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ASSESSMENT OF NATURAL REGENERATION POTENTIAL OF NATIVE TREE SPECIES IN A COMMUNITY MANAGED FOREST OF BANGLADESH

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Abstract

The study was conducted to explore natural regeneration potential of a community managed forest. Village Common Forest (VCF) has been managed as a commo n property resource under the leadership of Mouza Headmen based on traditional resource management pattern. Stratified random sampling method was carried out for the inventory of the regeneration status. The sampling plot size for regeneration was 5m × 5m. About 47 regenerating tree species belonging to 22 families were recorded from the studied village common forest where *Grewia nervosa* was the dominant regenerated seedlings. Euphorbiaceae was the dominant family with 7 species followed by Moraceae (5 species), Rubiaceae (4 species), Anacardiaceae (3 species), Combretaceae (3 species) and Mimosaceae (3 species). Maximum Importance Value Index (IVI) was found for *Grewia nervosa* (27.97) followed by *Brownlowia elata* (21.52), *Artocarpus chama* (14.74) and *Leea macrophylla* (12.53). A total of 78% of the regenerating tree species were regenerated from seeds and 22% from coppices. Shannon-Wiener's Diversity Index was found 3.37 where Simpson's Diversity Index was 0.055, Moreover, Margalef's Richness Index was calculated as 8.57 and Species Evenness Index was 0.88. The results depict that the regeneration status of studied VCF has been satisfactory and Village Common Forest still contains dense forests that represents rich biodiversity including rare species. The study might be helpful for increasing conservation importance of this forest. This study suggests further study on vegetation structure and carbon pool assessment to understand more about of this forest for future sustainability.

Key words: Biological diversity indices; Importance Value Index (IVI); Natural regeneration; Regeneration mode; Village Common Forest (VCF)

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Introduction

Community forestry first came to prominence in the mid-1970s and has continued to evolve over the last few decades in a growing number of countries. The availability of forest resources are often greatly reduced for use by the local people due to increasing pressures to cultivate the land, reliance on the forest resources are also affected by economic and political changes. For example, community forest is one of the successful conservation of forest and also fulfill the local demand of users in Nepal, Indonesia, Korea, Brazil, India and North America (Arnold, 2011). In a 2016 review of community-based forestry, FAO estimated that almost one-third of the world's forest area is under some form of community-based management (Don, 2016).

Village Common Forest (VCF) are mostly small (20-120 ha), consisting of naturally grown or regenerated vegetation (Jashimuddin and Inoue, 2012). The VCF are managed, protected and utilized by indigenous village communities under the leadership of the Mauza headman or village ‘‘karbaris’’or by educational or religious institutions, or a committee formed by leaders from one or more villages. VCF have set a standard model for the protection of biodiversity, environment and natural resources in Chittagong Hill Tracts (CHT) (Roy, 2000; Tiwari, 2003; Halim *et al*., 2007; Islam *et al.*, 2009; AF, 2010).

Village Common Forest (VCF) is a natural forest other than the government forest around the households of the ethnic communities and managed to fulfil their daily demands (Jashimuddin and Inoue, 2012). Although the entire area of the CHT was covered with dense forest in the early l9th century; now most of the area has been denuded and covered with some scattered trees and shrub (Kamruzzaman *et. al.*, 2018; Jannat *et al*. 2018). Evolving community-managed VCF in the CHT is a direct result of resource constraints caused by deforestation and the prevention of entry into and use of the resources of the newly acquired reserved forests (which were promptly declared as off limits to local people). These constraints led local communities to devise newer and more sustainable modes of the natural resources management. One such innovation, drawing upon indigenous traditional methods of forest fallow and jhum cultivation (shifting cultivation), gave birth to the VCF during the first quarter of the 20th century (Rasul, 2007; Baten *et al.*, 2009).

Natural regeneration refers to the natural process by which plants replace or re-establish themselves by means of self-sown seed or vegetative recovery by sprouting from stumps, rhizomes or roots (Petrie, 1999). The natural regeneration dynamics of the dry forest is an extremely complex process that depends on environmental factors such as distribution of rainfall, temperature, topographic, edaphic and light conditions (Gerhardt and Hytteborn, 1992; Bekele, 2000; McLaren and McDonal, 2003) and also factors such as seed viability and dormancy, seed predation and herbivory (Khurana and Singh, 2001). Information on natural regeneration potential leads to conservation measures of biological diversity (Verma *et al.,* 1999). It is an important indicator for evaluating overall condition of forest ecosystem (Rahman *et al.*, 2011)

Information on regeneration status of native plant species is of great importance in management and conservation measures. Quantitative inventories help in identification of economically useful species as well as species of special concern, i.e. rare, lesser known and vulnerable species, and thus to quantify conservation worthiness of the candidate sites (Keel *et al.*, l993). Thus, present study is carried out to explore regeneration status, quantitative structure of regenerating species, regeneration mode and diversity indices of Renikhayong para VCF in Bandarban district.

Materials and Methods

Study area

The study was carried out in Bandarban district located in Southeast side of Bangladesh between 21.15 ° and 22.20 °N latitudes and 91.05 ° and 92.40 ° E longitudes (Fig. 1). Area of Bandarban district is about 4,479 square kilometers with two-thirds characterized by steep slopes. Bandarban district is not only the most remote district of the country, but also is the least populous (population 292,900) (Chowdhury, 2012). As per the 2011 census, there were 215,934 Bengalis and 142,401 indigenous people in the district. Population density is about 87/km2. However, studied VCF was established in 1993 and other relevant information regarding study area is presented in Table-1.

Table 1: General information of studied VCF in Bandarban district

Village	**Renikhayong para**
Mouza	9 no. ward Renikhayong mouza
Year of village establishment	1990
Total household (No.)	32
Current population of the village (No.)	180
Year of VCF establishment	1993
Area (Ha)	16
Distance (km) from Upazilla Sadar	22
Electricity availability	No
Drinking water sources	GFS, Chora

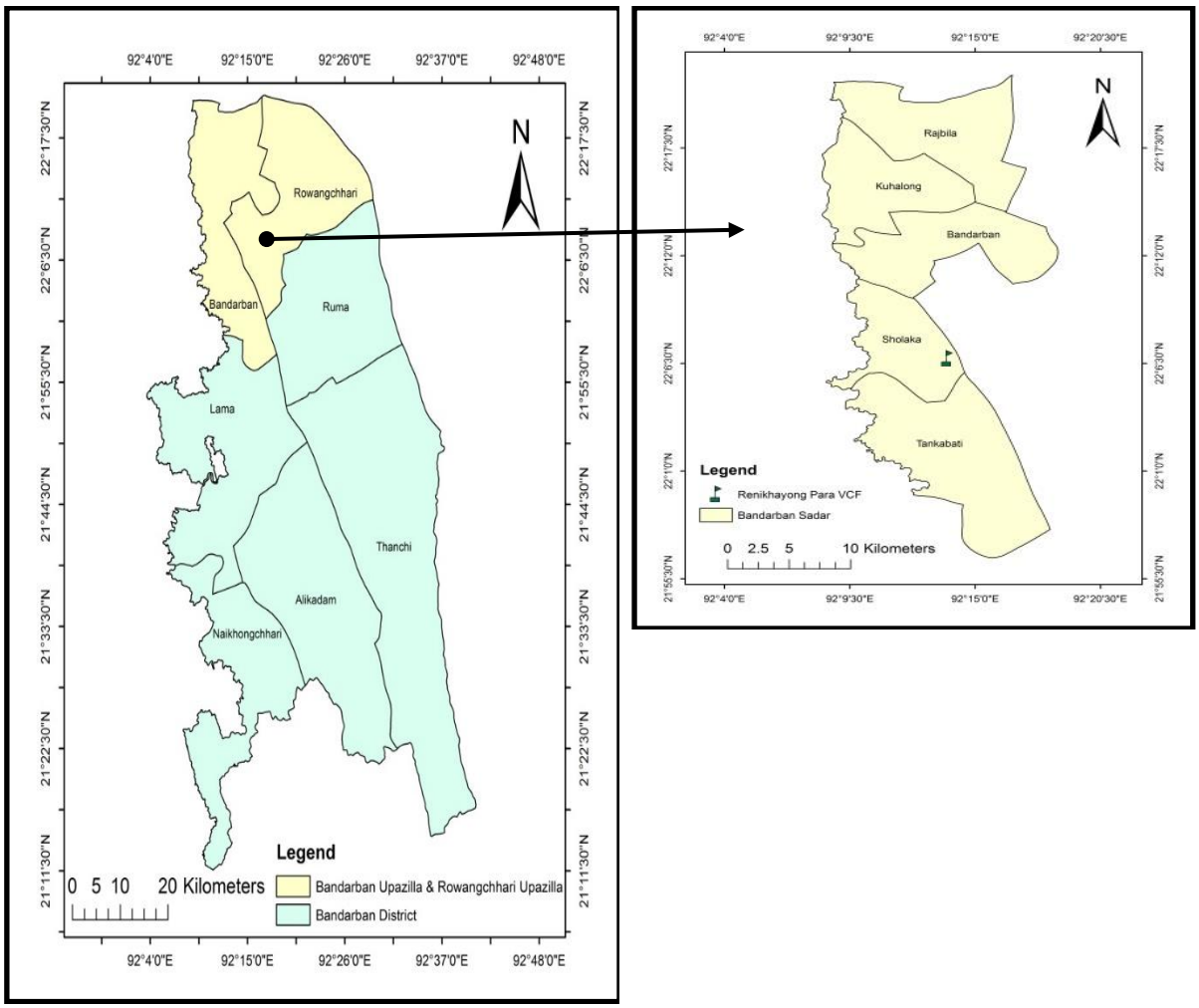

Fig. 1: Map of the study Area

Data collection method

The methods of the study consists of reconnaissance survey, field work, data analysis and report writing. To have an idea about location, accessibility, communication means and VCF area prior to selection of sampling procedure a pilot survey before main survey (field visits as well as formal discussion with director of Tahzingdong, a Non-Governmental Organization) was conducted.

Stratified random sampling was carried out for the inventory of the regeneration status. The sampling plot size for regeneration was 5m × 5m. A total of 15 randomly selected plots (nearly 0.23% sampling intensity) were surveyed. For each plot height of regenerating seedlings were measured. All the trees having dbh of < 5 cm were measured and recorded.

Data analysis

The quantitative structure of species were calculated using following formula derived in the past studies (Shukla and Chandal, 1980; Moore and Chapmamn, 1986; Sharma et. al., 1986; Ambust, 1987; and Dallmeier et. al., 1992).

1. Density of a species = $\frac{Total\ no.of\ individuals\ of\ a\ species\ in\ all\ the\ quardrats}{Total\ no.\ of\ quadrats\ studied}$

2. Relative density of a species = $\frac{Total\ No.\ of\ individuals\ of\ the\ species}{Total\ \ No.\ of\ individuals\ of\ all\ the\ species} \times 100$

3. Frequency of a species = $\frac{Total\ no.\ of\ quardrats\ in\ which\ the\ species\ occurs}{Total\ no.\ of\ quadrats\ studied}$

4. Relative frequency = $\frac{Frequency\ of\ one\ species}{Total\ \ frequency} \times 100$

5. Abundance of a species = $\frac{Total\ no.of\ individuals\ of\ a\ species\ in\ all\ the\ quardrats}{Total\ no.\ of\ quadrats\ in\ which\ the\ species\ occured}$

6. Relative abundance = $\frac{Abundance\ of\ one\ species}{Total\ abundance} \times 100$

7. IVI = Relative density + Relative frequency + Relative abundance

Four diversity indices, i.e. Shannon-Wiener's index (H), Simpson's diversity index (D), Margalef's species richness index (R) and Species evenness index (E) were analyzed following formulas to get a picture of tree species diversity in Renikhayong para VCF.

Shannon- Wiener diversity index (1963) was calculated according to Michael (1990).

$$H = -\sum_{i=1}^{n} P_i \ln P_i$$

Where,

H = Shannon-Wiener's diversity index

P_i = No. of individuals of one species.

One of the best- known diversity index based on measures of the quantities of different species in each sample plot is Simpson's index of concentration. Concentration of dominance (D) was measured by using in the calculation of the Simpson's index, which is usually formulated as (Simpson, 1949). Which follows equation:

$$D = \sum Pi^2$$

Where,

Pi = ni/N

ni is the number of individuals of each species; N is the total number of trees of all species.

Margalef's (1958) index of species richness was calculated by following equation:

$$R = (S - 1)/\ln N$$

Where,

R = Species richness index

S = Total no. of species

N = Total no. of individuals of all species

Pielous's measure of evenness as followed (Pielou, 1984):

$$E = H/\ln S$$

Where,

E = Species evenness

H = the Shannon- Weiner Index of Diversity

S = Total No. of species.

Results and Discussions

Natural regeneration status in Renikhayong para VCF

A total of 47 species belonging to 22 families were recorded from Renikhayong para VCF. Euphorbiaceae was the dominant family with 7 species followed by Moraceae (5 species), Rubiaceae (4 species), Anacardiaceae (3 species), Combretaceae (3 species) and Mimosaceae (3 species). Other families have only 1-2 species (Table 2).

Table 2: Naturally regenerated seedlings with family in Renikhayong para VCF

SL No.	Family	Scientific Name	Local Name	No. of seedling/ha
1	Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Bhadi	27
		Spondias pinnata (L.f) Kurz	Jongli amra	80
		Mangifera sylvatica Roxb.	Uriam	107
2	Apocynaceae	*Alstonia scholaris* (L.) R. Br.	Chatian	53
		Holarrhena antidysenterica (L.) Wall. *ex* Decne	Kuruch	267
3	Bignoniaceae	*Stereospermum colais* (Buch.-*ex* Dillw.) Mabberley	Dharmara	53
4	Bombacaceae	*Bombax insigne* Wall.	Shimul Tula	107
5	Burseraceae	*Protium serratum* (Wall. *ex* Coelbr.) Engl.	Gutgutia	80
6	Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	Bohera	27
		Anogeissus acuminata (Roxb. *ex* DC.) Gull. & Perr.	Sikori	240
		Terminalia sp.	Terminalia sp	107
7	Dipterocarpaceae	*Anisoptera scaphula* (Roxb.) Pierre	Boilam	27
8	Euphorbiaceae	*Glochidion multiloculare* (Roxb. *ex* Wild.) Muell.-Arg.	Aniatori/Pannyatori	133
		Suregada multiflora (A. Juss.) Bail.	Bon-naranga	80

SL No.	Family	Scientific Name	Local Name	No. of seedling/ha
		Callicarpa arborea Roxb.	Bormala	80
		Bridelia sp.	Bridelia sp	53
		Antidesma acidium Retz.	Chutki	27
		Aporosa dioica (Roxb.) Muell.-Arg.	Harula	53
		Aporosa octandra (Buch.-Ham. *ex* D.Don) A.R. Vickery	Kechua	53
9	Lauraceae	*Litsea glutinosa* (Lour.) Robinson	Menda	53
10	Leeaceae	*Leea macrophylla* Roxb. *ex* Hornem.	Chaigas	293
11	Lythraceae	*Lagerstroemia speciosa* (L.) Pers.	Jongli Jarul	27
12	Meliaceae	*Swietenia macrophylla* King	Mehogoni	160
		Toona ciliata M. Roem.	Toon	53
13	Mimosaceae	*Albizia chinensis* (Osb.) Merr.	Chakua Koroi	53
		Albizia sp.	Goal Koroi	27
		Albizia procera (Roxb.) Benth	Koroi	80
14	Moraceae	*Artocarpus lacucha* Buch.-Ham.	Borta	27
		Artocarpus chama Buch.-Ham. *ex* Wall.	Chapalish	373
		Ficus hispida L.f.	Dumur	27
		Ficus sp.	Ficus sp.	80
		Artocarpus heterophyllus Lamk.	Kanthal	80
15	Myristicaceae	*Myristica linifolia* Roxb.	Amberala	80
16	Myrtaceae	*Syzygium fruticosum* (Wall.) Masamune	Putijam	187
17	Rhizophoraceae	*Carallia brachiate* (Lour.) Merr.	Keubong	80
18	Rubiaceae	*Mitragyna parvifolia* (Roxb.) Korth var. *Macrophylla* (Kurz) Ridsdale	Keli Kadam	27
		Neolamarckia cadamba (Roxb.) Bosser	Kadam	80
		Neonauclea sessilifolia (Roxb.) Merr.	Kom	27
		Morinda angustifolia Roxb.	Ronggas	133
19	Rutaceae	*Zanthoxylum rhetsa* (Roxb.) DC.	Bajna	80
20	Sterculiaceae	*Sterospermum semisegitattum* Buch. – Ham. *ex* Roxb.	Lana-achor	80
		Sterculia villosa Roxb. *ex* Smith	Udal	160
21	Tiliaceae	*Grewia nervosa* (Lour.) Panigr.	Assargula	880
		Brownlowia elata Roxb.	Moos	613
22	Verbenaceae	*Vitex peduncularis* Wall. *ex* Schauer	Goda	107
23	Unidentified	*Unidentified-1*	Klanku	53
		Unidentified-2	Puronma	133

Quantitative structure of regenerating species in Renikhayong para VCF

The maximum seedling per hectare was calculated for *Grewia nervosa* (880) followed by *Brownlowia elata* (613), *Artocarpus chama* (373), *Leea macrophylla* (293), *Holarrhena antidysenterica* (267) and *Anogeissus acuminata* (240). *Grewia nervosa* occupied the highest relative density (15.42%) followed by *Brownlowia elata* (10.75%), *Artocarpus chama* (6.54%), *Leea macrophylla* (5.14%), *Holarrhena antidysenterica* (4.67%) and *Anogeissus acuminata* (4.21%). *Grewia nervosa* and *Brownlowia elata* showed the highest relative frequency (6.67%) followed by *Leea macrophylla* (4.44%), *Holarrhena antidysenterica* (4.44%), *Artocarpus chama* (3.70%) and *Anogeissus acuminata* (3.70%). Maximum relative abundance was found for *Grewia nervosa (*5.88%) followed by *Artocarpus chama* (4.49%), *Brownlowia elata* (4.1%) and

Stereospermum colais (3.21%). Importance Value Index (IVI**)** was found highest for *Grewia nervosa (*27.97) followed by *Brownlowia elata* (21.52), *Artocarpus chama* (14.74) and *Leea macrophylla* (12.53) (Table 3)

Table 3: Relative density (RD), relative frequency (RF), relative abundance (RA) and Importance Value Index (IVI) in Renikhayong para VCF

Scientific Name	**RD (%)**	**RF (%)**	**RA (%)**	**IVI**
Myristica linifolia	1.40	2.22	1.60	5.23
Glochidion multiloculare	2.34	2.96	2.01	7.31
Grewia nervosa	15.42	6.67	5.88	27.97
Zanthoxylum rhetsa	1.40	2.22	1.60	5.23
Lannea coromandelica	0.47	0.74	1.60	2.81
Terminalia bellirica	0.47	0.74	1.60	2.81
Anisoptera scaphula	0.47	0.74	1.60	2.81
Suregada multiflora	1.40	2.22	1.60	5.23
Callicarpa arborea	1.40	1.48	2.41	5.29
Artocarpus lacucha	0.47	0.74	1.60	2.81
Bridelia sp.	0.93	1.48	1.60	4.02
Leea macrophylla	5.14	4.44	2.94	12.53
Albizia chinensis	0.93	1.48	1.60	4.02
Artocarpus chama	6.54	3.70	4.49	14.74
Alstonia scholaris	0.93	1.48	1.60	4.02
Antidesma acidium	0.47	0.74	1.60	2.81
Stereospermum colais	0.93	0.74	3.21	4.89
Ficus hispida	0.47	0.74	1.60	2.81
Ficus sp.	1.40	1.48	2.41	5.29
Albizia sp.	0.47	0.74	1.60	2.81
Vitex peduncularis	1.87	2.22	2.14	6.23
Protium serratum	1.40	2.22	1.60	5.23
Aporosa dioica	0.93	1.48	1.60	4.02
Spondias pinnata	1.40	2.22	1.60	5.23
Lagerstroemia speciosa	0.47	0.74	1.60	2.81
Neolamarckia cadamba	1.40	1.48	2.41	5.29
Artocarpus heterophyllus	1.40	1.48	2.41	5.29
Aporosa octandra	0.93	1.48	1.60	4.02
Mitragyna parvifolia	0.47	0.74	1.60	2.81
Carallia brachiate	1.40	2.22	1.60	5.23
Neonauclea sessilifolia	0.47	0.74	1.60	2.81
Albizia procera	1.40	2.22	1.60	5.23
Holarrhena antidysenterica	4.67	4.44	2.67	11.79
Sterospermum semisegitattum	1.40	1.48	2.41	5.29
Swietenia macrophylla	2.80	2.96	2.41	8.17
Litsea glutinosa	0.93	1.48	1.60	4.02
Brownlowia elata	10.75	6.67	4.10	21.52

Scientific Name	RD (%)	RF (%)	RA (%)	IVI
Syzygium fruticosum	3.27	3.70	2.25	9.22
Morinda angustifolia	2.34	2.96	2.01	7.31
Bombax insigne	1.87	2.22	2.14	6.23
Anogeissus acuminata	4.21	3.70	2.89	10.80
Terminalia sp.	1.87	2.22	2.14	6.23
Toona ciliata	0.93	1.48	1.60	4.02
Sterculia villosa	2.80	2.96	2.41	8.17
Mangifera sylvatica	1.87	2.22	2.14	6.23
Unidentified-1	0.93	1.48	1.60	4.02
Unidentified-2	2.34	2.96	2.01	7.31
Total	**100.00**	**100.00**	**100.00**	**300.00**

Regeneration mode

A total of 214 regenerating individuals from sample plots were recorded in Renikhayong para VCF. Among them 167 individuals were regenerated from seed and another 47 from coppice. A total of 78% of the regenerating tree species were regenerated from seed and 22% from coppice (Fig. 2).

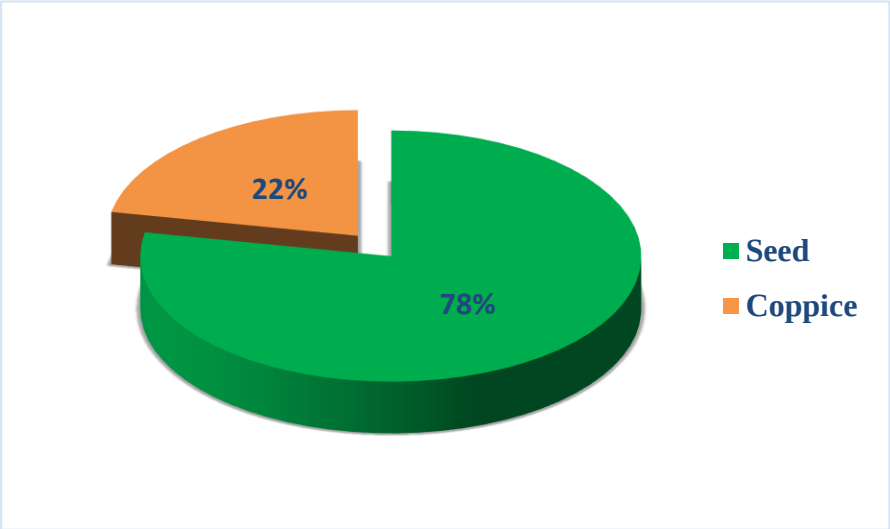

Fig. 2: Regeneration mode of the regenerating species in studied VCF

Percentage distribution of regeneration individuals into height (cm) classes

Percentage distribution of regeneration individuals into different height (m) classes showed that height range (20 - <100) cm holds maximum (51.40%) percentage of regeneration individuals. The minimum percentage (2.80%) was represented by the height range ≥ 340 cm. Both the number of species and number of individuals decreased regularly with the increase of total height (cm) (Fig. 3).

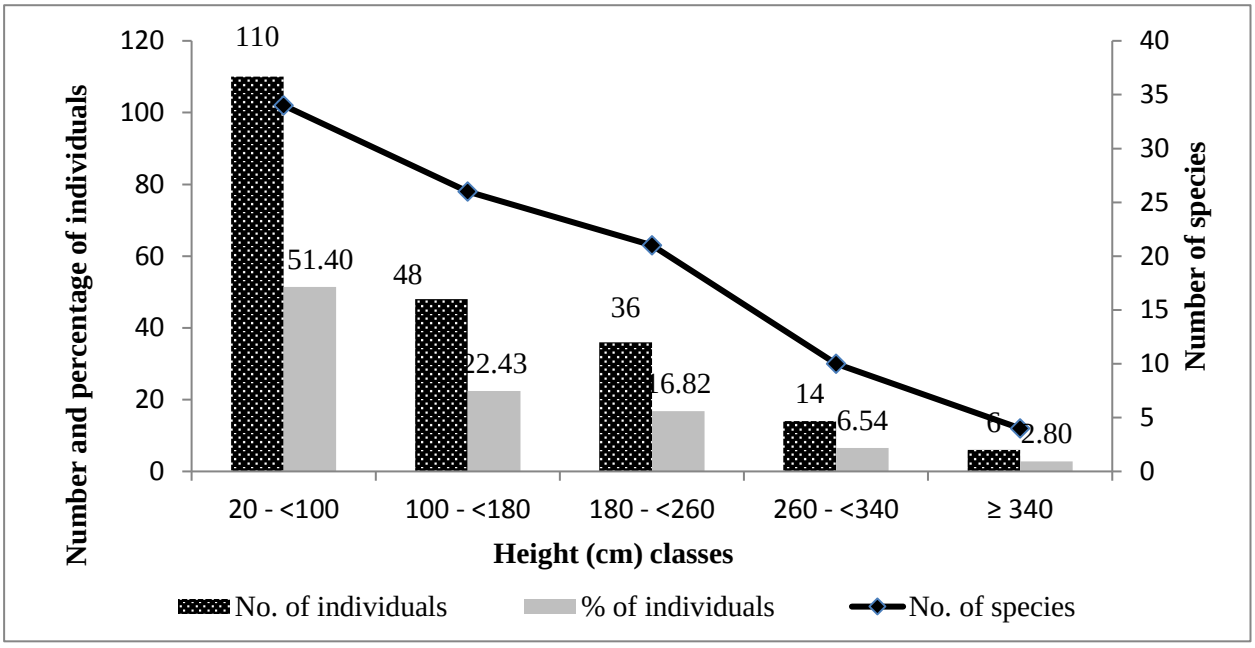

Fig. 3: Distribution of regeneration individuals into height (cm) classes

Diversity indices

Different biological diversity indices were calculated to depict regenerated seedling diversity of the study area. Shannon-Wiener's Diversity Index was found 3.37 where Simpson's Diversity Index was 0.055, Moreover, Margalef's Richness Index was calculated as 8.57 and Species Evenness Index was 0.88 (Table 4).

Table 4: Biological diversity indices for regenerating seedling in the VCF

Serial No.	Name of the indices	Diversity index Values
1	Shannon-Wiener's Diversity Index (H)	3.37
2	Simpson's Diversity Index (D)	0.055
3	Margalef's Richness Index (R)	8.57
4	Species Evenness Index (E)	0.88

Discussion

Natural regeneration potential is an important indicator for any forest ecosystems. Information on regeneration potential leads to conservation measures of biological diversity (Hossain *et al.* 2013). It is important indicator for evaluating overall condition of forest ecosystem (Rahman *et al.* 2011). There is scarce information on the regeneration status of native tree species of Renikhayong para VCF.

Many other scientists conducted study on floristic composition, diversity and population dynamics in different tropical natural forests of the world (Upadhaya, 2003; Eilu *et al.*, 2004; Davidar *et al.*, 2005 and Krishnamurthy *et al.*, 2010). A total of 47 species under 22 families were recorded from Renikhayong para VCF which is very poor compared to the findings of Baten *et al.* (2010) who found 173 floral species from

the VCF in CHT. This is may be due to environmental factors as Joshi *et al.* (2019) reported that the forest community structure, composition and diversity pattern is influenced by environmental factors like temperature, precipitation, light, etc. as well as anthropogenic disturbance stimuli including tree felling, over grazing and forest fires. However, Kamruzzaman *et al.* (2018) found a total of 35 regenerating tree species under 20 families in the Babu para VCF of Bandarban district which shows comparatively rich floristic diversity in the studied VCF. The higher regeneration status of Renikhayong para VCF may be result of minimum human interferences and increased awareness regarding forest conservation of surrounding ethnic communities.

Euphorbiaceae, Moraceae and Rubiaceae showed higher regeneration potential due to maximum seed dispersal capability, and favorable conditions prevailing for natural regeneration. *Grewia nervosa, Brownlowia elata, Artocarpus chama, Holarrhena antidysenterica* and *Leea macrophylla* were found as dominant regenerating species due to their profuse seed production and convenient environmental conditions for natural regeneration success.

The Importance Value Index (IVI) of any species indicates the dominance of species in a mixed population (Rahman *et al.* 2011). From the present study, it was found that *Grewia nervosa, Brownlowia elata, Artocarpus chama, Leea macrophylla, Holarrhena antidysenterica,* and *Anogeissus acuminate* were dominated species. Probably, the dominance of these species is due to the excellent dispersal capacities of their seeds, pollen grains, etc. by wind, water, birds, mammals, bats, and humans.

Most of the species (about 78%) were regenerated from seed whereas Kamruzzaman et al. (2018) found a total of 89% regenerating tree species regenerated from seed in case of Babu para VCF of Bandarban district, Bangladesh. However, it varies from study area to study area.

About fifty percent of the tree species have the height range of (20 - <100) cm whereas Hossain and Hossain (2014) reported that in chunati WS maximum seedlings were within height range of 50 - <100 cm which has similarities with the present study. They also reported that percentage of seedling individuals decreases with the increase of total height. Collection of saplings and poles by local people for fencing purpose resulted in reduced percentage in the upper class. However, Kamruzzaman et al. (2018) reported that height range 100 - <180 cm holds maximum (38.97%) percentage of regeneration individuals in case Babu Para VCF of Bandarban district.

Species richness is one of the foremost criteria in recognizing the importance of an area for conservation of biodiversity (Khumbongmayun *et al.* 2005). Rahman *et al.* (2011) reported that higher the value of diversity, greater would be the stability of community. In the present study, Shannon-Wiener's Diversity Index was found 3.37 where Simpson's Diversity Index was 0.055, Margalef's Richness Index was calculated as 8.57 and Species Evenness Index was 0.88. Present study has similarities with the findings of Kamruzzaman *et al.*

(2018) who reported to be found Shannon-Wiener's Diversity Index 3.28 where Simpson's Diversity Index 0.047, Margalef's Richness Index 6.92 and Species Evenness 0.92 for Babu Para VCF.

Conclusion

Natural regeneration is essential for conservation and maintenance of biodiversity in natural forests. Species composition of a forest is essential for its management in terms of economic value, natural regeneration potential and biodiversity. Plants maintain and expand their populations in time and space by the process of regeneration. Regeneration is a complex ecosystem process involving asexual and sexual reproduction, dispersal and establishment in relation to environmental factors. The strategies by which plants regenerate are soil seed bank and vegetative parts. Regeneration profile is used to determine their regeneration status. It has great importance in forest conservation and management.

The present study may serve as a primary input towards further study on vegetation structure and carbon pool assessment. Renikhayong para VCF is equipped with valuable medicinal plants, which help the disadvantaged indigenous communities to get rid of various diseases. Species conservation measures may be employed for the regenerating seedlings having low IVI and poor regeneration status. Conclusively, VCF still contain dense forests containing rich biodiversity including rare plant species. So, there is an urgent need to protect and manage these VCFs from being degraded for the sake of indigenous people and the ecosystem as a whole.

Disclosure statement

No potential conflict of interest was reported by the authors.

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