INTERNATIONAL JOURNAL OF ENVIRONMENT

Volume-8, Issue-3, 2019 ISSN 2091-2854

Received: 4 Oct 2019 *Revised: 25 Nov 2019* *Accepted: 26 Nov 2019*

VEGETATION ANALYSIS IN COMMUNITY FORESTS OF TERAI REGION, NEPAL

Rajeev Joshi[1]*, Ramesh Chhetri[1] and Karan Yadav[2]

[1]Forest Research Institute (Deemed to be) University, Dehradun-248195, Uttarakhand, India

[2]Department of Forestry, HNB Garhwal University, Srinagar (Garhwal), Uttarakhand-246174, India

*Corresponding author: joshi.rajeev20@gmail.com

Abstract

This paper deals with the study of vegetation analysis of tree species in Ganesh and Ramnagar community forests (CF) of the Terai region. For the study, altogether 63 concentric sample plots (each plot of 500 m^2) were laid using systematic sampling with a sampling intensity of 0.5%. A total of 967 individual trees representing 16 different tree species were identified. Both CF was dominated by monospecies such as *Mallotus philippensis* (Ganesh CF) and *Shorea robusta (*Ramnagar CF) based on the Importance Value Index (I.V.I). Likewise, the Shannon-Wiener diversity index was higher in Ganesh CF whereas the dominance index was low. Similarly, the index of evenness and richness was also slightly higher in Ganesh CF than Ramnagar CF. The study provided information about the structure, composition, and dominance of tree species which is essential for conservation and sustainable management of community forests. Therefore, this article serves as an example of establishing community forests so as to initiate the conservation and preservation of local biodiversity.

Keywords: Evenness; Richness; Abundance; Diversity; Importance Value Index

DOI: http://dx.doi.org/10.3126/ije.v8i3.26667

Introduction

Tropical forests are the richest biological communities on earth and these forests have been recognized to harbor a significant proportion of global biodiversity (Naidu *et al.,* 2016). The study which deals with quantitative analysis of vegetation is known as Phytosociology (Mandal and Joshi, 2014). It is important to know the phytosociological information of particular tree species for a better understanding of their ecology (Kharakwal, 2009). The identification of the plant communities helps us to acquire information about habit, habitat, niche, vegetation structure as well as various interactions among them (Khan *et al.*, 2017). Likewise, identification of the vegetation and species diversity patterns is fundamental for the conservation of natural areas and these patterns have frequently been focusing on ecological studies (Zhang *et al*., 2013). For studying the dynamic nature of vegetation along with specific eco-environmental situation several information on plant diversity and distribution is required (Sorecha and Deriba, 2017). Therefore, vegetation analysis is an important tool for a plant ecologist and has many uses in range management and comparative studies (Tarin *et al.,* 2017).

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, overgrazing and forest fires (Timilsina *et al.,* 2007; Gairola *et al.*, 2008; Shaheen *et al.,* 2012). Similarly, Shrestha *et al.* (2000) had also reported that the annual rate of deforestation (ca. 1.7%) in the last 16 years has been attributed in Nepal mainly to human population growth leading to greater demand for farming land, fuel wood, fodder, timber etc. These disturbances constitute serious threats to the ecosystem and may cause an irreversible damage (Archer and Stokes, 2000).

To procure competent conservation of forest, a better understanding of the particular forest and their past instabilities play a vital role (Geldenhuys and Murray, 1993). It shows that the conservation of plant diversity possess greater significance to the world from unprecedented loss of biological diversity (Brilliant, 2012). Further, knowledge and information about the plant diversity of particular forests is baseline information for the management and conservation of biodiversity (Dutta and Devi, 2013). However there are very limited studies in Nepal, therefore this study is an attempt to fill the gap and provide baseline information on the structure, composition, and dynamics of the current tree species in selected community forests in the Terai region of Nepal.

Methodology

Study area

The study was done in the two different community forests (CF) namely Ganesh CF and Ramnagar CF of Terai region in Kanchanpur district of Nepal. Terai region experiences tropical to sub-tropical climate (Figure 1). Kanchanpur district is located in Farwestern Province, southern west part of Nepal with Bhimdatta as its district headquarters which is bounded by Dadeldhura district (Churia hills) in the north, India border in the south, Kali River (India) in the west and Kailali district in the east. Ganesh CF is natural mixed Sal broad-leaved forest which covers a total area of 434.48 ha ranges to the elevation 221-300 masl. Similarly, Ramnagar CF is natural Sal forest covers an area of 197.16 ha at an elevation of 120-145 masl. These two community forests were handed over to the community forest user groups in the years 2001 and 2010 A.D., respectively. The main characteristic of two community forests is summarized in Table 1.

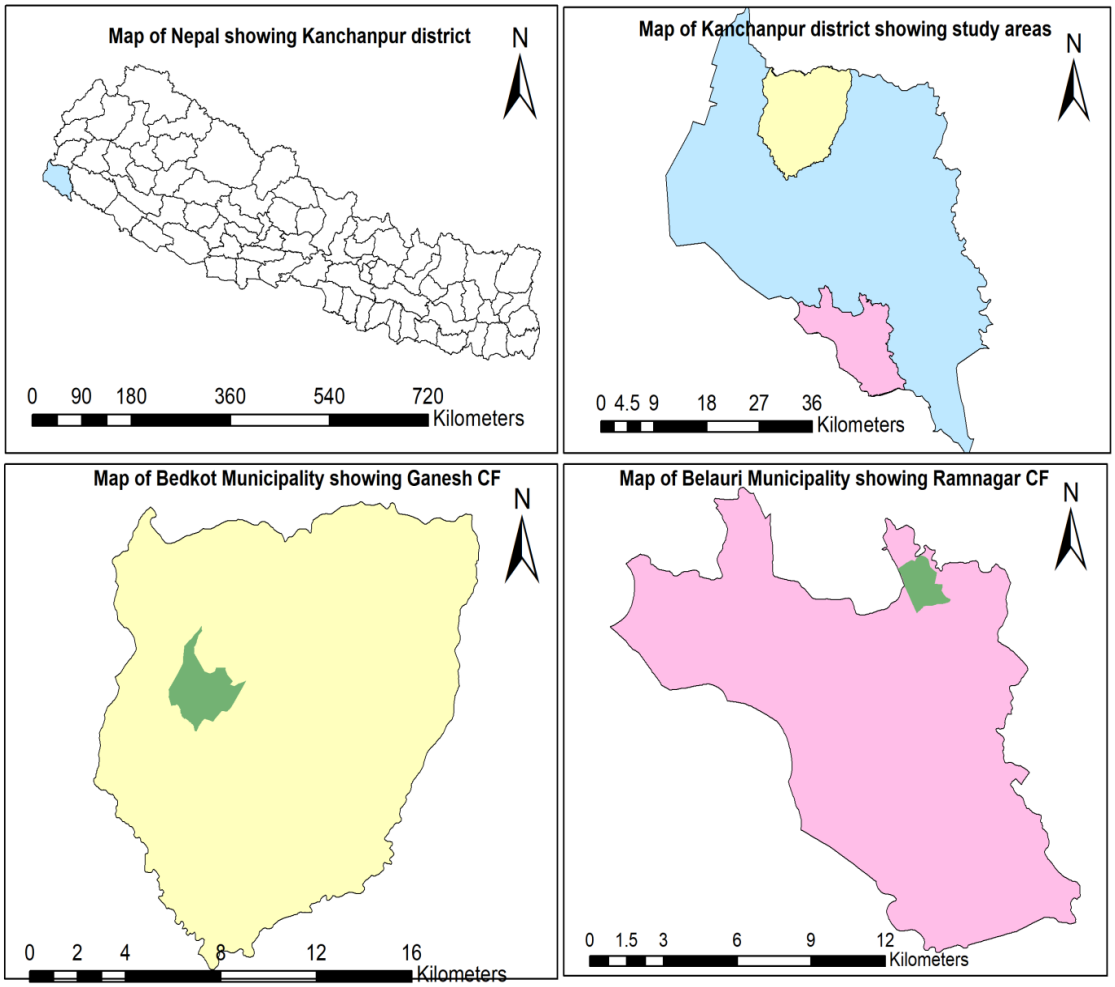

Figure 1: Map of study sites

Table 1: The main characteristic of community forests (CFs)

Name	Ganesh CF	Ramnagar CF
Address	Ward no. 6, Bedkot municipality, Kanchanpur district	Ward no 5, Belauri municipality, Kanchanpur district
Area (ha)	434.48	197.16
Territorial unit	3 block	8 sub compartment
Boundary	North-Chure National Forests boundary	North-Buffer zone area boundary
	South-Musepani village area	South- Sitanagar CF boundary
	East- Bachela CFUG	East- Ramnagar village area
	West- Chunepani river with Amar CFUG boundary	West- Belauri-Kaluwapur highway
Altitude	221m - 300 m above masl	120m - 145 m above masl
Soil type	Alluvial, sandy and graveled soil	Black. alluvial and mixed clayey soil
Crown cover (%)	40	65
Major plant species	*Shorea robusta, Mallotus philippensis, Adina cardifolia*	*Mallotus philippensis, Shorea robusta,Terminalia tomentosa*
Associated plant species	*Schleichera oleosa, Anogeissus latifolia, Lagerstroemia parviflora*	*Pterocarpus marsupium, Anogeissus latifolia, Lagerstroemia parviflora*
Wild animal species	*Sus scrofa, Panthera pardus, Lepus nigricollis, Boselaphus tragocamelus, Macaca mulata*	*Axis axis, Boselaphus tragocamelus Panthera pardus, Sus scrofa, Canis lupus, Macaca mulata*

Data Collection

The area of both community forests was larger than 100 ha. Therefore, altogether 63 concentric sample plots were laid using systematic sampling with a sampling intensity of 0.5% as per Community Forest (CF) Inventory Guidelines, 2004. The area of each circular sample plot was taken 500 m^2 along with 12.62 meter radius was used for sampling trees species and the number of sample plot in each community forest was determined by the formula given as:

$$\text{Number of Sample plot} = \frac{\text{Area of CF (sq. m.)} \times \text{sampling intensity (\%)}}{\text{Area of sample plot (sq. m.)} \times 100}$$

Diameter at breast height (dbh) of each tree within the plot was measured using diameter tape at 1.3 m and tree height was measured by using SILVA clinometer.

Data analysis

Vegetation Parameters

Shannon - Wiener diversity index (H')

The species diversity of the forest community was calculated to get the better quantitative description of the community. For the calculation of the species diversity, Shannon -Wiener diversity index (H') was applied. Shannon-Wiener index (H') can be calculated as:

$H' = -\sum (ni/N)\ln(ni/N) = -\sum Pi \ln pi$ (Shannon-Wiener 1963), Where, N =Total no of species., ni = number of individuals of species., Pi = ni/N.

Index of dominance (c)

Index of dominance was calculated by the following formula:

$c = \sum (Pi)^2$ (Simpson 1949), Where, c = Simpson index of dominance, Pi = the proportion of important value of the i^{th} species (Pi = ni/N, ni = number of individuals of each species and N = total number of individuals. Simpson index of dominance is inversely related to diversity; therefore, it is usually expressed as 1-D or 1/D (Daly *et al*., 2018).

Evenness index (e)

Species evenness refers to closeness in the number of each species in a community. It was calculated by the following formula:

$e = H'/\ln S$ (Odum1967), Where, H' = Shannon -Wiener Diversity Index, S = numbers of k species.

Species richness (D)

The species richness was calculated by using the method 'Margalef's (1958) index of richness' (D).

$D = (S-1)/\ln N$, Where, S = Total number of species, N = Total number of individuals.

Quantitative Data Analysis

For the quantitative data analysis frequency, density, basal area, abundance and I.V.I. of tree species is calculated by using the method described by Zobel *et al.* (1987) with some modifications. The description and formulas used for calculation of these attributes are given below:

Frequency and Relative frequency

Frequency designates the dispersion of species in a community. It is the percentage of sampling units in which a particular species occurs.

$$\text{Frequency}(\%) = \frac{\text{No. of plots in which species A occured}}{\text{Total no. of plots sampled}} \times 100$$

Relative frequency specifies frequency of a particular species in relation to total frequency of all the species present in the community.

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of species A}}{\text{Total frequency of all the species}} \times 100$$

Density and Relative density

Density shows the number of individual trees per unit area and it indicates the statistical strength of a species in a community.

$$\text{Density } \left(\frac{\text{no}}{\text{ha}}\right) = \frac{\text{Number of individuals of species}}{\text{Total no. of plots studied x area of each plot}} \times 10000$$

The proportion of density of species with respect to the total density of all the species within an area is referred to as relative density. In other words, it is the numerical strength of a species in relation to the total number of individuals of all species.

$$\text{Relative density (\%)} = \frac{\text{Density of species A}}{\text{Total densities of all species}} \times 100$$

Basal area and Relative basal area

Basal area refers to the ground actually penetrated by the stems (Hanson and Churchill, 1961). It is one of the characters that determine dominance.

$$\text{Basal area (sq. cm)} = \frac{\pi \times (\text{dbh})^2}{4}$$

Similarly,

$$\text{Relative basal area (\%)} = \frac{\text{Basal area of species A}}{\text{Total basal area of all species}} \times 100$$

Abundance and Relative abundance

It is the study of the number of individuals of different species in the community per unit area (Curtis and Mclntosh, 1950).

$$\text{Abundance} = \frac{\text{Total number of individuals of the species}}{\text{Total number of plots in which the species occur}}$$

Similarly,

$$\text{Relative abundance} = \frac{\text{Abundance of the species A}}{\text{Total abundance}} \times 100$$

Importance Value Index (I.V.I.)

It can be calculated by adding the relative values of the three parameters density, frequency, and basal area. Importance Value Index is calculated by:

I.V.I. = Relative Density + Relative Frequency + Relative Basal area (Curtice, 1959).

I.V.I. is a reasonable measure to assess the overall significance of a species since it takes into account several properties of the species in the vegetation.

Statistical analysis

Data analysis was done with the help of Microsoft - Excel (2010) and SPSS Software. Microsoft Excel spreadsheet was also used to draw graphs, tables and interpret data. The independent t-test was performed to determine whether there is a statistically significant difference between the means in two unrelated groups or not.

Results

Vegetation parameters

Different parameters were analyzed for the vegetation analysis of both community forests. In this study, twenty-two tree species were identified and recorded from 63 sample plots of both the community forests. In Ganesh CF, sixteen species (Table 2) of trees with a total individual of 318 trees were identified and measured. Similarly, in Ramnagar CF, 16 species (Table 2) of trees with total individual of 649 trees were identified and measured. *Shorea robusta, Mallotus philippensis, Adina cordifolia, Schleichera oleosa, Lagerstroemia parviflora, Cassia fistula, Terminalia bellerica etc.* were the common tree species in both the community forests.

Table 2: Descriptive statistics of vegetation parameters with variation in CF sites

S.N.	Parameters	Ganesh CF	Ramnagar CF
1	Number of species	16	16
2	Number of individual trees	318	649
2	Shannon-Wiener Index (H')	1.61	1.12
3	Index of Dominance (c)	0.36	0.51
4	Richness Index (D)	2.60	2.32
5	Evenness Index (e)	0.58	0.4
6	Mean ± SE Tree dbh (cm)	31.69 ± 3.63	22.5 ± 5.16
7	Mean ± SE Tree height (m)	9.61 ± 1.13	10.26 ± 1.66
8	Mean ± SE Tree density (number ha^{-1})	9.24 ± 5.21	40.56 ± 28.12
9	Mean ± SE Tree basal area (m^2 ha^{-1})	16.11 ± 0.39	24.47 ± 1.28

Mallotus philippensis and *Shorea robusta* were dominating tree species in Ganesh and Ramnagar CF respectively. In Ganesh CF, *Mallotus philippensis* (85 trees ha^{-1}) had a higher density than other tree species whereas, in Ramnagar CF, *Shorea robusta* (449 trees ha^{-1}) had a higher density than other tree species. Two tree species such as *Terminalia bellerica* and *Bombax ceiba* had less than one tree per hectare in Ganesh CF

and three tree species such as *Adina cordifolia, Dalbergia sissoo* and *Ziziphus mauritiana* had less than 1 tree per hectare in Ramnagar CF. The maximum frequency of tree species was *Mallotus philippensis* (67.44%) and *Shorea robusta* (100%) in Ganesh and Ramnagar CF respectively. In Ganesh and Ramnagar CF, relative density of *Mallotus philippensis* (57.55%) and *Shorea robusta* (69.18%) was found to be highest respectively (Table 3). Similarly, the relative frequency was found to be highest in *Mallotus philippensis* (29.90%) for Ganesh CF and *Shorea robusta* (25%) for Ramnagar CF. The relative dominance of *Mallotus philippensis* (35.93%) was found maximum in Ganesh CF whereas *Shorea robusta* (84.30%) had maximum relative dominance in Ramnagar CF. Similarly, *Acacia catechu* (38.72%) had maximum relative abundance in Ganesh CF and *Shorea robusta* (40.21%) had maximum relative abundance in Ramnagar CF (Table 3).

Table 3: Species wise Relative density, Relative frequency, Relative dominance, Relative abundance and Importance Value Index in Ganesh CF

S.N	Species	Relative density (%)	Relative frequency (%)	Relative dominance (%)	Importance Value Index	Relative abundance (%)
1	*Acacia catechu*	5.66	1.03	0.55	7.24	38.72
2	*Adina cordifolia*	2.52	6.19	22.14	30.84	2.87
3	*Anogeissus latifolia*	4.09	10.31	2.75	17.14	2.80
4	*Bombax ceiba*	0.31	1.03	1.75	3.10	2.15
5	*Cassia fistula*	3.77	8.25	0.92	12.94	3.23
6	*Ficus bengalensis*	0.94	3.09	7.15	11.19	2.15
7	*Ficus spp.*	1.57	3.09	0.32	4.98	3.59
8	*Holoptelia integrifolia*	1.89	2.06	3.87	7.82	6.45
9	*Lagerstroemia parviflora*	4.09	9.28	1.78	15.15	3.11
10	*Madhuca indica*	0.63	1.03	0.48	2.14	4.30
11	*Mallotus philippensis*	57.55	29.90	9.72	97.16	13.57
12	*Schleichera oleosa*	1.57	5.15	7.13	13.85	2.15
13	*Shorea robusta*	13.84	15.46	35.93	65.23	6.31
14	*Syzygium cumini*	0.63	1.03	0.04	1.70	4.30
15	*Terminalia bellerica*	0.31	1.03	2.22	3.56	2.15
16	Unknown spp.	0.63	2.06	3.25	5.95	2.15

Table 4: Species wise Relative density, Relative frequency, Relative dominance, Relative abundance and Importance Value Index in Ramnager CF

S.N	Species	Relative density (%)	Relative Frequency (%)	Relative dominance (%)	Importance Value Index	Relative abundance (%)
1	*Adina cordifolia*	0.15	1.25	0.01	1.41	1.79
2	*Anogeissus latifolia*	1.85	8.75	0.17	10.77	3.07

3	*Bombax ceiba*	0.46	3.75	0.10	4.31	1.79
4	*Cassia fistula*	0.62	3.75	0.16	4.53	2.39
5	*Dalbergia sissoo*	0.15	1.25	0.17	1.58	1.79
6	*Dillenia pentagaina*	0.46	3.75	0.06	4.27	1.79
7	*Diospyrous melanoxylon*	0.46	2.50	0.05	3.01	2.69
8	*Lagerstroemia parviflora*	2.00	5.00	0.39	7.39	5.82
9	*Mallotus philippensis*	18.03	11.25	3.51	32.79	23.28
10	*Pterocarpus marsupium*	1.54	7.50	2.30	11.34	2.99
11	*Schleichera oleosa*	0.77	3.75	0.12	4.64	2.99
12	*Shorea robusta*	69.18	25.00	84.30	178.49	40.21
13	*Syzygium cumini*	0.77	5.00	0.09	5.86	2.24
14	*Terminalia bellerica*	0.62	5.00	0.98	6.60	1.79
15	*Terminalia tomentosa*	2.77	11.25	7.57	21.59	3.58
16	*Ziziphus mauritiana*	0.15	1.25	0.01	1.42	1.79

Importance Value Index (I.V.I.)

The Importance value index (I.V.I.) was calculated by summing relative density, relative basal area, and relative frequency. The most dominant tree species in Ganesh CF was *Mallotus philippensis (*97.16) (Table 3) and *Shorea robusta* (178.49) (Table 4) was in Ramnagar CF based on I.V.I. *Syzygium cumini* (1.70) (Table 3) and *Adina cordifolia* (1.41) (Table 4) had the lowest IVI in Ganesh and Ramnagar CF, respectively.

Distribution of diameter class

Ganesh CF has the maximum number of trees in diameter class of (11-20) cm which attributes 165 tree individuals (Table 5). Similarly, Ramnagar CF has the maximum number of trees in diameter class of (>5-10) cm which accounts for 516 individuals. In both CF, the diameter class of (31-40) cm has the least number of individual trees i.e. 3 and 2 respectively (Figure 2).

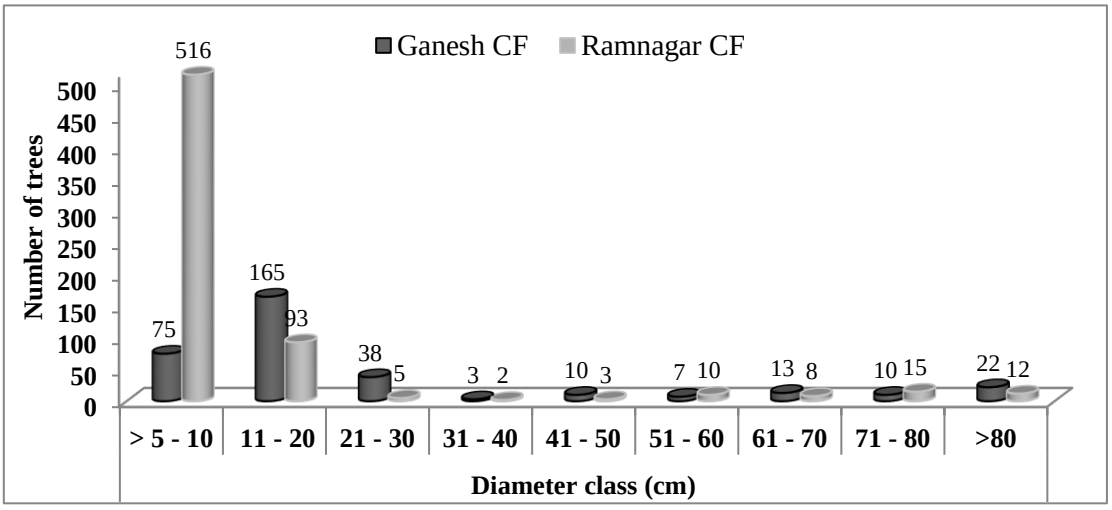

Figure 2: No. of tree individual distribution with different DBH class

Table 5: Percentage distribution of tree diameter at breast height

S.N.	DBH class (cm)	Ganesh CF (n = 343)		Ramnagar CF (n = 664)	
		No. of individuals	Percentage	No. of individuals	Percentage
1	> 5 – 10	75	21.87	516	77.71
2	11 – 20	165	48.10	93	14.01
3	21 – 30	38	11.08	5	0.75
4	31 – 40	3	0.87	2	0.30
5	41 – 50	10	2.92	3	0.45
6	51 – 60	7	2.04	10	1.51
7	61 – 70	13	3.79	8	1.20
8	71 – 80	10	2.92	15	2.26
9	>80	22	6.41	12	1.81

About fifty percent of the tree species have the DBH range 11-20 cm in Ganesh CF whereas in Ramnagar CF more than seventy-five percent of the tree species are found to be in the DBH range >5-10 cm, which shows that the both of community forests have more pole stages trees. The species distribution in both community forests primarily consists of small-sized trees with a diameter range of >5-20 cm. In both community forests, there is less percentage of trees with a diameter exceeding 30 cm (Table 5). After the statistical analysis, the *p* value was found to be more than 0.05 for Shanon-Weaver index, evenness index and dominance index which indicates that there is no significant difference among the community forests with respect to different vegetation attributes (Table 6).

Table 6: Independent t-test for different vegetation attributes

Vegetation attributes	Ganesh CF			Ramnagar CF			t-value	*p*-value
	No.	Mean ± SD	df	No.	Mean ± SD	df		
Shanon-Weaver Index	16	0.1 ± 0.09	15	16	0.07 ± 0.09	15	1.0064	0.32243
Evenness Index	16	0.04 ± 0.03	15	16	0.03 ± 0.03	15	-1.0627	0.2694
Dominance Index	16	0.02 ± 0.08	15	16	0.03 ± 0.12	15	-0.2753	0.78498

Where, * $p < 0.05$ is considered as statistically significant, No. = number of observations.

Discussion

Equal numbers (16 each) of species were recorded in both CFs but the higher number of individuals was found in Ramnagar community forests than Ganesh. The decrease in the total number of species individuals towards the Ganesh CF site and small number of major species found here may reflect repeated anthropogenic

exploitation pressure on those major species (Sagar *et al.,* 2003). Too much anthropogenic degradation and disturbances in community forests may lead to the loss of major plant species, while favoring the growth of fewer disturbance tolerant plant species (Johnson and Miyanishi, 2007).

However, Shannon-Wiener diversity index was also higher in Ganesh CF whereas the index of dominance was lower in Ganesh CF and found to be more in Ramnagar CF. Higher diversity means more variety of species whereas high dominance index means only a few species are dominant in the specific community. Likewise, analysis of the evenness index showed that evenness was high in Ganesh CF indicating that the species were relatively evenly distributed in Ganesh CF. Additionally, Ganesh CF possesses higher species richness than Ramnagar CF. Similarly, Mean dbh of tree species was recorded higher in Ganesh CF but the mean height of trees species was found slightly higher in Ramnagar CF. This might be due to the fact that Ganesh CF contained a higher number of species towards maturity and trees were slightly smaller in height due to the results of forest degradation by various human disturbances and livestock grazing pressure. In the case of Ramnagar CF, the age class distribution of most of the Sal species was evenly distributed. Dar and Sundarapanian (2016) also reported that the variation in species composition and richness may be due to the age structure of forest types, level of anthropogenic pressure, and difference in climatic conditions. Whereas, our study shows that the plant species diversity and their quantitative features show that the overall community is heterogeneous; however it is not statistically significant (Table 6).

The most dominant species in Ganesh and Ramnagar CF were *Mallotus philippensis* and *Shorea robusta,* respectively. The disappearance of previously dominant species like *Shorea robusta* and appearance of *Mallotus philippensis* with other non-woody species as a dominant character at their recruitment stage has been commonly observed as a result of severe forests degradation or disturbance activities such as grazing and browsing pressure (Onaindia *et al.* 2004). In this study, higher tree density (649 number ha^{-1}) was observed in Ramnagar CF followed by 148 number ha^{-1} in Ganesh CF. In the study conducted by Shrestha and Jha (1997), the densities in Bardiya National Park was found to be 348 number ha^{-1} which is low in comparison to the Ramnagar community forest.

Similarly, I.V.I. values express the dominance and ecological succession of any species with the single value. In the Ganesh CF, *Mallotus philippensis* had the highest value of I.V.I followed by *Shorea robusta* and *Adina cordifolia*. Similarly, in Ramnagar CF, *Shorea robusta* had the highest value of I.V.I. followed by *Mallotus Philippensis* and *Terminalia tomentosa.* This showed that *Mallotus Philippensis* and *Shorea robusta* are dominant species on the basis of I.V.I. value in Ganesh and Ramnagar CFs respectively. It may be concluded that the community studied exhibited high diversity of plant forms, better ranking on I.V.I. and other associated parameters.

Similarly, while analyzing diameter distribution in CFs types, number of trees found to be decreased with the increase in dbh up to dbh class 30 – 40 cm in the case of Ramnagar CF. But the trend was irregular in Ganesh CF as the number of trees in >5 - 10 cm dbh class was less than that in the 10 - 20 cm dbh class. The total mean basal area of trees in Ganesh and Ramnagar CF was estimated to be 16.11 m^2 ha^{-1} and 24.47 m^2 ha^{-1}, respectively which was comparatively lower than in the study conducted by Shrestha and Jha (1997), in Bardiya National Park (36 m^2 ha^{-1}). It could be due to the natural and human disturbances against the lower dbh plants.

Conclusion

The study demonstrated vegetation analysis of tree species in Ganesh and Ramnagar community forests. The most dominated single species was *Shorea robusta* in Ramnagar CF and *Mallotus philippensis* in Ganesh CF based on the I.V.I. The information about the dominance of tree species in these communities plays a vital role to assess the economic potential of the forest. Thus, the investigation of tree species composition, diversity and interaction of tree species in community forests provide a frame of reference to other researchers and policy-makers that will ultimately support in managing the community forests and further studies. Hence, it is strongly recommended that for the conservation and preservation of community forests, awareness and training program related to biodiversity conservation of forests should be encouraged at the local level which will ultimately help in balancing healthy nature and life as well.

Conflict of interest

It is hereby declared that no competing interest exists among the authors.

Acknowledgement

The authors would like to acknowledge Divisional Forest Office, Kanchanpur Nepal and the CFUG members of Ganesh and Ramnagar community forests for their technical support in the fieldwork.

References

Archer, S. and Stokes, C., 2000. Stress, disturbance and change in rangeland ecosystems. In *Rangeland desertification* (pp. 17-38). Springer, Dordrecht.

Bhatt, R.P. and Khanal, S.N., 2010. Vegetation analysis and differences in local environment variables in indrawati hydropower project areas in Nepal. International Researchs Journal of Plant Science, 1(4), pp. 084-093. http://www.interesjournals.org/IRJPS

Brilliant, R., Varghese, V.M., Paul, J. and Pradeep kumar, A.P., 2012. Vegetation analysis of Montane forest of Western Ghats with special emphasis on RET species. International journal of Biodiversity and Conservation, 4(15), pp.652-664. DOI: 10.5897/IJBC11.041

Curtis, J.T., 1959. The vegetation of Wisconsin: an ordination of plant communities. University of Wisconsin Pres. pp. 657.

Curtis, J.T. and Mcintosh, R.P., 1950. The interrelations of certain analytic and synthetic phytosociological characters. Ecology, 31(3), pp.434-455. https://doi.org/10.2307/1931497

Daly, A.J., Baetens, J.M. and De Baets, B., 2018. Ecological diversity: measuring the unmeasurable. Mathematics, 6(7), pp.119. https://doi.org/10.3390/math6070119

Dar, J.A. and Sundarapandian, S., 2016. Patterns of plant diversity in seven temperate forest types of Western Himalaya, India. Journal of Asia-Pacific Biodiversity, 9(3), pp.280-292. https://doi.org/10.1016/j.japb.2016.03.018

Debnath, T., 2018. Plant Diversity And Conservation : A Case Study Of Colonial Darjeeling. Journal of Humanities and Social Science, 23(8), pp. 84-91.

Dutta, G. and Devi, A., 2013. Plant diversity, population structure, and regeneration status in disturbed tropical forests in Assam, northeast India. Journal of Forestry Research, 24(4), pp.715-720.

Gairola, S., Rawal, R.S. and Todaria, N.P., 2008. Forest vegetation patterns along an altitudinal gradient in sub-alpine zone of west Himalaya, India. African Journal of Plant Science, 2(6), pp. 42-48.

Geldenhuys, C.J. and Murray, B., 1993. Floristic and structural composition of Hanglip forest in the Soutpansberg, Northern Transvaal. South African Forestry Journal, 165(1), pp. 9-20.

Hanson, H.C. and Churchill, E.D., 1961. The plant community Rein hold publishing corporation. New York Plant, Sci, 12(1), pp. 35-40.

Miyanishi, K. and Johnson, E.A., 2007. Plant disturbance ecology: the process and the response. Elsevier. Pp. 698.

Index, I.V., SHRESTHA, R., KARMACHARYA, S. and JHA, P., 2000. Vegetation analysis of natural and degraded forests in Chitrepani in Siwalik region of Central Nepal. Tropical Ecology, 41(1), pp.111-114.

Khan, M., Khan, S.M., Ilyas, M., Alqarawi, A.A., Ahmad, Z. and Abd_Allah, E.F., 2017. Plant species and communities assessment in interaction with edaphic and topographic factors; an ecological study of the mount Eelum District Swat, Pakistan. Saudi journal of biological sciences, 24(4), pp.778-786. https://doi.org/10.1016/j.sjbs.2016.11.018

Kharkwal, G., 2009. Qualitative analysis of tree species in evergreen forests of Kumaun Himalaya, Uttarakhand, India. African Journal of Plant Science, 3(3), pp. 049-052.

Mandal, G. and Joshi, S.P., 2014. Analysis of vegetation dynamics and phytodiversity from three dry deciduous forests of Doon Valley, Western Himalaya, India. Journal of Asia-Pacific Biodiversity, 7(3), pp. 292-304. https://doi.org/10.1016/j.japb.2014.07.006

Margalef, R., 1958. Temporal succession and spatial heterogeneity in phytoplankton. Perspectives in marine biology, pp. 323-349.

Naidu, M.T. and Kumar, O.A., 2016. Tree diversity, stand structure, and community composition of tropical forests in Eastern Ghats of Andhra Pradesh, India. Journal of Asia-Pacific Biodiversity, 9(3), pp. 328-334. https://doi.org/10.1016/j.japb.2016.03.019

Odum, E.P., 1971. Fundamentals of Ecology–WB Saunders Company. Philadelphia, London, Toronto. Pp. 574.

Onaindia, M., Dominguez, I., Albizu, I., Garbisu, C. and Amezaga, I., 2004. Vegetation diversity and vertical structure as indicators of forest disturbance. Forest Ecology and Management, 195(3), pp. 341-354. https://doi.org/10.1016/j.foreco.2004.02.059

Sagar, R., Raghubanshi, A.S. and Singh, J.S., 2003. Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. Forest ecology and Management, 186(1-3), pp. 61-71. https://doi.org/10.1016/S0378-1127(03)00235-4

Shaheen, H., Ullah, Z., Khan, S.M. and Harper, D.M., 2012. Species composition and community structure of western Himalayan moist temperate forests in Kashmir. Forest Ecology and Management, 278, pp.138-145. https://doi.org/10.1016/j.foreco.2012.05.009

Shannon, C. E. and Wiener, W., 1963. The mathematical theory of communication. Champaign, IL: University of Illinois Press. pp.117.

Shrestha, K.K. and Jha, P.K., 1997. Plant diversity and evaluation of conservation measures in the Royal Bardia National Park (RBNP). A report submitted to World Wildlife Fund Nepal Program, Kathmandu, Nepal.

Simpson, E. H.,1949. Measurement of Diversity. Nature, 163:688-688.

Sorecha, E.M. and Deriba, L., 2017. Assessment of Plant Species Diversity, Relative Abundances and Distribution in Haramaya University, Ethiopia. Journal of Physical Science and Environmental Studies, 3(3), pp. 30-35.

Tarin, M. W., Nizami, S. M., Jundong, R., Lingyan, C., You, H., Farooq, T. H., and Mohsin, M., 2017. Range vegetation analysis of Kherimurat Scrub Forest, Pakistan. International Journal of Development and Sustainability, 6(10).pp. 1319-1333.

Timilsina, N., Ross, M.S. and Heinen, J.T., 2007. A community analysis of Sal (Shorea robusta) forests in the western Terai of Nepal. Forest Ecology and Management, 241(1-3), pp. 223-234. https://doi.org/10.1016/j.foreco.2007.01.012

Zhang, J.T., Xu, B. and Li, M., 2013. Vegetation patterns and species diversity along elevational and disturbance gradients in the Baihua Mountain Reserve, Beijing, China. Mountain Research and Development, 33(2), pp.170-179. https://doi.org/10.1659/MRD-JOURNAL-D-11-00042.1

Zobel, D.B., Jha, P.K., Behan, M.J. and Yadav, U.K.R., 1987. A practical manual for ecology. Ratna Book Distributors, Kathmandu, Nepal, pp.149.