medicinal plants. Bamboo resources of 18 taxa, both wild and planted are available in the country (Alam 1982). There are at least nine species of rattans, including a recently reported one (Alam and Basu 1988), along with 12 other palm species (Khan 1996). However, it must be noted that comprehensive information on forest genetic resources (FGR) is not available in the country. Information on species diversity in terms of (i) chromosome numbers, (ii) morphological variation, (iii) flowering and seed production habits, (iv) flowering time and (v) seed morphology and viability, etc. are available only for a few agricultural species. Forest species have been neglected in this respect (Hassan 1995).

Identification of threats

Forests in Bangladesh are declining at an alarming rate. An estimated 73 000 ha of forests were lost to encroachment for agriculture and aquaculture by the year 1980. Some species are disappearing fast and are considered as threatened. A total of 19 tree species and nine rattan species need immediate conservation measures (Khan 1996). The on-going loss of germplasm is a threat to FGR. High population pressure on land, clearing of forests, exploitation, draining and filling of wetlands, introduction of exotic species, introduction of improved genotypes, pests, improper silvicultural techniques and management and lack of public awareness are some of the major threats to FGR. Poverty and the attitude of the people towards exploitation of natural habitats of plants as free goods also contribute to the loss of germplasm in the country.

The destruction of forests by shifting cultivation is another problem in Bangladesh. The forests are cut and cultivated for a short time only, and when the residual nutrients in the soil are leached as a result of erosion removing the topsoil, the shifting cultivators move to another location.

The country has four wild gymnosperms, viz. *Cycas pectinata*, *Gnetum scandens*, *G. funiculare* and *Podocarpus nerifolia*. *C. pectinata* is regionally threatened and the two *Gnetum* species have become very rare while the populations of *P. nerifolia* are much depleted. Immediate appropriate conservation measures are needed to protect these species in the country. Khan (1996) reported that the number of plant species threatened in the country is 45. Among mammals, birds, reptiles and amphibians, 15 species have become extinct and 33 species are endangered. According to the Government of Bangladesh (GOB 1992), there are 27 threatened and 39 endangered species of wildlife in Bangladesh at present.

Links between forestry sector and FGR

Genetic resources play an important role in improving the quality and quantity of forest products. In this respect, FGR provide the source material for selection of mother trees, provisional plus trees and establishment of seed orchards. It is associated with the conservation of superior genetic materials and their subsequent improvement. Ultimately, the improved materials will be utilized in national programmes to enhance the productivity of forests, and in order to do so the following activities are undertaken by the Forest Department:

- Use of fast-growing genotypes for increasing the production
- Use of best genotype/provenance of proven trees for particular site type
- Use of best genotype to develop interim and alternate sources of improved seeds required for national plantation programme
- Use of best genotypes in tree improvement programmes

Links between agriculture and FGR

The Bangladesh Agriculture Research Institute (BARI), Bangladesh Rice Research Institute (BRRI) and Bangladesh Jute Research Institute (BJRI) initiated systematic germplasm conservation activities around the mid-70s. The assistance of Institute of Jute Organization (IJO) added extra emphasis and BJRI now has a global germplasm collection of jute and associated fibre crops. FGR have not received much attention until recently.

Although Bangladesh is a small country it has a diverse ecosystem with hills, plains, coastal areas and wetlands, and a wide variety of FGR as a result of the diverse agroecological conditions [38 agroecological zones and 88 subzones]. The landraces have survived here under the hostile climates over centuries and acquired some characteristics, which are of immense importance to the breeders for development of new cultivars, hybrids, etc, and face challenges of more violent pathogens, pests and a hostile climate (drought, salinity, temperature, etc).

With regard to tree species, collecting, conserving and utilizing fruit germplasm has received some attention. A total of 817 fruit germplasms have been collected so far. Moreover, 53 fruit species have been identified to be occurring mainly in the forests. The conservation of these fruit species is implemented by BARI, the Department of Agriculture Extension (DAE) and the Bangladesh Agriculture Development Corporation (BADC).

FGR are needed for the incorporation of genotypes into the existing agricultural production systems, reforestation programmes, agroforestry, social forestry and commercial timber estates. Agriculture utilizes FGR in selection of superior traits, selection breeding, identification of high-yielding varieties (HYV) and domestication of fruit germplasms.

Links between agroforestry and FGR

Large-scale agroforestry projects have been initiated in heavily degraded *Shorea robusta* forests of the central and northern regions of the country. A community forestry project at Dinajpur is considered a success story of the Forest Department (FD). In this area, plantations have been established in close cooperation with local people on a benefit-sharing basis. At the moment, the people are harvesting the trees. The major tree species are *Eucalyptus camaldulensis*, *Acacia auriculiformis* and *Cassia siamea*. During the first two to three years after planting, people cultivated rice, wheat and vegetables, etc.

The farmers in the northern region are also cultivating tree species along with their agricultural crops. They keep different tree species at a wide distance in their crop fields. The species used include *Acacia nilotica*, *A. catechu*, *Azadirachta indica*, *Eucalyptus* spp., *Dalbergia sissoo*, *Borassus flabellifer*, *Phoenix sylvestris*, etc. In some areas, they have also planted mulberry for feeding silkworms to produce silk.

There are homestead agroforestry systems all over the country. These homesteads are rich in genetic resources. Ninety tree species and 13 bamboo species are grown in homestead forests. The Bangladesh Forest Research Institute (BFRI) has started research to develop improved rubber agroforestry systems in some rubber estates and trying to find out shade tolerant genotypes of economic crops. Ginger, turmeric and *Colocasia* (Arum) have given satisfactory results when planted at the early stage of rubber plantation.

For agroforestry purposes, farmers use different forest species for soil fertility management, fodder and living fences, as well as timber. Agroforestry utilizes forest genetics resources in selection of superior trees, selection of multi-purpose tree species (MPTS) and fast-growing tree species, selection of leguminous tree species and selection of wild crops.

Past and present activities in conservation, utilization and management of FGR

Establishment of forest plantations in Bangladesh started in 1871 with teak (*Tectona grandis*) using seeds brought from Myanmar. Since then plantation forestry became a part of the overall clearfelling silvicultural systems. Teak was the main species planted because of its high value. Other species, such as *Gmelina arborea*, *Artocarpus integrifolius*, *Dipterocarpus turbinatus*, *Swietenia mahagoni*, *Lagerstroemia speciosa*, *Toona ciliata*, *Artocarpus chaplasha*, *Xylia kerrii* and *Syzygium grande* were introduced later. Most of the plantations were monocultures

established by shifting cultivators through taungya system. Since the plantations were established through clearfelling followed by artificial regeneration, there was a severe loss of native vegetation. Moreover, with the development of mechanized logging for commercial purposes, the shifting cultivators could not cope with the extensive area cleared, which resulted in a rapid loss of FGR. In many cases plantation establishment failed. The above-mentioned species used for plantation establishment were slow-growing and long-rotation species. Plantations with these species were unable to meet the growing needs of the rapidly increasing population.

In 1974, the Forest Department (FD) began to establish plantations with fast growing species such as *Gmelina arborea*, *Paraserianthes falcataria* and *Anthocephalus chinensis*. During this period, plantations of industrial species such as rubber, oil palm, mulberry and cashew were established but the results were disappointing.

Presently, industrial and fuelwood plantations comprise a mixture of species with long rotation (40 years), medium rotation (12–18 years) and short rotation (5–6 years). In addition, agroforestry plantations are being raised in encroached land with the active participation of local people on a benefit-sharing basis. Encroachment is a serious problem both in sal forests and Hill Forests.

Forest plantations cannot be the substitute to natural forests. The most important reason is that plantations are severely degraded in genetic resources compared to natural forests. In fact, the forests of Bangladesh, particularly the plain land sal forests and hill forests, are severely degraded due to indiscriminate exploitation, the sal forest are even on the verge of extinction. Therefore, the GOB has taken initiatives for the conservation of ecosystems and forest gene resources in the remaining natural forests.

Conservation strategies

Major international efforts to conserve FGR began in the 1960s with the guidance and support of FAO. Conservation efforts of FGR have been implemented with the following strategies:

***In situ* conservation**

In situ conservation is carried out in the following areas: nature reserves, national parks, wildlife sanctuaries and world heritage sites.

(a) Nature Reserves – The objectives of a nature reserve are to protect communities and species and to maintain natural processes in order to have ecologically representative examples of the natural environment. However, in Bangladesh there are no nature reserves. There are some wilderness areas in Chittagong Hill Tracts but there are no records of these areas.

(b) National Parks – There are four national parks in Bangladesh. Details of the national parks are presented in Table 1 below.

Table 1. National Parks in Bangladesh

Name & location	Area (ha)	Year est.	Purpose/Flora
Himchari National Park (Cox's Bazar)	1729	1980	To preserve the fauna and habitats as well as to provide facilities for research, education and recreation. Semi-evergreen and moist deciduous forests. <i>Dipterocarpus</i> spp., <i>Albizia procera</i> , <i>Artocarpus chaplasha</i> , <i>Salmalia malabarca</i> , <i>Sterculia alata</i> , <i>Quercus</i> spp., <i>Castanopsis</i> spp., <i>Eugenia</i> spp., <i>Lannea grandis</i> , undergrowth mixed with canes, palms, orchids and ferns and sometimes as pure stands.

Name & location	Area (ha)	Year est.	Purpose/Flora
Bhawal National Park (Gazipur)	5022	1982	To preserve and develop the habitats and provide facilities for research, education and recreation. About 90 percent of the forest cover is composed of coppice-origin sal (<i>Shorea robusta</i>) in association with <i>Dillenia pentagyna</i> , <i>Lagerstroemia parviflora</i> , <i>Adina cordifolia</i> , <i>Miliusa velutina</i> , <i>Lannea grandis</i> , <i>Albizia</i> spp., <i>Bauhinia variegata</i> , <i>Spondias mangifera</i> , <i>Butea frondosa</i> , <i>Barringtonia acutangula</i> , etc. Common undergrowths are <i>Eupatorium</i> spp., <i>Pennisetum setosum</i> , <i>Asparagus racemosus</i> and <i>Rauvolfia serpentina</i> .
Madhupur National Park (Tangail)	8436	1982	To preserve and develop the habitats and provide facilities for research, education and recreation. Flora similar to that of the Bhawal National Park. About 40% of the forest flora is composed of sal.
Ramsagar National Park (Dinajpur)	52	1974	To preserve and develop the habitats and provide facilities for research, education and recreation. The park does not contain any type of natural forest of the country but is artificially raised. The species planted consist mostly of fruit and ornamental trees.

(c) **Wildlife Sanctuaries** – There are 14 wildlife sanctuaries and game reserves in Bangladesh and details on these are as given in Table 2 below.

Table 2. Wildlife Sanctuaries in Bangladesh (Sarker 1989; Rahman 1996)

Name & location	Area (ha)	Year est.	Purpose/Flora
Sundarbans World Heritage Site (Khulna)	16 065	1998	To preserve breeding habitats. The Sundarbans mangrove forest is fairly evergreen with low floristic diversity. The two main dominant species are <i>Heritiera fomes</i> and <i>Excoecaria agallocha</i> . Both species are gregarious in nature but the latter is more saline tolerant and therefore, predominates in the saline zones. Other species are <i>Rhizophora</i> spp., <i>Cerriops</i> spp., <i>Kandelia candel</i> , <i>Sonneratia apetala</i> , <i>Avicennia</i> spp., <i>Aegiceras corniculatum</i> , <i>Bruguiera gymnorrhiza</i> , <i>Phoenix paludosa</i> , <i>Nipa fruticans</i> , etc. and among grasses <i>Imperata cylindrica</i> , <i>Typha elephantina</i> and <i>Phragmites karka</i> are prominent.
Sundarbans East (Khulna)	5439	1977	To preserve the Royal Bengal Tiger (<i>Panthera tigris</i>) and its habitats. Flora similar to the Sundarbans World Heritage Site.
Sundarbans South (Khulna)	17 878	1977	To preserve the Royal Bengal Tiger (<i>Panthera tigris</i>) and its habitats. Flora similar to the Sundarbans World Heritage Site.
Sundarbans West (Khulna)	9069	1977	To preserve the Royal Bengal Tiger (<i>Panthera tigris</i>) and its habitats. Flora similar to the Sundarbans World Heritage Site.
Rema-Kalenga (Sylhet)	1095	1981	To preserve the existing fauna and flora in the area. Flora is same as in tropical evergreen and semi-evergreen forests.
Char Kukri-Mukri (Bhola)	40	1981	To preserve the existing habitat used by local and migratory birds. The sanctuary is covered very thickly by a small spiny plant locally called tambulkanta that grows up to 2.5 metres in height. There are patches of hogla (<i>Typha elephantina</i>), hargoja (<i>Acanthus illicifolius</i>) and keora (<i>Sonneratia apetala</i>) scattered throughout the sanctuary area. Khalisha (<i>Aegiceras malus</i>) is also seen.

Name & location	Area (ha)	Year est.	Purpose/Flora
Pablakhali WS (Chittagong Hill Tracts)	42 087	1983	To preserve fauna and habitat for white-winged wood duck (<i>Cairina scutulata</i>). The following types of forest cover are recognized in the sanctuary area: a) Tropical evergreen; important species are <i>Pterygota alata</i> and <i>Quercus</i> spp. b) Tropical semi-evergreen; important trees are <i>Dipterocarpus</i> spp., <i>Mangifera</i> , <i>Amoora</i> , <i>Cinnamomum</i> , <i>Syzygium</i> , <i>Tetrameles</i> , <i>Artocarpus</i> , <i>Salmalia</i> , <i>Albizia</i> , etc. c) Tropical moist deciduous; the characteristic tree species are <i>Albizia</i> , <i>Salmalia</i> , <i>Terminalia</i> , <i>Ficus</i> spp., etc. Bamboos grow in all the types as undergrowth.
Hail Haor (Sylhet)	1427	1983	To preserve habitats for migratory ducks. At present all the wetland areas are under management control of Haor Development Board. Their activities probably place more emphasis on paddy production and other agricultural crops. It is the most threatened habitat in the country.
Hazarikhil (Chittagong)	2909	1970	To preserve local fauna and habitats. The forest cover of the sanctuary is of evergreen/semi-evergreen type. Main species of trees are <i>Dipterocarpus</i> spp., <i>Artocarpus chaplasha</i> , <i>Tetrameles nudiflora</i> , <i>Cedrela toona</i> , <i>Mesua ferrea</i> , <i>Eugenia</i> spp., <i>Ficus</i> spp., <i>Albizia procera</i> , etc. Undergrowth consists mostly of bamboo and <i>Eupatorium odoratum</i> .
Rampahar-Sitapahar (Rangamati)	3026	1973	To preserve local fauna and habitats. Same as Hazarikhil except bamboos occur as prominent undergrowth.
Chunati (Chittagong)	7764	1986	To preserve habitats. As in the case of mixed evergreen forests, the upper storey of the sanctuary forest consists of deciduous trees such as <i>Dipterocarpus turbinatus</i> with fewer <i>D. pilosus</i> and <i>D. costatus</i> , <i>A. chaplasha</i> , <i>Salmalia insignis</i> and <i>S. malabarica</i> , <i>Ficus</i> spp., <i>Swintonia floribunda</i> , <i>Bandarholla</i> , etc. The second storey consists of evergreen species, such as <i>Quercus</i> spp., <i>Eugenia</i> spp., <i>Lannea</i> spp., <i>Lagerstroemia</i> spp., <i>Aphanomixis</i> spp., <i>Hargaza</i> , etc. The undergrowth consists mostly of smaller evergreen trees with bamboo and <i>assamlata</i> (<i>Eupatorium odoratum</i>).
Dulhazara Safari Park (Cox's Bazar)	1600	1995	To preserve habitats. Flora is same as in tropical semi-evergreen forests.
Khagrachari (Chittagong Hill Tracts)	n.a.	n.a.	To preserve elephants. Flora is same as in tropical wet evergreen forests.
Teknaf (Cox's Bazar)	11 615	1983	To preserve the Asian elephant (<i>Elphas maximus</i>) and its habitats. Semi-evergreen and moist deciduous forests. <i>Dipterocarpus</i> spp., <i>Albizia procera</i> , <i>Artocarpus chaplasha</i> , <i>Salmalia malabarica</i> , <i>Sterculia alata</i> , <i>Quercus</i> spp., <i>Castanopsis</i> spp., <i>Eugenia</i> spp., <i>Lannea grandis</i> , <i>Lagerstroemia</i> spp., <i>Amoora</i> spp. etc. Bamboo occurs as undergrowth mixed with canes, palms, orchids and ferns and sometimes as pure stands. This category does not fall in any of the ten categories described by the IUCN.

(d) World Heritage Site – The Sundarbans has been declared a world heritage site.

Ex situ conservation

In contrast to *in situ* conservation, *ex situ* conservation includes any practices that conserve genetic materials outside the natural habitat of the parent population. *Ex situ* conservation methods and materials include genebanks for seed or pollen as well as clonal banks, arboreta, preservation plots, sample plots, etc:

- **Preservation plots** – The BFRI has established five preservation plots at different hill forest areas and 27 at the Sundarbans (mangrove) forest.
- **Clone banks** – The BFRI has established two clonal banks, one at Hayko, Chittagong (4 ha) and another at Ukhia, Cox's Bazar (4 ha). Seven tree species (*Tectona grandis*, *Gmelina arborea*, *Bombax ceiba*, *Dipterocarpus turbinatus*, *Syzygium grande*, *Swietenia mahagoni* and *Paraserianthes falcataria*) are preserved in these two locations.
- **Botanical gardens**
 - Mirpur Botanical Garden: area 85 ha, with 255 tree species (total 28 200 plants), 310 shrub species (8400 plants), 385 herb species (10 400 plants). The total number of families of trees, herbs and shrubs is 114 (Ranjit 1997).
 - Baldha garden: area 1.15 ha with 18 000 trees, herbs and shrubs from 820 species and 92 families (Ranjit 1997).
- **BFRI Bamboo Arboretum** – The BFRI Bambusetum (1.5 ha) has been established at the BFRI campus. This arboretum contains 27 bamboo species (*Bambusa balcooa*, *B. bambos* var. *spinosa*, *B. burmanica*, *B. cacharensis*, *B. comillensis*, *B. jaintiana*, *B. multiplex*, *B. nutans*, *B. polymorpha*, *B. salarkhanii*, *B. tulda*, *B. vulgaris*, *B. ventricosa*, *Dendrocalamus giganteus*, *D. hamiltonii*, *D. longispathus*, *D. strictus*, *D. brandisii*, *Gigantochloa andamanica*, *G. atroviolacea*, *G. apus*, *Melocalamus compactiflorus*, *Melocanna baccifera*, *Schizostachyum dullooa*, *Thyrsostachys oliveri*, *T. regis* and *T. siamensis*), including six exotic species. One arboretum of medicinal plants (1 ha) has been established at the BFRI campus with a collection of 40 species. One cane arboretum (0.5 ha) of seven species has also been established (Banik 1997). Three arboreta of tree species have been established at the BFRI HQ with 56 species, Keochia Forest Research Station with 56 species and Charaljani Silviculture Research Station with 52 species.
- **Seed storage** – There is a National Forest Seed Center (NFSC) at the BFRI; however, the centre does not have any facility for long term storage of seeds.
- **Tissue culture** – Tissue culture on forest tree species has been done only at the BFRI tissue culture laboratory. The BFRI has so far developed tissue culture techniques for six tree species and seven bamboo species.

Appendices 2–4 provide information on the conservation of important tree species in Bangladesh, their use and threats.

Conservation of provenances within a species:

The BFRI has established provenance trials of *Acacia mangium*, *A. auriculiformis*, *Eucalyptus camaldulensis*, *E. brassiana*, *E. tereticornis*, *E. urophylla*, *Tectona grandis*, *Gmelina arborea*, *Pinus caribaea*, *P. oocarpa*, *Paraserianthes falcataria*, *Leucaena leucocephala*, *Melaleuca leucadendra*, *Gliricidia sepium* and *Populus deltoides* from 68 provenances.

Institutional framework

Roles of different institutions are crucial in guiding the course of events and ensuring the successful achievement of aims and objectives. The Forestry Master Plan considered five interrelated areas, i.e. policy, legislation, organizational structure, human resource development, research and extension.

Today the forestry and forest institutions in Bangladesh are judged in much wider context than before. The interrelated and multiple roles of forests are vital for human welfare and sustained socioeconomic development.

Bangladesh signed the convention of the Earth Summit on 5 June 1992 in Rio and subsequently ratified it on 20 March 1994. As a result, the country has certain obligations under the convention.

National forest policy

In accordance with the National Forest Policy promulgated in October 1994, the following policy objectives are set in order to eliminate any uncertainty regarding the aims of the Government:

- i) To meet the basic needs of the present and future generations and also to ensure greater contribution of the forestry sector in economic development.
- ii) To create employment opportunities, strengthening the rural and national economy the scope for poverty alleviation and trees and forest-based rural development sectors will be extended and consolidated.
- iii) Biodiversity of the existing degraded forests will be enriched by conserving the remaining natural habitats of birds and animals.
- iv) Agricultural sector will be strengthened by conserving the land and water resources.
- v) National responsibilities and commitments will be fulfilled by implementing various international efforts and agreements ratified by the government relating to global warming, desertification and control of trade and commerce of wild birds and animals.
- vi) Through the participation of the local people, illegal occupation of the forestlands, illegal tree felling and hunting of wild animals will be prevented.
- vii) Effective use and utilization of the forest goods at various stages of processing will be encouraged.
- viii) Implementation of afforestation programmes on both public and private lands will be provided with encouragement and assistance.

List of national priority species

The following species are the priority species in the Forest Department plantation programme:

Long rotation plantation species: *Tectona grandis*, *Dipterocarpus turbinatus*, *Syzygium grande*, *Swietenia macrophylla*, *Chukrasia tabularis*, *Michelia champaca*, *Hopea odorata*, *Xylia kerrii*, *Lagerstroemia flos-reginae*, *Shorea robusta* and *Toona ciliata*

Medium rotation species: In addition to the long rotation plantation species *Pinus caribaea*, *Albizia flacatana*, *Bombax ceiba*, *Gmelina arborea*, *Anthocephalus chinensis* and *Eucalyptus camaldulensis*, *E. tereticornis*, *Dalbergia sissoo*, *Azadirachta indica*, *Samanea saman*, *Bombax ceiba*, *Acacia nilotica* and *A. catechu*

Short rotation species: *Acacia auriculiformis*, *Acacia mangium*, *Eucalyptus camaldulensis*, *Melia azadirachta*, *Albizia chinensis*, *Leucaena leucocephala*, *Trewia nudiflora* and *Casuarina equisetifolia*

Village groves: *Artocarpus heterophyllus*, *Mangifera indica*, *Aegle mermelos*, *Litchi chinensis*, *Psidium guajava*, *Ziziphus spp.*, *Syzygium*, *Albizia*, *Barringtonia*, *Eucalyptus*, *Erythea*, *Ficus*, *Albizia fuman*, *Anthocephalus*, *Tamarindus indica*, *Bombax ceiba*, *Swietenia macrophylla*, *Alstonia scholaris*, *Cocos nucifera*, palmyra palm and bamboo

On marginal lands such as roadsides: *Tectona grandis*, *Mangifera indices*, *Artocarpus heterophyllus*, *Dalbergia sissoo*, *Butea frondosa*, *Polyanthina longifolia*, *Eucalyptus camaldulensis*, *Acacia auriculiformis*, *Swietenia*, *Albizia*, *Samanea*, *Syzygium* and *Casuarina equisetifolia*

Multipurpose tree species for different zones:

Hillzones: *Albizia lebbeck*, *A. procera*, *Phyllanthus emblica*, *Eucalyptus camaldulensis*, *Elaeocarpus robusta*, *Artocarpus heterophyllus*, *Acacia auriculiformis* and rattans

Coastal zone: *Casuarina equisetifolia*, *Albizia lebbeck*, *Acacia procera*, *S. grandiflora*, *Cocos nucifera*, *Phonek sylvestria* and *Erythrina indica*

Mangrove: *Heritiera fomes*, *Avicennia sp.*, *Bruguiera gymnorhiza*, *Ceriops decandra*, *Rhizophora mucronata* and *Sonneratia apetala*

Research on FGR

The BFRI conducts research under 12 programme areas. Each year the Institute undertakes a number of priority research studies following the suggestions of the Bangladesh Forest Department, Bangladesh Forest Industrial Development Corporation, Bangladesh Chemical Industries Corporation, Bangladesh Tea Board, Rural Electrification Board, other wood-based industries, private owners and non-government organizations. A Technical Committee scrutinizes the suggested studies. An Advisory Committee approves the selected studies.

The BFRI conducts a number studies on FGR conservation and management under the following programme areas: (i) Biodiversity and its conservation, (ii) Production of quality planting materials, (iii) Plantation techniques and forest management, (iv) Breeding and improvement, (v) Social and non-timber forest products, (v) Social forestry and farming system research and (vi) Pest and diseases. Seed Orchard Division, Silviculture Research Division, Silviculture Genetics Division, Mangrove Silviculture Division, Plantation Trial Unit Division, Minor Forest Products Division, Soil Science Division, Forest Protection Division and Farming System Research Component are involved in conducting these studies.

A total of 44 technologies have been developed and out of these, 28 technologies have been transferred to end-users. A total of 16 technologies on conservation and management of FGR have been developed and transferred to different end-users. Training programmes based on these new technologies are arranged as and when required.

Conclusion and recommendations

The natural forests of Bangladesh have been seriously degraded, resulting in serious genetic erosion of FGR. There is a critical need to develop coordinated efforts to conserve and manage FGR. Effective and hopeful efforts have been developed into conservation activities, but national and international financial and technical assistance are needed to bring about success. The following recommendations have been put forward for the conservation and sustainable utilization of FGR in Bangladesh:

- Development of a database on the present status of flora and fauna in different ecosystems of Bangladesh.
- *In situ* and *ex situ* programmes to conserve, manage and use FGR should be significantly expanded.
- Community-based resource conservation needs to be emphasized.
- Improved silvicultural methods should be applied in the management of natural and plantation forests.
- The method of clear-felling followed by burning for plantation establishment must be stopped.
- Silvicultural measures for aided natural regeneration should be followed.
- Enrichment planting should be conducted in the forest gaps with diversified genetic resources collected from natural regeneration in the forest floor.
- Establishment of preservation plots and permanent sample plots in the reserved forest.
- Establishment of a genebank for conservation of FGR.
- Logging in the remaining natural forests must be stopped.

- Creation of diversified job opportunities for the hill people through Farming System approach.
- Improvement of shifting cultivation by improved technologies like SALT, DSA, etc.
- Introduction of a forest certification system for sustainable forest resources management.
- Awareness should be developed among the shifting cultivators about the detrimental effect of shifting cultivation.
- Education and training of professionals and technicians should be given to equip them with the latest knowledge of forest genetic resource survey, management and conservation.
- Strengthening the international cooperation for FGR conservation.

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Species name	Value code	Present, future or potential use												
		ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**	
65. <i>D. peregrina</i>	3	+			+								ts	
66. <i>D. toposia</i>	3	+				+								
67. <i>Dipterocarpus alatus</i>	2												bb,rs	
68. <i>D. turbinatus</i>	1								+				bb,c	
69. <i>Dolichandrone spathacea</i>	3										+		pw,d	
70. <i>Duabanga grandiflora</i>	3	+			+									
71. <i>Dysoxylum binectariferum</i>	3	+			+									
72. <i>D. hamiltonii</i>	3	+			+									
73. <i>Ehretia serrata</i>	3	+			+								agi	
74. <i>Elaeocarpus floribundus</i>	1	+			+			+						
75. <i>E. sphaericus</i>	3										+			
76. <i>E. varunna</i>	3										+		tc	
77. <i>Engelhardtia spicata</i>	3	+			+									
78. <i>Erioglossum rubiginosum</i>	3	+				+							c	
79. <i>Erythrina fusca</i>	3								+					
80. <i>E. variegata</i>	2			+					+				d,v,t	
81. <i>E. fusea</i>	3			+					+					
82. <i>Eucalyptus alba</i>	3				+							+	c,v,rs,pw	
83. <i>E. camaldulensis</i>	1			+										
84. <i>E. brassina</i>	2			+										
85. <i>E. tereticornis</i>	2			+										
86. <i>E. urophylla</i>	2			+										
87. <i>E. citriodora</i>	2			+									c, agi	
88. <i>Excoecaria agallocha</i>	1				+									
89. <i>Ficus benghalensis</i>	1	+		+	+				+					
90. <i>F. hispida</i>	2			+					+				pc	
91. <i>F. racemosa</i>	2			+					+					
92. <i>F. religiosa</i>	1			+					+					
93. <i>Flacourtia jangomas</i>	3			+					+				va	
94. <i>Garcinia cowa</i>	2			+					+					
95. <i>Garuga pinnata</i>	2			+					+					
96. <i>Gliricidia sepium</i>	2			+					+					
97. <i>Gmelina arborea</i>	1	+			+				+				v,d	
98. <i>Grevillea robusta</i>	3	+			+				+					

Appendix 2

Conservation and management of important FGR by ecogeographic zone in Bangladesh

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	In situ conservation stands	Managed forests	Unmanaged forests	Plantations	Ex situ conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Hill Forest (Chittagong, Chittagong Hill Tracts, Sylhet)								
<i>Artocarpus chaplasha</i>	+	+	+		+			+
<i>Swintonia floribunda</i>	+	+	+					+
<i>Dipterocarpus turbinatus</i>	+	+	+		+			+
<i>D. pilosus</i>	+							
<i>D. costatus</i>	+							
<i>D. gracilis</i>	+							
<i>Mesua ferrea</i>							+	
<i>Hopea odorata</i>	+	+	+		+		+	+
<i>Syzygium</i> spp.		+	+		+			+
<i>Calophyllum</i> spp.	+							
<i>Palaquium</i> spp.	+							
<i>Chukrasia tabularis</i>	+	+	+		+			+
<i>Ficus</i> spp.	+							
<i>Michelia champaca</i>	+				+		+	+
<i>Pterygota alata</i>	+							
<i>Lophopetalum fimbriatum</i>	+							
<i>Amoora</i> spp.	+							
<i>Dysoxylum</i> spp.	+							
<i>Albizia procera</i>	+	+			+		+	+
<i>A. lebeck</i>	+	+			+		+	+
<i>A. chinensis</i>	+	+			+		+	+
<i>Gmelina arborea</i>	+	+			+		+	+
<i>Alstonia scholaris</i>	+	+						
<i>Toona ciliata</i>	+	+					+	+
<i>Quercus semiserrata</i>	+							
<i>Q. gomeziana</i>	+							
<i>Podocarpus neriloforcis</i>	+							
<i>Cassia fistula</i>	+							
<i>Phyllanthus emblica</i>	+						+	+
<i>Tetrameles nudiflora</i>	+							
<i>Bombax insigne</i>	+							

Species in ecogeographic (or genealogical) zones	Nature reserves, protected areas	<i>In situ</i> conservation stands	Managed forests	Unmanaged forests	Plantations	<i>Ex situ</i> conservation stands	Villages, fields, homesteads	Experiment, fields, trials
<i>B. ceiba</i>	+						+	
<i>Duabanga grandiflora</i>	+							
<i>Lithocarpus elegans</i>	+							
<i>Castanopsis tribuloides</i>	+							
<i>Calophyllum polyanthum</i>	+							
<i>Macaranga</i> spp.	+							
<i>Terminalia bellirica</i>	+							
<i>Pterospermum acerifolium</i>	+							
<i>Diospyros embryopteris</i>	+							
<i>Sterculia villosa</i>	+							
<i>Garuga pinnata</i>	+							
<i>Meliosma pinnata</i>	+							
<i>Callicarpa macrophylla</i>	+							
<i>Vitex glabrata</i>	+							
<i>Saraca indica</i>	+							
<i>Elaeocarpus robustus</i>	+							
<i>Lagerstroemia</i> spp.	+				+			+
<i>Mitragyna parvifolia</i>	+							
<i>Calamus guruba</i>	+				+			+
<i>C. viminalis</i>	+				+			+
<i>C. latifolius</i>	+				+			+
<i>Daemonorops jenkinsanus</i>	+				+			+
<i>Melocanna baccifera</i>	+				+			+
<i>Dendrocalamus longispatus</i>	+				+			+
<i>D. hamiltonii</i>	+							+
<i>Neohouzeaua dullooa</i>	+							+
<i>Bambusa tulda</i>	+							+
<i>B. polymorpha</i>	+							+
<i>Melocalamus compactiflorus</i>	+							+
<i>Oxytenanthera nigrocialata</i>	+							+
<i>B. vulgaris</i>				+			+	+
Plainland Sal Forest (Comilla, Dhaka, Dinajpur)								
<i>Shorea robusta</i>	+							+
<i>Terminalia bellirica</i>	+							
<i>T. chebula</i>	+							

Species in ecogeographic (or geneecological) zones	Nature reserves, protected areas	<i>In situ</i> conservation stands	Managed forests	Unmanaged forests	Plantations	<i>Ex situ</i> conservation stands	Villages, fields, homesteads	Experiment, fields, trials
<i>Millettia velutina</i>	+							
<i>Albizia procera</i>	+				+			+
<i>Dillenia pentagyna</i>	+				+			+
<i>Lagerstroemia</i> spp.	+							
<i>Garuga</i> spp.	+							
<i>Cassia fistula</i>	+							
<i>Phyllanthus emblica</i>	+				+			+
<i>Adina cordifolia</i>	+							
<i>Butea monosperma</i>	+							
<i>Careya arborea</i>	+							
<i>Schleichera oleosa</i>	+							
<i>Sterculia</i> spp.	+							
<i>Semecarpus anacardium</i>	+							
<i>Litsea polyantha</i>	+							
<i>Aphanamixis polystachya</i>	+							
<i>Microcos paniculata</i>	+							
Littoral and Swamp Forest								
<i>Casuarina equisetifolia</i>					+			+
<i>Calophyllum inophyllum</i>	+							
<i>Terminalia catappa</i>	+						+	
<i>Erythrina variegata</i>	+							
<i>Barringtonia</i> spp.	+							
<i>Hibiscus tiliaceus</i>	+							
<i>Thespesia populnea</i>	+							
<i>Vitex negundo</i>	+							
<i>Trewia nudiflora</i>	+							
<i>Dolichandrone spathacea</i>	+							
Mangrove Forest (Sundarban and Coastal Forest)								
<i>Heritiera fomes</i>	+				+			+
<i>Excoecaria agallocha</i>	+				+			+
<i>Sonneratia apetala</i>	+				+			+
<i>Avicennia officinalis</i>	+				+			+
<i>Xylocarpus granatum</i>	+				+			+
<i>Nipa fruticans</i>	+				+			+

+ = Available

Species in ecogeographic (or geneecological) zones	Nature reserves, prot. areas	<i>In situ</i> conservation stands	Managed forests	Unmanaged forests	Plantations	<i>Ex situ</i> conservation stands	Villages, fields, homesteads	Experiment fields, trials	Degree of threat index
29. <i>Bauhinia malabarica</i>	+								
30. <i>Castanopsis tribuloides</i>	+								
31. <i>Derris robusta</i>	+								
32. <i>Diospyros cordifolia</i>	+								
33. <i>Hydnocarpus kurzii</i>	+								
34. <i>Lophopetalum fimbriatum</i>	+								
35. <i>Mesua ferrea</i>	+								
36. <i>Mitragyna parvifolia</i>	+								
37. <i>Podocarpus nerifolius</i>	+								
38. <i>Pterospermum acerifolium</i>	+								
39. <i>Pterygota alata</i>	+								
40. <i>Schleichera oleosa</i>	+								
41. <i>Sterculia foetida</i>	+								
42. <i>Swintonia floribunda</i>	+								
43. <i>Tamarindus indica</i>	+								

+ = Available

Species	End use				Operations / activities needed											
	W	NW	FW	O	Exploration & collection			Conservation			Germplasm use			REMARKS		
	1	2	3	4	5	6	7	8	9	10	11	12				
33. <i>Hevea brasiliensis</i>	+	+	+													
34. <i>Hopea odorata</i>	+		+													
35. <i>Hydnocarpus kurzii</i>			+	+												
36. <i>Lagerstroemia speciosa</i>	+		+													
37. <i>Leucaena leucocephala</i>			+	+												
38. <i>Madhuca indica</i>	+	+	+	+												
39. <i>Mangifera indica</i>	+		+	+												
40. <i>Michelia champaca</i>	+		+	+												
41. <i>Paraserianthes falcataria</i>	+		+													
42. <i>Phyllanthus emblica</i>	+		+	+												
43. <i>Pinus caribaea</i>	+	+	+													
44. <i>Rhizophora mucronata</i>	+		+													
45. <i>Samanea saman</i>	+		+	+												
46. <i>Saraca asoca</i>			+	+												
47. <i>Sesbania grandiflora</i>			+	+												
48. <i>Shorea robusta</i>	+		+													
49. <i>Sonneratia apetala</i>	+		+													
50. <i>Swietenia mahagoni</i>	+		+													
51. <i>Syzygium grande</i>	+		+													
52. <i>Tamarindus indica</i>			+	+												
53. <i>Tectona grandis</i>	+															
54. <i>Terminalia bellirica</i>	+		+	+												
55. <i>T. chebula</i>	+		+	+												
56. <i>Toona ciliata</i>	+		+													
57. <i>Xylocarpus granatum</i>	+		+													
58. <i>Xylocarpus granatum</i>	+		+													
59. <i>Ziziphus mauritiana</i>			+	+												

End uses: **1** = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); **2** = Industrial non-wood products (gums, resin, oils, tannins); **3** = Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); **4** = Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: **5** = Biological information (natural distribution, taxonomy, geneecology, phenology etc.); **6** = Collection of germplasm for evaluation

Evaluation: **7** = *In situ* (population studies); **8** = *Ex situ* (provenance and progeny tests)

Conservation: **9** = *In situ*; **10** = *Ex situ*

Reproductive use/germplasm use: **11** = Semi-bulk/bulk seedlots, reproductive materials; **12** = Selection and improvement

Remarks (13): PVT = provenance trials; E = endangered at species or provenance level; PGT = progeny trials; MPTS = multi-purpose tree species; CLT = clonal trials; SO = seed orchard; NGB = narrow genetic base