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Research Article

Tree Species Composition and Natural Regeneration Status in South Eastern Bangladesh

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ABSTRACT

The study aimed to quantify and discuss the current condition of the tree species composition and natural regeneration of southeast parts of Bangladesh (Cox's Bazar North Forest Division). A total of 121 stems having dbh ≥10cm and 3481 stems of regenerating tree species (dbh <10cm) per hectare were recorded. A large trees comprised of 17 species belonging to 10 families and 14 genera and 30 regenerating tree species belonging to 19 families and 27 genera have been found. The forests were highly non-uniform, with three or four species represented most of the stands. The values of diversity indices indicated limited plant diversity, which is dominated by two or three tree species. Stems of 10-30 cm dbh contributed almost 90% of the total stem density, whereas more than 80% of the total basal area still belonged to trees with dbh 100 cm or above. *Dipterocarpus turbinatus* was the most dominant species which have the highest Importance Value Index (IVI) with 135.82 and embodied 37.71% of the total stand density and 72.19% of total basal area. The study will provide scientific basis for the future implementation of forest conservation strategies in tropical forests of Southeast Asia, particularly in Bangladesh. This study may also pave the way to further research on regeneration potentials of the native species for conservation and enhancement of forests in future.

Keywords: tree species composition; biodiversity index; South-East Asia; tropical forest; natural regeneration status.

INTRODUCTION

Tropical forests are often considered as the world's most species-rich plant communities and are both ecologically and economically important for the livelihood of local communities. However, vegetation covers are rapidly decreasing in the tropical areas. Due to increasing anthropogenic pressure, tropical forests are depleting at an alarming rate by 1–4% of their current land area (Laurance et al. 1998). In South and Southeast Asia, from 2010 to 2015 the net forest loss was about 25% higher compared to 1990 (Keenan et al. 2015).

Bangladesh lies within the tropical forest region of southeast Asia, covering 2.5 million ha of forest lands managed by the forest department, land ministry and other individuals (Sobuj & Rahman 2011). The forests of this country have been severely damaged over the past several decades by both biotic and abiotic disturbances affecting the regeneration and dynamics population. The major causes of forest degradation in Bangladesh are agricultural expansion, over-extraction of wood and non-wood resources, deforestation, urbanization, and inappropriate management practices (Hasan & Alam 2006). The forest degradation in Bangladesh has brought about an alarming rate of biodiversity reduction.

Quantitative information on tree species composition and distribution is important to understand the structure of a forest community and also for formulating conservation strategy for the community (Malik et al. 2014). Species diversity and regeneration status of tree species largely portray the nature of the forest community, as they provide resources and habitat for almost all other forest species (Cannon et al. 1998). The very existence of species in a community depends on the regeneration status. In forest management, regeneration study describes the current condition as well as possible future changes in forest composition (Malik & Bhatt 2016; Sharma et al. 2014).

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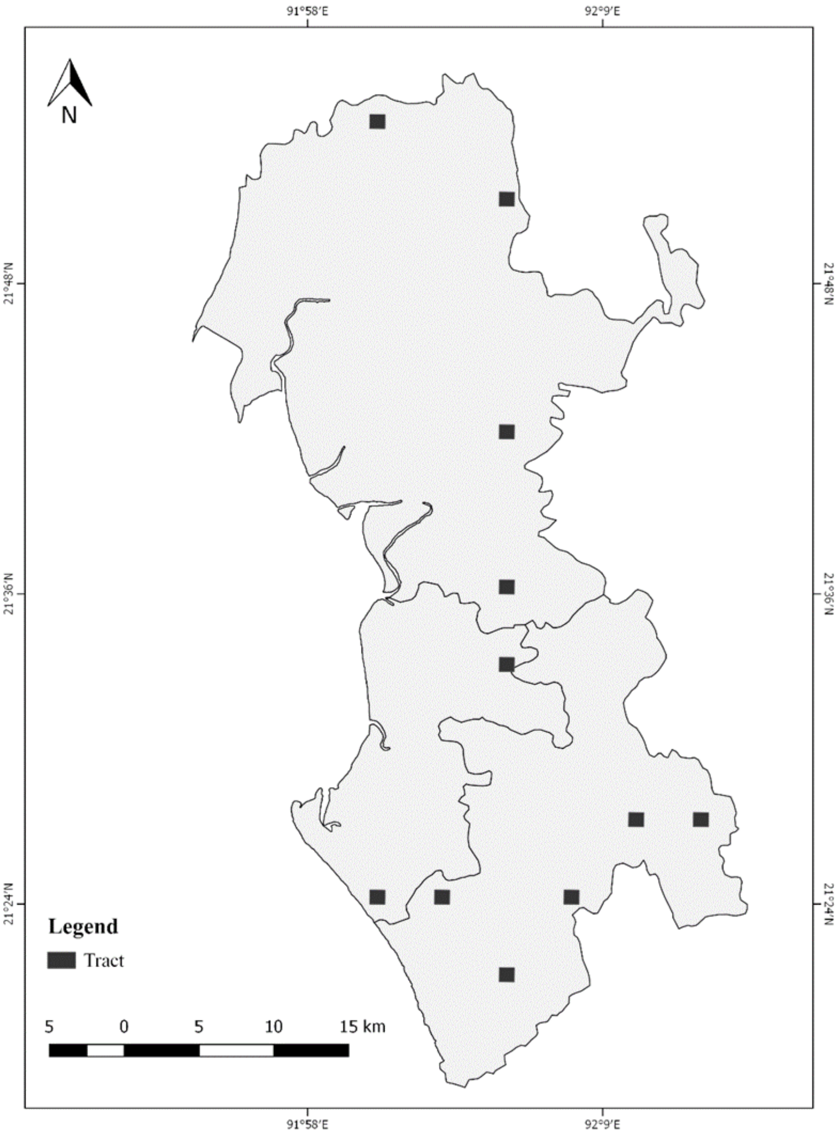

Figure 1. Location of tracts in Cox's Bazar North Forest Division

Well-timed and precise information on forest resources is essential for sustainable forest policy. The southeast parts of Bangladesh have natural forest patches, which are degrading at an alarming rate, and thus require a due attention. A rationalized strategy based on scientific information and complete knowledge of species distribution is required for these forests management. Therefore, the study was designed to provide quantitative information of the species composition, diversity, stem and basal area distribution of tree species in different diameter classes, and natural regeneration of this region.

MATERIALS AND METHODS

Study site

The study was conducted in the forests of Cox's Bazar North Forest Division, lying along the north-eastern coast of the Bay of Bengal. Its geographical location is between 20°30´ and 22° N latitude and between 91°45´ and 92°15´ E longitude. Cox's Bazar was initially established as a separate forest division on April, 1st 1920 (Choudhury 1969). The forests in the region are mostly tropical semi-evergreen types. It covers 74780.96 ha of forest area, which 62352.01 ha is managed as a reserve and 12428.95 ha as a protected forest, including 17 ranges, 66 beats, 74 blocks, 9 beat-cum-check stations and 2 check stations.

Sampling design

The sampling units were selected using random sampling design followed by Food and Agriculture Organization (FAO). The sampling units are termed as Tracts. The whole area was divided into units or tracts, 500 × 500m in size, distributed throughout Cox's Bazar North forest division at an interval of 3-minute latitude and 2.5-minute longitude. From them, 11 tracts were selected randomly for the study (Figure 1).

Methods

The Tract represents a square of 500 × 500m (25 ha) within which the field data was collected. Each Tract comprised of 4 Plots with the dimension of 20 × 100m (0.2 ha), one at each corner of the tract. The coordinates of the tracts and plots were precisely located using GPS for future relocation. A total of 8.8 ha area has been surveyed for this study. Information on species name, measurements of diameter and height of individual trees, and regeneration data were collected from the field. The measurements of trees having a diameter at breast height (dbh) larger than 30cm were collected along the central line of the plot. Measurements involved both left and right sides from the central line on a 10m wide extension. Additionally, two circular subplots were also established at the centre of each plot. Trees having 10-30cm dbh were measured inside sub-plot 1 (10m radius) and measurement of regeneration was taken inside sub-plot 2 (3.99 m radius) (Figure 2).

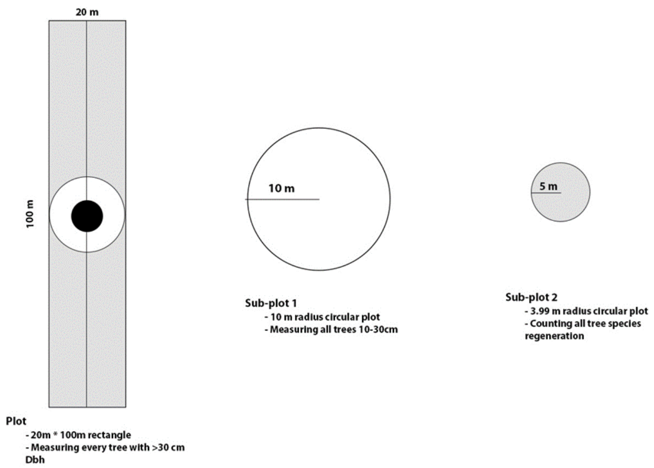

Figure 2. Plot design for data collection

The collected information was used to measure the basal area, Relative Frequency (RF), Relative Density (RD), Relative Dominance (RDo) and Relative Abundance (RA), which were then used to calculate IVI of each species. For this purpose, the following formulas were used (Dogra et al. 2009; Nebel et al. 2001):

$$\text{Basal area} = \frac{\pi \times dbh^2}{4} \quad (1)$$

$$\text{Frequency} = \frac{\text{Total no. of quadrats of sampling units in which the species occurs}}{\text{Total no. of quadrats}} \quad (2)$$

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of occurence of each species}}{\text{Sum of frequencies of occurence of all species}} \times 100 \quad (3)$$

$$\text{Relative Density (RD)} = \frac{\text{Total no. of individual of each species}}{\text{Total no. of individuals of all species}} \times 100 \quad (4)$$

$$\text{Relative Dominance (RDo)} = \frac{\text{Basal area of all individuals of species}}{\text{Total basal area of all individuals of all species}} \times 100 \quad (5)$$

$$\text{Abundance} = \frac{\text{Total no. of individuals of each species in all quadrats}}{\text{Total no. of quadrats in which the species occured}} \quad (6)$$

$$\text{Relative Abundance (RA)} = \frac{\text{Abundance of each species}}{\text{Total abundance of all quadrats}} \times 100 \quad (7)$$

For calculating IVI of tree species having dbh 10cm or above, the following equation has been used. For the IVI calculation of regeneration (dbh <10cm) instead of RDo, RA has been used.

IVI = RF + RD + RDo

Diversity indices are useful tools to understand the vegetative structure of a natural forest by providing information on the composition and status of vegetation in the designated area. The species richness was accessed using The Margalef's diversity index (Clifford & Stephenson 1975) and Menhinick's index (Whittaker 1977). The Shannon's index (H) (Shannon 1948) and Simpson's index of domination (D) (Simpson et al. 1949) were used to determine species diversity. The species evenness index (Pielou 1975) was also measured in the study.

$$\text{Shannon's Index (H)} = -\sum p_i \ln(p_i) \quad (8)$$

$$\text{Simpson's Index (D)} = \sum p_i^2 \quad (9)$$

$$\text{Species evenness index, E} = \frac{H}{\text{Ln}(S)} \quad (10)$$

$$\text{Margalef's index, } D_{Mg} = \frac{(S-1)}{ln(N)} \quad (11)$$

$$\text{Menhinick's index, } D_{Mn} = \frac{S}{\sqrt{N}} \quad (12)$$

Where:

p_i = the ratio of number of individuals of one species to the total number of individuals of all species

N = the total number of individuals,

S = the total number of species in the study area.

RESULTS AND DISCUSSION

A total of 131 individual stems with dbh ≥ 10 cm has been enumerated in 4.4 ha vegetation areas of

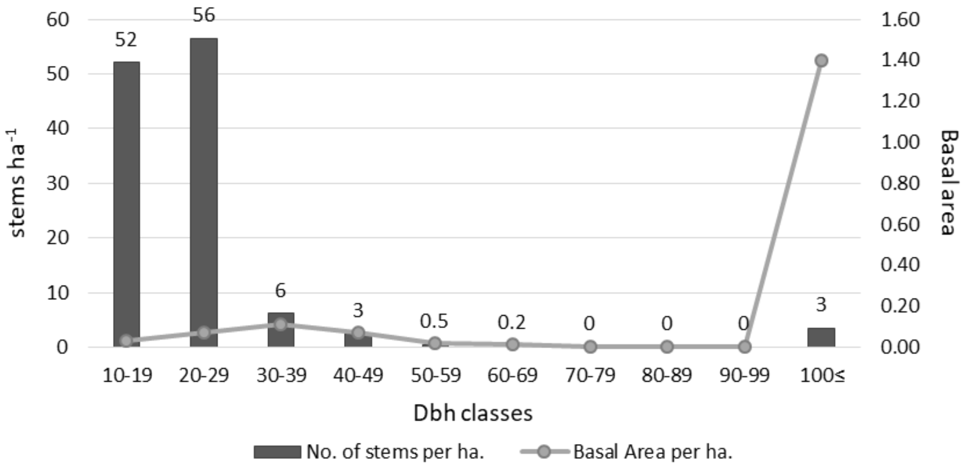

Figure 3. Distribution of tree density and basal area (m^2) per ha. in different diameter classes

Cox's Bazar North forest division, which were represented by 17 tree species belonging to 14 genera and 10 families. The figure 3 shows that stems with dbh between 10--30 cm contributed almost 90% of the total stem density. However, more than 80% of the total basal area still belonged to trees with dbh 100 cm or above. Stems of all dbh classes in the forests are not evenly distributed. There is no stem belonging to 70-99 cm dbh classes and rapid decline in stem density from ≥30 cm diameter class can be observed. The reason might be that trees were likely to be cut down, legally or illegally, after reaching diameter of 30 cm because of high market demand and easy transportation of logs.

Table 1. Density, basal area and tree diversity indices of Cox's Bazar North forest division

Index	Value
Density (Stems ha^{-1})	121
Basal Area (m^2ha^{-1})	11.533
Menhinick's index	0.329
Margalef's index	2.028
Shannon's diversity index	1.735
Shannon's maximum diversity index	2.833
Simpson's index	0.238
Shannon's equitability index or species evenness index	0.613

Species Diversity Analysis

The stem density and basal area of the vegetation covers in Cox's Bazar North forest division were 121 trees ha^{-1} and 11.533 m^2ha^{-1} respectively. The value of species evenness index was 0.613. The Shannon's diversity index was 1.735. The Menhinick's and Margalef's indices were 0.329 and 2.028 respectively. The Simpson's index value was 0.238. The values of Shannon's, Menhinick's and Margalef's indices indicate limited plant diversity. On the other hand, Simpson's index value shows the species were not uniformly distributed; but dominated by 2 or 3 tree species (Table 1).

Structural Composition of Tree Species

Among the 17 tree species, four species embody 88% of the stand density (*Dipterocarpus turbinatus* 37.71%, *Acacia auriculiformis* 24.05%, *Syzygium grande* 15.51%, *Syzygium cumini* 10.93%). Similarly, these four species represent 87% of the total basal area, where *Dipterocarpus turbinatus* alone comprises 72.19%. *Dipterocarpus turbinatus* has the highest stem density (46 stems ha^{-1}) followed by *Acacia auriculiformis* (29), *Syzygium grande* (19), and *Syzygium cumini* (13). The maximum relative density was in *Dipterocarpus turbinatus* (37.71%) followed by *Acacia auriculiformis* (24.05%), *Syzygium grande* (15.51%), and *Syzygium cumini* (10.93 %). The highest relative frequency was found in *Dipterocarpus turbinatus* (25.93%) followed by *Syzygium cumini* (11.11%), *Acacia auriculiformis* (7.41%), and *Syzygium grande* (7.41%). The study area was mainly dominated by *Dipterocarpus turbinatus* with relative dominance 72.19%, followed by *Syzygium grande* (5.62%), *Acacia auriculiformis* (5.43%), and *Anthocephalus chinensis* (3.96%). The importance value index (IVI) has been observed highest in *Dipterocarpus turbinatus* (135.82), followed by *Acacia auriculiformis* (36.89), *Syzygium grande* (28.54), and *Syzygium cumini* (25.97). The other species with low IVI values indicates their infrequency in the forests. The figure 4 and figure 5 illustrate the relative frequency, relative density, relative dominance and IVI, and the stem density and basal area per ha., respectively, for the top 7 tree species in the study area.

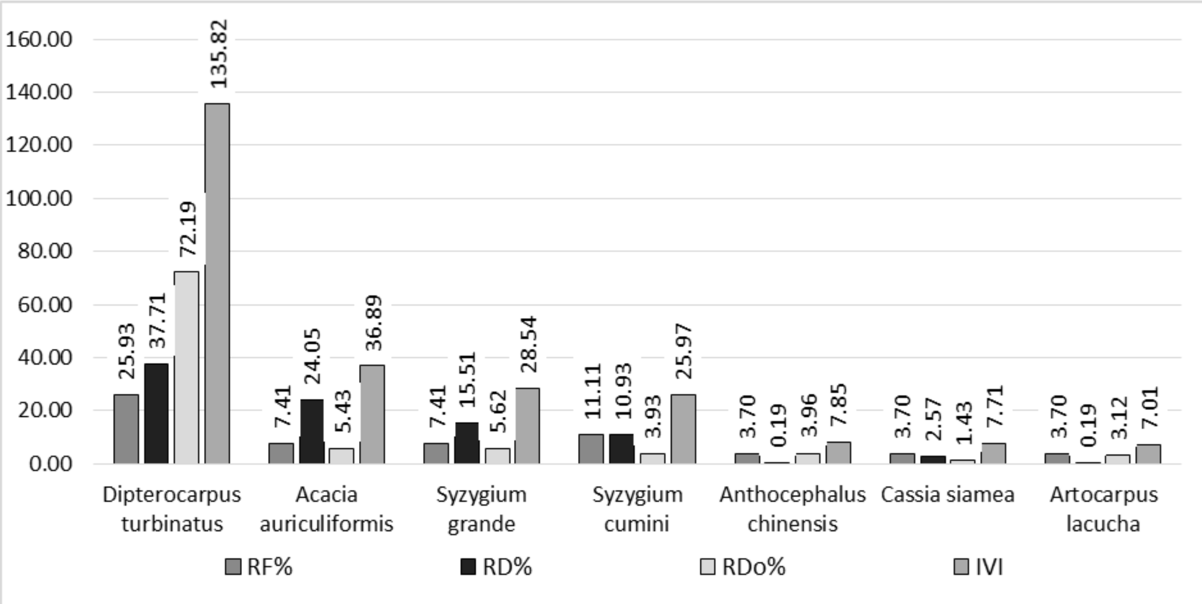

Figure 4. Relative frequency, Relative density, Relative dominance, and IVI of the top 7 tree species in the study area

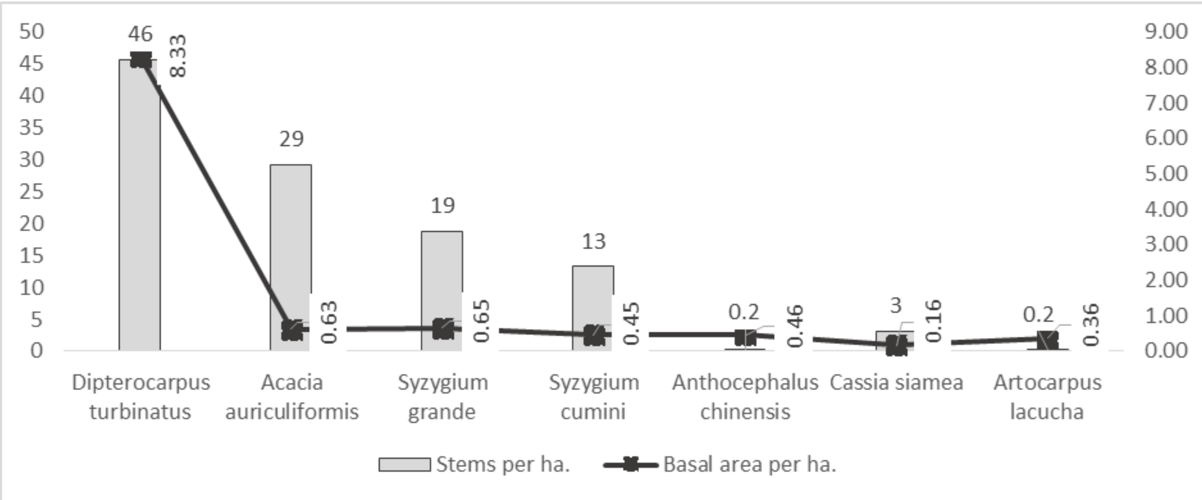

Figure 5. Stem density and Basal area per ha. of the top 7 tree species in the study area

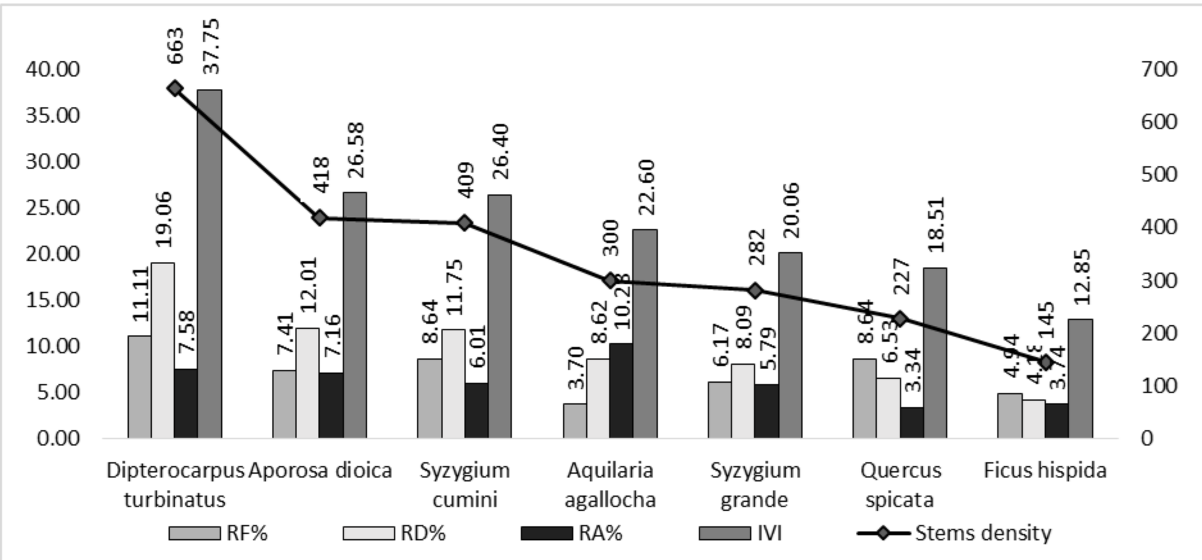

Figure 6. Stem density, Relative frequency, Relative density, Relative abundance, and IVI of the top 7 regeneration species in the study area

Quantitative Structure of Naturally Regenerated Seedling

Thirty tree species have shown regeneration in the study area. *Dipterocarpus turbinatus* has the highest regeneration status with 663 stems ha^{-1}, followed by *Aporosa dioica* (418), *Syzygium cumini* (409), *Aquilaria agallocha* (300), and *Syzygium grande* (282). These five species represent about 60% of the total regeneration. The study showed that *Dipterocarpus turbinatus* has the highest relative frequency (11.11%), followed by *Quercus spicata* (8.64%), *Syzygium cumini* (8.64%), and *Aporosa dioica* (7.41%). The highest relative density was found in *Dipterocarpus turbinatus* (19.06%) followed by *Aporosa dioica* (12.01%), *Syzygium cumini* (11.75%), and *Aquilaria agallocha* (8.62%). Relative abundance was highest in *Aquilaria agallocha* (10.28%), followed by *Dipterocarpus turbinatus* (7.58%), *Aporosa dioica* (7.16%), and *Syzygium cumini* (6.01%). The IVI was also highest in *Dipterocarpus turbinatus* (37.75), followed by *Aporosa dioica* (26.58), *Syzygium cumini* (26.40), and *Aquilaria agallocha* (22.60). Regeneration of the following five species was not found in the study: *Anthocephalus chinensis, Bauhinia acuminate, Dipterocarpus alatus, Ficus benghalensis, and Litsea glutinosa.* The stem density, relative frequency, relative density, relative dominance and IVI of the top 7 regeneration species have been shown in Figure 6.

Discussion

The study reveals the poor forest condition of Cox's Bazar North forest division. Usually, tropical forests are species rich with low frequent occurrence (Pitman et al. 1999). However, the study has found more than 50% of species were comprised of only one individual and more than 60% of total population were represented by two species.

The species diversity of the study area (H= 1.735) is lower than some tropical forests. According to other studies, the Shannon–Wiener diversity index of tropical rainforests of Xishuangbanna, China and tropical moist forests of Mizoram, northeast India were 3.45, 4.08 and 4.37 respectively (Devi et al. 2018; Lü et al. 2010). Same conditions can be observed in other forest areas of Bangladesh, where the index values were as follows: Fashiakhali WS 2.06, Sitapahar RF 2.98, Chunati WS 3.27-3.58, and Dudhpukuria-Dophachari WS 4.45 (Das et al. 2018; Hossain & Hossain 2014; Hossain et al. 2013; Nath et al. 2000). These values suggest the poor condition of species diversity in the forest division.

The stem density is severely affected by natural and anthropogenic disturbances. In 1988, Haque and Alam recorded 215 stems ha^{-1} in Cox's Bazar forest division (Haque & Alam 1988), which was much higher than the present stem density 121 stems ha^{-1}. It is lower than the density range 245– 859 stems per hectare for tropical forests as suggested by Campbell (Campbell et al. 1992). The basal area of the study area (11.53 m^{2}h^{-1}) is also lower than other tropical forests, i.e. in tropical rain forest of western India 30.87 m^{2}h^{-1}, in tropical forest Malaysia 32-51 m^{2}h^{-1} (Sha 1990; Swaine et al. 1987).

Due to human intervention, the establishment of new seedlings and their transition to mature stands are very poor. If this continues, the local species diversity will decline followed by the introduction of exotic species. The native people are dependent on the forest for fuel woods and other non-timber products and are often ignorant of the adverse effect this trend of logging on the forest. Regulations on logging operation and illegal felling can ensure recovery of forest structure, though it may take a long time and supports from local people. A well-developed management system and enrichment programs can further ensure the achievement of the desired goal.

CONCLUSION

Tree composition and their regeneration status show the overall well-being of the local forest community. The overall aim of the study was to provide quantitative structure of tree composition and regeneration status of southeastern Bangladesh. A total of 17 tree species (having dbh 10 cm or above) and 30 regenerating tree species were found in the study area. The study has revealed that the species diversity (H= 1.735) and stem density (121 stems ha^{-1}) of Cox's Bazar North forest division were lower than some of the tropical forests of Southeast Asia. The forests were largely populated by young trees with 10-30cm dbh (~90% of total density), though trees with dbh 100 cm or above hold more than 80% of the total basal area. A quick decline in stem density after reaching dbh 30 cm has been witnessed, due to illegal felling. *Dipterocarpus turbinatus* was the most valued species for both mature stand and regeneration composition. Effective and timely measures should be taken to conserve the forests using the latest technologies and adaptable management system. Planning forest policies and decision-making requires up-to-date information on forests and land uses, which can be obtained through continuous assessment and monitoring system. The study may be helpful for the future implementation of forest inventory and silvicultural techniques. This study may pave the way for further research on regeneration potentials of the native species for conservation and enhancement of forests in the future.

DECLARATION OF INTEREST

The authors confirm that there are no known conflicts of interest associated with this publication and there has been no financial support for this work that could have influenced its outcome.

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