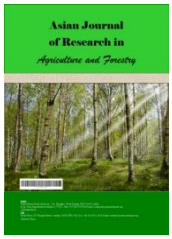

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An Overview on the Current Status and Conservation Practices of Forest Land and Plant Diversity of Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MIH and ZAR designed the conceptual framework of study, performed relevant reviews and wrote the first draft of the manuscript. Authors MAR and JF managed the most updated literature and assisted in the formulation of tabular and graphical constituents. Author SRS rewrote the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The study is based on intensive survey of relevant literature which reviews the present status, threats, conservation initiatives and major legislation related to conservation of forest ecosystems and plant diversity. The three natural forests (Hill, Sal and mangrove forest) are the key habitats of plant diversity and cover about 2 million hectares of land. Despite a flora diversity rich country, the existence of many plant species is currently under threat as evident by continuous degradation of natural forest in Bangladesh. There is an increasing pressure on the biodiversity of this country to meet the needs of the increasing population of Bangladesh. As a result, many plant species are gradually declining and are facing extinction. Over exploitation of natural ecosystems, land use changes, permanent infrastructures in natural ecosystems, illegal logging, natural disasters, climate change effects and limited forest protected areas (FPAs) are key threats to plant diversity.

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Government has made some initiative to conserve the remaining plant diversity including declaration of FPAs, national conservation strategies and establishment of environment related acts. At present 47 FPAs are established as in-situ and ex-situ conservation approaches to preserve plant diversity. Several preservation plots, clone banks and arboreta are also functioning as conservation approaches. The country has several laws that address forest and biodiversity conservation, several of which has been amended in last decade. Recently the country has taken some policies and projects in small scale to ensure effective conservation of plant diversity through sustainable management practices. Although co-management by FPAs authority and local participant has some advantageous effects, the existing conservation practices are still poor to effective conservation of flora diversity.

Keywords: Forest ecosystems; plant diversity; threats; forest protected area; conservation.

1. INTRODUCTION

Bangladesh is the world largest deltaic country with a total area of 147570 sq. kilometer and situated in the north-eastern part of South Asia between 20°34' to 26°38' N latitude and 88°01' to 92°41' E longitude [1]. It is a subtropical country where the tropic of cancer passes over its centre. The most of the land is formed by alluvium from the three major rivers (Padma, Meghna and Jamuna) and their tributaries [2]. The majority of the land is floodplain (80%) with few hilly areas (12%) and Pleistocene terraces (8%) [3]. Geographically, the country is situated between Indo-Chinese and Indo-Himalayas sub-regions with various forms of ecosystems rich in biodiversity [4]. The climatic conditions and geographic location makes Bangladesh one of the most biologically diverse landscapes and enriched with wide variety of flora and fauna biodiversity. The natural ecosystems of the country include various types of forests, costal and marine types and freshwater wetlands; all harbors a huge number of faunal and floral biodiversity [5].

Forests are one of the major terrestrial ecosystems in Bangladesh. Natural forests cover three major types of vegetation occurring in three distinct land types (mangrove forest, hill forest and plain land sal forest). The forestry sector contributes about 3% of the country's GDP and 2% of the labor force; more than 19 million people are extensively dependent on forests for their subsistence in Bangladesh [6]. Biodiversity is the primary resources to our livelihoods and economic development, especially in a country like Bangladesh, where a vast group of population depend on natural resources for their subsistence. At present, more than 90% of the calories consumed by people come from 80 plant species worldwide; still 4.5 billion people use plant products as their primary source of medicine and about 30% of all pharmaceutical products in the market were manufactured from plants and animals [7]. Biodiversity makes an important contribution to the national GDP in terms of agriculture, livestock, fishery, forestry and eco-tourism. Plant diversity provides two types of values, direct values (food, medicine, fiber, fuel, fodder, shelter, timber etc.) and indirect values (fresh air, C sequestration, and watershed protection, others environmental services, aesthetic, religious and cultural uses).

Although Bangladesh is noted for being a biodiversity rich country, it has very low per capita forest land and the forest coverage area is diminishing at an alarming rate [1]. Bangladesh has experienced one of the highest rates of deforestation in south Asian region [8] and between the year 1990 and 2015, on an average the country lost 2600 hectares of natural forest land per year [9]. Degradation of natural forests is serious threat to existing flora biodiversity of Bangladesh. In Bangladesh during last couple of decades, natural forest and biodiversity has been experiencing a substantial decline mainly due to anthropogenic disturbances and many plant species have gone extinct [10]. Due to degradation and rapid loss of natural habitats of biodiversity, conservation of biodiversity has been received extensive attention in Bangladesh during the recent years. The government of the country along with various NGOs and international agencies has been trying to increase the forest cover area and conserve remaining biodiversity. A number of approaches have been taken by the government, including protected areas (PAs), development of plans and policies to address the issues regarding biodiversity conservation and sustainable use of the ecosystems.

In Bangladesh, necessary information on the forest ecosystem and flora diversity are rather

scattered; so the present study aimed to accumulate the available information as far as possible. This paper reviews the published articles and summarizes the available information on forest and biodiversity with a view to analyze the overall aspects of forest ecosystems and plant diversity. Finally few recommendations have been suggested to help in successful conservation strategies.

2. TOTAL FOREST LAND AND TREE COVERED AREA

In Bangladesh, the total forest and tree covered area is about 3 million hectares [11]; 2.3 million ha of forest land under the government of the county, out of which 1.6 million ha is under the management of forest department and remaining about 0.7 million ha un-classed state forest (USF) is under the district councils [6,12]. Presently 21% of total land area is under tree coverage and forest area [11]. Only hill forest accounts 44% of total forest area and 9.33% of total country's land area. Natural mangrove forest covered 20% and 4.08% of total forest land and total country's land respectively (Table 1). More than 90% of the state owned forestland is concentrated mostly in 12 districts in the eastern and south-western regions of the country (Fig. 1) and out of 64 districts, 32 districts have no state owned forest at all [13]. The community forests scattered throughout the country amounts to 0.77 million hectares. Total tree covered area of the country increased due to expanse of mangrove plantation, community based social forestry and agroforestry practices. However, there is a controversy that total forest area is only 1.43 million ha which covered 11% of the total land area of Bangladesh [9]. In Bangladesh only 0.015 ha per capita of forest area is available where the global average is 0.60 ha [14,15].

2.1 Forest Ecosystems

Despite being a small country Bangladesh has an impressive variety of forest ecosystems supporting a diversified flora and fauna. Based on topography and location forest are classified as hill forests, natural mangrove, mangrove/costal plantation forest, plain land sal forests, community/village forests and fresh water swamp forests [6]. Three major types of forest land (Hill, mangrove and sal forest) are under the supervision of Bangladesh Forest Department (BFD). About 1594000 ha of forest land is under the control of BFD which covered 51.35% of total forest area and 10.79% of total country's land area. About 42% of hill forest and 38% of natural mangrove forest are managed by BFD which together represents 41% of total forest area of Bangladesh (Table 2). Though, once the natural forest resources were very wealthy but during the last few decades these resources have been degraded heavily due to various anthropogenic pressures [17].

Table 1. Forest and tree covered area of Bangladesh

Forest type		Area (ha)	% of total forest land area in BD	% of country's total land area
Hill forest		1377000	44	9.33
Mangrove forest	Natural	610000	20	4.08
	Plantation	200000	6	1.36
Sal forest		120000	4	0.81
Village/community forest		774000	25	5.24
Swamp forest		23000	1	0.16
Total		3104000	100	20.98

Source: [11;12]

Table 2. Forest area under the management of Bangladesh Forest Department

Forest ecosystem		Area (ha)	% of forest area managed by FD	% of total forest area in BD	% of country's total land area
Hill forest		664000	41.66	21.40	4.50
Mangrove	Natural	610000	38.27	19.65	4.13
Forest	Plantation	200000	12.55	6.44	1.35
Sal forest		120000	7.52	3.86	0.81
Total		1594000	100	51.35	10.79

Source: [12]

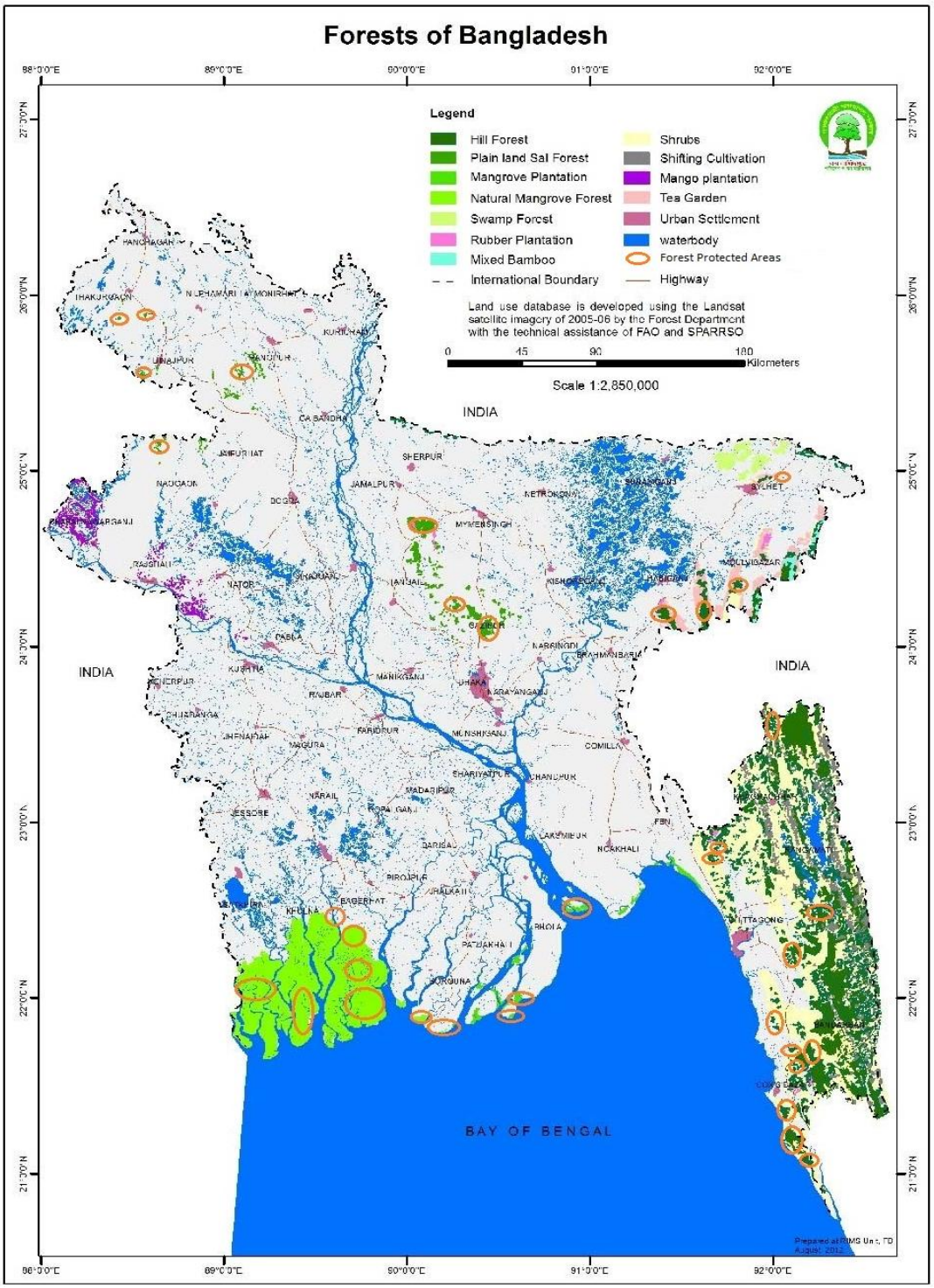

Fig. 1. Different forest covered area and distribution of FPAs in Bangladesh
Source: [16]

3. CURRENT STATUS OF PLANT DIVERSITY

Phytogeographically Bangladesh is situated near the Indo-Burma region which is considered as one of the global biodiversity hot-spot [18]. Despite the natural forests of Bangladesh are rich in floral diversity, unfortunately the total flora is not fully investigated yet. Only 3763 species of angiosperms, 3600 algal species, 290 bryophyte

species, 200 pteridophyte species and 7 gymnosperm species has been identified in the country (Table 3). Bangladesh National Herbarium identified 342 tree species are the main constituents of the natural forest ecosystems of the country. Till now 1048 tree species of 432 genera under 99 families (angiosperms and gymnosperms) were recorded from the country [19]. About 160 plant species with a rich genetic diversity has been extensively used as crops in the country. Plant Genetic Resources Centre (PGRC) of the Bangladesh Agricultural Research Institute maintains 10,085 accessions of 137 different agri-horticultural crops including 1727 accessions are cereals, 3902 vegetables, 3460 pulses, 455 oilseeds, 199 spices, 170 fruits, 92 roots and tuber crops, and 60 fiber, narcotic and other crops [20]. Besides, Bangladesh Rice Research Institute maintains 8044 accessions of rice; a total of 1132 accessions of sugarcane and 6012 accessions of jute and allied fiber germplasm stored in the gene bank of Bangladesh Sugarcrop Research Institute and Bangladesh Jute Research Institute, respectively [20].

The Hill, Mangrove and Sal forests of Bangladesh are the main harbor of plant diversity. About 528 plant species and 63 species of 36 families are recorded from mangrove and sal forest respectively; Hill forests known as evergreen to semi-evergreen tropical forest and about 2260 plant species were recorded from these ecosystems (Table 4). In addition 104 species of swamp flora recorded from haor areas and 73 species of plants was recorded from ratargul freshwater swamp forest [22]. Rich flora diversity might be attributed to the geographic position and climatic conditions of Bangladesh.

3.1 Threatened Plant Species

Though the country is rich in floral biodiversity, the present situation is at risk, as evident about 486 vascular plant species are identified as threatened species in Bangladesh [6]. In the last few decades the country had lost many plant species and it has been assumed that about 10% floras extinct from the country [17]. Around 486 vascular plant species including 449 species of

Table 3. Recorded and estimated number of plant species of different plant groups of Bangladesh and the world

Categories	Recorded	Estimated	World described	World estimated
Algae	3600	6000	40000	200000
Bryophytes	290	400	14000	23000
Pteridophytes	200	250	12000	13500
Gymnosperms	7	7	650	650
Angiosperms	3763	5700	250000	300000

Source: [7;21]

Table 4. Floral diversity in the major forest ecosystems of Bangladesh

Forest type	Species	Vegetation type and major tree species	References
Mangrove forest	528	Tidal swamp forest: Sundari (*Heritiera fomes*), Keora, Gewa, Goran, Golpata etc.	[23,24]
Hill forest	2260	Evergreen to semi-evergreen tropical forests: Shegun (*Tectona grandis*), Garjan, Gamar, Telsur, Chapalish etc.	[25]
Sal forest	63	Deciduous forest: Sal (*Shorea robusta*), Sonalu, Ashwath, Azuli, Chapma, Haritaki etc.	[26]

Table 5. Number of threatened floral species of major vascular plant groups in Bangladesh

Vascular plant category		Total no. of species	Critically Endangered (CR)	Endangered (EN)	Vulnerable (VU)	Total
Angiosperms	Dicotyledons	2623	8	80	179	267
	Monocotyledons	988	22	46	114	182
	Total	3611	30	126	293	449
Gymnosperms		7	0	1	0	1
Pteridophytes		195	0	0	36	36
Total		3813	30	127	329	486

Source: [30]

angiosperms, 1 species of gymnosperms and 36 species of pteridophytes are under threats (Table 5). Nearly 10% angiosperm species are under threats to be extinct due to population pressure, habitat loss and over consumption [27]. Even 75 medicinal plant species only under the two families (*Apocynaceae* and *Vitacease*) and 28 species to be threatened due to habitat destruction and over exploitation [28]. In addition, 94 of 179 species of *Orchidaceae* and 26 of 86 species of *Lamiaceaeae* are threatened [29].

3.2 Threats to Forest Ecosystems and Plant Diversity in Bangladesh

Threats to plant diversity and the forests are increasing due to illegal land grabbing, over consumption of natural resources, natural disasters and climatic changes. There are many direct and indirect threats to natural forest and plant diversity in Bangladesh. Several anthropogenic and natural causes are identified as direct threats to biodiversity. Shifting cultivation, tobacco cultivation, rubber plantation, mass settlement, hill cutting, illegal logging, construction of infrastructures, etc. are major threats to hill forest; Habitat destruction, extraction of poles for fixing fishing nets, poaching, poison fishing, uncontrolled tourism, invasive alien species, shrimp cultivation, illegal logging, poor regeneration, natural disasters, salinity increase, pollution are serious threat to mangrove forest; Illegal logging, expansion of agriculture, plantation of rubber and others exogenous species, urbanization, industrialize tion, eco-resort, road networks, grazing, pollution are prime threat to sal forest [31]. Most of the deciduous sal forests have been converted into agricultural land and plantation of monoculture of *Accacia spp.* and only 17500 ha of the original 125000 ha has some sort of natural tree cover now [32].

There are also some indirect secondary threats to FPAs and plant diversity in Bangladesh and these are mainly related to institutional and environmental conditions. The main indirect threats including poor institutional capacity, lack of coordination among different agencies, policy and information gaps, lack of enforcement, inadequate and poorly managed system of protected areas, corruption, lack of political commitment, lack of awareness, climate and biophysical changes (sea level rise) and lack of alternate livelihoods in sensitive habitats [5]. Tidal surges and strong cyclones affect natural vegetation and ecosystems in coastal region [31]. In Bangladesh, high flora diversity, limited forest area and local people's dependence on forests are the great challenges of conservation [33].

Although Bangladesh has different FPAs, enforcement of protection and management is weak, resulting in severe degradation of natural habitats and ecosystems [5]; despite extensive coverage of FPAs in the world, these are not immune to biodiversity and ecosystem degradation [34]. In practice, most of the FPAs are not actually protected and both legal and illegal activities are continuously happening which reduces the quality of biodiversity in Bangladesh [7].

4. STATUS OF CONSERVATION PRAC-TICES IN BANGLADESH

4.1 Forest Protected Areas (FPAS)

Since the flora diversity of Bangladesh has been decreased alarmingly like other developing countries, the government has adopted different initiatives including PAs to conserve the remaining plant diversity [35]. The government has taken conservation strategies in two ways i.e., *in-situ* and *ex-situ* conservation. The conservation vision is to improve ecosystem quality and service through conservation of forests and biodiversity [36]. According to IUCN protected areas are, "areas especially dedicated to the protection and maintenance of biological diversity and associated cultural resources, and managed through legal or other effective means". PAs are one of the most effective conservation tools for preserving biodiversity and currently 15.4% of the terrestrial land surface of the world is covered by PAs [37]. The visions of the PAs are to conserve ecosystems and biodiversity, and to facilitate livelihood opportunities for the natural resources dependent population through adopting sustainable management initiatives [38]. In Bangladesh five types of FPAs (NP: National Parks, WS: Wildlife Sanctuaries, GR: Game Reserves, EP: Eco-parks and SP: Safari Parks) have been defined by forest department and the distribution of the FPAs (excluding SP and EP) is shown in Fig. 1.

Currently 47 FPAs collectively covered 293350 ha including 18 NP, 17 WS, 2 SP and 10 EP that accounts 18.40% of all forest area managed by forest department in the country. The establishment of FPAs in Bangladesh started from 1980 and most of the FPAs established in

this decade (Fig. 2a). Maximum FPAs are concentrated to the two major forest ecosystem (Mangrove and Hill Forest) of Bangladesh. About 13.51%, 10%, 23.74% and 14% of sal forest, mangrove plantation, natural mangrove and hill forest, respectively under FPAs network of forest area are managed by forest department (Fig. 2b).

4.1.1 Plant diversity in forest protected areas (FPAS)

Measuring and monitoring the two important initiatives to explore and quantify the flora for achieving the functions of FPAs. Table 6 contains the number of plant species present in some major FPAs of Bangladesh.

4.2 *IN-SITU* Conservation

Any practices that conserve the species in its natural habitat is called *in-situ* conservation. Forest protected areas (FPAs) i.e. WS, NP and GR are considered as in-situ conservation approaches [1]. Currently, the country has 35 FPAs as *in-situ* conservation site including 18 NP, 16 WS and a GR distributed in various forest ecosystems of the country (Table 7).

EP and SP have been defined for both in-situ and *ex-situ* conservation approaches [17]. At present there are 10 EP and 2 SP in Bangladesh and covered 10763 ha. Table 8 contains the name, location, area and year of establishment of EP and SP.

4.3 *EX-SITU* Conservation

On the other hand, *ex-situ* conservation includes any approaches that conserve species or genetic materials outside the natural habitat of the parent population. Most of these practices are limited to Bangladesh Forest Research Institute (BFRI); *ex-situ* conservation includes the followings conservation practices (Table 9).

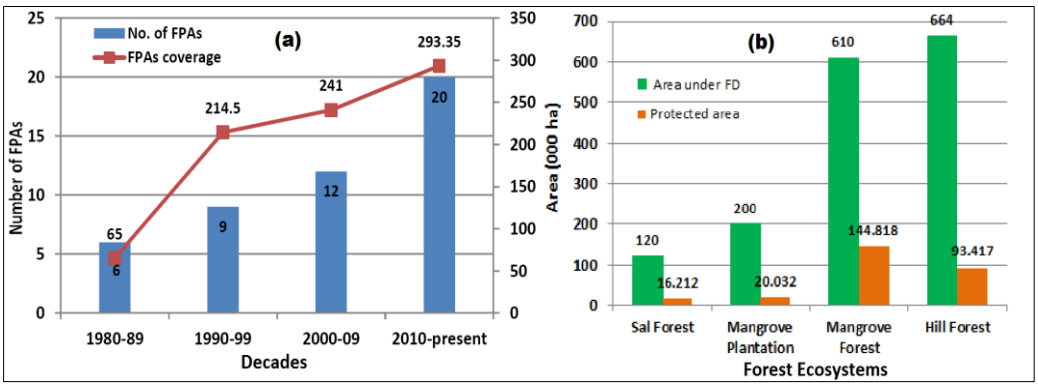

Fig. 2. Temporal changes in the number and area coverage of FPAs (a) and FPAs in different forest ecosystems of Bangladesh (b)

Table 6. Number of plant species recorded from some forest protected areas

FPAs	Trees	Shrubs	Herbs	Climbers	Epiphytes	Parasites	Ferns	Total
Rema-Kalenga WS	142	163	190	102	16	7	-	620
Dudhpukuria-Dopachari WS	182	125	200	71	7	6	17	608
Fasiakhali WS	82	66	88	41	8	-	-	285
Chunati WS	240	102	211	106	19	7	6	691
Teknaf WS	142	112	184	87	10	1	-	536
Sitakunda EP	140	79	54	28	2	-	9	312
Madhupur NP	139	48	136	46	5	2	9	385
Satchari NP	73	46	86	37	3	-	-	245
Nijhum Dweep NP	66	15	58	13	-	-	-	152
Sheikh Jamal Inani NP	151	85	140	60	7	-	-	443

Source: [7]

Table 7. FPAs functioning as *In-situ* conservation

Sl. No.	Name of FPAs	Forest type	Area (ha)	IUCN Category	Year of Notification
1	Bhawal NP	Plain land	5022	IV	1982
2	Himchari NP	Hill forest	1729	IV	1980
3	Lawachara NP	Hill forest	1250	II	1996
4	Madhupur NP	Plain land	8436	IV	1982
5	Kaptai NP	Hill forest	5465	II	1999
6	Ramsagar NP	Plain land	52	IV	2001
7	Nijhum Dweep NP	Mangrove plantation	16352	II	2001
8	Medakochchopia NP	Hill forest	396	IV	2008
9	Satchari NP	Hill forest	242	II	2005
10	Khadim Nagar NP	Hill forest	679	IV	2006
11	Baryardhala NP	Hill forest	2933	II	2010
12	Kuakata NP	Mangrove plantation	1613	II	2010
13	Nobabgonj NP	Plain land	517	IV	2010
14	Shingra NP	Plain land	305	IV	2010
15	Kadigor NP	Plain land	344	IV	2010
16	Altadhigi NP	Plain land	264	IV	2011
17	Birgonj NP	Plain land	168	IV	2011
18	Sheikh Jamal Inani NP	Hill forest	17500	IV	2018
19	Rema-Kalenga WS	Hill forest	1795	II	1996
20	Char Kukri Mukri WS	Mangrove plantation	40	IV	1981
21	Sundarbans East WS	Mangrove	31227	Ib	1996
22	Sundarbans West WS	Mangrove	71502	Ib	1996
23	Sundarbans South WS	Mangrove	36970	Ib	1996
24	Pablakhali WS	Hill forest	42087	II	1983
25	Chunati WS	Hill forest	7764	IV	1986
26	Fashiakhali WS	Hill forest	1302	IV	2007
27	Doodpukuria-Dhoopchari WS	Hill forest	4716	IV	2010
28	Hazarikhil WS	Hill forest	1177	II	2010
29	Sangoo WS	Hill forest	2332	II	2010
30	Teknaf Game Reserve	Hill forest	11615	IV	2010
31	Tengragiri WS	Mangrove	4048	II	2010
32	Dudmukhi WS	Mangrove	170	II	2012
33	Chandpai WS	Mangrove	560	II	2012
34	Daingmari WS	Mangrove	340	II	2012
35	Sonar Char WS	Mangrove plantation	2026	II	2011

Source: [12;32;35]

4.4 Legislative Approaches for the Conservation of Plant Diversity

There are several acts and national strategies as regards to environment, biodiversity and forest of Bangladesh, most of them are created and few laws have been amended in last two decades. The country has also an environment court system. The major acts that have been initiated to address forests ecosystem and plant diversity conservation in Bangladesh are briefly presented in Table 10. Despite having different laws related to environmental protection, these are not well enforced in the field level [5].

Government of Bangladesh has also developed different legislative policies and conservation projects to preserve the plant diversity. Followings are the key policies and programs implemented by the country to conserve forest and flora diversity [5,7,17,32,35,41].

- National Forest Policy 1994.
- Forestry Master Plan 1993-2012.
- National Biodiversity Strategy and Action Plan (NBSAP).
- National Conservation Strategy (NCS).
- Sustainable Environment Management Program (SEMP).

- Climate Resilient Participatory Afforestation and Reforestation Project (CRPARP).
- National Environment Management Action Plan (NEMAP).
- Sundarban Biodiversity Conservation Programs (SBCP).
- Nishorgo Support Project (NSP).
- Integrated Protected Area Co-management (IPAC).

4.5 CO-management of FPAS

Despite in small scale, recently the government has taken co-management strategy. The previous strategies were social forestry and agro-forestry in the communities to increase the supply of tree products [6]. Co-management approaches have been taken to involve the local people in the governance of FPAs through the partnerships between government agencies and forest dependent community [35]. The co-management was started through Nishorgo Support Project (NSP) which later developed as Integrated Protected Area Co-management (IPAC) and currently running as Climate-Resilient Ecosystems and Livelihoods (CREL) project [42]. The main objective of co-management in FPAs is to reduce high dependency of people in the adjoining localities on the protected areas through involving the local people in alternative income generation activities like strip plantation, fuel wood plantation in buffer zone, home craft, eco-tour guides etc. In PAs management, active participation of local people and increased economic incentives for their participation makes success the PAs and ensure sustainable uses of resources [43]. Co-management not only provides empower of participation to the local people but also

Table 8. Protected area both for *In-situ* and *Ex-situ* conservation

Sl. No.	Name of Pas	Location	Area (ha)	Year of notification
1	Madhobkundo EP	Moulavi Bazar	265	2001
2	Shitakundo EP	Chittagong	808	1998
3	Modhutila EP	Sherpur	100	1999
4	Bashkhali EP	Chittagong	1200	2003
5	Kuakata EP	Patuakhali	5661	2005
6	Tilagar EP	Sylhet	45.34	2006
7	Borshijoora EP	Moulavi Bazar	326	2006
8	Jamuna Shetu west EP	Pabna	50	2008
9	Pirujpur Riverview EP	Pirujpur	2.54	2010
10	Sheikh Rashel Aviary and EP	Chittagong	210	2018
11	Bangabandu Shekh Mujib SP, Dulahazra	Cox's Bazar	600	1999
12	Bangabandu Shekh Mujib SP, Dhaka	Gazipur	1494	2013

Source: [11;32]

Table 9. *Ex-situ* conservation practices in Bangladesh

Conservation type	Descriptions
Botanical gardens	There are two botanical gardens under the management of BFD. National Botanical Garden (Mirpur) accounts 84 ha of land having 255 tree species, 310 shrub species and 385 herb species under 114 families. Baldha Garden situated on 1.37 ha of land with 820 species of 92 families.
Preservation plots	BFRI has established 5 preservation plots at different hill forest areas and 27 at the Sundarban.
Clone banks	There are two clonal banks (Hyako, Chittagong and Ukhia, Cox's Bazar) established by BFRI and preserved seven tree species.
BFRI arboretum's	Bambusetum: Contains 27 bamboo species including 6 exotic species Arboretum of medicinal plants: 40 medicinal species are conserved here Cane arboretum: 7 cane species are conserved here Arboreta of tree species: Three arboreta of tree species have been established at the BFRI-HQ with 56 species, Charaljani Silviculture Research Station with 52 species and Keochia Forest Research Station with 56 species

Source: [17;39]

Table 10. Major laws implementing in Bangladesh on forest and biodiversity conservation

Acts	Functions
Bangladesh environment conservation act 1995 (revised 2012)	The act covers conservation in all its meaning from lower to higher organisms of biodiversity through ecosystem management and controlling pollution
The Forest Act, 1927 (amendment in 2000)	Established state ownership of forest areas. Legal authority for the Bangladesh Forest Department to gazette forest areas, manage timber and other forest resources
Wildlife (Conservation and Security) Act 2012	The Act has got the required provisions to conserve wild animals and plants
Brick manufacturing and Kiln establishment (Control) Act 2013	The Act was designed to control establishment of brick kilns in agricultural land, reserve forests, wetlands and protected areas. This act also has the impetus on promotion of energy-efficient brick manufacturing technologies that is essentially helping biodiversity
Environment Court Act, 2000 and Environment Protection Act, 2000 (Amendment 2010)	Established environmental courts. Enforcement of protection of Ecologically Critical Areas and wetlands. This act also deals with environmental pollution, establishes penalties and compensation for pollution
Climate Change Trust Act, 2010	Enhances the capability to create climate resilience in the country
Plant Quarantine Act, 2011	It has provisions to regulate carrying-in plants or plant products from abroad, and ensure sanitary and phyto-sanitary measures
Bangladesh Biodiversity Act-2017	Conservation of biodiversity and sustainable uses of its components

Source: [5;31;40]

provides various direct and indirect benefits for sustaining livelihood which makes fruitful of FPAs and ensure sustainable uses of resources [35, 38].

5. CONCLUSION

Bangladesh is endowed with rich biological resources having glorious plant diversity. Only 1.6 Million ha of forest area are under the management of forest department. Natural ecosystems are decreasing rapidly due to various human interferences and natural causes, which increasing challenges to conserve the remaining plant biodiversity. Though Bangladesh has made good progress in some areas by implementing a good number of conservation approaches including forest protected areas, the distribution, the existing number and area of FPAs are inadequate to conserve the natural ecosystems and dwelling plant biodiversity. Moreover current management strategies of conservation site and enforcements of laws are still weak. Based on the overall situations, some measures can therefore, be suggested:

Restoration of degraded forests, expanding the coverage of FPAs, soil and water conservation, strict enforcement of laws, restrict the establishment of eco-resort in critical biodiversity area and collaboration of stakeholders (government and NGOs) with effective co-management that ensures clearly defined rights and responsibilities of various stakeholders on FPAs and active participation in decision-making process are various manner that lead to better conservation. Increasing the awareness among the local people who are traditionally forest dependent for their livelihood. Strengthening the institutional capacity of BFD and DoE especially the Wildlife Crime Control Units with more resources, personnel, tools and training.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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