

Forests and forest management practices in Bangladesh: the question of sustainability¹

S. R. BISWAS and J. K. CHOUDHURY

IUCN – The World Conservation Union, Bangladesh Country Office, House 11, Road 138, Gulshan 1, Dhaka 1212, Bangladesh

Email: shekhar.forest@gmail.com, junaidch@bol-online.com

SUMMARY

As a relatively new country, the forests of Bangladesh have only been managed for 34 years under current management authority. During this period, forest management practices have been changed and revised from time to time in accordance with Government policy and legal regimes. The status of forest ecosystems has also changed. This paper reviews and analyzes the past 34 years of forest management practices in Bangladesh and identifies the effects of management practices on the forest ecosystem. The paper also discusses sustainability issues in addition to constraints and opportunities of the forests and forest management practices in Bangladesh.

Keywords: sustainable forest management, community forestry, forest policy, conservation, Bangladesh

Forêts et pratiques de gestion des forêts au Bengladesh: la question de la durabilité

S.R. BISWAS et J.K. CHOUDHURY

Du fait de la jeunesse relative du pays, les forêts du Bengladesh n'ont été mises sous gestion que 34 ans sous l'égide de l'autorité de gestion actuelle. Les pratiques de gestion forestière ont été changées et révisées de temps en temps durant cette période, en accord avec le gouvernement et les régimes légaux. Le statut des écosystèmes forestiers a également changé. Cet article fait un rapport et analyse les pratiques de gestion forestière de ces 34 dernières années au Bengladesh, et identifie les effets de ces pratiques sur l'écosystème forestier. Cet article examine également les questions de durabilité, les contraintes et les opportunités liées aux forêts, et les pratiques de gestion forestières au Bengladesh.

Sostenibilidad: bosques y técnicas de manejo forestal en Bangladesh

S. R. BISWAS y J. K. CHOUDHURY

Dado el origen relativamente reciente del país, los bosques de Bangladesh sólo han sido gestionados por las autoridades actuales durante 34 años. Durante este período, las técnicas de manejo forestal se han modificado y revisado de vez en cuando de acuerdo con las políticas gubernamentales y el régimen legal. El estatus de los ecosistemas forestales ha cambiado también. Este artículo resume y analiza las técnicas de manejo forestal de los últimos 34 años en Bangladesh, e identifica los efectos de estas prácticas en el ecosistema forestal. El artículo trata también temas de sostenibilidad y limitaciones y oportunidades relacionadas con los bosques y las técnicas de manejo forestal en Bangladesh.

INTRODUCTION

In the broadest sense, the concept of sustainability systematically involves both the moral responsibilities of the current generation towards its descendants and concerns about the preservation of all services and goods that can be provided by the forest, currently and in the future (Toman and Ashton 1996, Knight 1996, Thomas and Huke 1996). In 1987, the Brundtland Commission shifted the policy focus towards the achievement of sustainable development

(Atkinson *et al.* 1997) and thereafter forests and biodiversity issues received much attention in the negotiations leading to the 1992 United Nations Conference on the Environment and Development (UNCED). This resulted in the formation of a number of instruments, including the Framework Convention on Climate Change, the Convention on Biological Diversity and the Statement of Forest Principles. In Agenda 21 (Earth Summit 1992), attention is given to the integrated and sustainable management of natural resources (UNCED 1992). Following the Earth Summit, sustainable forest

¹ The opinions expressed in this paper are that of the authors own, not necessarily that reflects the opinions of IUCN – The World Conservation Union in any way.

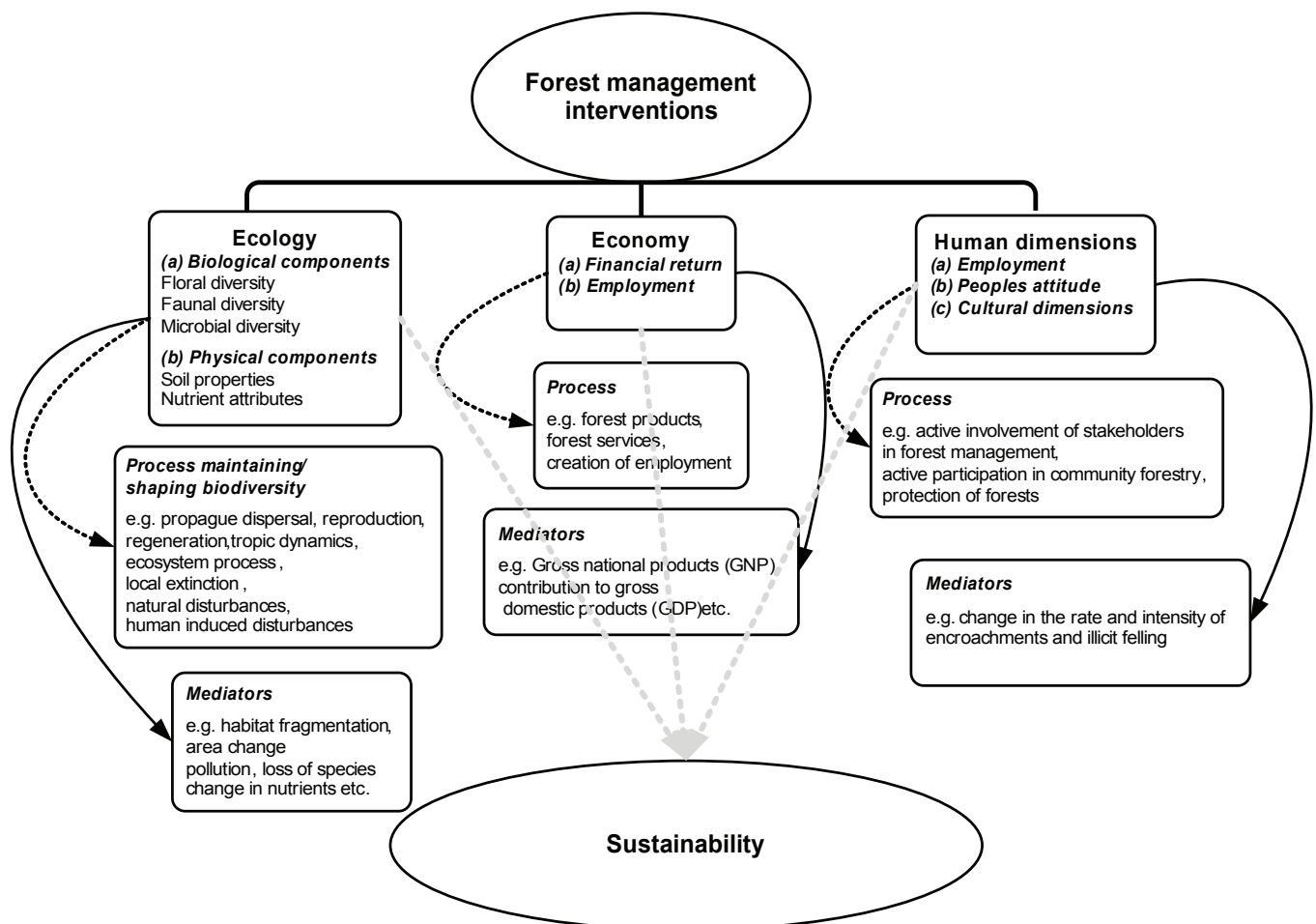
management has been an objective of forest policies in most countries irrespective of the degree of human interventions in forests (Choudhury 2005). Consequently, any discussion of sustainable forest management should include natural forests, secondary forests and plantations (Dupuy *et al.* 1999).

Most ecological systems, such as forests, are in a permanent state of flux caused by naturally evolving biological processes and changes. Sustainable forest management attempts to develop systems whereby resources can be harvested without harming the environment or the interests of future generations. However, it is difficult to assess the sustainability of any particular system. In the case of forest management, the situation is even more complex (Biswas 2001). It is essential to consider the timescale, ecology, economy and socio-cultural aspects while evaluating the sustainability of any particular system (Dupuy *et al.* 1999). There is also controversy concerning the minimum time period required to assess the sustainability of any system. The management intervention needs to be ecologically viable. The ecology can be assessed in terms of biological and physical components. The crucial part consists of the economic and socio-cultural considerations. A system will no longer be sustainable unless it produces sustainable economic returns and is accepted by society. Considering

these, sustainability has thus become a principle ‘that cannot be proven or measured but which serves to create a sense of community, connection and purpose’ (McCool and Stankey 2001) (Figure 1). Sustainability, in this modern, broad sense may be no easier to define than love, hope and charity (Sheil *et al.* 2004).

Historically, Asia is an extremely rich region in terms of tropical rain forests and biodiversity. However, numerous tropical forest areas have become impoverished and degraded (Dupuy *et al.* 1999). In the region, sustainable forest management systems were based on sustained wood production, and numerous silvicultural techniques were used for the management of forests. In real terms of sustainability, economic and human dimensions need to be considered in addition to wood production. Thus the concept of ecosystem management appears to be a suitable framework for management. One of the basic ideas of ecosystem management is that by maintaining forest conditions within their natural range of variation, there is a greater chance to preserve all the values present in a natural forest (Hauffler *et al.* 1996, Thomas and Huke 1996), thereby making the interventions sustainable (Biswas 2001). Knowledge of the historical range of variation of forest conditions (Wallin *et al.* 1994), trends in the changes of management objectives, trends in policy

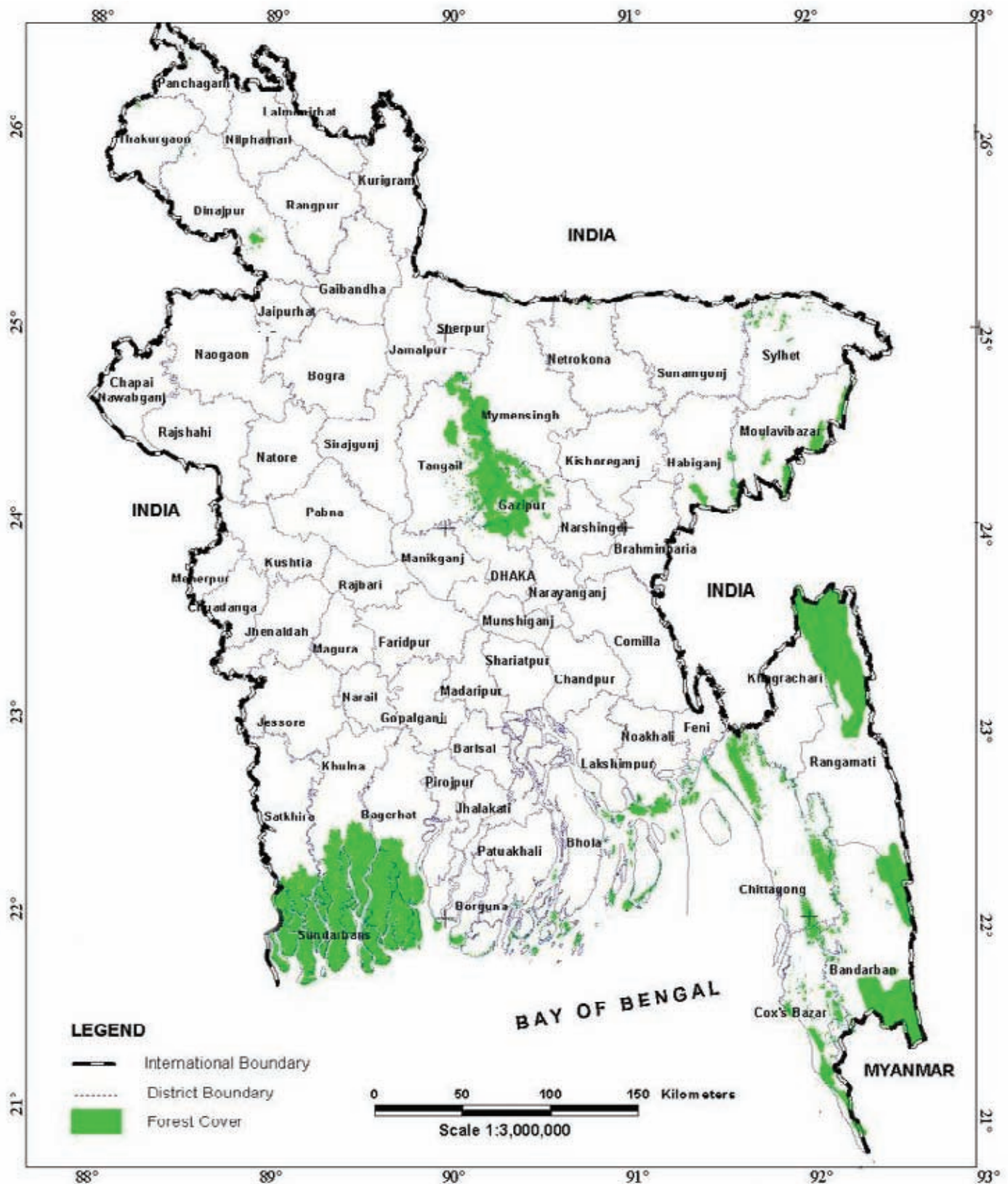
FIGURE 1 Considerations for assessing sustainability of forest management intervention



changes and other legal instruments is critical in judging the sustainability of any particular system. For a sustainable forest management system to be functional it must be viewed as a continuous and ongoing process (Bunnell 1997) and assessment of the effects of interventions at certain stages is

essential. Forest management needs to be objective oriented. Accordingly, the forest department of Bangladesh manages its forestland within a set of objectives, although these are rarely evaluated. This paper aims to assess the sustainability issues of forest management in Bangladesh.

FIGURE 2 Forest areas of Bangladesh



HISTORY OF FOREST AND FOREST MANAGEMENT IN BANGLADESH

Forest type and area

Bangladesh is a densely populated country, lying between 88° 34' and 26° 38' North and between 88° 10' and 92° 41' East (Hossain *et al.* 1997), with an area of 147,570 square kilometers (Figure 2). It occupies a unique geographical location, spanning a relatively short stretch of land between the Himalayan chain and the Indian Ocean, and it is virtually the only drainage outlet for the river basin complex consisting of the Ganges, Brahmaputra and Meghna rivers and their network of tributaries (GoB 1992).

The majority (64.2%) of land is under agricultural use and only 10.2% of the total land is under forest cover (FAO 2005), although this figure is often disputed (according

Mondal *et al.* (2004), the forest cover is 17.5%). The estimated rate of deforestation in natural forests during 1981-85 was 8000 ha annually, which increased during 1990-95, to an annual rate of deforestation of 8800 ha (FAO 1999). At the same time, the population of Bangladesh has increased rapidly. The annual deforestation rate in South Asia is 0.6% (Gain 2002) whereas in Bangladesh it is estimated to be between less than 1% (FAO 1999) and 3.3% (FMP 1993). Such variation may be explained by the fact that the areas affected by forest degradation and deforestation have not been properly surveyed and mapped (Amin *et al.* 2002). However, per capita forestland in Bangladesh has shrunk to 0.022 hectares, considered to be one of the lowest in the world (Choudhury 2005).

The exact sizes and location of forests has never been reliably determined, except by periodic estimations based on visual observations (e.g. FMP 1993). Only 61% of the

TABLE 1 Forest types of Bangladesh

Forest type	Distribution	Major species
Tropical wet evergreen forests	The hill forests of Sylhet and some small pockets of forests in Chittagong and Chittagong Hill Tracts	<i>Artocarpus chaplasha</i> , <i>Syzygium</i> spp, <i>Lophopetalum fimbriatum</i> , and <i>Duabanga sonneratioides</i> . Their associated species are <i>Dipterocarpus</i> spp, <i>Hopea odorata</i> , <i>Tetrameles nudiflora</i> , <i>Shorea robusta</i> , <i>Dillenia pentagyna</i> , <i>Salmalia</i> spp, and <i>Albizia</i> spp. The second story consists of <i>Talaruma phellocarpa</i> , <i>Chikrassia tabularis</i> , <i>Cinnamomum</i> spp, <i>Amoora</i> spp, <i>Toona ciliata</i> , <i>Alstonia scholaris</i> , <i>Mesua ferrea</i> , <i>Gmelina arborea</i> , <i>Terminalia ballerica</i> , <i>Melocanna bambusoides</i> , <i>Bambusa tulda</i> , <i>Teinostachyum dulloa</i> , <i>Dendrocalamus lognispatus</i> , <i>Oxytenanthera nigrosiliata</i> , <i>Teinostachyum griffithii</i> . The undergrowth usually is a tangle of shrubs in which canes, bamboo and wild banana plants are common. Epiphytes are abundant. Aroids, ferns, mosses and orchids are very common. Climbers are also many.
Tropical semi ever green forests	Most of the hill forests of Chittagong, Cox's Bazar and Chittagong Hill Tracts	<i>Dipterocarpus</i> spp, <i>Swintonia floribunda</i> , <i>Pterygota alata</i> , <i>Albizia</i> spp., <i>Tetrameles nudiflora</i> , <i>Michelia excelsa</i> , <i>Palaquium polyanthrum</i> , <i>Callophyllum</i> spp., <i>Artocarpus chaplasha</i> , <i>Mesua ferrea</i> , <i>Aphanamyxis polystachya</i> , <i>Syzygium</i> spp., <i>Duabanga senneratioides</i> , <i>Michelia champaca</i> , <i>Cedrela toona</i> , <i>Lopopetalum fimbriatum</i> , <i>Quercus</i> spp., <i>Lagerstroemia speciosa</i> , <i>Hydnocarpus kurrzii</i> , <i>Trewia nudiflora</i> , <i>Gmelina arborea</i> , <i>Mengifera sylvatica</i> , <i>Terminalia belerica</i> , <i>Terminalia chebula</i> , <i>Eleocarpus robustus</i> , <i>Saraca indica</i> , <i>Melocanna bambusoides</i> , <i>Bambusa tulda</i> , <i>Teinostachyum dulloa</i> , <i>Dendrocalamus lognispatus</i> , <i>Oxytenanthera auriculata</i> , <i>Oxytenanthera nigrosiliata</i> , <i>Bambusa vulgaris</i> , <i>Teinostachyum griffithii</i> etc.
Tropical moist deciduous forests	The sal forests situated in the grater districts of Dhaka, Mymensingh, Dinajpur, Rangpur and Comilla	<i>Shorea robusta</i> , <i>Lagerstroemia flosreginae</i> , <i>Lagerstroemia parviflora</i> , <i>Gmelina arborea</i> , <i>Adina cardifolia</i> , <i>Artocarpus chaplasha</i> , <i>Phyllanthus emblica</i> , <i>Dillenia pentagyna</i> , <i>Butea frondosa</i> , <i>Cassia fistula</i> , <i>Holarrhena antidysenterica</i> etc.
Fresh water wetland forests	These sites get flooded and/or inundated during monsoon. The reed land and the hijal-koroj forests of Sylhet haor area	<i>Barringtonia acutangula</i> , <i>Pongamia pinnata</i> , <i>Crataeva murvala</i> , <i>Anthocephalous cadamba</i> and <i>Salix tetrasperma</i> , <i>Asclepiad</i> spp., <i>Asparagus racemosus</i> , <i>Ficus heterophylla</i> , <i>Ipomea fistulosa</i> , <i>Lipia javanica</i> , and <i>Rosa involucrate</i> , <i>Phragmitei karka</i> , <i>Saccharum spontaneum</i> , and <i>Lemna</i> spp.
Mangrove forests	All the coastal estuarine tidal forests including Sundarban	<i>Heritiera fomes</i> , <i>Bruguiera gymnorhiza</i> , <i>Avicennia officinalis</i> , <i>Sonneratia apetala</i> , <i>Excoecaria agallocha</i> , <i>Ceriops decandra</i> , <i>Xylocarpus moluccensis</i> , <i>Rhizophora mucronata</i> , <i>Nypa fruticans</i> , <i>Phoenix paludosa</i> , <i>Cynometra ramiflora</i> , <i>Aegiceras corniculatum</i> etc.

gazetted State Forests were estimated to carry tree cover in 1988 (FAO 1988), and it is thought that nearly half of the forestlands are without significant tree cover. In land designated as the Hill Forest, only 54% can be considered to be forested. In designated Mangrove forest, 99% of the land is forested, but only 32% of the designated Sal forest is covered in forest (Amin *et al.* 2002). About half of the area of the Mangrove Forest of the Chakoria Sundarbans, some 3,000 ha, has been cleared for shrimp cultivation.

In recognition of these deficiencies, since 1994 the Government has shifted its policy and placed emphasis on participatory and social forestry. Large-scale afforestation has been initiated through this programme (Amin *et al.* 2002), and in the period from 1990 to 2000, the total forest area has been increasing at a rate of 1.3% per year (FAO 2005).

The forests of Bangladesh consist of a mosaic of units with high (e.g., natural forests), moderate (e.g., semi-natural forests) and poor (e.g., plantations) floristic and faunal diversity (Biswas 2001). Das (1990) classified the forests of Bangladesh into four broad types based on their ecological attributes (see Table 1).

Of the forest area, 46.9% is under forest plantations including roadside plantations. Though the percentage of area under plantation is quite satisfactory in reality the status of forest plantations are really poor. The remaining 43.1% of the forest area consists of natural forest and barren forestland

(Choudhury 2005). The Forest Department manages 9.5% of the forest area, and 55% is under the jurisdiction of district administrations (Das and Siddiqi 1985). Almost half of the existing forestland is under different types of non-forest land use, including shifting agriculture, illegal occupation, unproductive areas and other areas (ADB 1999). According to Khan *et al.* (2004), two parallel systems of production forests exist in Bangladesh, namely government forests, run by the Forest Department, and private forests. Although at present 10.2% of the land area of Bangladesh is under 'forest cover', most is no longer covered with trees or vegetation (GoB 1992). Among the forests of Bangladesh, natural forest is disappearing vary rapidly and at present a high proportion (46.9%) consists of forest plantations (FAO 2001). However, the area of plantations will not meet future demands for wood (Biswas 2001).

Protected areas of Bangladesh

In Bangladesh, protected areas include wildlife sanctuaries, national parks and game reserves. The Government has declared seven wildlife sanctuaries, four national parks and one game reserve in forest areas through notification in the official gazette (Table 2). Some additional areas are being considered for protection. The Forest Department has also established an Eco-Park over an area of 815 ha of reserved forests.

TABLE 2 *Protected areas of Bangladesh*

Sl. No	Name	Forest Type	Area (ha.)	Year of establishment
<i>National Parks</i>				
1	Modhupur National Park	Sal forest	8,436	1962/1982
2	Bhawal National Park	Sal forest	5,022	1974/1982
3	Himchari National Park	Hill forest	1,729	1980
4	Lawachara National Park	Hill forest	1,250	1996
5	Kaptai National Park	Hill forest	5,464	1999
6	Ramsagar National Park	Sal forest	28	2001
7	Nijhum Dwip National Park	Coastal Mangroves	16,352	2001
8	Meda Kochchapia National Park	Hill forest	395	2004
9	Satchari National Park	Hill forest	240	Proposed
<i>Wild Life Sanctuaries</i>				
10	Sundarban East WS	Natural mangroves	31,227	1960/1996
11	Pablakhali WS	Hill forest	42,087	1962/1983
12	Char Kukri Mukri WS	Coastal mangroves	40	1981
13	Chunati WS	Hill forest	7,761	1986
14	Rema Kalenga WS	Hill forest	1,796	1996
15	Sundarban West WS	Natural mangroves	71,502	1996
16	Sundarban South WS	Natural mangroves	36,970	1996
17	Hazarikhil WS	Hill forest	2,443	Proposed in 1974
<i>Game Reserves</i>				
18	Teknaf GR	Hill forest	11,615	1983

Source: Choudhury 2005

Forest management

General aspects of management

Forests and their sustainable management are a major concern of the Bangladesh Government (Biswas 2001). For nearly one hundred years, the British colonial system shaped Bangladesh's forest management, as in India and Pakistan (Rishi 2002). During the colonial period, forests were managed following a management plan with the prime objective of meeting the needs for wood in various forms (e.g., sleepers and fuel for the railways, wood for construction and such other uses) on a sustained yield basis (Choudhury 2005). During the Pakistan period (1948-1971), while meeting the demands of wood of the country by harvesting the natural forests, attempts were initiated to convert the existing less commercially valuable natural forest to more valuable forest plantations. Forests were managed following a management plan (Pant 1982). These management plans, termed *working plans*, were written for a given area, and were valid for a period of 10 years (e.g. Ahmed 1961, Choudhury 1960, Curtis 1931).

After liberation in 1971, a total ban was imposed on the felling of trees, suspending the ongoing management plans. Plantation forestry was continued on a limited scale in denuded areas (GoB 1992). Most of the plantations were under different development projects (e.g. Thana Unnayan and Nursery Development project, FSP, FRM). By 1980 Bangladeshi foresters had developed the innovative approach of afforesting the newly formed mud flats along the coast and foreshores.

The conventional central management system of forest resources in Bangladesh has been recognized as being unsuitable for the resource base and the socio-economic situation. Because of the inability to prevent widespread over-exploitation of forest resources, many state forest areas have open access and have been rapidly degraded under population pressure and increasing demands of forest products. To cope with these problems, since 1992 the Bangladeshi Government has developed a participatory forest management and conservation program. The concept of forest management initiated with sustained yield (Das 1982), has transformed to 'multiple use' (Das 1982, Choudhury 2005) and is now entering into the era of sustainable integrated management (Choudhury 2005). Recently, Canonizado and Hussain (1988a,b,c) have written *Integrated Forest Management Plans* for several forest divisions viz. Sunderban, Cox's Bazaar and Sylhet. Canonizado and Ishtiaque (1988) have written an Integrated Forest Management Plan for the newly afforested coastal areas of Noakhali. However, the Forest Department has current forest management plans for these four divisions only and for the remaining forested areas have no current forest management plans (Choudhury 2005). These areas are being worked either on the basis of 'advanced prescriptions' (e.g. Blamforth 1985) or project-oriented 'annual development programs' (Ahmed 2003).

Current knowledge of the mechanisms of human-forest dynamics under diverse and changing circumstances is

challenging the success of the national forestry policy reform and sustainability of the managed forest ecosystems. The objectives of recently expired forests management plans in Bangladesh, in general, were as follows (Choudhury 2005):

- To convert the existing irregular forests into normal ones with better species.
- To provide a sustained supply of forest products to meet the demand of agriculture and industries.
- To meet the demand of forest produce of the local population.
- To prevent denudation of the hills and consequent erosion of the soil so as to maintain natural flow of rivers and streams.
- To derive maximum economic benefits out of a given tract of forests.
- To provide forest cover for preservation and propagation of wild life.

In addition to these goals, the national forestry master plan, considered as a key document in the forestry sector for the country, specifically emphasized the need for forest rehabilitation and securing ecosystems and human well-being.

Silvicultural aspects

The silvicultural systems practiced in the forests of Bangladesh varied according to forest type and management objectives. Since the independence of Bangladesh in 1971, felling has been banned in all forest areas. However, before that, three silvicultural systems dominated, namely the selection system, the coppice system and clear felling followed by artificial regeneration (Pant 1982). In the tropical moist evergreen and semi-evergreen forests, the main silvicultural system was clear felling followed by artificial regeneration, as developed during the British colonial period. However the rotation lengths have been periodically reduced. Initially the rotation was 120 years (Banrjee 1943); thereafter it was reduced to 100 years, 80 years (Zahiruddin 1954), 60 years (Chowdhury 1969) and then 40 years (Blamforth and Howlader 1988). In the moist deciduous forest, the principle silvicultural system has been the coppice system. In the mangroves of Sundarban, several types of systems are followed depending on the species, such as the selection system for *Heritiera fomes*, clear felling for *Sonneratia apetala*, and the coppice system for *Ceriops* spp.

Development projects and programmes in the forestry sector

In the Bangladeshi forestry sector, two broad types of development projects and programmes are on-going. These are externally (donor) assisted projects/programme and development programmes initiated by Non Governmental Organizations (NGOs). Ten donor-assisted forestry sector development programmes are on-going and eleven have been completed.

Ongoing development projects:

- Forestry Sector Project (1997-1998 to 2005-2006)
- Development of Bamboo, Cane and Murta Plantation (1998-1999 to 2005-2006)
- Afforestation of Denuded Hill in the Ramgarh-Sitakunda Area.(2000-2001 to 2006-2007)
- Development of Mudhupur National park. (1999-2000 to 2007-2008)
- Development of Kaptai National Park (1999-2000 to 2005-2006)
- Development of Dulahazara Safari Park , Cox's Bazar (2nd Phase) (2003-2004 to 2005-2006)
- Natural Environment /Biodiversity Conservation and Development at Banskhali, Chittagong. (2003-2004 to 2007-2008)
- Nishorgo Support Project. (2004-2005 to 2008-2009)
- A study on behaviour and ecology of the Tigers in the Sundarban Reserved Forests of Bangladesh. (T.A) (January 2005-December 2005)
- Strengthening Capacity To Generate Quality Information On Forest Resources (T.A) (July 2004 to December 2005)

to Dec 2001)

- Extended Forest Resources Management Project (Jan 2002 to June 2004)
- The Coastal Greenbelt Project (1995-1996 to 2001-2002)
- Food Assisted Rural Development Project (1997-1998 to 2000-2001)
- Nagar Banyan Prokolpa (1993-1994 to 1999-2000)
- Afforestation and Rehabilitation of Jhumia Families in the U.S.F. and Reserved Forest Lands of C.H.T. (3rd phase) (1995-1996 to 2001-2002)
- Infrastructural Reconstruction and Facilities Development of Forest Department in Chittagong Hill Districts(1999-2000 to 2001-2002)
- Development of Bhawal National Park, Baldha Garden and National Botanic Garden (2nd Phase)(1997-1998 to 2002-2003)
- Establishment of Bangabandhu Sheikh Mujib Safari Park, Cox's Bazar(1998-1999 to 2002-2003)
- Establishment of Botanical Garden and Eco-park at Shitakunda, Chittagong (1999-2000 to 2003-2004)
- Establishment of Eco-Park at Modhutila and Gazni Recreational Centre (1999-2000 to 2003-2004)

Completed development projects:

- Forest Resources Management Project (1992-1993

During the last two decades there has been a gradual shift in the forest management approach of Forest Department from its traditional custodian role to a more participatory approach (FD 2006). As might be expected, NGO activities

TABLE 3 *Mangrove plantations in coastal areas of Bangladesh (1980-2004)*

Name of the Forest Division	Name of the Project and duration					Area affected after planting (ha)			Predicted reclaimable land for plantation (ha)
	Mangrove Afforestation Project (MAP) (1980-85)	Second Forestry Project (1985-92)	Forest Resources Management Project (FRMP) (1992-2001)	Extended Forest Resources Management Project (FRMP) (2002-2004)	Total mangrove Plantation (1980-2004) (ha)	River erosion (ha)	Encroached forest land (ha)	Total area of plantation affected (ha)	
Coastal Forest Division, Chittagong	11,437	10,057.0	4,958.0	550.0	27,002.0	11,371.25	5,604.0	16,975.25	5,000.0
Coastal Forest Division, Noakhali	14,615.0	15,314.0	18,200.0	1,163.0	49,292.0	14,153.8	15,700.0	29,853.8	80,000.0
Coastal Forest Division, Bhola	11,011.0	7,758.0	5,845.0	800.0	25,414.0	11,849.15	2,036.0	13,885.15	4,000.0
Coastal Forest Division, Patuakhali	6,114.0	5,932.0	4,565.0	552.0	19,163.0	2,233.0	190.0	2,423.0	5,000.0
Total	43,177.0	39,061.0	33,568.0	3,065.0	118,871.0	39,607.20	23,530.0	63,137.20	94,000.0

Source: Bangladesh Forest Department (Personal Communication)

are concentrated on community and social forestry. Among the NGOs, BRAC, Proshika, RDRS, Caritas Bangladesh, and SDC are amongst the most important for forestry sector and plantation programmes. The Government also put extensive effort to enrich mangrove forestry with massive afforestation programme along the coastal areas of Bangladesh (Table 3).

Policy and legal regimes

Forest policy

During the reign of the Mughals (1203-1538), local kings used to lease the forest for revenue and/or for settlement (Choudhury 2005). Forest management started in this tract of Bengal with the establishment of a Forest Department in the province of Bengal, in India. In 1855 for the first time in what was then India, in an attempt to articulate the need to conserve forest resources, the British Government issued the 'Charter of Indian Forest'. This is the earliest management mandate for the forests and natural resources of what is now Bangladesh. Forest management by the British focused initially on revenue earning, which eventually led to the creation of 'Reserved Forest' and good forestry management arrangements, under 'Acts' and 'Rules' formulated with due care. These acts and rules were formulated periodically by the Government as part of existing policies.

The first forest policy for this part of the globe was formulated during the British colonial period, in 1894. It was revised in 1955 and again in 1979. The latest forest policy was developed and implemented during 1994. With policy changes, the mission of the Forest Department has also undergone many transformations. In the past, the Department's mission was primarily focused on the administration and management of the Reserve Forests and controlling activities within them. Subsequently, a new mission has been assigned to it, including forest harvesting, protected area management, and plantation development. At the end of 1980s, the concept of social forestry, promoting collaborative forest management, was introduced and it has since been formalized in the Forest Act (amended) 2000. The need to increase Bangladesh's land area under forest cover has been an issue that has consistently featured in forest policy throughout the last 100 years.

Interlinks with other policies

Land-related policies have major impacts on forestry practices. The land-use policy of Bangladesh was declared on June 13, 2001. The policy clearly argues against the conversion of forests to other forms of land use. Although the policy includes the conservation of natural resources, conservation approaches are seldom followed. Various land laws and land reforms have been formulated that favour agriculture and industry over forest conservation, including the establishment of industries in privately- or government-owned forest land, conversion of forests to agriculture, and the establishment of fisheries in mangrove forests. There has been a lack of co-ordination between the land administrating

agency and the forest department, especially at the local level. Deputy Commissioners deal with land on behalf of the land ministry, and often fail to address the needs of forestry or the environmental aspects of land use. For example, mangroves have been leased for fisheries and hilly tracts with steep slopes leased for horticulture or farming. Such acts often lead to conflict with local forest officials, with the Deputy Commissioners invariably winning. As a result, much forest land has been converted to other forms of land use, clearly contravening official forest policy.

Since the industrial policy 1991 emphasized establishment of export oriented joint ventures, steps may be taken to use forest produce of various kinds as raw material of such industries. Such field of co-operations between industry and forestry is possible. Similarly private fishery in the mangroves may retain 80% of its land under forest cover and derive benefits from each other but such restrictions are never put to use. The agriculture extension policy is compatible to the forestry policy. Similarly the environment policy is also compatible to forestry policy. National water policy by laying emphasis on erosion control and afforestation has fortified the forest policy.

Forest acts and rules

The Forest Act was first enacted in this region in 1865 through a bill based on rules proposed by the Chief Commissioner of Burma (now Myanmar). *The Indian Forest Act of 1878* is rather similar to the Acts passed for other areas under British administration at the time. The Act was largely revised in 1927, and has been repeatedly revised since then, most recently in 1989 and 2000. The 1989 amendment strengthened the provisions for forest protection. It made provisions for heavier punishments to offenders and restricted the discretionary powers of forest officials and magistrates. This revision was strongly biased towards traditional forest protection, rather than accommodating the concepts and practices of social forestry. This led to the quick realization that the incorporation of strict provisions alone would not bring about the results that were recognized as being important for social forestry. The Forest Act was therefore again revised in 2000 in conjunction with a series of Asian Development Bank (ADB) loans connected to the Forestry Sector Project. The revisions incorporated some relaxations for privately-owned forest products. Provisions were made to accommodate some aspects of social forestry. However, these were insufficient to meet present day needs.

In private forests, there was no systematic management arrangement. The only practice was to harvest wood and/or to clear the forest for conversion to agricultural fields. As a result, the management of privately-owned forests was taken over by the Government under the provisions of the Private Forest Act and Private Forest Ordinance. The Private Forest Act was introduced in 1945, followed by the Private Forest Ordinance 1959; these two regulations introduced a limited amount of management to privately-owned forests. In 1959, the State Acquisition and Tenancy Act were also passed. The major aim of this Act was to remove tenants from the control

of their landlords and instead bring them under the direct control of the Government. Under the provisions of this State Acquisition and Tenancy Act many private properties, including 'forest land', were acquired by the Government. The lands were then brought under the management of the Forest Department as reserved forest under an order passed by the then 'Board of Revenue'.

Forest rules are framed under the provisions of the Forest Act. The existing rules, however, were framed earlier and are still in force, namely the *Forest Transit Rules* and *Drift Rule*. These rules regulate the movement of forest products, irrespective of origin. The movement of timber or other forest products collected or harvested from private land also comes under these rules. The existing rules have no arrangement to account for or accommodate participatory forestry activities. As the Forest Department has continued to manage its forest lands (Reserved, Protected, Acquired Forest) under traditional forestry management concepts and new plantations are mostly restricted to denuded tracts of land under their control, many areas of existing forest are not only being gradually depleted but are also being encroached upon by local people. No new rules have yet been introduced under the revised Forest Act 2000, although a set of draft rules has been prepared and are awaiting Government approval.

THE QUESTION OF SUSTAINABILITY

Ecological perspectives

The sustainable management of lands, forests and other natural resources of Bangladesh are at a critical stage (Biswas and Misbahuzzaman 2005), not only in relation to providing benefits to local people but also for the national interest (Choudhury 2005). The ever-increasing population is now exerting tremendous pressure on natural resources. Forest loss not only involves the disruption of many natural systems, but also directly threatens food security and increases poverty amongst local inhabitants. Even if timber production were to be successful, certain tree species (Robinson 1993, Boot and Gullison 1995) and wildlife (Frumhoff 1995) could fare poorly in forests managed for sustained yield alone (Dickinson *et al.* 1996).

Due to a shift in forest policy and the nature of government management interventions, forest ecosystems, and especially tree species composition and growing stock, have been changed. The practice of converting mixed heterogeneous stands to pure uniform forest by artificial regeneration on an extensive scale has created many ecological imbalances (Biswas 2001). Both forested (Biswas 2001) and non-forested areas are becoming increasingly important for the opportunities that they provide for the conservation of biological diversity (Sayer and Whitmore 1991, McNeely 1994, Dickinson 1995, O'Connell 1996). The increasing rate of deforestation in the natural forest of Bangladesh has led to a growing concern about the loss of biodiversity (Biswas 2001), as in other humid tropical forests (Myers 1993, Sayer

and Whitmore 1991). However, information about the loss of forest biodiversity in Bangladesh is very limited. Preliminary studies (e.g. Choudhury *et al.* 2004^{a, b, c, d, e}, Biswas 2001, Nath *et al.* 2000, Nath *et al.* 1998, Nath *et al.* 1997, Hossain *et al.* 1997, Haque and Alam 1988, Das and Siddiqi 1985, Das 1980, Prain 1903) indicate that the species diversity in the forests of Bangladesh is decreasing.

According to GOB (1993), 31.7% of the total forest area is natural forest and 20.5% of the country's total forest area is semi natural under medium to high density and only 4.30% of total forest area as barren forestland but the actual figure is much higher. The total area of hill forests is about 1,362,670 ha, including Unclassed State Forests (USF) of 713,652 ha. Of the total USF, only 7% have tree cover. Medium to high density natural forests amount to 85,316 ha and are situated in the CHT, Chittagong, Cox's Bazaar and Sylhet. Medium to high density hill forests amount to about 6.27%. PAs which cover about 5% of the hills are considered to have good forests but, in reality, the cover is discontinuous (Choudhury 2005). The tree resources of the Sundarbans Reserved Forest have decreased dramatically over the last 37 years, as indicated by the differences between the FORESTAL inventory in 1959, the ODA inventory in 1983 and the FRMP inventory in 1996. Estimates from the three inventories indicate that throughout the Sundarbans, *Heritiera fomes* had decreased from 211 trees/ha in 1959 to 125 in 1983 and 106 in 1996, based on >15cm dbh trees, or by about 50% over the 37-year period. The mangrove plantations established since the late 1960s in the newly accreted islands of the coastal districts are doing well except for damage caused by cyclones in 1991 (Choudhury 2005). One estimate puts the average growing stock in the Government forest area as decreasing, i.e. in 1980 the growing stock was approximately over 45 m³/ha and that the growing stock in the 1990s it has been reduced to 30 m³/ha (Amin *et al.* 2002). An estimated 50% of the original forest cover has been destroyed within the past 20 years (Amin *et al.* 2002).

In the Forestry Master Plan (FMP 1993), forest cover conditions for the different types of natural forests in the country have been categorized. The Resources Information Management Systems (RIMS) has made available a detailed inventory of some Forest Divisions. These categories vary from region to region and between types of forests. Although information on tree cover is not available for all forests, a synopsis of the overall quality of forest cover in Bangladesh (Fig. 3) indicates that the condition is deteriorating. RIMS, on the basis of a study by FAO (1993), proposed four categories of forest related to their cover condition:

- *Closed forest*: These are high forests with tall or shorter trees.
- *Open forest*: Trees are scattered and the canopy is open. Bushes and undergrowth are present. The forests have some sort of vegetation with scattered trees.
- *Shallow forest*: Area under only bush cover. No trees are present.
- *Fallow forest*: There is no vegetation or trees – the land is barren.

TABLE 4 Forest covers of Bangladesh

Forest Cover	Hill Forest (‘000 ha)	Plain land Forest (‘000 ha)	Mangrove Forest (‘000 ha)	Total (‘000 ha)
Forest (less PAs and Coastal Afforestation)				
Closed	104.073	0.0000	100.647	204.720
Opened	146.375	27.530	218.551	392.456
Shallow	10.319	25.286	.000	35.605
Fallow	21.764	0.000	.000	21.764
<i>Subtotal</i>	<i>282.531</i>	<i>52.816</i>	<i>319.198</i>	<i>654.545</i>
Protected Areas (PA)				
Closed	34.534	8.224	75.100	117.858
Opened	19.663	4.734	5.173	29.574
Shallow	1.013	.0000	0.000	1.013
Fallow	4.936	.0000	0.053	4.989
<i>Subtotal</i>	<i>60.146</i>	<i>12.962</i>	<i>80.326</i>	<i>153.434</i>
Plantation				
In Forest (less PAs)	105.387	21.086	0.192	126.665
In Protected Areas	3.842	0.000	1.900	5.742
In Coastal Afforestation	0.000	.000	76.533	76.533
<i>Subtotal</i>	<i>109.229</i>	<i>21.086</i>	<i>78.625</i>	<i>208.940</i>
Total	451.906	86.864	478.149	1016.919
Other				
encroachment + water + others	57.085	35.020	11.723	103.828
Grand Total	508.991	121.884	489.872	1120.747

Source: Amin et al. 2002

As a consequence of continuous forest depletion and degradation of forest cover quality, CO₂ emissions into the environment have increased significantly over the past 22 years, further reducing the sustainability of the forest. Increasing CO₂ emissions is an indicator of increased forest loss and degradation and thus numerous threats associated with increasing atmospheric CO₂ concentrations have been identified and are of major concern to both ecologists and foresters in Bangladesh.

Socio-economic perspectives

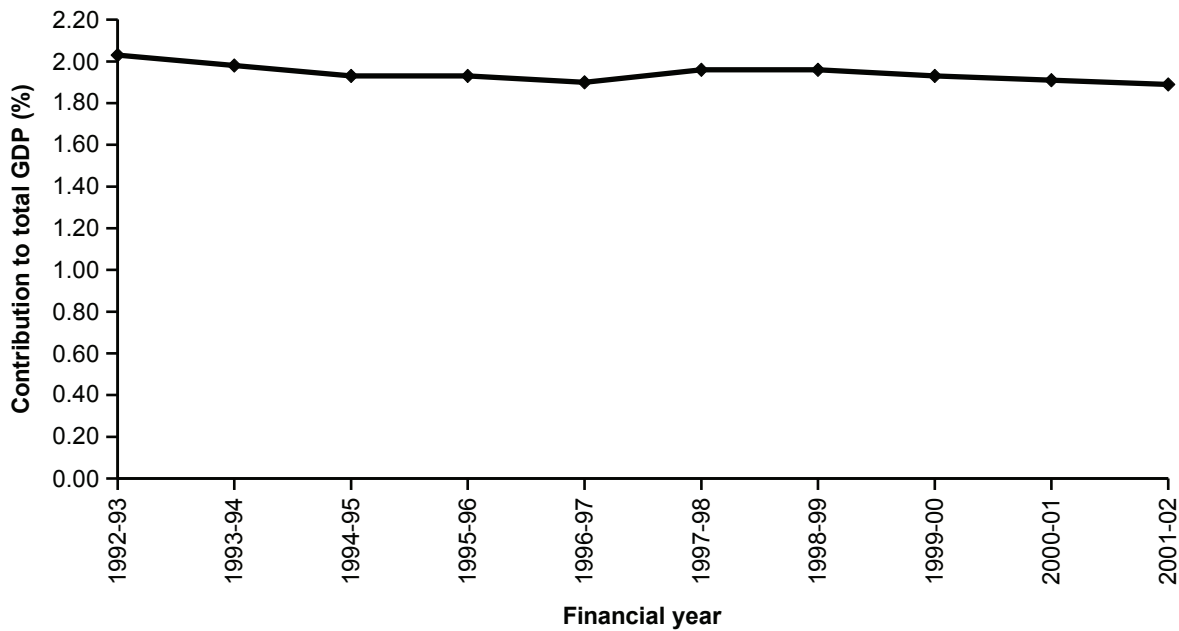
The contribution of the forestry sector to the national economy is very significant. The contributions are in the form of timber, electric poles, posts, cross arms, anchor logs, railway sleepers (Pant 1982), fuelwood and employment. The initial contribution was high (1992) but the Government's ban on felling has had the effect of reducing the contribution made by forestry to the Gross Domestic Products (GDP). In 1997-98, some mature plantations were felled to generate exports, but this was unsuccessful. Thus the forestry sectoral contribution to GDP is decreasing (Fig. 3). Around 2% of the labour force is employed in the forestry sector (GoB 2004) which provides employment of about 0.8 million workdays annually (FAO 2006). The livelihoods of people depend directly on the natural

resource base (Nishat *et al.* 2005). The conflict between people living adjacent to forests and the forest management authority is intensifying, resulting in an unsustainable ecosystem (Biswas 2001, Canizado and Mabud 1988 and Das 1980). A ban on felling of trees at a time (in 1971) when wood was in very high demand for the rehabilitation of war-damaged houses, coupled with the prevailing poor law and order situation, caused the most serious destruction of forest resources in the history of the country. The Government of Bangladesh normally highlights 'population pressure' as the main cause of forest depletion in Bangladesh. However, it is widely felt that it is not the poor who can be made solely responsible for forest degradation. Instead, the role of the rich and influential quarters of society should be questioned (Choudhury 2005).

DISCUSSION

Over the last 34 years the natural forest of Bangladesh has decreased significantly in terms of areas and quality (floristic structure and composition). Most of the natural forests (except Sundarbans) are now characterized by low species density. As a result, the contribution of the forestry sector to the national GDP is decreasing. Illegal felling contributed the most towards degradation of the natural

FIGURE 3 Contribution of forestry sector to the GDP



forest coverage. Apart from population pressure, the reasons for illicit felling are: (i) a lack of cooperation between management authorities and neighboring forest-dependent communities and (ii) corruption within the forest managers. The strict approach of earlier forest management policies and management plans, where people had no involvement also contributed towards this illicit felling. Realizing the adverse effect of such policies, the Government has shifted policy focus and management regimes, placing emphasis on participatory forestry/social forestry involving forest-dependent communities. Large-scale plantation programmes have been undertaken by the Government in recent years. However, plantation efforts by the Forest Department have been insufficient to compensate for the damage to natural forests. Plantations have also been affected by a number of factors, including inadequate site preparation, illegal removal and encroachment, unsuitable sites or incompatible species mixtures, disease and pest attack in some locations, and lack of monitoring and evaluation (FMP 1993; GOB 1999).

Ecologically, all the existing patches of natural forest in the country are degraded because they have already become unsuitable as habitat for arboreal mammals and other wildlife (Choudhury 2005). For example, the Capped Langur (*Presbytis pileatus*) prefers to live in closed-canopy Sal forests. The Madhupur National Park contained good habitat for the species until the mid-1980s, when the population of the species in the park was quite vigorous. Now, due to the lack of closed canopy in the forest, the population of the species has decreased markedly.

Within a socio-ecological context, the intricate interrelationships, interdependencies and diverse responses of forests ecosystems and local communities under different management regimes are poorly understood and have been mentioned above. Specifically, in the past, there has been very

little focus on forest management and the human ecological aspects of forest ecosystem management and livelihood linkages. Sustainable forest management will only succeed if all stakeholders are fully aware of their own impact on forests and forestry issues and are held accountable for their actions. It is important that the roles and rights of each stakeholder are acknowledged and understood. Difficulties encountered with implementing sustainable forest management have more often been found outside the technical arena, in areas such as land rights, socio-economic conditions and political circumstances. The present shift towards participatory forestry could help a great deal in regenerating the degraded forests and thereby the sustainability of existing forests. Thus it will be highly appreciated if authorities put greater emphasis on participatory forestry and ecosystem approach in Bangladesh.

Management interventions and policies, however well-intentioned, will not bring benefits to members of the public unless they are properly implemented. It is observed that in underdeveloped countries such as Bangladesh, policies are often very well formulated with assistance from abroad, but are also highly deviated during their implementation, for a variety of reasons. Correct and true implementation is very difficult because of the relative strength of various interest groups. Promulgation of Acts and Rules to carry out the theme of the policy is usually a very important and difficult task. The commitment of the Government to implement the acts and rules uniformly to harness the benefits for the nation at large is very important.

THE ROAD AHEAD

Forestry literature over the decades identified increasing

population pressure as the root cause of tropical deforestation especially for developing countries. In recent times, apart from poor management direction, illegal tree felling is considered an important factor responsible for forest degradation. To address the degradation of tropical forests, policy and management regimes have been revised from time to time, and focus has been changed from a purely scientific government control management towards participatory management. The identified main drawbacks of centralized management regime are lack of ownership of the forest dependent communities or people adjacent to the forest results massive illicit felling, forest encroachments etc. On this ground participatory forestry evolves with the broad aim of involving forest dependent poor peoples in managing the forest resources so that people themselves own the forests and protects. Though there are many good things, most often, participatory forestry failed to address the real participation of the local peoples thus the efforts collapse as soon as the programme is over. It is expected that participation should be true participation instead of 'show' participation. In line with effective participatory forestry, efforts should be made to incorporate alternative short term income generating activities (as forestry return long time to get return) in the participatory forestry programme. Alternative employment generation activities can also be incorporated in this line which will help to deter people from tropical deforestation and current participatory forestry can be improved.

For several decades, numerous government and nongovernmental bodies implementing participatory forestry programmes have shown interest in becoming involved in these programmes. So, perhaps we can now expect that rate of deforestation will be lower than before but in reality the rate of deforestation is ever increasing. Why? The answer is unclear, but it is difficult not to consider that corruption might be an influence.

Developing countries such as Bangladesh have experienced severe political instability which ultimately affects management of natural resources. Most of the time management authority follows the Government's political priority instead of the objectives laid down in the master plan. For example, until recently a priority was medicinal plant, which therefore became integrated into most of the forestry programmes. However, with the change of government management priorities have moved away from medicinal plants with the result that a significant amount of money and effort has amounted to very little. The country has already experienced a similar situation with different modes of participatory forestry. Since forestry operations require long term interventions, a political commitment is prerequisite for making the forest management efforts sustainable.

Although forestry activities are regulated by forest policy, they must be integrated into other land use policies such as those relating to agriculture, land management, industry, mineral extraction, water use, and with the country's Poverty Reduction Strategy document. Chokoria Sundarbans, one of the oldest mangrove forests has completely destroyed because of the conflicts between land, forestry and fisheries policies.

The forestry sector of Bangladesh suffers from lack of sufficient research. The only government agency involved in forest research is the Bangladesh Forest Research Institute from which the quality and standard of research is questionable. Basic research has yet to be carried out. For example, there remains no reliable data on the country's forest areas or growing stock. Sundarbans mangrove forest is the largest single tract of mangrove forest in the world but this is the least studied forest in Bangladesh. The tropical Dipterocarp forest in the hilly areas of Bangladesh is second is largest area of natural forest in Bangladesh yet this forest suffers from regeneration problems. The forestry master plan should place emphasis on in depth scientific research on these forests.

In the year 2006 most of the national policy documents such as the National Action Programme for Combating Desertification (NAP) National Biodiversity Strategy and Action Plan (NBSAP), National Programme of Action for Protecting Coastal and Marine areas from Land and Land Based Activities (NPA) emphasized the reclamation and restoration of the forest areas with native species. However, hardly any research has been conducted on ecosystem restoration in the forest areas of Bangladesh. It is expected that management authority should initiate degraded forest restoration in a pilot scale with scientific research instead of initiating a massive scale forest restoration programme without any research.

ACKNOWLEDGEMENTS

We gratefully acknowledge Bangladesh Forest Department for providing necessary data support. We are grateful to John Innes University of British Columbia, Canada, and M.K Alam of Bangladesh Forest Research Institute for their review and constructive comments in improving the manuscript. The highly valuable comments made by the editor and three anonymous reviewers are acknowledged.

REFERENCES

- ADB (Asian Development Bank). 1993. Forestry master plan, Volume 1. Government of Bangladesh, Ministry of Environment and Forests. Asian Development Bank, Manila, the Philippines, 162 pp.
- AHMED, H. 1961. Working plan for the Dhaka forest Division for the period of 1959-60 to 1963-64. Directorate of Forests. 18 p.
- AHMED, I.U. 2003. Forest management: Bangladesh perspective (in Bengali), Aranya. 11 (6). 19-28.
- AITKINSON, G., DUBOURG, K., HAMILTON, K., MUNASINGGHE, M., PEARCE, D. and YOUNG, C. 1997. Measuring sustainable development: macroeconomics and the environment. Edward Elger Publishing. 252 pp.
- AMIN, R., AKONDA, A.W. and NEYAMAT, H. 2002. National assessment of forestry restoration policy and

- practices in South Asia: Bangladesh. IUCN/WWF, 50 pp.
- ASIAN DEVELOPMENT BANK (ADB) 1999. Fighting poverty in Asia and the Pacific: The poverty reduction strategy of the Asian Development Bank. Manila.
- BANERJEE, S. 1943. Working scheme for Chittagong Hill Tracts (North & South) forest Division. For 1943 to 1953. Directorate of Forests.
- BISWAS, S.R. 2001. Structure, Composition and diversity of tree species in Idgaon forest reserve of Cox's Bazar forest division, Bangladesh. M. Sc. Thesis. Forestry and wood technology discipline, Khulna University, Bangladesh. 66pp.
- BISWAS, S.R. AND MISBAHUZZAMAN, K. 2005. Stem diameter in relation to dispersal behavior of *Dipterocarpus* species. *International Journal of Agriculture and Biology*. 7 (5) (in press)
- BLAMFORTH, E.G. 1985. Interim felling prescription for Sundarbans Reserved forests. FAO/UNDP project, BGD/85/085.
- BLAMFORTH, E.G. AND HOWLADER, N.I. 1988. Forest management plan for Chittagong division (1988 to 1997). Field document no 6. FAO/UNDP/BGD/85/085. Dhaka
- BOOT, R.G.A. and GULLISON, R.E. 1995. Approaches to developing sustainable extraction systems for tropical forest products. *Ecological Applications* 5: 896-903.
- BUNNEL, F. 1997. Operational criteria for sustainable forestry: focusing the essence. *For. Chron.* 73: 679-684.
- CANIZADO, L. and MABUD, M. 1998. General Management plans for the Cox's Bazar forest division. GOB/WB. FRMP project. The Meader group of companies, Dhaka.
- CANONIZADO, L AND HUSSAIN, M 1988a. Integrated Forest Management Plan for the Sundarbans Mangrove Forest, FRMP project, Bangladesh Forest Department. Dhaka.
- CANONIZADO, L AND HUSSAIN, M 1988b. Integrated Forest Management Plan for the Cox's Bazar Forest Division, FRMP project, Bangladesh Forest Department. Dhaka
- CANONIZADO, L AND HUSSAIN, M 1988c. Integrated Forest Management Plan for the Sylhet Forest Division, FRMP project, Bangladesh Forest Department. Dhaka
- CANONIZADO, L AND ISHTIAQUE, M.U. 1988. Integrated Forest Management Plan for the newly afforested coastal areas of Noakhali Forest Division, FRMP project, Bangladesh Forest Department. Dhaka.
- CHAMBERS, R. 1997. *Whose reality counts? putting the first last*. London: Intermediate Technology Publications.
- CHOUDHURY, .M. 1960. Working scheme for the Mymensingh division for 1960-61 to 1969-70. 73p.
- CHOUDHURY, A.M. 1960. Working scheme for the Mymensingh Division for 1960-61 to 1969-70. Directorate of Forests, 79 pp
- CHOUDHURY, A.M. 1969. Working plan for the forest of Chittagong Hill Tracts (North) forest Division. Volume I & II (1969-70 to 1988-89). Directorate of Forests.
- CHOUDHURY, J.A. 1985. Forestry statistics in Bangladesh. Forestry statistics in Asia Pacific region, RAPA. FAO, Bangkok. 55pp.
- CHOUDHURY, J.K., BISWAS, S.R., ISLAM, S.M., RAHMAN, O. and UDDIN, S.N. 2004a. Biodiversity of Tilagarh reserved forest, Sylhet. IUCN – The World Conservation Union, Dhaka, Bangladesh. 20 pp.
- CHOUDHURY, J.K., BISWAS, S.R., ISLAM, S.M., RAHMAN, O. and UDDIN, S.N. 2004b. Biodiversity of Rajeshpur Sal forest, Comilla. IUCN – The World Conservation Union, Dhaka, Bangladesh. 21 pp.
- CHOUDHURY, J.K., BISWAS, S.R., ISLAM, S.M., RAHMAN, O. and UDDIN, S.N. 2004c. Biodiversity of Jaflong, Sylhet. IUCN – The World Conservation Union, Dhaka, Bangladesh. 28 pp.
- CHOUDHURY, J.K., BISWAS, S.R., ISLAM, S.M., RAHMAN, O. and UDDIN, S.N. 2004d. Biodiversity of Ratargul swamp forest, Sylhet. IUCN – The World Conservation Union, Dhaka, Bangladesh. 24 pp.
- CHOUDHURY, J.K., BISWAS, S.R., ISLAM, S.M., RAHMAN, O. and UDDIN, S.N. 2004e. Biodiversity of Dulahazara safari park, Cox's Bazar. IUCN – The World Conservation Union, Dhaka, Bangladesh. 30 pp.
- CHOWDHURY, J. K. 2005. Forests and forestry in Bangladesh. Paper presented at BELA. 39 pp.
- CURTIS, S.J. 1931. Working plan for the forest of Sundarban Division for the period of 1 April 1931 to March 1951. Volume 1 (Parts I and II), 175 pp.
- DAS, S. 1980. Dipterocarp forests of Bangladesh and their management. *Bano Biggyan Patrika*, 9(1&2): 71-86.
- DAS, S. 1982. The forest management practices in Bangladesh. Proceedings of the Second national forestry conference, Bangladesh. January 21-26..
- DAS, S. and SIDDIQI, N.A. 1985. The mangroves and mangrove forests of Bangladesh. Bulletin no 2, Mangrove Silviculture Division, Bangladesh Forest Research Institute, Chittagong, Bangladesh.
- DICKINSON, M.B., DIKINSON, J.C. and PUTZ, F.E. 1996. Natural forest management as a conservation tool in the tropics: divergent views on possibilities and alternatives. *Commonwealth Forestry Review* 75(4): 309-315.
- DIKINSON, J.C.III. 1995. The need and potential for private biodiversity conservation. In: Saunier, R.E., and Meganck, R.A. (eds) *Conservation of Biodiversity and the new regional planning*. Organization of American States, Washington. D.C., USA.
- DUPUY, B., MAITRE, H.F. and AMSELIM, I. 1999. Tropical forest management techniques: a review of the sustainability of forest management practices in tropical countries. Working paper: FAO/FPIRS/04 prepared for the World Bank.
- FAO. 1888. Assistance to Forestry Sector, Bangladesh, Project Findings and Recommendations. BDG/81/028. Terminal Report. Rome
- FAO.1999. State of the world's forests 1999, FAO. Rome.
- FAO.2001. State of the world's forests 2001, FAO. Rome.
- FAO.2003. State of the world's forests 2003, FAO. Rome.
- FAO.2005. State of the world's forests 2005, FAO. Rome.
- FORESTRY MASTER PLAN (FMP). 1993. Forestry master plan. Ministry of Environment and Forest, Government

- of the Peoples Republic of Bangladesh. UNDP/FAO, BGD/88/025, Dhaka.
- FRUMHOFF, P.C. 1995. Conserving wildlife in tropical forests managed for timber to provide a more viable complement to protected areas. *BioScience* 45: 456-464.
- GAIN, P. 2002. The last forests of Bangladesh. 2nd Edition. Society for Environment and Human Development (SEHD), Dhaka, Bangladesh, 224 pp.
- GOVERNMENT OF BANGLADESH (GoB). 1992. Bangladesh national conservation strategy. Ministry of Environment and Forests, Dhaka.
- GOVERNMENT OF BANGLADESH (GoB). 1993. Forestry master plan. Main volume, Ministry of Environment and Forest, Dhaka.
- GOVERNMENT OF BANGLADESH (GoB). 1999. Planning and implementation methodology for WFP assisted Forestry master plan. Main volume, Ministry of Environment and Forest, Dhaka
- GOVERNMENT OF BANGLADESH (GoB). 2004. Bangladesh Economic Review. Ministry of Finance, Government of Bangladesh. 1-17.
- GRENIER, L. 1998. Working with indigenous knowledge. A guide for researchers. Ottawa: International development Research centre.
- HAQUE, S.M.S. and ALAM, M.S. 1988. Some aspects of practicing the clear felling followed by artificial regeneration system in the Cox's Bazar Forest Division. *Chittagong University Studies, Part II: Science* 12 (2): 87-95.
- HAUFFER, J.B., MEHL, C.A. and ROLOFF, G.J. 1996. Using a cross-filter approach with species for ecosystem management. *Wild. Soci. Bull.* 24: 200-208.
- HOSSAIN, M.K., HOSSAIN, M. and ALAM, M.K. 1997. Diversity and structural composition of trees in Bamu reserved forest of Cox's Bazar forest division, Bangladesh. *Bangladesh Journal of Forest Science* 26(1), 31-42.
- KHAN, N.A., CHOUDHURY, J.K., HUDA, K.S. and MONDAL, M.I. 2004. An overview of social forestry in Bangladesh. Forestry Sector Project, Government of Bangladesh, Dhaka, 198 pp.
- KNIGHT, R.L. 1996. Aldo Leopold, the land ethic and ecosystem management. *Journal of Wildlife Management* 60: 471-474.
- MAYERS, N. 1993. Tropical forests: the main deforestation fronts. *Environmental Conservation* 20: 9-25.
- MCCOOL, S and STANKEY, G. 2001. Representing the future: a framework for evaluating the utility of indicators in search for sustainable forest management. In RAISON, R.J. and BROWN, A. (eds.) *Criteria and indicators for sustainable forest management*. IUFRO. Series no 7. CAB International Publishing, Oxford, UK. 93-105 p.
- MCNEELY, J.A. 1994. Lessons from the past: forests and biodiversity. *Biodiversity and Conservation* 3: 3-20.
- MONDAL, M. I., KADER, M. B., IQBAL, Z. M., HAQUE, M. O. AND BEGUM, R. (Eds), 2004. Participatory Forestry Newsletter, June 2004. Bulletin No. 2, a Quarterly Newsletter of Forest Department's Ongoing Forestry Sector Project, 11 pp.
- NATH, T.K., HOSSAIN, M.K. and ALAM, M.K. 1997. Studies on the structural composition of a natural forest of Chittagong hill tracts (south) forest division based on diameter class distribution. *Chittagong University Studies, Part II: Science* 21 (1): 15-22.
- NATH, T.K., HOSSAIN, M.K. and ALAM, M.K. 1998. Diversity and composition of trees in Sitapahar forest reserve of Chittagong Hill Tracts (south) forest division, Bangladesh. *Ann. For.* 6 (1):1-9.
- NATH, T.K., HOSSAIN, M.K. and ALAM, M.K. 2000. Assessment of tree species diversity of Sitapahar forest reserve, Chittagong hill tracts (south) forest division, Bangladesh. *Indian Forester* 126 (1):16-21.
- NISHAT, A., CHOUDHURY, J.K., BISWAS, S.R. and KHAN, A.S.M. 2005. Ecological restoration of degraded hill forests through livelihood improvement: a community based approach, (in press).
- O'CONNELL, M.A. 1996. Managing biodiversity on private lands. In: Szaro, R.C. and Johnson, W.D. (eds.) *Biodiversity in managed landscapes: theory and practice*. Oxford University Press, Oxford.
- PANT, M.M. 1998. *Forest Management*. Institute of Forestry, Chittagong University, Chittagong, Bangladesh.
- PRAIN, D. 1903. *Bengal plants Vol. 1&2*, Calcutta.
- RISHI, P. 2002. Leading JFM through nurturance: an Indian scenario. *International Forestry Review* 4 (2), 143-148.
- ROBINSON, J.G. 1993. The limits to caring: sustainable living and the loss of biodiversity. *Conservation Biology* 7: 20-28.
- SAYER, J.A. and WHITMORE, T.C. 1991. Tropical moist forests: destruction and species extinction. *Biological Conservation* 55: 199-213.
- SHEIL, D., NASI, R. and JOHNSON, B. 2004. Ecological criteria and indicators for tropical forest landscapes: challenges in the search for progress. CIFOR
- THOMAS, J.W. and HUKER, S. 1996. The forest service approach to healthy ecosystem. *Journal of Forestry* 94:14-18.
- TOMAN, M.A. and ASHTON, P.M.S. 1996. Sustainable forest ecosystem management: a review article. *Forest Science* 42: 366-377.
- UNCED (United Nations Conference on Environment and Development). 1992. *Statement of forest principles* . 289-294 p.
- WALLIN, D.O., SWANSON, F.J. and MARKS, B. 1994. Landscape pattern response to changes in pattern generation rules: land-use legacies in forestry. *Ecological Applications*. 3: 569-580.
- ZAHIRUDDIN, A.S.M. 1954. Working plan for the forest of Chittagong Hill Tracts (North & South) forest Division. Volume I & II (1953-54 to 1972-73). Directorate of Forests.