# Natural Regeneration and Diversity of the Tree Species at Satchari National Park in Bangladesh

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**Abstract**

Natural regeneration is the basic stage of forest dynamics which helps in the recovery of ecosystem functions. Therefore, the future of a forest ecosystem depends on proper knowledge on the regeneration status and composition of tree species. Based on regeneration data collected from a total of 50 sample plots, this study aimed to explore the diversity and composition of the naturally regenerating tree species at Satchari National Park (SNP), a protected area with high conservation priority in Bangladesh. We found a total of 31 species belonging to 20 families. Moraceae was the dominant family with three species. Artocarpus chaplasha was the dominant regenerating species of the forest. On the contrary, Terminalia bellirica, Anthocephalus chinensis and Tectona grandis showed the lowest regeneration success. We found most of the regenerating species were shade intolerant and indigenous. The findings of this study can play an important role in selecting appropriate tree species for future plantation programs in the Satchari National Park.

**Keywords:** Relative Density, Regeneration Density, Relative Frequency, Relative Abundance, Importance Value Index.

## 1. Introduction

Geographically, Bangladesh belongs to the transitional zone of the Indian subcontinent and Southeast Asia. Again, it is situated in the Indo-Burma biodiversity hotspot renowned globally for its plentiful flora and fauna (Myers et al., 1998, Stanford, 1991). Approximately, 3, 723 species of angiosperms propagate in Bangladesh (Rahman et al., 2019). Researchers and activists claimed that the rate of deforestation of the tropical forests in Bangladesh accelerated at an alarming rate over the last few decades due to anthropogenic occurrences and other environmental disturbances like fire, encroachment, illegal felling etc (Rahman et al., 2019, Reza and Hasan, 2019). The impacts of both abiotic and biotic disturbances negatively affect the natural regeneration and population dynamics of these tropical forests (Kwit and Platt, 2003, Shafroth et al., 2002).

Natural regeneration is a slow and unpredictable process. It is the prior criteria for the natural conservation and restoration process (Chazdon and Guariguata, 2016). It occurs through the complex interaction between the seedling establishment and site factors such as soil, water, temperature etc. (Pardos et al., 2005). Natural regeneration gained attention after 1980 when the foresters were more curious about natural things and with time it became more popular day by day (Varga et al., 2015). But due to the gap of proper knowledge and experience on regeneration, most of the natural regeneration was unsuccessful. Also, restocking by natural regeneration was unsatisfactory in most cases (Harmer et al., 2004). The long-term sustainability of a forest can be triggered by successful regeneration (Malik and Bhatt, 2016). Therefore, a clear idea about natural regeneration status and composition is inevitable.

The quantitative and qualitative features of the plant population depict a clear picture of the forest. It indicates the satisfactory regeneration behavior, inadequate number of regeneration species, their future patterns and quality (Malik and Bhatt, 2016). Furthermore, it is a vital issue to predict the future of a forest by delineating the succession process and management (Rahman et al., 2019). Researchers carried out different studies about status and diversity of regeneration of different forest. Such as the natural forests located in the Durgapur and Netrokona districts have the minimum number of natural regeneration of tree species about to with concerning the other parts of Bangladesh. Grewia nervosa and Shorea robusta are dominating in these regions (Rahman, et al., 2020). Dudhpukuria-Dhopachori wildlife sanctuary of Chattogram division has higher species diversity belongs to around 36 families. The frequency of Euphorbiaceae and Moraceae families is very common over the others (Hossain, et al., 2013). Furthermore, the Baraitali Forest of Chunati Wildlife Sanctuary, also located in Chattogram is more diverse in species number and differences than the other part of Bangladesh (Hossain et al., 2004). Sitakunda Botanical Garden and Eco-park of Chattogram has identified species from 43 families (Nandi and Vacik, 2014). In the Sundarbans reserve forest of Bangladesh, Heritiera fomes is the major regeneration species in the oligohaline zone (Kamruzzaman et al., 2017). In some studies in the northern part of Bangladesh, Moraceae and Meliaceae were found to be the dominant families (Rahman et al., 2011, Haider, et al., 2018). However, we have a limited understanding of the natural regeneration status in the protected areas in Bangladesh, particularly, the Satchari National Park (SNP) which is a conservation priority area in Bangladesh. In particular, the scarcity of basic regeneration information such as the proportional abundance of plantation and native plant species across the forest patches has been impeding the reforestation activities of the Bangladesh Forest Department. Therefore, the overarching aim of this study was to uncover the status of natural regeneration and diversity of the naturally regenerating tree species at the Satchari National park. In addition, we demonstrated the silvicultural characteristics (i.e. light requirement) and conservation status of the naturally regenerating tree species.

## 2. Methodology

### 2.1 Description of Study area

The selected study site was Satchari National Park (SNP, N 24°5'- 24°10' and E 91°25' - 91°30') which is a part of the Raghunandan Hill Reserve Forest. It is located in the North-East part, specifically at the Chunarughat Upazila of Habiganj districts in Bangladesh (Figure 1). We prioritize the forest as our study site because of its unique biodiversity and geographical features. The National Park covers an area of 243 ha is surrounded by a few tea gardens, cultivated lands villages and towns. Hillocks, locally known as tillas, are scattered throughout the landscape and their altitudes range from 10-50 meters. The SNP forms an important part between the Indian subcontinent and the Indo-Chinese ecological region (Arefin et al., 2011). . The average annual rainfall is 4,162 mm, the maximum temperature is 32°C and minimum temperature is 12°C. Several streams drain the forest during the rainy season. The relative humidity ranges between 74% to 90% (Parvez Rana et al., 2010). The soil of SNP area are sandy loam, and humus accumulation is very low due to the rapid decomposition of debris, more acidic than the surrounding ecological zone (Akhter et al., 2009). The forest is semi-evergreen and mixed evergreen, where the tall tree is deciduous and the under-story evergreen. It is originally supported by both indigenous species namely Piper longum, Artocarpus chaplasha, Artocarpus lacucha, Ficus hispida, Ficus racemosa, Streblus asper, Castanopsis castanicarpa, Achyranthes aspera etc and exotic species are Swietenia Mahagoni, Bombax ceiba, Tectona grandis, Lagerstromia speciosa, Acacia auriculiformis etc. SNP has become a secondary forest due to the substantial alteration of the original forest except for 200 ha of natural forest (Mukul et al., 2010).

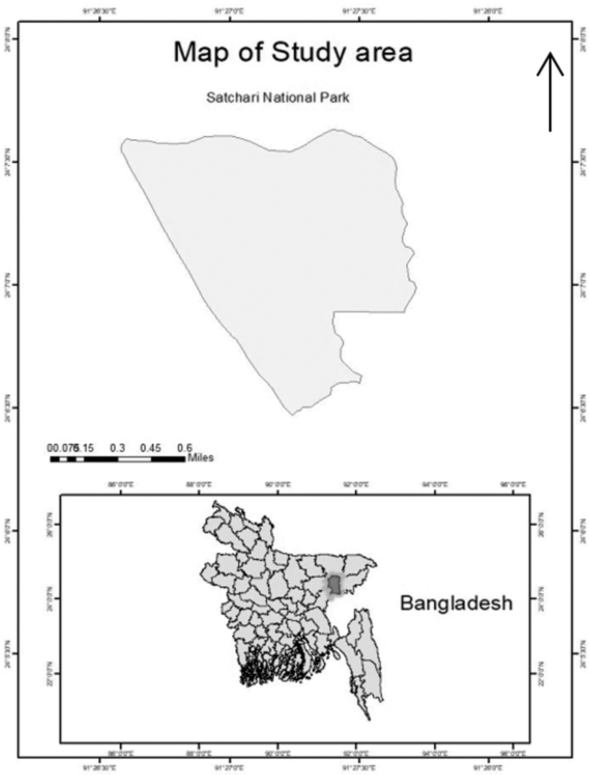


Figure 1: Study area

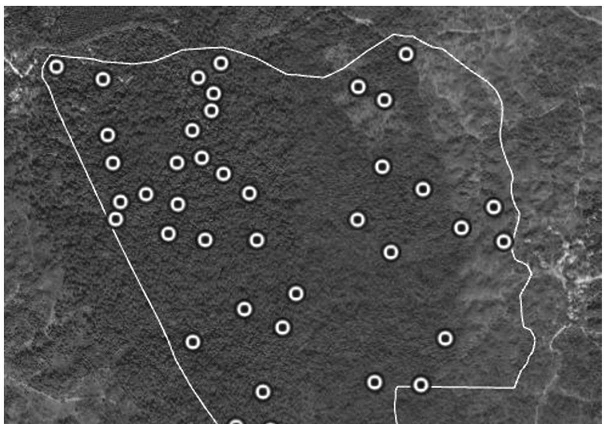

Figure 2: Map indicating the plots taken during the study

## 2.2 Sampling

A total of 50 sampling plots were selected at random with the help of Arc GIS software (Version 10.7) to represent the existing forest types (Gupta et al., 2019) at SNP during December 2019 to February 2020 (Figure 2). The sampling size was determined by constructing Species Area Curves (Conor and McCoy, 2017). Each plot was 20 x 20m in size. All tree regeneration (height ≤ 1m) counts were taken from five 2m × 2m sub-plots, placed at each corner of the main plot and one at the center.

## 2.3 Phyto-Sociological attributes of the regeneration

We calculated density, relative density, frequency, relative frequency, abundance, relative abundance, the indigenous or exotic species status of a species, Important Value Index (IVI), Species richness and Species diversity, either the species is light demanding or not and their conservation status. For calculating IVI, we used the formulas describes by Shukla and Chandal (2007) (Table 1), and for estimating species richness and diversity, we followed the formulas mentioned in Rahman et al. (2020) (Table 2).The light demanding and conservation status of species are collected from different articles (Rahman et al., 2020, Uddin, et al., 2011) and IUCN red list portal.

Table 1: The list of the formulae used for calculating the phyto-sociological characters of the vegetation

| No. | Formulae |
|---|---|
| 1 | Density of a species (Seedlings/ Plot) = (Total no. of individual of a spp. in all the quadrat)/ (Total no. of quadrat studies ) |
| 2 | Relative Density (RD)= (Total no of individual of the sp p.)/(Total no of individuals of all the sp p.) x100 |
| 3 | Frequency of a Species(F) = (Total no of individual of quadrats in which spp. occurs)/(Total no of quadrat studied) |
| 4 | Relative Frequency (RF) = (Frequency of one spp.)/(Total frequency) × 100 |
| 5 | Abundance of a species (A) = (Total no of individual of a spp. in all the quadrats)/(Total no of quadrats in which the spp. occurred) |
| 6 | Relative Abundance (RA) = (Abundance of one spp.)/(Total abundance) × 100 |
| 7 | IVI=Relative Density + Relative Frequency + Relative Abundance |

Table 2: The list of the formulae used for calculating the diversity indices of the vegetation

| no. | Description |
|---|---|
| 1 | Species Diversity Index, $S_{Di}$ = S/N |
| 2 | Margalef's Species Richness Index, R = (S-1)/ Ln (N) |
| 3 | Shannon- Winner diversity Index, H= $-\sum_{i=1}^{n}$ Pi ln Pi |
| 4 | Shannon maximum diversity index, $H_{max}$= Ln(S) |
| 5 | Species evenness index, E= H/ Ln (S) |
| 6 | Simpson's diversity index, D= $1/\sum_{i=1}^{n} P_i^2$ |
| 7 | Dominance of Simpson's index, $D_0$=1-D |

Where, S= Total number of species, N= Total number of individuals of all the species, Pi = No. of individuals of one species/Total no. of individuals in all the samples, H= Shannon-Winner's diversity index

## 3. Results and discussion

### 3.1 Qualitative characteristics

We found a total of 863 populations of 25 species belonging to 20 families (Table 3). Six species could not be identified by their local name due to lack of authentic resources. Among the 20 families, Moraceae was the most dominant family (3 species) where 2 species were notified individually from Fabaceae, Verbenaceae and Rubiaceae. The rest of the families had only one species. Among the species 6 were exotic (*Falcataria moluccana, Suregada multiflora, Lagerstromia speciosa, Pithecellobium angulatum and Adansonia digitata*) and the rest 19 were indigenous to the south Asian region specifically in Bangladeshi origin. We observed that most of the regeneration species of SNP were shade intolerant by their nature. The number of shade tolerant species was very low.

According to conservation status, 1 species of them was critically endangered, 1 species was endangered, 3 species were vulnerable, 5 species were not extinct, 7 species were on the least concern, and others were not evaluated (Table 3). Our outcomes were validated by different published articles based on different research objectives (Uddin, et al., 2011, Arefin et al., 2011).

Table 3: Family composition, exotic or individual and the conservation status of tree species of SNP

| Scientific name (Local Name) | Family | Indigenous/ Exotic | Shade Tolerant | Conservation Status | Density (seedling/ha) | RD (%) | RA (%) | RF (%) | IVI |
|---|---|---|---|---|---|---|---|---|---|
| *Achyranthes aspera* (Apang) | Amaranthaceae | I | M | Not Extinct | 160 | 3.01 | 2.34 | 5.00 | 10.35 |
| *Aquilaria agallocha* (Agar) | Thymelaeaceae | I | M | Vulnerable | 20 | 0.23 | 1.98 | 0.45 | 2.66 |
| *Vitex peduncularis* (Awal) | Verbenaceae | I | SI | Not Evaluate | 90 | 1.04 | 1.78 | 2.27 | 5.10 |
| *Falcataria moluccana* (Batai) | Fabaceae | E | SI | Not Evaluate | 190 | 2.20 | 18.79 | 0.45 | 21.45 |
| *Elaeocarpus floribundus* (Belpoi) | Elaeocarpaceae | I | M | Endangered | 150 | 1.74 | 2.47 | 2.73 | 6.94 |
| *Terminalia bellirica* (Bohera) | Combretaceae | I | SI | Least Concern | 10 | 0.12 | 0.99 | 0.45 | 1.56 |
| *Neolamarckia cadamba* (Bon kadam) | Rubiaceae | I | SI | Not Evaluate | 50 | 0.58 | 2.47 | 0.91 | 3.96 |
| *Citrus hystrix* (Bon lebu) | Rutaceae | I | SI | Not Evaluate | 90 | 1.04 | 1.48 | 2.73 | 5.25 |
| *Walsura robusta* (Bon lichu) | Meliaceae | I | SI | Vulnerable | 70 | 0.81 | 3.46 | 0.91 | 5.18 |
| *Moringa oleifera* (Bonag) | Moringaceae | I | SI | Not Extinct | 360 | 4.17 | 2.37 | 6.82 | 13.36 |
| *Suregada multiflora* (Ban-naranga) | Euphorbiaceae | E | SI | Critically Endangered | 20 | 0.23 | 1.98 | 0.45 | 2.66 |
| *Hydnocarpus kurzii* (Calmugra) | Flocourtiaceae | I | M | Vulnerable | 20 | 0.23 | 0.99 | 0.91 | 2.13 |
| *Artocarpus chaplasha* (Capalish) | Moraceae | I | SI | Not Evaluate | 1870 | 21.67 | 5.97 | 14.09 | 41.73 |
| *Ficus recemosa* (Dumur) | Moraceae | I | M | Least Concern | 1690 | 19.58 | 5.22 | 14.55 | 39.35 |
| *Syzygium cumini* (Jam) | Myrtaceae | I | M | Least Concern | 1760 | 20.39 | 5.80 | 13.64 | 39.83 |
| *Lagerstromia speciosa* (Jarul) | Lythraceae | E | SI | Least Concern | 80 | 0.93 | 3.96 | 0.91 | 5.79 |
| *Pithecellobium angulatum* (Kaimulla) | Fabaceae | E | SI | Not Evaluate | 50 | 0.58 | 4.95 | 0.45 | 5.98 |
| *Tabernaemontana devaricata* (Kakra) | Apocynaceae | I | M | Not Extinct | 300 | 3.48 | 1.98 | 6.82 | 12.27 |
| *Anthocephalus chinensis* (Kadam) | Rubiaceae | I | SI | Least Concern | 20 | 0.23 | 1.98 | 0.45 | 2.66 |
| *Adansonia digitata* (Mali) | Malvaceae | E | SI | Not Extinct | 130 | 1.51 | 2.57 | 2.27 | 6.35 |
| *Mangifera indica* (Mango) | Anacardiaceae | I | SI | Least Concern | 60 | 0.70 | 2.97 | 0.91 | 4.57 |
| *Calamus tenuis* (Rata) | Arecaceae | I | S | Least Concern | 150 | 1.74 | 2.97 | 2.27 | 6.98 |
| *Streblus asper* (Shewra) | Moraceae | I | SI | Least Concern | 70 | 0.81 | 2.31 | 1.36 | 4.48 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *Tectona grandis (*Segun) | Verbenaceae | E | SI | Not extinct | 10 | 0.12 | 0.99 | 0.45 | 1.56 |
| *Albizia procera (*Sil koroi) | Mimosoideae | I | SI | Not Evaluated | 20 | 1.23 | 1.98 | 0.45 | 2.66 |
| Unidentified 1 (Alopathic) | | | | | 430 | 4.98 | 3.04 | 6.36 | 14.38 |
| Unidentified 2 (Biscuit) | | | | | 200 | 2.32 | 2.83 | 3.18 | 8.33 |
| Unidentified 3 (Dahuk) | | | | | 90 | 1.04 | 1.78 | 2.27 | 5.10 |
| Unidentified 4 (Guti cara) | | | | | 30 | 0.35 | 1.48 | 0.91 | 2.74 |
| Unidentified 5 (Pepti) | | | | | 70 | 0.81 | 2.31 | 1.36 | 4.48 |
| Unidentified 6 (Picli) | | | | | 270 | 3.13 | 3.82 | 3.18 | 10.13 |

I=Indigenous, E= Exotic, S= Shade tolerant, M= Moderate shade tolerant, SI= Shade Intolerant

### 3.2 Quantitative characteristics

To know the family status of regenerating species we calculated the Family relative density (FRD), Family relative diversity (FRDI) and Family importance value (FIV) of the families. According to the quantitative data of the regeneration species of SNP, Moraceae was the dominant family which has 359 individuals belonging from 3 species followed by Myrtaceae family with 161 individuals. Other families showed very little regeneration rate. Family relative density and Family relative diversity were also high in both of these families.

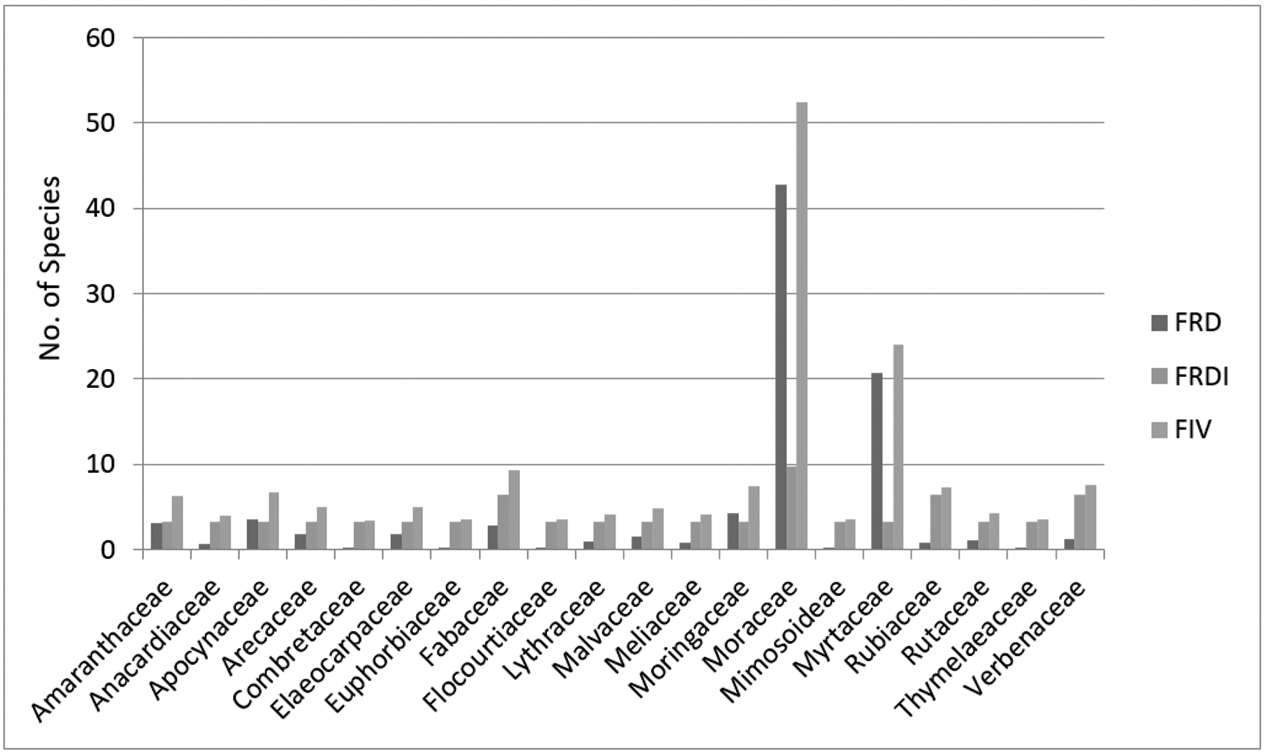


Figure 3: Family composition, Family Relative Density (FRD), Family Relative Diversity Index (FRDI), and Family Importance Value Index (FIV) of the regenerating species in SNP.

For Moraceae, Family relative density was 42.81% and Family relative diversity index was 9.68%compare to Myrtaceae where Family relative density was 20.75% and Family relative diversity index was 3.23% (Figure 3). Similarly, Moraceae had the highest rate of Family importance value of 52.48% followed by Myrtaceae (23.98%). On the contrary, Euphorbiaceae, Flocourtiaceae, Mimosoideae and Thymelaeaceae had second lowest family relative densities of 0.24% and Combretaceae family had the lowest Family relative density of 0.12% (Figure 3). The result of the study concluded that *Artocarpus chaplasha* had the highest number of regeneration species (1870 seedlings) and *Syzygium cumini* had 1760 seedlings per hactare (Table 3). This investigation of the regeneration status strongly supports the previous study done by other researchers in the same region (Haider, et al., 2018, Rahman et al., 2011). Haider, et al., (2018) found 70 regenerating species from 31 families and *Artocarpus chama* had the maximum IVI of 21.60%. Rahman et al.,( 2011) found 55 species from 28 families and *Tectona grandis* had the highest percentage of IVI (29.66%). Unlike these, the study in the Baraitali Forest, Chunati Wildlife Sanctuary and Sitakunda Botanical Garden and Eco-park found a number of variety regeneration species 66% and 61% respectively (Hossain et al., 2004, Nandi and Vacik, 2014) On the other hand, the regeneration status of Dudhpukuria- Dhopachori wildlife sanctuary of Chattogram was not so rich (only 36 families of regeneration) other than the previously cited two forests (Hossain, et al., 2013).

### 3.3 Relative Density

*A. chaplasha* had the highest relative density than others. This species had 21.67 % relative density as the seedlings per hectare of this species. The other two species from Moraceae family *Ficus recemosa* and *S. cumini* had shown relative density of 19.58% and 20.39% respectively (Table 3). On the other hand, *Terminalia bellirica* and *T. grandis* (0.12%) had the lowest relative density among the species. *Aquilaria agallocha, Suregada multiflora, Hydnocarpus kurzii, Anthocephalus chinensis* were also low in percentage of relative density which is only 0.23%. The species locally called Alopathic, Picli and Biscuit showed a good density in regeneration.

### 3.4 Relative Abundance

Unlike relative density, relative abundance was highest in *F. moluccana* (18.79%) followed by *A. chaplasha* (5.97%), *S. cumini* (5.80%) *F. recemosa* (5.22%). But this rate was lowest in three species called *T. bellirica*, *H. kurzii* and *T. grandis* which were 0.99% only (Table 3).

### 3.5 Relative Frequency

In the case of relative frequency, *A. chaplasha, F. recemosa* and *S. cumini* showed highest result (above 13%). Among the three F. recemosa was highest frequent than others that is 14.55%. This time lots of species showed lowest and same result of 0.45% namely *A. agallocha, F. moluccana, T. bellirica, Suregada multiflora, Pithecellobium angulatum, Anthocephalus chinensis, T. grandis* and *Albizia procera* (Table 3).

### 3.6 Important Value Index (IVI)

*A. chaplasha, S. cumini* and *F. recemosa* were recorded 41.73%, 39.83% and 39.35% respectively importance value index in SNP (Table 3). The species *F. moluccana* showed a satisfactory result than other species in the study site. On the other hand, *T. bellirica* and *T. grandis* did not show the successful result as importance Value Index. But previous studies mentioned *T. grandis* as the most important species in some regions (Rahman et al., 2011, Alamgir and Al-Amin, 2007). Although Haider, et al. (2018) suggested *A. chama* was the highest important value index species. Along with this result, different studies on different sites in Chattogram division found varieties of species e.g. *Lepisanthes rubiginosa, Acacia auriculiformis, Dipterocarpus turbinatus* were important based on important value index (Hossain et al., 2019, Rahman et al., 2020, Hossain et al., 2013). Among the six unknown species, Alopathic and Picli were showed 14.38% and 10.13% respectively important value index than the other four (Table 3).

### 3.7 Biological Diversity indices in Satchari National Park

With the help of the different biological diversity indices we can determine the diversity of the ecosystem of that area. It is also the foremost criteria to select any ecosystem for biodiversity conservation. Haider, et al. (2018) found promising biodiversity at Moulvibazar, Sylhet with Margalef's species richness index (5.645), Shannon- Winner diversity index (3.22) and Species evenness index (0.859 out of 1). Rahman et al. (2011) concluded that the study sites they mentioned are adequate and specific. According to Margalef's species richness index (4.44) SNP is rich in biodiversity. Species evenness index (0.72 out of 1) depicts the area was diverse. From the value of the species diversity index (0.046), Shannon- Winner diversity index (2.47) indicates that the place had rich species distribution (Figure 4). The present study reveals that the northern forest part like Sylhet region of Bangladesh is not that much diverse than the eastern part like Chittagong zone because the studies taken places in the eastern part showed a higher range of diversity (Ahmed, et al., 1992, Hossain, et al., 2013, Hossain et al., 2004, Hossain et al., 2019).

Considering the factors like Family importance value, Species important value index and diversity indices and based on our analysis, we can conclude that SNP is low diverse.

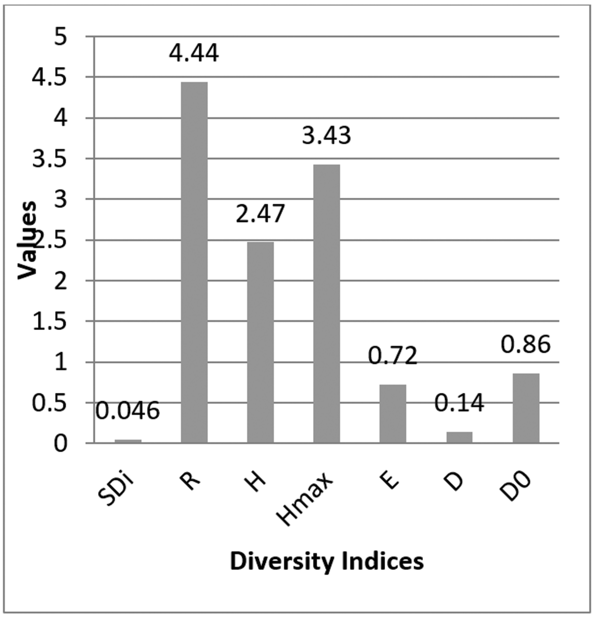


Figure 4: Different Biological Diversity Indices in SNP. [Here, SDi = Species Diversity Index, R = Margalef's Species Richness Index, H= Shannon Winner diversity Index, Hmax= Shannon maximum diversity index, E= Species evenness index, D = Simpson's diversity index, D0= Dominance of Simpson's index].

### 3.8 Implication for Forest Management

The main objective of natural regeneration is to replace exploited tress by juveniles that are compatible for the ecosystem of a particular forest. It helps to reduce logging impacts on a forest (Sarker et al., 2011). The result of the study will help to understand the right choice of species which are suitable for the forest according to the site. The aim behind the native and exotic criteria was to promote native species and their regeneration. Our results demonstrate that species specific light requirements in decision making for selecting the plantation of tree species. Again, the findings on species conservation status will help to understand which species need more concern in future conservation/protection initiatives. For example, the mother trees of the locally endangered species require immediate protection to ensure future seed sources. Our overall results on the species-wise composition and regeneration diversity will help forest managers to anticipate the future forest structure in advance, thus providing useful information for preparing effective management plan for the SNP.

## 4. Conclusion

SNP is an important forest in Bangladesh. Our results suggest that the area is rich in regeneration diversity. Moraceae and Myrtaceae are the two influential families. *A. chaplasha, F. recemosa* and *S. cumini* are dominating the regeneration tree communities, implying a better status of indigenous species compared to the exotic species. We found most of the regenerating species were shade intolerant and indigenous. Our results on diversity, composition, silvicultural characteristics and conservation status of the regenerating tree species will help forest managers in preparing efficient plantation programs and also in designing pragmatic management plan for the SNP. However, this study could not relate the influence of the abiotic and biotics factors with the current regeneration status because of data unavailability. Hence, future studies should focus on these and should also account for the impacts of human interference and natural disturbance on the regeneration ability of both indigenous and exotic flora in the SNP.

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