1. Introduction

The Chittagong Hill Tracts (CHTs) consist of three hilly districts—viz. Rangamati, Khagrachari, and Bandarban of Bangladesh, a part of the Himalayan region, covered with natural forests, which makes up nearly 40% of the total forests cover of the country (Ahammad & Stacey, 2016). This forest rich area has been degraded since the British colonial period due to the nationalization of forest, establishment of reserve forests, government-induced management system, and weakening of traditional institutions (Rasul, 2007). Presently, unsustainable land use leads CHTs to an environmentally imbalanced situation. Four visible land uses of CHTs are shifting cultivation (locally known as Jhum), agroforestry, orchards, and village common forest (VCF). Indigenous people practices Jhum and VCF traditionally, and the rest two has been introduced recently (Khibria, Inoue, & Nath, 2015). Jhum, agroforestry, and orchards are the outcomes of economic consideration with a little consideration for environment and nature.

However, VCF in CHTs is a pattern of community-led forest management approach and the model of sustainable forest management without government intervention. VCFs in the CHTs are fall under the unclassified state forests where customary rules and regulation by the indigenous people are followed for effective management activities (Baten, Khan, Ahammad, & Missbahuzzaman, 2010; Jashimuddin & Inoue, 2012; Miah & Ahmed, 2014). It refers to the forest lands outside the reserve forests in CHTs and managed by village community through informal indigenous rules (Haque & Myant, 2011; Nath, Jashimuddin, & Inoue, 2016). Indigenous people in the CHTs have been managing VCFs sustainably for at least 200 years (Nath et al., 2016) which have ecological, economic, and cultural importance (Baten et al., 2010). According to Haque and Myant (2011), VCF indicates any forest area in CHTs used and managed in a collective system, generally known as a “common” property, irrespective of legal classification of land. Their management has set a standard model for the sustainable protection of biodiversity, environment, and natural resources in CHTs (Jashimuddin & Inoue, 2012). The motivational factors behind the conservation of VCFs are the source of fresh water, medicinal plants, wood, and bamboo. Apart from these, VCFs are considered as the part of their religious and cultural ceremony (Baten et al., 2010; Haque & Myant, 2011).

VCFs are the main and sustainable source of wood, bamboo, medicinal plants, fuelwood, wild fruits,
other biomass for the hilly people (Haque & Myant, 2011; Jashimuddin & Inoue, 2012). Different floral and faunal species having versatile uses have been attached as Supplementary Appendix 1 in the supplements. Among the forest products, bamboo is used in highest amount by tribal community for household uses as well as generation of income (Haque & Myant, 2011; Jashimuddin & Inoue, 2012; Misbahuzzaman & Smith-Hall, 2015). However, the number of VCFs in CHTs is not consistent since some VCFs are diminishing whereas some new community managed forests are declared as VCF. Saha (2010) described that there are around 700–800 VCFs in CHTs. But, during our recent visit local elites engaged in VCF management informed that at present there are about 390 VCFs in CHTs. The area of VCFs ranged from 8 to 202 ha. The management system does not follow homogenous structure throughout the CHTs. VCF management in Rangamati is conducted by Headman (Mouza head) or Karbari (Village head). Meanwhile, in Bandarban and Khagrachari, VCF management followed a structural manner in which besides the Headman or Karbari other prominent figures (e.g. teachers, local government servant, journalists, etc.) of the society are included as well (Haque & Myant, 2011).

Biodiversity is a complex idea which has been evolved in the recent times. Plant biodiversity is a very obscure understanding which represents heterogeneity and great variation. Measuring species richness is vital to determine the importance of an area for biodiversity conservation (Rahman, Khan, Roy, & Fardusi, 2011). Diversity indices are known as the bio-indicators in the aquatic and terrestrial environments for different studies (Giavelli, Rossi, & Sartore, 1986). At present, the biodiversity of VCFs is under tremendous anthropogenic pressures due to rapid population growth and shift in land use change. VCFs are small in size but support richer biodiversity than any government managed forest and harbor rare plant and animal species (Basak, Mohiuddin, & Alam, 2014; Baten et al., 2010). Islam, Jashimuddin, and Hossain (2017) conducted a study in two VCFs of Bandarban district to trace out the status of biodiversity. They found that the density and basal areas are 354 stem/ha and 52.63 m²/ha, respectively. Basak et al. (2014) found a total of 148 plant species belonging to 128 genera under 61 families from a VCF covering only 20 ha area. These findings are the testimony that the biodiversity status of VCFs is still better than the government managed forests (Hossain, Hossain, Salam, & Rahman, 2013; Nath, Jashimuddin et al., 2016; Rahman et al., 2011; Rahman, Mahmoud, & Ahmed, 2017; Rahman, Mahmoud, Shahidullah, Nath, & Jashimuddin, 2016).

However, there are only a few studies regarding biodiversity status of VCFs. That's why it largely hinders policy formulation process regarding biodiversity conservation of community managed forests in CHTs. Furthermore, it is necessary to understand the present scenario of biodiversity status of each VCF and that is why rampant research work is required. This research work will help different stakeholders including policy makers, local government authorities and tribal communities to take actions to conserve VCFs in hilly areas of Bangladesh. Following the concern, we undertook this study to reveal an overall view of forest structure and biodiversity status of the Komolchori VCF to enhance future course of action regarding biodiversity conservation in CHTs. Therefore, this study aims (i) to assess the tree composition and structure of the Komolchori VCF and (ii) to compare the diversity indices of Komolchori VCF with other state-managed forest of the country.

2. Materials and methods

2.1 Study site

The study was conducted in the Komolchori VCF (locally known as reserve) area in Buarchari Mouza (Mouza no. – 264), Khagrachari Sadar (Figure 1) during June 2014 to December 2015. Komolchori VCF is situated about 5 km away from the village Komolchori. The area of this forest is 127.88 ha. The VCF area is surrounded by two Tripura villages known as Thana Chanra Para and Jadu Ram Para. Geographically, the VCF is located between latitude 23.5’ to 23.6’ North and longitude 91.1’ to 92.2’ East.

The geo-location of the Khagrachari district is latitude 22.38’ to 23.44’ North and longitude 91.42’ to 92.11’ East. The district is surrounded by Tripura of India in North-North-West, Rangamati district in East-South-East, Chittagong district in South West and Feni river & part of Tripura of India in west side. The annual average temperature of the district ranged from highest 34.6°C to lowest 13°C and the average annual rainfall is 3031 mm (Banglapedia, 2018). The topography of the area is mostly hilly with irregular plain land. It has a mild tropical climate with a little variation of temperature and rainfall. Rainfall is the heaviest during the monsoon period starting from June till October.

2.2 Data collection and analysis

Tree species was surveyed in the study area to assess the structure, composition, and biodiversity status. As the study area falls under the category of natural forest, the minimum quadrat size was determined to be 10 m × 10 m. A total of 25 randomly selected plots (nearly 0.20% sampling intensity) were surveyed. In each plot, dbh (diameter at breast height; 1.3 m above the ground) and height of all the trees having dbh ≥ 10 cm were recorded. All the tree species in the plots were identified and recorded by local and scientific names. In case of unknown species, plant samples
were collected to identify through consulting with taxonomists. Pasha and Uddin (2013) was followed to nomenclature all the recorded tree species.

The value of diversity has a proportional impact on the stability of a plant community (Rahman et al., 2011). There are many indices available which measure species richness and biodiversity. In this study, different phytosociological attributes were calculated for all the plots. These are species relative density, relative frequency, relative abundance, relative dominance, and importance value index (IVI) (Table 1). Besides, biodiversity indices such as Shannon’s index, Simpson’s diversity index, species evenness index, etc., for the Komolchori VCF were excerpt from published articles and compared it with the findings of other government managed forests of the country.

3. Results

3.1 Phytosociological characteristics of the tree species

The tree species survey in the Komolchori VCF recorded 55 species belonging to 47 genera and 31 families. Among all the families Malvaceae (6 species) contained the highest number of tree species followed by Fabaceae (5 species), Combretaceae (3 species), Euphorbiaceae (3 species), Lauraceae (3 species), Moraceae (3 species) and Rubiaceae (3 species) (Table 2). It is noteworthy to mention here that we were not able to identify the scientific name as well as the family name of Rebek, Rek ful, Rugni pata, and Simutta. This is a limitation of this study. The calculated phytosociological attributes of the tree species of the VCF has been presented in Table 2.

Table 2 represents that the highest relative density was occupied by Aglaia cucullata (20.41%) followed by Schima wallichii (11.94%), and Tarenna campaniflora (6.41%). Among all the recorded tree species, Aglaia cucullata (7.54%) showed the maximum relative frequency followed by Schima wallichii (6.23%) and Cassia fistula (5.23) (Table 2). Species with the highest relative dominance was found for Terminalia bellirica (6.07%) whereas Protium serratum scored the lowest relative dominance (2.30%) (Table 2). The most important species of Komolcari VCF in terms of IVI was Aglaia cucullata (29.65) followed by Schima wallichii (19.82) and Trema orientalis (11.86) (Table 2). It is a clear indication...
that the Komolchori VCF is dominated by native tree species and these species are playing vital role in enhancing ecological functions. It was a satisfactory outcome that exotics invasive species were absent there.

### 3.2 Tree stock and diversity indices

Result revealed that the density of tree species was 921 stem/ha and the mean basal area was calculated as 20.30 m²/ha in the Komolchori VCF (Table 2). The highest basal area was recorded for *Terminalia bellirica* (1.23 m²/ha) followed by *Garcinia cowa* (0.65 m²/ha) and *Persea bombicina* (0.62 m²/ha), meanwhile the lowest basal area was 0.47 m²/ha for *Protium serratum* (Table 2).

Diversity indices provide useful information about the composition and status of vegetation in a study area. Ultimately, it helps to understand the community structure of a natural forest. However, these indices are always interpreted while comparing with other study sites. Nath et al. (2016) calculated the species diversity index of the Komolchori VCF as 121.05 whereas we estimated it to be 66.03. Nath et al. (2016) considered all the vegetation (herbs, shrubs, and trees) in their study while we only counted the trees. This might be the reason to get a smaller species diversity index value. The estimated Shannon’s maximum diversity index of Komolchori VCF (4.01) (Table 3) was lower compared to the Dudhpukuria–Dhopachori Wildlife Sanctuary (5.21) (Hossain et al., 2013). However, the Shannon’s equitability index of this study (0.80) was close to the findings of Hossain et al. (2013) (0.85). The dominance of Simpson index for the Komolchori VCF (0.93) was also close to the Khadin Nagar National Park and Tilagar Eco Park (0.97) as discussed by Rahman et al. (2011). Based on the diversity indices (Table 3), it could be inferred that the study area harbors diverse tree species.

Figure 2 shows the comparison of the mostly used diversity indices across the country. We compared the findings of Alam and Masum (2005), Alamgir and Al-Amin (2005), Deb, Roy, and Wahedunnabi (2015), Hossain et al. (2013), Islam et al. (2017), Islam et al. (2016), Kibria and Anik (2010), Mamun, Hossain, Hassan, and Alam (2015), Muhammed et al. (2011), Rahman et al. (2011), Rahman et al. (2016), and Roy, Rahman, and Fardusi (2012) with our study to have an insight about the species diversity status of the country. The highest Shannon’s index was found for the Dudhpukuria–Dhopachori Wildlife Sanctuary (4.45) (Hossain et al., 2013) whereas the lowest was estimated for the Korangpara VCF (1.15) (Islam et al., 2017). The Shannon’s index for the Komolchori VCF was 3.22 (Figure 2).

The lower value of Simpson index indicates the better species diversity in an area. The lowest Simpson index value was found for the Tilagar Eco Park, Khadin Nagar National Park (0.1) (Rahman et al., 2011) and the Dudhpukuria–Dhopachori Wildlife Sanctuary (0.02) (Hossain et al., 2013). On the other hand, the higher value of Simpson index was calculated for the Korangpara VCF (0.38), the Kaprupara VCF (0.24) (Islam et al., 2017), and the Kaptai National Park (80.20) (Rahman et al., 2016). The Simpson index of the Komolchori VCF was 0.07 which indicates the moderate species richness of the study area compared with the others (Figure 2).

Based on the Margalef’s (richness) index, it can be inferred that the Sundarban Mangrove Forest was rich in diversified species (131.00) whereas Tilagar Eco Park performed the poorest in this regard (2.01) (Islam et al., 2016; Rahman et al., 2011). The calculated Margalef’s index for the Komolchori VCF was 7.91 (Figure 2).

### Table 1. Specification of phytosociological parameters and biodiversity indices for tree species in the Komolchori VCF, Khagrachari, Bangladesh.

| Biodiversity attributes | Equation | References |
|-------------------------|----------|-----------|
| Species diversity index ($S_{div}$) | $S_{div} = \Sigma \log(n/N) / \log(1/S)$, where $S$ is the total number of species and $N$ is the total number of individuals of all the species | Kohli, Singh, and Rani (1996) |
| Margalef’s index ($R$) | $R = (S - 1)/\ln (N)$, where $n$ is the number of individuals of each species. | Margalef (1958) |
| Shannon’s index ($H$) | $H = -\sum P_i \ln P_i$, where $P_i$ is the number of individuals of one species/total number of individuals in the samples. | Michael (1990) |
| Shannon’s maximum diversity index ($H_{max}$) | $H_{max} = \ln(S)$, where $S$ is the total number of species | Kent and Coker (1992) |
| Shannon’s equitability index ($E_s$) | $E_s = H / H_{max}$, where $H$ is the Shannon’s index and $H_{max}$ is the Shannon’s maximum diversity index | Kent and Coker (1992) |
| Simpson index ($K$) | $K = \Sigma P_i^2$, where $P_i$ is the number of individuals of one species/total number of individuals in the samples. | Magurran (1988) |
| Species evenness index ($E$) | $E = H / \log(S)$, where $H$ is the Shannon’s index and $S$ the total number of species. | Pielou (1966) |
| Dominance of Simpson index ($K'$) | $K' = 1 - K$, where $K$ is the Simpson index | Magurran (1988) |
| Basal area/ha (BA) | $BA = \sum \frac{T_i}{\sum T_i} \times 10000$, $D = \text{dbh}$ | Shukla and Chandal (2000) |
| Relative density ($F_d$) | $F_d = \%N_i / T_i \times 100$, where $N_i$ is the number of individuals in a family; $T_i$ is the total no. of individuals | Mori, Boom, Carvalino, and Santos (1983) |
| Relative frequency ($F_r$) | $F_r = \%N_i / T_i \times 100$, where $N_i$ is the number of species in a family; $T_i$ is the total number of species. | Mori et al. (1983) |
| Relative dominance (RDo) (%) | $\text{RDo} = \frac{\text{basal area of one species}}{\text{total basal area}} \times 100$ | Hossain et al. (2013) |
| Importance value index (IVI) | IVI = Relative density + Relative frequency + Relative dominance | Hossain et al. (2013) |
Table 3. Different diversity indices calculated for the Komolchori VCF, Khagrachari, Bangladesh.

| Diversity indices                        | Value |
|-----------------------------------------|-------|
| Species diversity index (Sd)            | 66.03 |
| Shannon’s maximum diversity index (H_{max}) | 4.01 |
| Shannon’s equitability index (E_h)      | 0.80 |
| Dominance of Simpson index (K)          | 0.93  |

3.3 Hierarchical cluster of the species based on the dominance of the tree species in the Komolchori VCF

In order to determine the number of clusters, we have produced the scree plot for the clusters. It is evident that the recorded tree species could be grouped into five hierarchical clusters based on the IVI (Figure 3).

Figure 4 shows the hierarchical cluster of the recorded tree species in the Komolchori VCF. *Aglaea cucullata* and *Schima wallichii* are the most dominant species which are the member of first cluster. *Persea bombaycina*, *Lannea coromandelica*, *Tarenna campani*, *Quercus oxyodon*, *Trema orientalis*, *Syzygium cumini*, *Senna siamea* and *Cassia fistula* form the second dominant cluster of the tree species in the study area. The rest of the tree species form the 3rd, 4th, and 5th cluster (Figure 4). All these species are of natural origin. This signifies the importance of the VCFs for native tree diversity conservation.
4. Discussion

Natural forests conservation requires authentic and consistent information on species composition and their diversity pattern. Species recorded in this study may provide base line information for formulating management and conservation strategy for community managed forests in the CHTs. Moreover, the findings of this study will help to understand structure and function of hill forest ecosystem in this region. Future trend of change can be compared by using these findings.

Calculated phytosociological attributes delineated that Komolchori VCF had mixed diversity of tree species. In terms of relative frequency, Aglaia cucullata was found highly dispersed tree species followed by Schima wallichii and Cassia fistula (Table 2). The phytosociological attributes and diversity indices of the Komolchori VCF are comparable with the other findings of community managed forests and government managed forests of Bangladesh. Nath et al. (2016) conducted a study at the same site and their findings differ from the findings of this study. Nath et al. (2016) found 587 ± 351 stem/ha which was not on the same line with this study. Meanwhile, they found 92 species which is significantly higher than the findings of this study. Different methods of survey might make the significant differences between the results of these two studies. However, Nath et al. (2016) found Shannon’s index, species diversity index, Margalef’s (richness) index, and species evenness index as 4.11, 121.05, 42.80, and 0.50, respectively. These indices were superior to the findings of this study and Chowdhury, Zahir, Rahman, and Islam (2018). Calculated mean basal area per hectare was found significantly lower than other studies (Islam et al., 2017; Nath et al., 2016) regarding VCFs in CHTs. These findings revealed that tree diversity status is deteriorating day by day and the
driving force behind this may the tremendous pressures by the people living in the vicinity.

However, the result of this study showed that the biodiversity status and forests stock condition of community managed forests is still in better condition than other government managed forests in Bangladesh. Hossain et al. (2013), Hossain, Hossain, Alam, and Uddin (2015), Nath, Jashimuddin et al. (2016), Rahman et al. (2011), and Rahman et al. (2017, 2016) conducted different studies in different government managed forests throughout the country to calculate phytosociological attributes and biodiversity indices. Findings of these studies showed the poor diversity than our findings. It was alarming findings of above mentioned studies that different invasive exotics species (e.g. Acacia auriculiformis, Eucalyptus camaldulensis, Tectona grandis, etc.) were going to be dominant in government managed forests. These exotics species may change the functional activity and food chain of terrestrial ecosystems in near future. Furthermore, these exotics species may accelerate the extinction of native floral and faunal species.

5. Conclusion and recommendation

Natural forests of Bangladesh are degrading gradually. The revealed biodiversity status is a decisive scenario against the condition of the labeled forests in Bangladesh. The varied nature of the VCF recommends that the indigenous communities are maintaining the excellent form of forest management to protect the plant diversity. Tree species found in this study are of natural origin which indicates the importance of indigenous tree species conservation in the VCF. The IVI and the hierarchical cluster of the tree species in this study indicate the most naturally important and dominant tree species in the Komolchori VCF. These species need to be considered for further conservation initiatives. Following this, further research should be conducted on present knowledge and practices of indigenous communities in the perspective of VCF management to enhance the forest health of VCF as a forest management model.

Bangladesh Forest Department may provide different means of incentives to promote community induced forest biodiversity conservation. Alternative
income generation activities may reduce the dependency on forest resources as well as forest land. Degraded landscapes under VCF may be brought under plantation activities with financial and technical help from government and non-government organizations. Such type of initiative may foster native biodiversity conservation along with sustainable livelihoods for ethnic community in the hilly region of Bangladesh.

Acknowledgments

We would like to thank the anonymous reviewers and editor of the journal for their constructive comments and suggestions which definitely helped us improving the quality of the manuscript.

Disclosure statement

No potential conflict of interest was reported by the authors.

ORCID

Kazi Nazrul Islam http://orcid.org/0000-0003-0222-5900

Kamrul Islam http://orcid.org/0000-0003-3443-9030

References

Ahammad, R., & Stacey, N. (2016). "Forest and agrarian change in the Chittagong Hill Tracts region of Bangladesh." In E. L. Deakin, M. Ksatriya and T. C. H. Sunderland (Eds.) Agrarian Change in Tropical Landscape (pp. 190-233). Bogo: Center for International Forestry Research (CIFOR).

Alam, M., & Masum, K. (2005). Status of homestead biodiversity in the offshore island of Bangladesh. Research Journal of Agriculture and Biological Sciences, 1(3), 246–253. Retrieved from citeulike-article-id:3338401.

Alamgir, M., & Al-Amin, M. (2005). Plant diversity and their distribution pattern at strategically selected conserved forest of Banskhali, Chittagong. Journal of Forestry and Environment, 3, 69–75.

Banglapedia. (2018). Khagrachhari District. Retrieved from July 15, 2018 http://en.banglapedia.org/index.php?title=Khagrachhari_District

Basak, S. R., Mohiuddin, M., & Alam, M. K. (2014). Plant diversity of village common forests managed by the Murung community in Bandarban hill district of Bangladesh. Bangladesh Journal of Forest Science, 33(1 & 2), 11–20.

Baten, M. A., Khan, N. A., Ahammad, R., & Missabhuzzaman, K. (2010). Village common forests in Chittagong Hill Tracts, Bangladesh: Balance between conservation and exploitation. First International Community Forestry Conference, Nepal, 16, 13. Dhaka, Bangladesh: Unnayan Onneshan-The Innovators.

Chowdhury, M. A., Zahra, F.-T., Rahman, M. F., & Islam, K. (2018). Village common forest management in Komolchori, Chittagong Hill Tracts, Bangladesh: An example of community based natural resources management. Small-Scale Forestry, 1–19. doi:10.1007/s11842-018-9402-9.

Deb, J. C., Roy, A., & Wahedunnabi, M. (2015). Structure and composition of understory treelets and overstory trees in a protected area of Bangladesh. Forest Science and Technology, 11(2), 76–85.

Giavelli, G., Rossi, O., & Sartore, F. (1986). Comparative evaluation of four species diversity indices related to TZO specific ecological situations. Field Studies, 6, 429–438.

Haque, S. M. S., & Myant, M. H. (2011). Watershed Management Extension and Environmental Conservation in Bangladesh. Chittagong, Bangladesh: Institute of Forestry and Environmental Sciences, University of Chittagong.

Hossain, M. A., Hossain, M. K., Alam, M. S., & Uddin, M. M. (2015). Composition and diversity of tree species in Kamalchari Natural Forest of Chittagong South Forest Division, Bangladesh. Journal of Forest and Environmental Science, 31(3), 1–11.

Hossain, M. A., Hossain, M. K., Salam, M. A., & Rahman, S. (2013). Composition and diversity of tree species in Dudpukuria–Dhophorli wildlife sanctuary of Chittagong (south) forest division, Bangladesh. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 4(2), 1447–1457.

Islam, K., Jashimuddin, M., & Hossain, N. (2017). Tree diversity and management of village common forests in Bandarban. Environment, Earth and Ecology, 1(2), 39–51.

Islam, S., Feroz, S. M., Ahmed, Z. U., Chowdhury, A. H., Khan, R. I., & Al-Mamun, A. (2016). Species richness and diversity of the floristic composition of the Sundarbans mangrove reserve forest, Bangladesh in relation to spatial habitats and salinity. Malaysian Forester, 79(1–2), 7–38.

Jashimuddin, M., & Inoue, M. (2012). Management of village common forests in the Chittagong Hill Tracts of Bangladesh: Historical background and current issues in terms of sustainability. Open Journal of Forestry, 02(03), 118–134.

Kent, M., & Coker, P. (1992). Vegetation description and analysis. Baffins Lane, Chichester, West Sussex, England: John Wiley and Sons Ltd.

Kibria, A. S. M. G., Inoue, M., & Nath, T. K. (2015). Analysing the land uses of forest-dwelling indigenous people in the Chittagong Hill Tracts, Bangladesh. Agroforestry Systems, 89(4), 663–676.

Kibria, M. G., & Anik, S. I. (2010). Homestead plant species diversity and its contribution to the household economy: A case study from northern part of Bangladesh. Journal of Forest Science, 26(1), 9–15.

Kohli, R. K., Singh, H. P., & Rani, D. (1996). Status of floor vegetation under some monoculture and mixedculture plantations in North India. Journal of Forest Research, 1(4), 205–209.

Magurran, A. E. (1988). Ecological diversity and its measurement. New York: Chapman and Hall Publishers.

Mamun, A., Hossain, M. A., Hossain, M. K., & Alam, M. S. (2015). Quantifying diversity and composition of tree species in secondary hill forests of chunati forest, Chittagong. Indian Forester, 141(5), 566–572.

Margalef, R. (1958). Information theory in ecology. General Systematics, 3, 36–71.

Miah, M. D., & Ahmed, F. U. (2014). Conservation of a tropical wet semi-evergreen forest ecosystem by an indigenous community in the Bandarban hill district of Bangladesh: The role of intervention. Small-Scale Forestry, 13(3), 319–331.

Michael, P. (1990). Ecological methods for field and laboratory investigations. New Delhi, India: Tata McGraw-Hill Publishing Company Limited.
Misbahuzzaman, K., & Smith-Hall, C. (2015). Role of forest income in rural household livelihoods: The case of village common forest communities. *Small-Scale Forestry*, 14, 315–330.

Mori, S. A., Boom, B. M., Carvalino, A. M., & Santos, D. (1983). The ecological importance of myrtaceae in eastern Brazilian wet forest. *Biotropica*, 15, 68–70.

Muhammed, N., Masum, M. F. H., Hossain, M. M., Chakma, S., Oesten, G., & Von Detten, R. (2011). Floral composition and biodiversity conservation in homestead forests in Mymensingh, Bangladesh. *International Journal of Biodiversity Science, Ecosystem Services and Management*, 7(4), 247–257.

Nath, T. K., Jashimuddin, M., & Inoue, M. (2016). *Community-based forest management (CBFM) in Bangladesh*. Switzerland: Springer. doi:10.1007/978-3-319-42387-6. ISSN.

Nath, T. K., Jashimuddin, M., Kamruzzaman, M., Mazumder, V., Hasan, M. K., Das, S., & Dhali, P. K. (2016). Phytosociological characteristics and diversity of trees in a comanaged protected area of Bangladesh: Implications for conservation. *Journal of Sustainable Forestry*, 35(8), 562–577.

Pasha, M. K., & Uddin, S. B. (2013). *Dictionary of plant names of Bangladesh (vascular plants)*. Chittagong, Bangladesh: Janokalyan Prokashani.

Pielou, E. C. (1966). Species-diversity and pattern-diversity in the study of ecological succession. *Journal of Theoretical Biology*, 10(2), 370–383.

Rahman, M. H., Khan, M. A. S. A., Roy, B., & Fardusi, M. J. (2011). Assessment of natural regeneration status and diversity of tree species in the biodiversity conservation areas of Northeastern Bangladesh. *Journal of Forestry Research*, 22(4), 551–559.

Rahman, M. M., Mahmud, M. A. A., & Ahmed, F. U. (2017). Restoration of degraded forest ecosystem through non-forestry livelihood supports: Experience from the Chunati Wildlife Sanctuary in Bangladesh. *Forest Science and Technology*, 13(3), 109–115.

Rahman, M. M., Mahmud, M. A. A., Shahidullah, M., Nath, T. K., & Jashimuddin, M. (2016). The competitiveness of the phytosociological attributes of the protected areas in Bangladesh with that in the other tropical countries. *Journal of Sustainable Forestry*, 35(6), 431–450.

Rasul, G. (2007). Political ecology of the degradation of forest commons in the Chittagong Hill Tracts of Bangladesh. *Environmental Conservation*, 34(2), 153–163.

Roy, B., Rahman, M. H., & Fardusi, M. J. (2012). Impact of banana based agroforestry on degraded Sal Forest (Shorea Robusta C.F. Gaertn) of Bangladesh: A study from Madhupur National. *Journal of Biodiversity and Ecological Sciences (JBES)*, 2(1), 62–72.

Saha, P. S. (2010). Prabattya Chattagramer Mouza Ban: Prachin Praggyar Arek Rup. Society for Environment and Human Development (SEHD). Retrieved from http://www.sehd.org/publications/%0Aamagazines/dhartiali%0A

Shukla, R., & Chandal, P. S. (2000). *Plant ecology and soil science* (9th ed.). New Delhi, India: Ramnagar S. Chanda and Company Limited.