Songklanakarin J. Sci. Technol.
42 (4), 819-829, Jul. - Aug. 2020

http://www.sjst.psu.ac.th

Original Article

The phytosociological attributes of village common forests in Chittagong Hill Tracts, Bangladesh

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Received: 11 February 2019; Revised: 2 March 2019; Accepted: 29 April 2019

Abstract

In the face of continuous forest degradation, the Village Common Forests (VCFs) are the relics of biodiversity rich areas that are traditionally conserved by indigenous communities for a long time in Chittagong Hill Tracts (CHT), Bangladesh. A vegetation survey was conducted in four VCFs of Khagrachori district to ascertain the phytosociological attributes of VCFs. We set nine quadratic plots (each 10 m × 10 m) for every VCF following three plots in each of base, mid and top of the hill. We had identified the species and measured the diameter of trees ≥ 1 m in height. Biodiversity indices of tropical forests were also collected from published literatures to compare the biodiversity of VCFs and other tropical countries. The results of the phytosociological study revealed that 124 species belonging to 44 families were found in VCFs of Khagrachori district. The dominant family was Euphorbiaceae followed by Moraceae and Rubiaceae. Importance value index (IVI) indicated that the dominant species was *Oroxylum indicum* (32.34) followed by *Vitex peduncularis* (13.14) and *Grewia nervosa* (12.90). The value of Shannon-wiener diversity index (H′), Simpson index (Ds) and Evenness index (EI) of VCFs were 3.26, 0.929 and 0.486 respectively. Analysis of biodiversity indices among the forests did not show any significant ($p \leq 0.05$) difference indicating that the biodiversity status of VCFs was similar to other natural forests. Moreover, the VCFs of Khagrachori district harbored eight least concerned (LC) and three threatened (T) species of the country. Therefore, we suggested that the forest managers and the policy makers of the country should pay sincere attention to the conservation of local biodiversity through VCFs.

Keywords: VCFs, conservation, phytosociological attributes, biodiversity index, tropical forests

1. Introduction

Forests play a vital role in conserving major parts of the world's biodiversity (Brockerhoff, Jactel, Parrotta, & Ferraz, 2013). The process of forest degradation or destruction may cause the subsequent loss of biodiversity (Lindenmayer, 2009) which in turn results in the declination of ecosystem services (Thompson, MacKey, McNulty, & Mosseler, 2009). Therefore, a clear relationship is evident between forest biodiversity and its ecosystem services (Thompson *et al.*, 2009). Tropical forests in the world are known to produce many ecosystem services such as reducing soil erosion and serving as habitats for plants and animals (Djuikouo, Doucet, Nguembou, Lewis, & Sonke′, 2010). Tropical regions cover about 52% of the world's forests that have a significant role in conserving biodiversity (Anbarashan & Parthasarathy, 2013).

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Bangladesh is a tropical country that has about 17.5% of land area (2.53 million ha) under forest coverage. The forest department of Bangladesh manages 1.53 million ha of forest. About 50% of the natural forests that are managed by the forest department of Bangladesh are located in the Chittagong Hill Tracts (CHT). Like other tropical terrains in South and Southeast Asia, CHT is undergoing deforestation and land degradation due to shifting cultivation, tobacco farming, illicit logging, development activities, climate change, and population growth which are threatening the unique forest-dependent lifestyle and culture of the indigenous communities. In 1900 AD, according to the Chittagong Hill Tracts Regulation (CHTR) manual, the headman, or local village administrator, of each Mouza, which is an administrative unit for land, was entrusted to manage the forest within the Mouza. Since 1939, the indigenous communities started conserving small patches of forests called Village Common Forests know locally as para bon, mouza bon or Mouza reserve in the CHTs. In 1965, the then government issued a circular to each headman asking them to raise and conserve VCFs in the face of continuous forest degradation. In recent times, many tropical forests are facing great anthropogenic pressure and it has become increasingly difficult to maintain overall biodiversity, productivity, and sustainability of forests, which requires management interventions (Kumar, Marcot, & Saxena, 2006). Assessing the sustainability of forest ecosystems and species conservation necessitates understanding the tree composition and structure of the forest (Kacholi, 2014). Having the knowledge of the forest structure, species richness and ecological attributes of vegetation can set the foundation for long-term biodiversity conservation goal (Ifo *et al.,* 2016).

In the CHT, the sizes of the VCFs vary greatly from 20 to 120 acres and most of them are smaller compared to other natural forests conserved by the forest department of Bangladesh (Jashimuddin & Inoue, 2012). Though smaller, the VCFs are rich in biodiversity and harbor rare plants and animals than many of the other natural forests managed by the government of Bangladesh (Basak, Mohiuddin, & Alam, 2014). A few scattered studies were done to assess the biodiversity of the VCFs in the CHT; however, those studies remained generally piecemeal and localized (Islam, Jashimuddin, & Hossain, 2017). Baten, Khan, Ahammad, and Missbahuzzaman (2010) found that the VCFs were enriched with more biodiversity than those of the government managed forests of Bangladesh. Basak *et al.* (2014), Chowdhury, Islam, Hafiz, and Islam (2018), Islam *et al.* (2017), and Jashimuddin and Inoue (2012) also stated the biodiversity status of the VCFs in the CHT and they suggested conservation of the VCFs. The village *fengshui* forest in China (Hu, Li, Liao, & Fan, 2011) and church forests in Ethiopia (Wassie, Sterck, & Bongers, 2010) reported the conservation of endangered species by those forests. Nevertheless, the scattered reports on VCF biodiversity are not sufficient to attract national or international attention for conservation. Moreover, no study reported on the local endangered and threatened plant species which is very crucial for a conservation strategy. More recently, the development organizations and researchers of the country have placed emphasis on the biodiversity status of the VCFs rather than the other forests. Therefore, it is worthy of study to justify the status of the VCF biodiversity compared to other natural forests and to determine the local endangered species traditionally conserved in the VCFs. Thus, the aims of this study were: (i) ascertain the phytosociological attributes of the VCFs in the Khagrachori District; (ii) identify the endangered species available in the VCFs; and (iii) test the significance of biodiversity indices with other natural forests in the country and in the world. This work provides more information on the VCF species composition and richness compared to other protected areas of the government in the tropical region. This information will help the government to take the necessary actions needed for the conservation of the local biodiversity.

2. Materials and Methods

2.1 Study area

This study included the Khagrachori District of the CHT which covers an area of 2749 km^2 with tropical evergreen and semi-evergreen forest types. Khagrachori District lies between the latitude 22.38′ to 23.44′ North and longitude 91.42′ to 92.11′ East. Indigenous communities such as the Chakma, Marma, and Tripura live in this district. The topography of the area is mostly hilly with irregular plain land. The monsoon period is from June to October with the heaviest rainfall in this region. The annual average temperature of this district varies from 34.6 °C to 13 °C and the average annual rainfall is 3031 mm. The soils are usually brown in color, acidic in reaction, and loam to silty-clay in various textures. The VCFs are not only the habitats for plants and animals but are also the vital source of water in streams used by the communities for their household and agricultural activities (Chakma, 2018). The VCFs are considered virgin and have been protected by the indigenous communities for a long time without any support or control from the government (Uddin *et al.,* 2019). The community people collectively set the management committee and the rules, which are common among the communities in the CHT. Therefore, considering the similarity of VCF management and feasibility of the working environment we selected the VCFs of the indigenous communities living in Khagrachori District for this study.

2.2 Data collection

The study was conducted from January to April 2018 in the VCFs of Khagrachori District, Bangladesh. According to interviews with the local indigenous community leaders, there are 25 VCFs in Khagrachori District. We used the random lottery design to select four VCFs (Table 1). The Geographical Positioning System (GPS) was used to record

Table 1. Description of the four Village Common Forests (VCFs) in Khagrachori District, Bangladesh.

Sl No.	Name of VCF	Est. year	Elevation (m) base–top	Managing community	Area (acre)
1	Betchori	1960	60–98	Chakma	159.35
2	Shantivilla	2015	101–107	Marma	105.13
3	Maijchori	2002	73–185	Tripura	127.43
4	Dhonpata	1965	83–99	Chakma	286.66

the data to prepare a map of the VCFs (Figure 1). Following quadratic sampling, trees and shrubs were measured to assess the structure, composition, and biodiversity status of the VCFs in Khagrachori District. According to Alamgir and Al-Amin (2005), Chowdhury *et al.* (2018), and Gotelli and Colwell (2001) we used the same quadrat size as 10×10 m for this study. Thirty-six quadrats were laid out in the four VCFs with each VCF having nine quadratic plots. In order to have a better representation of the VCF biodiversity assessment, the nine plots were arbitrarily distributed at the base, middle, and top of the VCF hills. For every quadrat, we identified and counted the species and measured the diameter at breast height (DBH) of plants ≥1 m height. Local names and binomial names were recorded accordingly. If the species could not be identified in the field, we made herbarium specimens and consulted with the taxonomist in the laboratory of Chittagong University, Bangladesh. For the nomenclature of all the recorded species, we followed Pasha and Uddin, (2003).

2.3 Biodiversity indices and data analysis

To have a general idea of the species diversity of the VCFs in Khagrachori District we calculated the phytosociological attributes of the four VCFs by counting 36 plots all together. The major phytosociological attributes were species stem density, relative density, relative frequency, relative dominance, and the importance value index (IVI). Furthermore, important biodiversity indices, that included the Simpson diversity index (Ds), species evenness index (EI), and the Shannon-Wiener diversity index (H′), were also calculated for each VCF using the standard method stated in Table 2. We assumed there were considerable differences of phytosociological attributes among the VCFs, the natural forests conserved by the forest department of Bangladesh, and the tropical countries of the world. We decided to verify whether the phytosociological characteristics of VCFs differed significantly. For this, we conducted one-way ANOVA at 5% level of significance to test the null hypothesis H_0 that $M_{vcf} = M_{nf} = M_{tc}$, where M_{vcf}, M_{nf}, and M_{tc} are the mean values of the biodiversity indices for the VCF, natural forests of Bangladesh, and tropical countries of the world, respectively. The alternative hypothesis is $H_1 \neq M_{vcf} \neq M_{nf} \neq M_{tc}$. The acceptance of the null hypothesis leads to the conclusion that no significant differences exist in the biodiversity indices in the studied VCFs and other forests. The basis for such comparison was that the study area enjoys similar bioclimatic and geographic characteristics of tropical countries. For this type of analysis, we collected biodiversity indices of other government managed tropical natural forests around the world from reports available in published articles and compared them with the findings of our study.

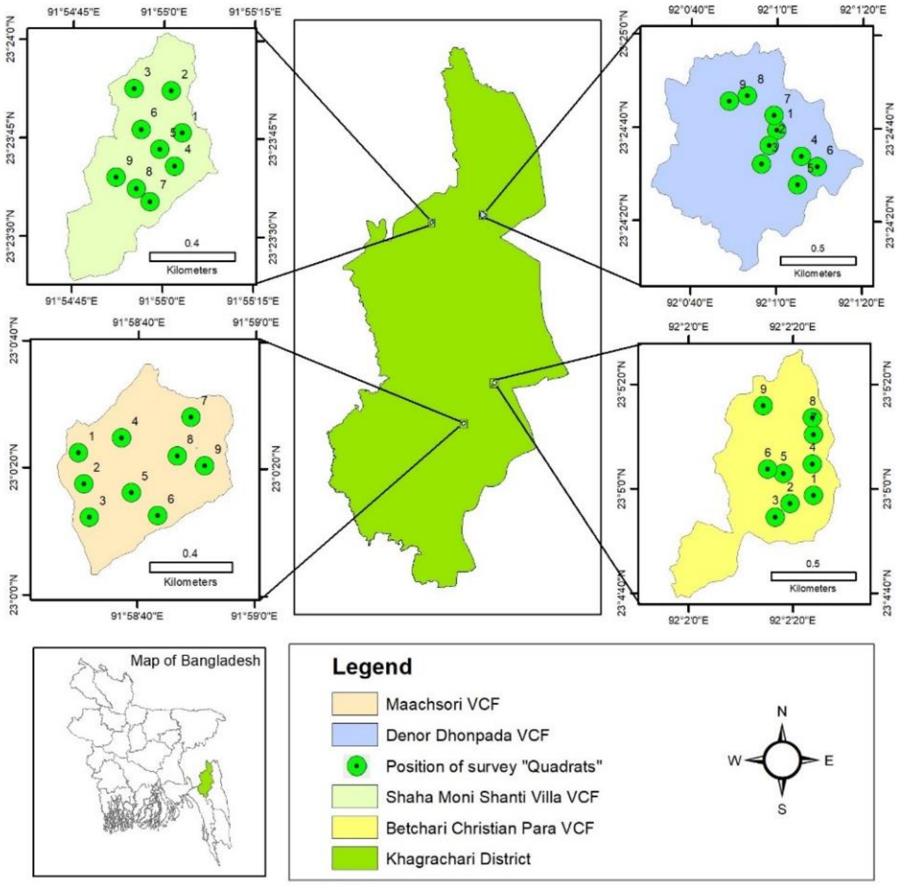

Figure 1. Location of the survey quadrats in the study area of Khagrachori District, Bangladesh.

Table 2. Specifications of the phytosociological attributes and biodiversity indices for trees and shrubs in the Village Common Forests of Khagrachori District, Bangladesh.

Biodiversity attributes	Definitions
Density (D)	D = T/T_1 (Shukla & Chandel, 2000)
Frequency (F)	F = T_2/T_1 (Shukla & Chandel, 2000)
Basal area (BA)	$(\pi/4) \times (DBH)^2$
Basal area per hectare (BA/ha)	($\sum$ BA/area of all quadrats) × 10000 m^2 (Shukla & Chandel, 2000)
Relative density (RD)	RD = (Total number of individual of a species/total number of individuals of all the species) × 100 (Dallmeier, Kabel, & Rice, 1992)
Relative frequency (RF)	RF = (Frequency of one species/Total frequency of all the species) × 100 (Dallmeier, *et al.,* 1992)
Relative dominance (RDo)	RDo = (Basal area of a species/Total basal area of all the species) × 100 (Dallmeier, *et al.,* 1992)
Importance value index (IVI)	IVI = RD + RF + RDo (Hossain *et al.,* 2013)
Shannon-Wiener index (H′)	$H' = -\Sigma Pi \times Ln(Pi)$, where Pi is the number of individuals of one species/total number of individuals in the samples (Michael, 1990)
Simpson diversity index (Ds)	$Ds = 1 - D$ where D is $\sum[n_i(n_i-1)/N(N-1)]$ n_i = the number of individuals in the *i*th species, N= the total number of individuals (Colwell, 2009).
Species evenness index (EI)	EI = (H′)/Log(S) (Pielou, 1966)

Note: T is the total number of individuals of a species in all the quadrats, T_1 is the total number of quadrats studied, T_2 is the total number of quadrats in which the species occurs, and S is the total number of species.

3. Results

3.1 Species composition of the VCFs

A summary of the taxonomic composition of the trees and shrubs available in the study area are presented in Appendix. The VCFs of Khagrachori District harbored 44 plant families with 124 plant species which included 27 shrubs, 90 species of trees and seven species remained unidentified. Euphorbiaceae was the dominant family with 14 species followed by nine species of Moraceae and eight species of Rubiaceae. According to the values of IVI, the most dominant species was *Oroxylum indicum* (32.34) followed by *Vitex peduncularis* (13.14), and *Grewia nervosa* (12.90) and the maximum numbers of stem density/ha were 850, 194.44, and 697.22 for *Oroxylum indicum*, *Grewia nervosa*, and *Gardenia coronaria*, respectively (Appendix). The relative density was the highest for *Oroxylum indicum* (9.04) followed by *Grewia nervosa* (7.42) and *Gardenia coronaria* (4.08). Relative dominance of the species in Khagrachori District revealed the highest value for *Oroxylum indicum* (20.39) followed by *Vitex peduncularis* (8.03) and *Castanopsis indica* (3.13) (Appendix). The results indicated that *Oroxylum indicum* outweighed the number of individuals of all other species in the VCFs of Khagrachori District. *Vitex peduncularis* (stem density 194.44 plants/ha) and *Castanopsis indica* (stem density 38.89 plants/ha) showed higher diameters but their numbers were less compared to other species. From Appendix, it could be inferred that *Oroxylum indicum* was better suited to the site and better distributed than other species in the study area. It can also be confirmed from Appendix 1 that 11 species, those that were least concerned (LC) or threatened (T) according to IUCN red data list of Bangladesh, were also harbored by the VCFs of Khagrachori district namely *Alstonia scholaris*, *Aphanamixis polystachya*, *Saraca asoca*, *Cassia fistula*, *Dipterocarpus alatus*, *Erythrina variegata*, *Mangifera sylvetica*, *Podocarpus nerifolius*, *Saurauia roxburghii*, *Schima wallichii*, and *Vitex pinnata*.

3.2 Biodiversity indices of the VCFs

This study revealed that the value of the Shannon-Wiener diversity index ranged from 3.10 to 3.54, whereas the value reported from a study on natural forests of Bangladesh ranged from 1.15 to 3.69, and in the other tropical countries of the world the value ranged from 0.83 to 4.27 (Table 3). Similarly, the values of the Simpson diversity index of our study, the natural forest of Bangladesh, and of the tropical countries were 0.917–0.952, 0.12–0.98, and 0.02–0.97, respectively. The species evenness index showed ranges of 0.45–0.51, 0–0.79, and 0.23–0.99 for the VCFs of our study, the natural forests of Bangladesh, and the tropical countries, respectively. The highest Shannon-Wiener diversity index value was for Dhonpata VCF (3.54) followed by Betchori (3.21), and Maijchori (3.20) (Table 3). It was also evident that the species evenness index values of the Betchori, Shantivilla, Maijchori, and Dhonpata VCFs were 0.472, 0.454, 0.507, and 0.511, respectively (Table 3). These values of the evenness index described how evenly the species were distributed in the VCFs. A value of the evenness index that approaches zero indicates a large difference in the abundance of the species in the study area and an evenness index that approaches 1.0 indicates that all species are equally abundant (Ifo *et al.*, 2016). According to the evenness index, about 0.5% of the species found in the study area was equally distributed (Table 3). The Simpson diversity index was also the highest for the Dhonpata VCF compared to the other VCFs in Khagrachori district. Generally, the Shannon-Wiener diversity index ranges from 1.5 to 3.5 and very rarely does it show 4.5 (Magurran, 1988). The VCFs of our study showed that the Shannon-Wiener index values were within the general range and the Dhonpata VCF had the highest value (Table 3). The Dhonpata VCF could be used as a standard for conservation of the local biodiversity in the district of Khagrachori.

3.3 Analysis of diversity indices

The biodiversity indices of our study were significantly different from the other types of forests in the country and the tropical countries of the world. The biodiversity indices among the VCFs, natural forests of Bangladesh, and tropical countries did not show any significant variation at 5% level of significance (Table 4). From Figure 2, it is evident that the diversity indices of VCFs were very close to each other while the diversity indices of natural forests of Bangladesh and tropical countries were in wider ranges (Table 3). According to the one-way ANOVA

Table 3. Comparison of the biodiversity indices among the Village Common Forests, natural forests of Bangladesh, and other tropical forests in the world.

Study site	Specific location	H′	Ds	EI
The VCFs in this study	Betchori VCF	3.213	0.923	0.472
	Shantivilla VCF	3.10	0.917	0.454
	Maijchori VCF	3.201	0.924	0.507
	Dhonpata VCF	3.54	0.952	0.511
Natural forests and protected areas of Bangladesh	Lawachara National Park, (Deb *et al.,* 2015)	3.66	-	-
	Sundarbans, (Islam *et al.,* 2016)	3.80	0.86	-
	Bamer chara and Daner Chara (Alamgir and Al-Amin, 2005)	2.77	0.12	-
	Khadimnagar National Park (Rahman, Khan, Roy, & Fardusi, 2011). (two	3.69	0.97	-
	sites)	2.66	0.93	-
	Chunati Wildlife Sanctuary (Mamun *et al.*,2015)	3.35	0.91	-
	Dudhpukuria-Dhopachori Wildlife Sanctuary (Hossain, Hosain, Salam, & Rahman, 2013)	4.44	0.98	-
	Kamolchori VCF (Chowdhury *et al.,* 2018)	2.91	0.91	-
	Kaptai National Park (Rahman, Mahmud, Shahidullah, Nath, & Jashimuddin, 2016)	1.22	0.15	0.79
	Sitapahar (Nath, Hossain, & Alam, 2000)	2.98	-	-
	Kapru Para and Korang Para VCF, (two sites)	1.56	0.76	-
	(Kamrul, Jashimuddin, & Hossain, 2017)	1.15	0.62	-
Tropical forests of the world	Gopalakrishna, Kaonga, Somashekar, Suresh, & Suresh, 2015. India	2.6	0.90	0.60
	Panda, Mahapatra, Acharya, & Debata, 2013. India	1.99	0.02	0.99
	Thakur & Khare, 2006. India	2.94	-	-
	Parthasarathy & Sethi, 1997. India	2.28		
	Tripathi *et al.,* 2004. India	3.58	0.06	0.88
	Velho & Krishnadas, 2011. India	3.50		0.87
	Parthasarathy & Karthikeyan, 1997. India (two sites)	2.35	0.17	0.63
		2.50	0.12	0.70
	Kumar, Marcot & Saxena, 2006. India	4.27	-	-
	Bhuyan, Khan & Tripathi, 2003. India	2.02	0.06	0.46
	Aye *et al.,* 2014. Myanmar	2.41	0.84	-
	Mishra & Garkoti, 2016. Nepal	1.34	0.52	-
	Hayat, Kudus, Faridah, Noor, & Nazre, 2010. Malaysia	5.42	0.96	0.26
	Ndah , Andrew, Bechem, 2013. Cameroon	3.87	0.03	0.90
	Nangendo, Stein, Gelens, De Gier, Albricht, 2002. Uganda	2.91	-	-
	Shaheen and Shinwari, 2011. Kashmir (three sites)	1.96	0.92	0.61
		1.77	0.91	0.49
		0.83	0.93	0.23
	Mishra and Garcoti, 2014. Nepal	1.34	0.515	-
	Kunwar & Sharma, 2004. Nepal	2.69	0.76	-
	Mandal, Dutta, Jha, Karmacharya, 2013. Nepal (three sites)	2.33	0.39	0.85
		2.28	0.41	0.83
		2.21	0.44	0.79
	Yam and Tripathi, 2016. India	3.89	0.97	-

VCFs=Village Common Forests, H′=Shannon-Wiener index, Ds=Simpson diversity index, EI=evenness index.

Table 4. Analysis of variance for different biodiversity indices among the Village Common Forests in Khagrachori District, natural forests of Bangladesh, and other tropical forests of the world.

Study area	Statistics	Biodiversity indices		
		H′	Ds	EI
VCFs of Khagrachori district (N=4)	Mean (SD)	3.26 (0.19)	0.929 (0.0156)	0.486 (0.0276)
Natural forests of Bangladesh (N=12)	Mean (SD)	2.85 (1.06)	0.721 (0.327)	0.79
Tropical countries (N=24)	Mean (SD)	2.64 (1.03)	0.522 (0.366)	0.673 (0.233)
	F-statistic	0.736	2.935	1.485
	df = n−1	2	2	2
	P-value	0.4859	0.0685	0.254

VCFs=Village Common Forests, H′=Shannon-Wiener index, Ds=Simpson diversity index, EI=evenness index, SD=standard deviation.

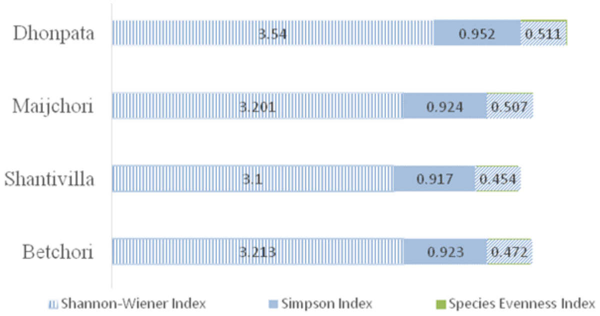

Figure 2. Biodiversity indices of the four Valley Common Forests in Khagrachori District, Bangladesh.

test, we accepted the null hypothesis that the VCFs were not significantly different from the other types of natural forests.

4. Discussion

Our study identified 124 plant species belonging to 44 plant families and Euphorbiaceae was the dominant plant family in the study area. Jashimuddin and Inoue (2012), reported 163 species of both flora and fauna. Chowdhury, Islam, Hafiz, and Islam (2018) recorded 921 individuals belonging to 55 plant species at the Komolchori VCF. Basak, *et al.* (2014) recorded 148 plant species at the Ampupara VCF and Islam *et al.* (2017) reported Moraceae was the dominant plant family. The most dominant species in the Khagrachori VCFs was *Oroxylum indicum* followed by *Vitex peduncularis* and *Grewia nervosa*. In a similar study in the Komolchori VCF of Khagrachori District, the dominant species were identified as *Aglaia cuculata* and *Schima wallichii* (Chowdhury *et al.*, 2018). Due to the different VCF sites and edaphic conditions, the dominance of species varied. In another study, in two VCFs of Bandarban District, Kamrul *et al.* (2017) found that the two dominant species were *Schleicher oleosa* and *Anisoptera scaphula*. It was evident from the study on VCFs that, since the VCFs were isolated from each other and they had fragmented natural forests conserved by indigenous communities, the species dominance might vary in most cases. In each VCF of our study, the stem density/ha was comparatively higher in number than those of other studies. For instance, in the Komolchori VCF of Khagrachori District, Chowdhury *et al.* (2018) recorded a stem density/ha of 3684, whereas in our study we found stem density/ha to be 10000, 10122, 6100, and 11300 for the Betchori, Shantivilla, Maijchori, and Dhonpata VCFs, respectively (Table 5). It was because we counted all trees and shrubs having a height ≥1.0 meter, but in the Komolchori VCF, Chowdhury *et al.* (2018) counted only the trees that were more than 1.3 meters tall which were suitable to measure the DBH. Nath *et al.* (2016) found 587±351 stem/ha in the Komolchori VCF because they counted only the trees having a diameter >5 cm in big plots. Meanwhile, in our study, we found 124 species but Nath *et al.* (2016) found 92 species and Chowdhury *et al.* (2018) found 55 species. Since the methodologies to survey the biodiversity were different, the stem density/ha and number of species differed accordingly. Similarly, the basal area found in our study (Table 5), was more or less similar to the other studies on VCFs, such as Nath *et al.* (2016) and Chowdhury *et al.* (2018) in the Komolchori VCF, which reported basal areas/ha as 34.13±13.94 m²/ha and 20.30 m²/ha, respectively. Therefore, we could say that the VCFs had similar biodiversity and stock. In the Lawachara National Park of Bangladesh, the stem density was 578 plants/ha (Deb, Roy, & Wahedunnabi, 2015). Haider, Rahman, Khair, and Islam (2013) recorded a stem density of 1051 plants/ha in the natural forest of Moulvibazar, Bangladesh. Nath, Hossain, and Alam (1998) reported 381 plants/ha in the Sitapahar Reserve Forest, Bangladesh.

Table 5. Dominant species having an importance value index ≥10 in each Village Common Forest of Khagrachori District.

Name of VCF	Dominant species	Stem density (plants/ha)	BA (m^2/ha)	IVI (%)
Betchori	*Oroxylum indicum*	10000	38.7248	68.149
	Bridelia retusa			17.122
	Stereospermum colais			13.493
	Syzygium grande			12.10
	Grewia nervosa			11.567
Shantivilla	*Oroxylum indicum*	10122	19.6843	40.836
	Grewia nervosa			36.685
	Antidesma bunius			22.234
	Litsea monopetala			14.948
	Vitex peduncularis			12.003
	Vitex pinnata			10.799
Maijchori	*Trevesia palmata*	6100	20.3205	28.363
	Boehmeria glomerulifera			24.384
	Ficus hispida			18.211
	Oreocnide integrifolia			13.815
	Erythrina variegata			12.004
Dhonpata	*Vitex peduncularis*	11300	38.7290	22.653
	Gardenia coronaria			18.427
	Trema tomentosa			18.335
	Glochidion multiloculare			15.941
	Dipterocarpus alatus			13.588
	Castanopsis indica			12.201
	Madhuca longifolia			11.687
	Oroxylum indicum			11.323
	Mallotus nudiflorus			10.553

VCF=Village Common Forest, BA=basal area, IVI=importance value index.

Chowdhury *et al.* (2018) found 13.13 plants/ha in the Rampahar Forest Reserve, Bangladesh. Rahman, Rashid, and Wilcock (2000) reported a basal area of 33.77 m^2/ha in the Chunati Wildlife Sanctuary, Bnagladesh. Neto, Guarim, and Prance (1990) found 14.99 m^2/ha in the dry deciduous woodland in Brazil. Mamun, Hossain, Hossain, and Alam (2015) found 12.47 m^2/ha in the Chunati Wildlife Sanctuary, Bangladesh. Comparing the stem density and basal area per hectare of the VCFs with other forests of the country, it could be inferred that the VCFs harbored a good number of species as well as basal areas. In the face of acute forest destruction in the CHT, these VCFs drew attention for the conservation of native biodiversity. Under the threat of land use change, forest destruction, and land tenure insecurity in the CHT, the VCFs have become very critical for conservation purposes in recent times. Uddin *et al.* (2019) identified 'no land tenure security' as the most important factor to be resolved for the conservation of VCFs in the CHT. Moreover, there is a lack of information on VCF biodiversity, especially for the locally endangered plant species, and the government entities have not been well informed about the VCFs until now. Therefore, the acquired information will be helpful to convince the policy makers to conserve the local biodiversity. The biodiversity indices of the VCFs implied that the VCFs were diverse and dense enough compared to other natural forests of the country and the world. From the study, it was ascertained that the biodiversity status and forest stock condition was comparatively better than the natural forests of Bangladesh though they did not vary significantly ($\alpha \leq 0.05$). Moreover, containing 8 least concerned and 3 threatened species in the VCFs of Khagrachori District requires urgent attention for the conservation of local biodiversity in the face of continuous forest degradation in Bangladesh.

5. Conclusions

We calculated different phytosociological attributes of the trees and shrubs available in selected VCFs of Khagrachori District, Bangladesh. The VCFs of Khagrachori District were dominated by *Oroxylum indicum* followed by *Vitex peduncularis* and *Grewia nervosa*. The VCFs were fragmented forests conserved by the local indigenous communities in the face of a serious threat for forest destruction in the CHT. The biodiversity indices of the VCFs and other attributes, such as stem density/ha and species richness, indicated that the forest health of the VCFs were better than those of other natural forests conserved by the forest department of Bangladesh although there was no significant difference of biodiversity among them. The VCFs contained a huge number of smaller trees rather than big trees. The reasons for the better forest health was that these VCFs have remained undisturbed for a long time and the indigenous people traditionally conserve these fragmented forests for their own needs, such as conservation of water during the dry season, medicinal plants, livelihood support in time of need, and protection from local community people to keep the VCFs intact. Moreover, a comparison of the biodiversity indices among the VCFs and other natural forests demonstrated no significant differences in the biodiversity indices among the forests under consideration. Thus, upon accepting the null hypothesis, we concluded that the biodiversity of the VCFs was similar to other natural forests. Overall, the biodiversity of the VCFs was good and often better than the natural forests of Bangladesh, especially the VCFs that were the abode to many of the least concerned and threatened species of Bangladesh. Therefore, to conserve and rehabilitate the local biodiversity, sincere attention is needed at the policy level of the government to take the necessary initiative for the conservation of the VCFs.

Acknowledgements

I would like to thank Naresuan University for giving me the opportunity to do this research for my study. I am also indebted to my supervisors for their support and guidance in preparing the manuscript. I am grateful to the anonymous reviewers for their valuable suggestions and comments to improve the manuscript for a broad readership.

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Appendix

Table A. Combined species composition of four VCFs in Khagrachori district, Bangladesh.

Name of the species	Family	Habit	stem/ha	RD	RF	RDo	IVI
Actephila excelsa	Euphorbiaceae	S	63.89	0.68	1.06	0.04	1.77
Actinodaphne angustifolia	Lauraceae	T	155.56	1.65	1.85	0.28	3.79
Albizia chinensis	Mimosaceae	T	5.56	0.06	0.13	0.23	0.42
Albizia odoratissima	Mimosaceae	T	8.33	0.09	0.26	1.33	1.69
Albizia procera	Mimosaceae	T	63.89	0.68	1.32	0.49	2.49
Allophylus cobbe	Sapindaceae	T	5.56	0.06	0.13	0.00	0.19
Allophylus trifoliatus	Sapindaceae	T	47.22	0.50	0.93	0.03	1.46
Alstonia scholaris (LC)	Apocynaceae	T	2.78	0.03	0.13	0.00	0.16
Anogeissus lanceolata	Combretaceae	T	127.78	1.36	1.98	0.86	4.20
Antidesma bunuis	Euphorbiaceae	S	358.33	3.81	1.59	1.75	7.15
Aphanamixis polystachya (LC)	Meliaceae	T	13.89	0.15	0.53	0.09	0.77
Aporosa microstachya	Euphorbiaceae	T	77.78	0.83	1.19	2.18	4.20
Aporosa wallichii	Euphorbiaceae	S	8.33	0.09	0.26	0.03	0.39
Ardisia elliptica	Myrsinaceae	S	22.22	0.24	0.53	0.01	0.77
Artocarpus chama	Moraceae	T	36.11	0.38	0.93	2.34	3.65
Artocarpus lacucha	Moraceae	T	16.67	0.18	0.53	0.21	0.91
Averrhoa carambola	Oxalidaceae	T	2.78	0.03	0.13	0.00	0.16
Boehmeria glomerulifera	Urticaceae	S	238.89	2.54	1.19	0.60	4.33
Bombax ceiba	Bombacaceae	T	2.78	0.03	0.13	0.01	0.17
Bridelia retusa	Euphorbiaceae	T	291.67	3.10	1.59	1.75	6.44
Bridelia sikkimensis	Euphorbiaceae	T	5.56	0.06	0.13	0.09	0.28
Bridelia stipularis	Euphorbiaceae	S	2.78	0.03	0.13	0.00	0.16
Caesalpinia digyna	Caesalpiniaceae	T	2.78	0.03	0.13	0.00	0.17
Cajanus crassus	Fabaceae	S	2.78	0.03	0.13	0.00	0.16
Callicarpa arborea	Verbenaceae	T	50.00	0.53	0.93	0.76	2.22
Cassia fistula (LC)	Caesalpiniaceae	T	2.78	0.03	0.13	0.13	0.29
Cassia javanica	Caesalpiniaceae	T	2.78	0.03	0.13	0.04	0.20
Castanopsis armata	Fagaceae	T	16.67	0.18	0.40	0.90	1.48
Castanopsis indica	Fagaceae	T	38.89	0.41	0.40	3.13	3.94
Castanopsis tribuloides	Fagaceae	T	2.78	0.03	0.13	0.00	0.16
Clausena heptaphylla	Rutaceae	T	108.33	1.15	1.98	0.08	3.22
Clerodendrum nutans	Verbenaceae	S	5.56	0.06	0.13	0.00	0.20
Clerodendrum viscosum	Verbenaceae	S	5.56	0.06	0.13	0.00	0.19
Dalbergia volubilis	Fabaceae	T	336.11	3.57	2.25	0.55	6.38
Derris robusta	Fabaceae	T	19.44	0.21	0.26	0.02	0.49
Desmodium gangeticum	Fabaceae	T	52.78	0.56	1.46	0.04	2.06
Desmos chinensis	Annonaceae	T	94.44	1.00	1.46	0.34	2.79
Dillenia pentagyana	Dilleniaceae	T	69.44	0.74	1.06	0.96	2.75
Diospyros malabarica	Ebenaceae	T	55.56	0.59	0.79	0.08	1.46
Dipterocarpus alatus (LC)	Dipterocarpaceae	T	75.00	0.80	0.66	2.88	4.33
Dracaena spicata	Agavaceae	S	38.89	0.41	0.40	0.01	0.82
Elaeocarpus floribundas	Elaeocarpaceae	T	30.56	0.32	0.79	2.19	3.31
Engelhardtia roxburghii	Juglandaceae	T	116.67	1.24	0.53	0.85	2.62
Erythrina variegate (LC)	Fabaceae	T	16.67	0.18	0.66	1.60	2.44
Ficus fistulosa	Moraceae	T	2.78	0.03	0.13	0.00	0.17
Ficus glaberrima	Moraceae	T	19.44	0.21	0.53	1.37	2.11
Ficus hispida	Moraceae	T	183.33	1.95	2.91	1.52	6.38
Ficus racemosa	Moraceae	T	8.33	0.09	0.26	0.03	0.38
Ficus rumphii	Moraceae	T	11.11	0.12	0.13	0.80	1.05
Ficus semicordata	Moraceae	T	8.33	0.09	0.26	0.14	0.49
Flacourtia jangomas	Flaourtiaceae	T	13.89	0.15	0.26	0.07	0.48
Flemingia stricta	Fabaceae	S	2.78	0.03	0.13	0.00	0.16
Gardenia coronaria	Rubiaceae	S	383.33	4.08	1.19	0.29	5.56
Getonia floribunda	Combretaceae	S	30.56	0.32	1.06	0.01	1.39
Glochidion ellipticum	Euphorbiaceae	S	11.11	0.12	0.40	1.30	1.82
Glochidion multiloculare	Euphorbiaceae	T	258.33	2.75	1.32	0.08	4.15
Gmelina arborea	Verbenaceae	T	2.78	0.03	0.13	0.81	0.98
Grewia nervosa	Tilliaceae	T	697.22	7.42	2.78	2.70	12.90
Haldina cordifolia	Rubiaceae	T	8.33	0.09	0.26	0.18	0.53
Holarrhena antidysenterica	Apocynaceae	T	55.56	0.59	1.59	0.23	2.41
Holigarna longifolia	Anacardiaceae	T	33.33	0.35	0.66	0.00	1.02

Table A. Continued.

Name of the species	Family	Habit	stem/ha	RD	RF	RDo	IVI
Hymenodictyon orixensis	Rubiaceae	S	2.78	0.03	0.13	0.01	0.17
Ixora nigricans	Rubiaceae	S	36.11	0.38	1.06	0.00	1.45
Jesminum auriculatum	Oleaceae	S	11.11	0.12	0.26	0.01	0.39
Justicia adhatoda	Acanthaceae	S	2.78	0.03	0.13	2.04	2.20
Lannea coromendelica	Anacardiaceae	T	161.11	1.71	2.25	0.01	3.97
Leea indica	Leeaceae	S	11.11	0.12	0.40	0.10	0.61
Lepisenthes senegalensis	Sapindaceae	T	122.22	1.30	1.72	0.36	3.38
Litsea glutinosa	Lauraceae	T	75.00	0.80	0.66	1.55	3.01
Litsea monopetala	Lauraceae	T	269.44	2.87	1.98	1.09	5.94
Macaranga denticulata	Euphorbiaceae	T	111.11	1.18	1.72	2.38	5.28
Madhuca longifolia	Sapotaceae	T	63.89	0.68	0.66	0.01	1.36
Maesa indica	Myrsinaceae	T	108.33	1.15	0.93	0.05	2.13
Mallotus nudiflorus	Euphorbiaceae	T	241.67	2.57	1.32	0.53	4.43
Mangifera indica	Anacardiaceae	T	16.67	0.18	0.26	0.07	0.51
Mangifera sylvetica (T)	Anacardiaceae	T	41.67	0.44	0.93	0.69	2.05
Manihot esculenta	Euphorbiaceae	S	83.33	0.89	0.26	0.21	1.36
Melastoma malabathricum	Melastomataceae	S	97.22	1.03	1.59	0.10	2.72
Meyna spinosa	Rubiaceae	T	2.78	0.03	0.13	0.01	0.17
Micromelum hirsutum	Rutaceae	T	16.67	0.18	0.40	0.25	0.82
Mitragyna parvifolia	Rubiaceae	T	147.22	1.57	2.51	1.27	5.34
Murraya koenigii	Rutaceae	T	69.44	0.74	1.06	0.07	1.87
Mussaenda roxburghii	Rubiaceae	S	13.89	0.15	0.40	0.01	0.55
Myristica linifolia	Myristicaceae	T	2.78	0.03	0.13	0.00	0.16
Oreocnide integrifolia	Uiticaceae	T	38.89	0.41	0.40	1.58	2.39
Oroxylum indicum	Bignoniaceae	S	850.00	9.04	2.91	20.3	32.34
Paramignia scandens	Rutaceae	T	286.11	3.04	3.17	0.24	6.45
Phyllanthus emblica	Euphorbiaceae	T	72.22	0.77	1.46	0.21	2.44
Podocarpus nerifolius (T)	Podocarpaceae	T	25.00	0.27	0.13	0.01	0.41
Protium serratum	Burseraceae	T	69.44	0.74	0.79	0.50	2.03
Psychotria adenophylla	Rubiaceae	S	2.78	0.03	0.13	0.00	0.17
Pterospermum acirifolium	Sterculiaceae	T	72.22	0.77	0.93	0.33	2.03
Saraca asoca (T)	Caesalpiniaceae	T	108.33	1.15	1.72	0.27	3.14
Sarcochlamys pulcherima	Urticaceae	S	5.56	0.06	0.26	0.03	0.35
Saurauia roxburghii (LC)	Actinidiaceae	T	91.67	0.97	0.66	2.24	3.88
Schefflera elliptica	Araliaceae	S	2.78	0.03	0.13	0.00	0.16
Schima wallichii (LC)	Theaceae	T	41.67	0.44	0.26	0.41	1.12
Spondias pinnata	Anacardiaceae	T	2.78	0.03	0.13	0.23	0.39
Sterculia foetida	Sterculiaceae	T	8.33	0.09	0.40	0.61	1.09
Sterculia villosa	Sterculiaceae	T	111.11	1.18	2.25	1.11	4.54
Stereospermum colais	Bignoniaceae	T	66.67	0.71	0.79	3.54	5.04
Stereospermum suaveolens	Bignoniaceae	T	27.78	0.30	0.66	0.16	1.11
Streblus asper	Moraceae	T	5.56	0.06	0.26	0.00	0.32
Suregada multiflora	Euphorbiaceae	T	125.00	1.33	1.32	0.20	2.85
Swintonia floribunda	Anacardiaceae	T	13.89	0.15	0.26	0.45	0.86
Syzygium fruticosum	Myrtaceae	T	222.22	2.36	1.85	0.94	5.16
Syzygium grande	Myrtaceae	T	100.00	1.06	1.72	1.96	4.74
Tectona grandis	Verbenaceae	T	30.56	0.32	0.40	1.54	2.26
Terminalia arjuna	Combretaceae	T	36.11	0.38	0.40	0.37	1.15
Terminalia bellerica	Combretaceae	T	41.67	0.44	1.19	0.95	2.59
Trema tomentosa	Ulmaceae	T	186.11	1.98	1.19	2.56	5.73
Trevesia palmata	Araliaceae	S	291.67	3.10	0.79	0.87	4.76
Unknown-3			16.67	0.18	0.40	0.05	0.63
Unknown-4			19.44	0.21	0.36	0.04	0.61
Unknown-5			5.56	0.06	0.33	0.05	0.44
Unknown-6			2.78	0.03	0.13	0.58	0.75
Unknown-7			8.33	0.09	0.23	0.13	0.45
Unknown-1			16.67	0.18	0.53	0.00	0.71
Unknown-2			30.56	0.32	0.53	0.27	1.13
Vitex peduncularis	Verbenaceae	T	194.44	2.07	3.04	8.03	13.14
Vitex pinnata (LC)	Verbenaceae	T	11.11	0.12	0.40	1.85	2.37
Wrightia arborea	Apocynaceae	T	8.33	0.09	0.40	0.03	0.51
Xylia xylocarpa	Mimosaceae	T	2.78	0.03	0.13	0.00	0.16
Ziziphus oenopolia	Rhamnaceae	T	8.33	0.09	0.40	0.03	0.51
Total= 124	44		9402.7	100	100	100	300