Restoration and rehabilitation potential of the remnant natural forests of Himchari National Park (HNP) in Cox’s Bazar, Bangladesh

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INTRODUCTION

Forest degradation is a kind of canopy gap forming process and/or retrogressive actions against plant succession process caused by natural disasters and human activities (Kobayashi et al. 1999). Major factors of forest degradation are agricultural exploitation, commercial logging, and wildfire (Mori et al. 2000). Reduction of the tropical forest is related to global warming through acceleration of the greenhouse gas emissions such as carbon dioxide, methane, and nitrogen oxide and accumulated decrease of carbon dioxide through photosynthesis by tropical trees (Kira 1991; Uchijima 1991). The harvesting of timber affects forest ecosystems in various ways, which include site degradation, reduced forest water supply, soil loss, and greenhouse gas emission. Selective and clear-cutting, fire and burning are major causes of land degradation, and forest harvesting becomes a trigger for other forms of land utilization (Kobayashi 1988, 1994).

The extent of biodiversity loss in Bangladesh is not exactly known due to very poor database and often based on scarce information (Hossain et al. 2004). 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). Rahman et al. (2000) and Hossain (2001) stated that the depletion of native species was also accelerating at an alarming rate through the rapid loss and degradation of forests in Bangladesh. In Bangladesh, it is an urgent need to effectively protect and manage the existing natural forests for the future generation (Hossain 2004). 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).

Forest rehabilitation can be defined as promoting measures that maximize forest functions to satisfy human needs. The forests are managed for many purposes, including biodiversity conservation carbon sinks, soil and water conservation, wildlife conservation, timber production and needs of local people. Himchari National Park (HNP), located in southeastern region of Bangladesh comprising an area of 1729 ha, gazetted in 1980 and is very important due to its proximity to Cox's Bazar tourist city. Once this forest area was rich in floral and faunal diversity, number of waterfalls, streams cascades down towards the sandy beach on the west. But, unfortunately, the scenario has totally changed due to heavy biotic pressure like encroachment, illegal felling, and conversion of land into agriculture and betel leaf cultivation (Hossen and Hossain 2018). Biodiversity monitoring and evaluation are essential for taking effective conservation measures of this protected area immediately.

Abstract. Hossen S, Hossain MK, Uddin MF. 2019. Restoration and rehabilitation potential of the remnant natural forests of Himchari National Park (HNP) in Cox’s Bazar, Bangladesh. Asian J For 3 : 25-30. The present study was conducted by taking 51 stratified random sample quadrats (20 m × 20 m), where, naturally occupied vegetation (dbh ≥ 5cm) was found in maximum (16 plot, 31%) number of plots. The highest number of regenerated seedlings was accounted for Grewia nervosa (12.37 %) followed by Acacia auriculiformis (8.95%). For regeneration study, 5 m × 5 m subplots were taken at the centre of each of the 51 sample quadrats and thus a total of 51 regeneration subplots were studied. The maximum Importance Value Index (IVI) of regenerated seedlings was found for Grewia nervosa (26.43) followed by Acacia auriculiformis (20.27). Different biological diversity indices such as species diversity index, Shannon-Wiener's diversity index, Shannon's maximum diversity index, species evenness index, Margalef's diversity index, and Simpson's diversity index were 0.054, 3.166, 3.714, 0.853, 6.03 and 0.057 respectively. Maximum natural regeneration was observed in the sample plots of Natural and plantation forest type rather than remnant natural forests or patches. Based on result, the following research outputs are also recommended: (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.
MATERIALS AND METHODS

Descriptions of the study area

Himchari National Park (HNP) is located (21°35’ to 21°44’ N and 91°08’ to 92°05’ E) on the outskirts of Cox’s Bazar city extending from Lighthouse para on the north to Rejhukhal on the south with an expansion of around 17 sq. km. It consists of three union namely South Mithachari, Jhillonga, and Khuniapalong union. In exercise of the power conferred by the section 23 (II) of Bangladesh Wildlife Preservation Act 1974 the Government of the People’s Republic of Bangladesh proclaimed the forest area measuring about 1729 ha (4,271.15 acres) of Cox’s Bazar District to be a National Park on 15th February 1980. It was proclaimed as National Park under three forest block named Bhangamura Reserve Forest (872 ha), part of Chainda Reserve Forest (62 ha), and part of Jhilonga Protected Forest (795 ha). These three blocks at present cover four forest beat namely Kolatoli, Chainda, Jhilonga, and Link Road. The total landscape 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 quadrat survey applied separately for tree species. The whole HNP was divided into four broad areas/blocks (1,729 ha) considering homogeneous beat area namely Chainda (62 ha), Jhilonga (450 ha), Kolatoli (872 ha) and Link Road (345 ha). Total fifty-one (51) plots from four blocks were taken by using simple random sampling. The number of quadrats was fixed considering the sample plot size (20 m x 20 m) to have a sampling intensity of more than 0.117% for quantitative assessment of the tree species throughout the sites. For regeneration study, 5 m x 5 m subplots were taken at the center of each of the 51 sample plots, and thus a total of 51 regeneration subplots were studied from the study area. All the sample plots were well demarcated, and then all the tree species, including seedlings and saplings in each plot were identified and recorded with the help of taxonomist 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 (eg. 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 with the help of MS Excel.

![Study Area (Himchari National Park)](image)

**Figure 1.** Location map of Himchari National Park (HNP) at Cox’s Bazar District, Bangladesh
Relative Abundance = \frac{Abundance \ of \ one \ species}{Total \ abundance} \times 100

IVI = Relative \ Density + Relative \ Frequency + Relative \ Abundance

Species diversity index, SDI = S/N

Margalef’s/ Species richness index, R = (S-1)/ln (N)

Shannon-Wiener’s diversity index, H = \sum_{i=0}^{n} P_i \ln P_i

Shannon’s maximum diversity index, H_{max} = \ln (S)

Simpson’s diversity index, D = \sum_{k=0}^{n} P_k^2

Dominance of simpson index, D’ = 1-D

Simpson’s reciprocal index, D_1 = 1/D

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

Family relative density, FRD (%) = N_i/T_i \times 100

Family relative diversity index, FRDI (%) = N_i/T_i \times 100

Family importance value (FIV) = FRD + FRDI

Where,

H : Shannon-Wiener’s diversity index
N_i : 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

Forest restoration process in HNP

The present study was conducted by taking 51 stratified random sample quadrats, where, naturally occupied vegetation was found in maximum (16 plot, 31%) number of plots. Whereas, the remaining plots were dominant with Natural and Plantation (15 plot, 29%), Plantation (8 plot, 16%), Mixed Plantation (7 plot, 14%), Enrichment Plantation (2 plot, 4%), Coppice and Plantation (2 plot, 4%) and Coppice and Natural (1 plot, 2%) (Figure 2). Maximum natural regeneration was observed in the sample areas of Natural and plantation forest type rather than remnant natural forests or patches. It is concluded that the forests of HNP are restoring with vegetation coverage through artificial means than that of natural processes.

Natural regeneration status in HNP

A total of 760 seedlings/trees of 41 species under 21 families were recorded from Himchari National Park. About 57.14% (12) families were represented by only one species and 14% (3) by more than two species. Maximum 5 species were found for each Moraceae and Myrtaceae family followed by Mimosaceae (4), Caesalpinaceae (3), Combretaceae (3), and Meliaceae (3) (Table 1). Highest (14.34%) family relative density was represented by Myrtaceae family followed by Dipterocarpaceae (12.37%) family. Family relative diversity was also found maximum (12.12%) for each Myrtaceae and Moraceae family followed by Mimosaceae (9.76%) family. Maximum (26.54) Family Importance Value (FIV) index was found for Myrtaceae followed by Mimosaceae (21.99), Moraceae (21.54), Dipterocarpaceae (17.25), and Tiliaceae (14.81) (Figure 3).

![Figure 2. Forest restoration process (%) in HNP, Cox’s Bazar District, Bangladesh through 51 stratified random plots represented by, CN: Coppice and Natural, CP: Coppice and Plantation, EP: Enrichment Plantation, MP: Mixed Plantation, N: Natural forests, NP: Natural and Plantation and P: Plantation](image)

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|
| Caesalpinaceae  | 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 naturally regenerating tree species of the 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. | | 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. | Chaitim | 7 | 0.92 | 1.47 | 1.71 | 4.10 |
| Artocarpus chuma Buch.-Ham. | Chapalish | 2 | 0.26 | 0.37 | 1.96 | 2.59 |
| Artocarpus heterophyllus Lamk. | Kamthal | 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 Gaertn. | Teha 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 bengalensis L. | Bot | 37 | 4.87 | 5.86 | 2.27 | 12.99 |
| Ficus hispida L.f. | Dumur | 5 | 0.13 | 0.37 | 0.98 | 1.48 |
| 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 sylavta 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 |
| Suanamea 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 bellirica (Gaertn.) 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 ciliata Roem. | Suruj | 23 | 3.03 | 4.03 | 2.05 | 9.10 |
| Ziziphus mauritiana Lamk. | Bori | 26 | 3.42 | 3.66 | 2.55 | 9.63 |

760 | 100 | 100 | 100 | 300 |

Quantitative characters of naturally regenerating tree species of HNP

The quantitative structure of naturally regenerating tree species in Himchari National Park (HNP) was studied on the basis of the density, relative density, relative frequency, relative abundance, and Importance Value Index. The highest relative density was accounted for *Grewia nervosa* (12.37 % (94)) followed by *Acacia auriculiformis* 8.95% (68) and *Syzygium fruticosum* 8.82% (67). 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). Maximum relative density (12.32%) was recorded for *Grewia nervosa* (12.37%) followed by *Acacia auriculiformis* (8.95%), *Syzygium fruticosum* (8.82%), *Dipterocarpus turbinatus* (8.29%). Maximum relative frequency (10.99%) was recorded for *Grewia nervosa*.
followed by *Acacia auriculiformis* (8.42%), *Psidium guajava* (6.23%). The highest (4.38%) relative abundance was calculated for *Syzygium fruticosum* 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).

**Biological diversity indices for regeneration status of HNP**

The study revealed that the value of species diversity index in the whole survey area was 0.054. The Shannon-Wiener’s diversity index in the area was 3.166 with Shannon’s maximum diversity index of 3.714. The species evenness index was 0.853. Margalef’s diversity index was 6.03. 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 Shannon-Wiener and Margalef’s diversity index indicate proficient presence of tree species in the area. Lower value of Simpson’s index also indicator for diverse tree species.

**Table 3.** Different biological diversity indices for regeneration status of HNP, Cox’s Bazar District, Bangladesh

| Parameters                              | Total for HNP |
|-----------------------------------------|---------------|
| Species diversity index (SDi)           | 0.054         |
| Shannon-Wiener’s diversity index (H)    | 3.166         |
| Shannon’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        |

**Recommendation/proposed for restoration and rehabilitation of degraded natural forests of HNP**

![Diagram showing the restoration and rehabilitation technique for remnant natural forests of HNP, Cox’s Bazar District, Bangladesh.](image)

*Note: *Actual target is development of adequate techniques. **Final target is conservation of biodiversity and environment of forest*

**Figure 4.** Identify the restoration and rehabilitation technique for remnant natural forests of HNP, Cox’s Bazar District, Bangladesh.
In conclusion, the phytosociological attributes of the HNP are comparable to other tropical forests. 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. It has shown that these forests had been under manifold anthropogenic pressures. The forest areas had been fragmented and converted into other land uses including agriculture, betel leaf, and houses. The natural regeneration counts, 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 coming up, but cutting of seedlings and saplings particularly by fuelwood collectors and betel leaf cultivators impose 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. 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 future.

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