ASIAN JOURNAL OF FORESTRY
Volume 3, Number 1, June 2019 E-ISSN: 2580-2844
Pages: 25-30 DOI: 10.13057/asianjfor/r030104

Restoration and rehabilitation potentials of the remnant natural forests of Himchari National Park (HNP), Cox's Bazar, Bangladesh

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Manuscript received: 12 February 2019. Revision accepted: 12 May 2019.

Abstract. *Hossen S, Hossain MK, Uddin MF. 2019. Restoration and rehabilitation potentials of the remnant natural forests of Himchari National Park (HNP), Cox's Bazar, Bangladesh. Asian J For 3 : 25-30.* Himchari National Park (HNP) in Cox's Bazar, Bangladesh has been threatened by various anthropogenic activities, yet there are opportunities that the remaining vegetation can regenerate either naturally or with assistance. This study aimed to investigate the process of forest regeneration in Himchari National Park by looking at the state of regenerating vegetation, its community composition and biodiversity indices. As many 51 stratified random sample quadrats (20 m x 20 m) were surveyed. The result showed that natural vegetation (dbh ≥ 5cm) was found in dominance in 16 plots, equaling 31% of the total 51 plots sampled. The highest number of regenerated seedlings was *Grewia nervosa* (12.37%) followed by *Acacia auriculiformis* (8.95%). The maximum Importance Value Index (IVI) of regenerated seedlings was found for *Grewia nervosa* (26.43) followed by *Acacia auriculiformis* (20.27). The Shanon-Wiener's diversity index, Shanon's maximum diversity index, species evenness index, Margalef's diversity index, and Simpson's diversity index were 3.166, 3.714, 0.853, 6.03 and 0.057, respectively. Maximum coverage of natural regeneration was observed in the sampled plots of natural and plantation forest types rather than remnant natural forests or patches. Based on result, we recommend: (i). Evaluation of forest harvesting impacts on the forest ecosystems, (ii). Development of rehabilitation methods on logged-over forests and degraded forest lands, (iii). Development of silvicultural techniques on plantation and degraded lands, (iv). Network on the restoration and rehabilitation of degraded forest ecosystems.

Keywords: Degradation, National Park, regeneration, rehabilitation, restoration

INTRODUCTION

Forest degradation, from the perspective of vegetation cover, can be defined as a state of vegetation disturbance when the canopy is opened to form gap and plant succession process is disturbed (Kobayashi et al. 1999). It can be caused by natural disasters and human activities with major factors of forest degradation are agricultural exploitation, commercial logging, and wildfire (Mori et al. 2000). Such activities become a trigger for deforestation and land conversion to other forms of utilization, such as monoculture plantations, human settlements and so on (Kobayashi 1988, 1994).

Forest degradation affects forest ecosystems in various ways, including biodiversity loss, reduced capacity to regulate water, soil erosion, and greenhouse gas emission. Along with deforestation, forest degradation in tropical regions are the major contributors to global warming because both phenomena release a large amount of greenhouse gas emissions, such as carbon dioxide, methane, and nitrogen oxide, while at the same time reducing the capacity to sequester carbon dioxide through photosynthesis as the vegetation lost or degraded (Kira 1991; Uchijima 1991).

In Bangladesh, forests play an important role in various aspects including biodiversity conservation, carbon sinks, soil and water conservation, wildlife conservation, timber production and fulfillment of the needs of local people. Yet, many forests in Bangladesh are currently pressured by deforestation and forest degradation. As a results, Rahman et al. (2000) and Hossain (2001) stated that the depletion of native species is accelerating at an alarming rate due to the rapid loss and degradation of forests of the country. Numerous plant species are also at risk of being lost in all or part of their distribution ranges because of reduction in their population number due to overexploitation (Das 1987). Nonetheless, the extent of biodiversity loss in Bangladesh is not exactly known due to very poor database and is often based on scarce information (Hossain et al. 2004). As such, there is an urgent need to effectively protect and manage the existing natural forests in Bangladesh for the future generation (Hossain 2004). In addition, forest rehabilitation is also required to restore the degraded forest in Bangladesh.

Forest rehabilitation can be defined as coordinated measures to recover vegetation in deforested and degraded forests to maximize forest functions to satisfy human needs. Forest rehabilitation can be done by intended planting (active rehabilitation) or letting the remained vegetation proceed with natural regeneration (passive rehabilitation). While most understanding of forest rehabilitation is centered on intended planting activities, natural regeneration is essential for preservation and maintenance of biodiversity in natural forests (Hossain et al. 2004; Rahman et al. 2011). Knowledge about the pattern of natural regeneration is also important to answer the basic question of forest management (Hossain et al. 1999).

Himchari National Park (HNP) is located in southeastern region of Bangladesh, comprising an area of 1729 ha. It was established in 1980 and is very important due to its proximity to Cox's Bazar tourist city. Previously, this forest area was rich in floral and faunal diversity, number of waterfalls, streams cascades down towards the sandy beach on the west. Unfortunately, the national park was pressured by various factors like encroachment, illegal felling, and conversion of land into agriculture and betel leaf cultivation (Hossen and Hossain 2018). Nowadays, there is an increasing awareness to recover forest conditions in Himchari National Park through forest rehabilitation, yet limited information is available regarding the processes of regeneration. As such, this study aimed to investigate the process of forest regeneration in Himchari National Park by looking at state of regenerating vegetation, its community composition, and biodiversity indices. The results of these biodiversity monitoring and evaluation efforts are essential for taking effective conservation measures of the protected area immediately.

MATERIALS AND METHODS

Study area

Himchari National Park (HNP) geographically lies at $21^0$35' to $21^0$44`N and $91^0$98` to $92^0$05' E. It is located on the outskirts of Cox's Bazar city extending from Lighthouse para on the north to Rejhukhal on the south. It encompasses three unions namely South Mithachari, Jhillonja and Khuniapalong. The national park was established on 15th February 1980 through the decree of section 23 (II) of Bangladesh Wildlife Preservation Act 1974 by the Government of the People's Republic of Bangladesh with an area extent of about 1729 ha (4,271.15 acres). At the establishment, it consisted of three forest blocks namely Bhangamura Reserve Forest (872 ha), part of Chainda Reserve Forest (62 ha), and part of Jhilongja Protected Forest (795 ha). Currently, the national park covers four forest landscapes namely Kolatoli (872 ha), Chainda (62 ha), Jhilongja (450 ha), and Link Road (345 ha). The total area of the Protected Forest (PF) is about 10,849 ha of which 1,729 ha core zone, 5,247 ha buffer zone, and 3,873 ha private land (Figure 1). It is under the jurisdiction of Cox's Bazar South Forest Division within Cox's Bazar District.

Method and sampling design

The study was conducted from January 2017 to May 2018. The composition and diversity of the tree species in HNP were assessed through stratified random sampling using quadrat method applied separately for tree species. A total of 51 plots from four blocks were taken. The number of quadrats was fixed with plot size of 20 m x 20 m to have a sampling intensity of 0.117%.

For regeneration study, 5 m × 5 m subplots were taken at the center of each sample plot, and thus a total of 51 regeneration subplots were studied from the study area. All the sample plots were demarcated, and then all the tree species, including seedlings and saplings in each plot were identified and recorded with the help of taxonomists and local people. The relative density, relative frequency, relative abundance, and Important Value Index (IVI) were calculated following Shukla and Chandal (2000). Different biological diversity and richness indices (e.g., Species diversity index, Margalef's, Shannon-Wiener, Simpson's diversity index, etc.) were analyzed following Kent and Coker (1992), Margalef (1958), Michael (1990), Odum (1971), Pielo (1995), Shannon-Wiener (1963), Simpson (1949) and Hossain and Hossain (2014) to get a picture of regenerated seedlings in HNP. Family relative density and family relative diversity were calculated following Rahman et al. (2011). Empirical data were analyzed using MS Excel. The equations are presented below.

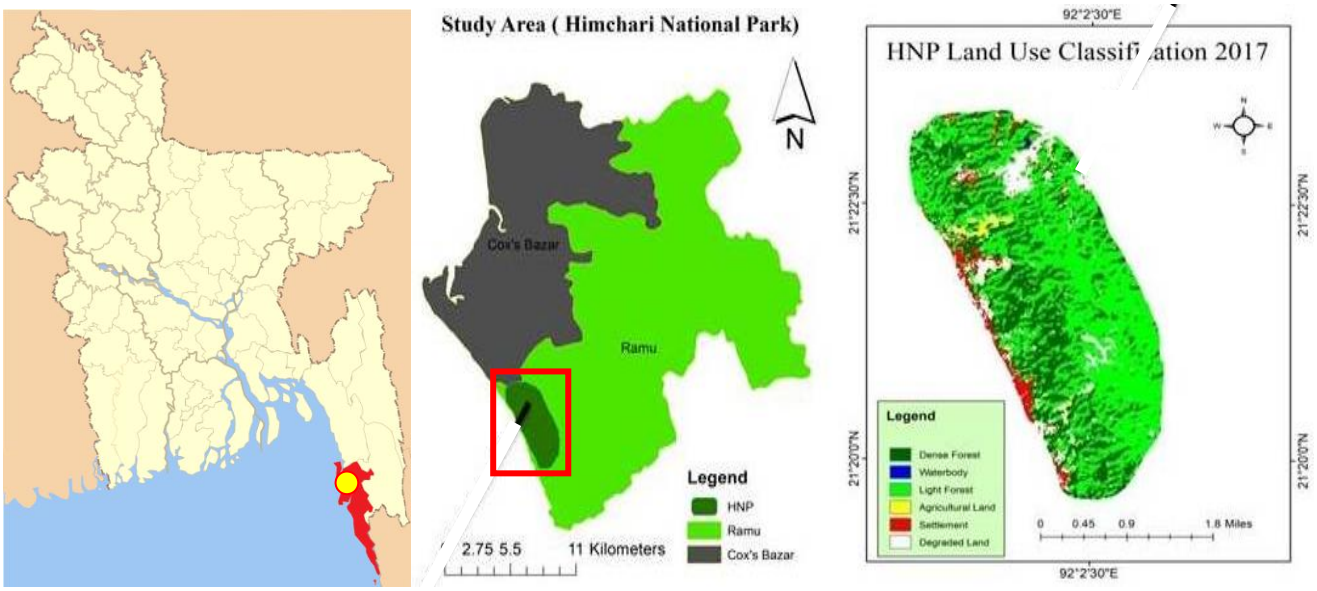

Figure 1. Map of the study location and land use classification of Himchari National Park (HNP), Cox's Bazar District, Bangladesh

$$\text{Density of a species} = \frac{\text{Total no.of individual of a species in all the quadrats}}{\text{Total no.of quadrats studied}}$$

$$\text{Relative density} = \frac{\text{Total no.of individual of the species}}{\text{Total no.of individuals of all the species}} \text{ X } 100$$

$$\text{Frequency of a species} = \frac{\text{Total no.of individual of quadrats in which the species occurs}}{\text{Total no.of quadrats studied}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of one species}}{\text{Total frequency}} \text{ X } 100$$

$$\text{Abundance of a species} = \frac{\text{Total no.of individual of a species in all the quadrats}}{\text{Total no.of quadrats in which the species occured}}$$

$$\text{Relative Abundance} = \frac{\text{Abundance of one species}}{\text{Total abundance}} \text{ X } 100$$

IVI = Relative Density + Relative Frequency + Relative Abundance

Species diversity index, SDi = S/N

Margalef's/ Species richness index index, R = (S-1)/ Ln (N)

Shannon-Wienner's diversity index, $H = -\sum_{i=0}^{n} Pi \ln Pi$

Shannon's maximum diversity index, Hmax =Ln (S)

Simpson's diversity index, $D = \sum_{k=0}^{n} Pi^2$

Dominance of simpson index, D´= 1-D

Simpson's reciprocal index, D_r= 1/D

Species evenness index, $E = \frac{H}{Ln(S)}$

Family relative density, FRD (%) = N_f / T_i X 100

Family relative diversity index, FRDI (%) = N_s / T_s X 100

Family importance value (FIV) = FRD + FRDI

Where,

H : Shannon-Wiener's diversity index

N_f : No. of individual in a family

N : Total no. of individuals of all the species

P_i : Number of individuals of one species/ Total number of individuals

T_i : Total number of individuals

N_s : No. of species

T_s : total number of species.

RESULTS AND DISCUSSION

State of vegetation regeneration in HNP

Of the 51 sampled plots, the dominance of natural vegetation was found in 16 plots (31%), while the remaining plots were dominated by natural and planted vegetation (15 plots, 29%), planted vegetation (8 plots, 16%), mixed plantation (7 plots, 14%), enrichment plantation (2 plots, 4%), coppice and plantation (2 plots, 4%) and coppice and natural vegetation (1 plot, 2%) (Figure 2). The natural regeneration was mostly observed in the sample plots of natural and plantation forest types rather than remnant natural forests. This result implies that the vegetation in HNP is regenerating mainly through artificial means than natural processes.

Family composition of regenerating vegetation in HNP

A total of 760 tree seedlings of 41 species under 21 families were recorded from the sampled areas. About 57.14% (12) families were represented by only one species and 14% (3) by more than two species. Families with the largest number of species were Moraceae and Myrtaceae with 5 species followed by Mimosaceae (4), Caesalpiniaceae (3), Combretaceae (3), and Meliaceae (3) (Table 1). Family with the highest relative density was Myrtaceae (14.34%) followed by Dipterocarpaceae (12.37%). Myrtaceae and Moraceae also had the highest relative diversity (12.12%) followed by Mimosaceae (9.76%). Family with the highest Family Importance Value (FIV) was Myrtaceae (26.54) followed by Mimosaceae (21.99), Moraceae (21.54), Dipterocarpaceae (17.25), and Tiliaceae (14.81) (Figure 3).

Species composition of regenerating vegetation in HNP

The community composition of regenerating vegetation at species level in Himchari National Park (HNP) was studied on the basis of the density, relative density, relative frequency, relative abundance and Importance Value Index. Species with the highest relative density were *Grewia nervosa* 12.37% (94) followed by *Acacia auriculiformis* 8.95% (68) and *Syzygium fruticosum* 8.82 % (67). The lowest number of seedlings was recorded for *Ficus microcarpa* 0.13% (1) followed by *Terminalia chebula* 0.26% (2), *Terminalia bellirica* 0.26% (2), and *Syzygium firmum* 0.26% (2) (Table 2).

Table 1. Family composition, number of species, number of individuals under each family, family relative density (FRD), family relative diversity index (FRDI) and family importance value (FIV) index of the regenerating trees in HNP, Cox's Bazar District, Bangladesh

Family	No. of species	No. of seedlings	FRD (%)	FRDI (%)	FIV
Anacardiaceae	2	25	3.29	4.88	8.17
Apocynaceae	1	7	0.92	2.44	3.36
Caesalpiniaceae	3	17	2.24	7.32	9.55
Casuarinaceae	1	23	3.03	2.44	5.47
Clusiaceae	1	3	0.39	2.44	2.83
Combretaceae	3	19	2.50	7.32	9.82
Dipterocarpaceae	2	94	12.37	4.88	17.25
Elaeocarpaceae	1	10	1.32	2.44	3.75
Euphorbiaceae	1	9	1.18	2.44	3.62
Fabaceae	1	18	2.37	2.44	4.81
Lythraceae	1	11	1.45	2.44	3.89
Magnoliaceae	1	2	0.26	2.44	2.70
Meliaceae	3	45	5.92	7.32	13.24
Mimosaceae	4	93	12.24	9.76	21.99
Moraceae	5	71	9.34	12.20	21.54
Myrtaceae	5	109	14.34	12.20	26.54
Oxalidaceae	1	2	0.26	2.44	2.70
Rhamnaceae	1	26	3.42	2.44	5.86
Rubiaceae	1	14	1.84	2.44	4.28
Tiliaceae	1	94	12.37	2.44	14.81
Verbenaceae	2	68	8.95	4.88	13.83
	41	760	100	100	200

Table 2. Phytosociological characters of the regenerating tree species in HNP, Cox's Bazar District, Bangladesh

Scientific name	Local name	No. of seedlings	RD (%)	RF (%)	RA (%)	IVI
Acacia auriculiformis A. Cunn. ex Benth. & Hook.	Akashmoni	68	8.95	8.42	2.90	20.27
Acacia mangium Willd.	Mangium	5	0.66	1.10	1.63	3.39
Albizia procera (Roxb.) Benth.	Sada Koroi	4	0.53	0.37	3.92	4.81
Alstonia scholaris L.	Chatim	7	0.92	1.47	1.71	4.10
Artocarpus chama Buch.-Ham.	Chapalish	2	0.26	0.37	1.96	2.59
Artocarpus heterophyllus Lamk.	Kanthal	29	3.82	4.03	2.58	10.43
Averrhoa carambola L.	Kamranga	2	0.26	0.37	1.96	2.59
Azadirachta indica A. Juss.	Neem	18	2.37	3.30	1.96	7.62
Butea monosperma (Lamk.) Taub	Palash	18	2.37	1.83	3.53	7.73
Caesalpinia pulcherrima L.	Radhachura	3	0.39	0.37	2.94	3.70
Cassia fistula L.	Sonalu	5	0.66	0.73	2.45	3.84
Casuarina equisetifolia Forst.	Jhau	23	3.03	2.93	2.82	8.77
Delonix regia Rafin.	Krishnachura	9	1.18	1.10	2.94	5.22
Dipterocarpus turbinatus Gaertin.	Telia Garjan	63	8.29	5.49	4.12	17.90
Elaeocarpus tectorius (Lour.) Poir	Jalpai	10	1.32	1.83	1.96	5.11
Eucalyptus camaldulensis Dehnhardt.	Eucalyptus	2	0.26	0.37	1.96	2.59
Ficus benghalensis L.	Bot	2	0.26	0.37	1.96	2.59
Ficus hispida L.f.	Dumur	37	4.87	5.86	2.27	12.99
Ficus microcarpa L.f.	Puti Bot	1	0.13	0.37	0.98	1.48
Garcinia cowa Roxb. ex DC.	Kao	3	0.39	0.37	2.94	3.70
Gmelina arborea Roxb.	Gamar	36	4.74	3.66	3.53	11.93
Grewia nervosa (Lour.) Panigrahi	Assargola	94	12.37	10.99	3.07	26.43
Lagerstroemia speciosa (L.) Pers.	Jarul	11	1.45	1.83	2.16	5.43
Mangifera indica L.	Aam	20	2.63	3.66	1.96	8.25
Mangifera sylvatica Roxb.	Uri Aam	5	0.66	1.10	1.63	3.39
Michelia champaca L.	Champa	2	0.26	0.37	1.96	2.59
Neolamarckia cadamba (Roxb.) Bosser	Kadam	14	1.84	2.56	1.96	6.37
Phyllanthus emblica L.	Amloki	9	1.18	1.47	2.20	4.85
Psidium guajava L.	Peyara	36	4.74	6.23	2.07	13.04
Samanea sam (Jacq.) Merr.	Raintree	16	2.11	2.56	2.24	6.91
Shorea robusta Roxb. ex Gaertin. f.	Sal	31	4.08	3.66	3.04	10.78
Swietenia mahagoni Jacq.	Mahagoni	4	0.53	0.73	1.96	3.22
Syzygium cumini (L.) Skeels	Kalo Jam	2	0.26	0.37	1.96	2.59
Syzygium firmum Thw.	Dhaki Jam	2	0.26	0.37	1.96	2.59
Syzygium fruticosum DC.	Puti Jam	67	8.82	5.49	4.38	18.69
Tectona grandis L.f.	Segun	32	4.21	3.30	3.48	10.99
Terminalia arjuna (Roxb. ex Dc.) Wight & Am.	Arjun	15	1.97	2.20	2.45	6.62
Terminalia belliria (Gaertin.) Roxb.	Bohera	2	0.26	0.37	1.96	2.59
Terminalia chebula Retz.	Haritaki	2	0.26	0.37	1.96	2.59
Toona ciliate Roem.	Suruj	23	3.03	4.03	2.05	9.10
Ziziphus mauritiana Lamk.	Boroi	26	3.42	3.66	2.55	9.63
		760	100	100	100	300

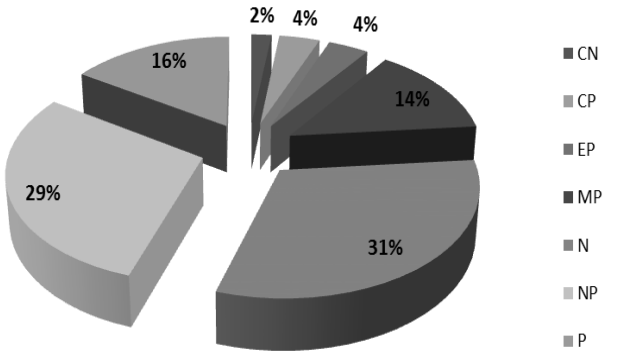

Figure 2. State of vegetation regeneration in HNP, Cox's Bazar District, Bangladesh resembled by the proportion of the 51 sampled plots across various vegetation types. Vegetation type: CN: Coppice and Natural, CP: Coppice and Plantation, EP: Enrichment Plantation, MP: Mixed Plantation, N: Natural forests, NP: Natural and Plantation and P: Plantation

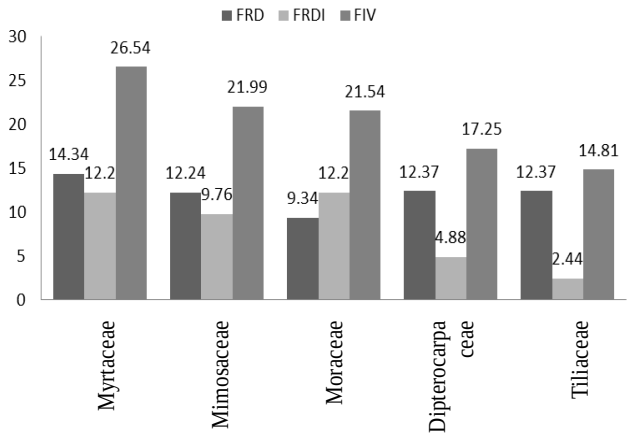

Figure 3. Family relative density, family relative diversity, and family importance value of some dominant tree families in HNP, Cox's Bazar District, Bangladesh

Recommended strategies for restoration and rehabilitation of degraded natural forests of HNP

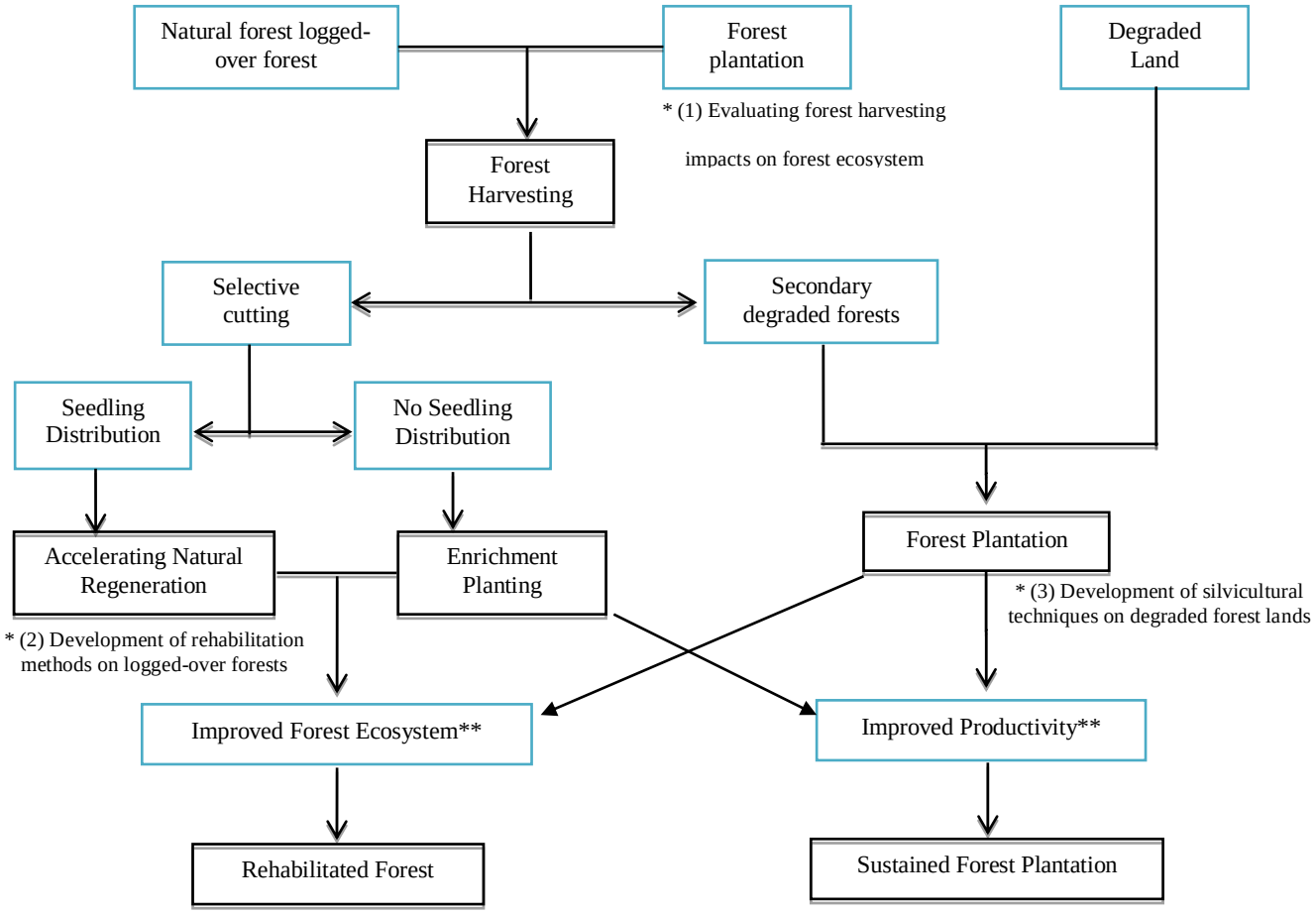

Figure 4. Proposed restoration and rehabilitation strategies for remnant natural forests in HNP, Cox's Bazar District, Bangladesh. Note: *Actual target is development of adequate techniques. ** Final target is conservation of biodiversity and environment of forest.

Maximum relative density was recorded for *Grewia nervosa* (12.37%) followed by *Acacia auriculiformis* (8.95%), *Syzygium fruticosum* (8.82%), *Dipterocarpus turbinatus* (8.29%). Maximum relative frequency was recorded for *Grewia nervosa* (10.99%) followed by *Acacia auriculiformis* (8.42%), *Psidium guajava* (6.23%). The highest relative abundance was *Syzygium fruticosum* (4.38%) followed by *Dipterocarpus turbinatus* (4.12%). The maximum Importance Value Index (IVI) was found for *Grewia nervosa* (26.43) followed by *Acacia auriculiformis* (20.27), *Syzygium fruticosum* (18.69) (Table 2).

Biodiversity indices of regenerating vegetation in HNP

The study revealed that the value of species diversity index in the whole surveyed area was 0.054. The Shanon-Wiener's diversity index in the area was 3.166 with Shanon's maximum diversity index of 3.714. The species evenness index was 0.853, Margalef's diversity index was 6.03 and Simpson's diversity index was 0.057. The values of Dominance of Simpson's index and Simpson's reciprocal index of HNP were 0.943 and 17.544 respectively (Table 3). The values of Shanon-Wiener and Margalef's diversity index indicate adequate presence of tree species in the area. Lower value of Simpson's index is also indicator for diverse tree species.

The results of this study showed that the phytosociological attributes of regenerating vegetation in the HNP are comparable to other tropical forests (Figure 4). The values of these variables indicate that even though the forest in HNP had been degraded and deforested severely, but it harbors a rich diversity of tree species. These forests had been under great anthropogenic pressures, indicated by fragmentation and land conversion into other land uses including agriculture, betel leaf, and houses. The natural regeneration coverage, composition and density reveal that the forests still have revival capacity and variety of trees have been growing from seeds and root suckers.

Although their natural regeneration was present, cutting of seedlings and saplings particularly by fuelwood collectors and betel leaf cultivators imposed threats on new recruitments. Many local people living in and around the national park area are dependent on the forests for their livelihood and daily necessary goods. Conflicts regarding land need to be resolved to protect trees and natural regeneration.

Table 3. Biodiversity indices of regenerating vegetation in HNP, Cox's Bazar District, Bangladesh

Parameters	Total for HNP
Species diversity index (SDi)	0.054
Shanon-Wiener's diversity index (H)	3.166
Shanon's maximum diversity index (Hmax)	3.714
Species evenness index (E)	0.853
Margalef's diversity index (R)	6.03
Simpson's diversity index (D)	0.057
Dominance of Simpson's index (D')	0.943
Simpson's reciprocal index (Dr)	17.544

Finally, it can be concluded that although the condition of the forest is poor, but still there is some hope as shown by the rich number of regeneration and potential of rehabilitation in the remnant natural forest. It is suggested that the results of these studies will contribute to the sustainable use of forest resources and environmental conservation. If it is possible to protect the national park in the current state with effective measures of diverting the forest-dependent people towards non forest-related livelihood alternatives or reducing dependency on the forest, there is a greater possibility of this forest to develop into a better quality forest in the future.

ACKNOWLEDGEMENTS

The authors are thankful to the Institute of Forestry and Environmental Sciences, Chittagong University (IFESCU), Bangladesh Forest Research Institute (BFRI), Cox's Bazar South Forest Division and local people of HNP for their cordial collaboration and cooperation.

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