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Vegetation diversity, structure, composition and carbon stock of community managed forests of Mid-hills, Nepal

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Abstract. *Joshi P, Joshi R, Sapkota RP, Panta M, Chand P. 2023. Vegetation diversity, structure, composition and carbon stock of community managed forests of Mid-hills Nepal. Asian J For 7: 29-36.* Depending on management practices, forests can serve as both carbon sinks and sources. The goal of reducing carbon emissions and increasing the carbon sink is thought to be feasible if carbon reservoirs in current forests are protected and conserved. This study was objectively conducted to assess the vegetation diversity, structure, and carbon stock of the Mid-hills of Nepal. The study was undertaken in the Lanta Community Forest, Jajarkot District, Nepal, which has an extent of 38.65 hectares. Data for vegetation analysis and carbon stock assessment were collected using systematic random sampling using quadrats of 10×10 m with a total number of 35 quadrats. Within each quadrat, individual trees and bamboo were identified in the sites, and their height (m) and DBH (cm) were measured. Density, frequency, basal area, and Important Value Index (IVI) were calculated as structural parameters of vegetation. The Above-Ground Tree Biomass (AGTB) and Below-Ground Tree Biomass (BGTB) were calculated using an allometric equation based on tree diameter, height, and wood-specific gravity. The species diversity, species richness, and evenness were found to be 2.2, 2.35, and 0.83, respectively. A total of 14 tree species, with 723 individuals and one bamboo species were recorded. *Rhododendron arboreum* Sm. had the highest tree density with 211 trees/ha, while *Tsuga dumosa* (D.Don) Eichler had the highest IVI. Total wood volume, biomass, and total carbon stock were estimated at 15.37 m^3 ha^{-1}, 31.99 t ha^{-1}, and 15.03 t ha^{-1}, respectively. There was a strong negative correlation (r = -0.59) between *R. arboreum* and *R. campanulatum* D. Don and a strong positive correlation (r = +0.65) between *Malus sikkimensis* and *Machilus* species. For the preservation and sustainable management of community forests, information regarding the structure, composition, and dominance of tree species is provided by the study. The establishment of community forests is thus demonstrated in this article as a means of promoting the protection and preservation of regional biodiversity.

Keywords: Basal area, community forestry, DBH, Gramineae, IVI

INTRODUCTION

Forests comprise over 31% of the earth's land surface and are estimated to contain 289 Gt of carbon in biomass, greater than the total quantity of carbon in the atmosphere (FAO 2010). Depending on management practices, forests can serve as both carbon sinks and sources. The goal of reducing carbon emissions and increasing the carbon sink is thought to be feasible if carbon reservoirs in current forests are protected and conserved (Brown et al. 1999). Besides their role in climate change mitigation by storing carbon, forests are also the main home of biodiversity. Forests have canopy layers and various structures that serve as flora and fauna habitats and provide various ecosystem services (Dronova 2017).

Nepal occupies 0.03% of the world's land area (Government of Nepal 2019), but it is home to almost 3.2% of the world's known flora (MoFSC 2014). There are 6,073 species of angiosperms, 26 gymnosperms, 534 pteridophytes, 1,150 bryophytes, 365 lichens, 1,822 fungi, and 1,001 algae species recorded in Nepal (MoFSC 2014), with 284 blooming plant species are native to the country (MoFSC 2014). Nepal's forest covers 44.74 percent of the country's total land, in which 40.36 percent of it is covered by forest, while Other Wooded Land (OWL) covers the remaining 4.38 percent (DFRS 2018). Based on the Forest Act, 2019, national forests in Nepal are divided into six type namely government-managed, protected, community, leasehold, religious, and collaborative forests (Poudel 2019). The community forestry program in Nepal is a government effort to reduce forest degradation, promote sustainable forestry practices, and improve the community's livelihood (Ojha et al. 2009).

The capacity of a forest as a carbon sink can be referred to from the Above-Ground biomass (AGB) stored by forest vegetation (Ketterings et al. 2001; Nur et al. 2022). Carbon storage estimation helps gather data relevant to Greenhouse Gas (GHG) reduction (Adame et al. 2020). Data and information regarding above-ground biomass are also required to undertake climate change-related initiatives and programs, such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation). The state and dynamic of above-ground biomass can also provide essential information on forest management to inform the necessary interventions (Brown et al. 1999). For instance, carbon (C) sequestration in existing forests can be increased by reducing timber harvesting or lengthening rotations, but it must be compensated by the reduced financial benefits, the risks of catastrophic wildfires, and the costs of C emissions from the manufacture of materials to replace wood products. Another example is the afforestation of marginal farmland, which is already happening in many regions of the eastern US, facilitated through federal incentive programs like the Conservation Reserve Program (CRP) and the Wetlands Reserve Program (WRP) (Brown et al. 1999).

Most of the community-based forest management systems are being managed by local people. However, there are continuous debates about whether forest management practices have improved or worsened after the local communities take control of forest resources. Therefore, this study aimed to investigate vegetation diversity, structure, composition, and carbon stock of community managed forests in Lanta Community Forest, Kushe Rural Municipality, Jajarkot District, Nepal. We expect the results of this study can enrich the understanding of the effectiveness.

MATERIALS AND METHODS

Study area

The study was conducted in Lanta Community Forest, a core area of Red Panda in Kushe Rural Municipality, Jajarkot District, Nepal. Jajarkot District is situated in the Bheri Zone of Karnali Province with a total of 2230 km^2 (Figure 1). Lanta Community Forest has an extent of 38.65 ha. The geographical coordinates of the area are 28° 50′ 24″ N and 82° 10′ 12″ E. It has an altitude ranging from 3000-5000 masl with an average annual rainfall of 183.5 mm and an average temperature of 21℃ and humidity of 56.14%, respectively. The study area has a loam type of soil.

Data collection

Field survey

Field observation was conducted to determine the observation sites that were identified in a Focus Group Discussion (FGD). A systematic random sampling strategy was used to collect vegetation and environmental data. The first quadrat, measuring 10×10m, was carried then the subsequent quadrats were laid at the interval of 100 m. Within each plot, habitat factors, including altitude, slope, aspect, canopy cover, primary vegetation, and distance to road, water supply, and settlements, were documented at each plot. In addition, individual plant species within the plot were identified, and the height (cm), seedling density (individuals/m^2), litter layer cover (%), and dead bamboo density (stems/m^2) were also measured.

Canopy, slope, and elevation

The densiometer was used to determine the canopy cover of the vegetation within the quadrat (Lemmon 1957), which was classified into low (<25%), medium (25-50%), high (50-75%), and extremely high (>75%). In addition, the slope was categorized as extremely low (<10°), low (10°-20°), moderate (20°-30°), high (30°-40°), and extremely high (>50°). Similarly, the elevation range was also categorized from 2000m to 3000m.

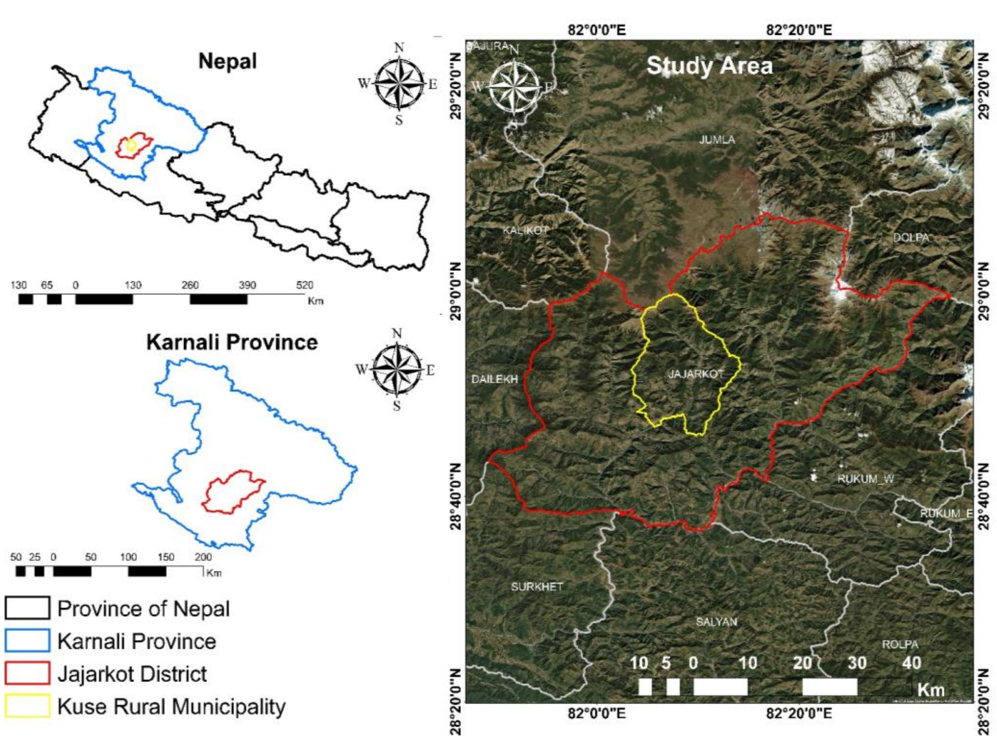

Figure 1. Map of the study area in Lanta Community Forest, Kushe Rural Municipality, Jajarkot District, Nepal

Secondary data

The documents and information about bamboo from DFO, Sector Forest Office, and Community Forest Office were reviewed and documented. Furthermore, pertinent references to various publications, the thesis and other publicly available information were examined.

Biodiversity parameters

Shannon-Wiener Diversity Index (H)

The species diversity was estimated to get a better quantitative picture of the forest community (Joshi et al. 2019). The Shannon-Wiener Diversity Index (H') was used to calculate the species diversity using the formula below:

H'= $-\sum$ (ni/N)ln(ni/N) = $-\sum$ Pi ln pi (Shannon and Weaver 1949)

Where; N is the total number of species, and ni is the number of individuals in each species; Pi = ni/N.

Evenness Index (e)

Evenness Index indicates the individual distribution/dispersion of a species whether a species is clumped or evenly distributed. The following formula was used to calculate it:

e =H'/ ln S (Odum 1971)

Where: H' is the Shannon-Wiener Diversity Index and S is the total number of species.

Species richness (D)

The Margalef Index was used to calculate the species richness using the following formula

D = (S-1)/ln N (Margalef 1958)

Where: S represents the total number of species and N represents the total number of individuals.

Floristic structure and composition

The floristic composition of the vegetation community in the studied area was analyzed using the Important Value Index (IVI). It is the sum of Relative Density (RD), Relative Frequency (RF), and Relative Basal Area (RBA) (Zobel et al. 1987). The following formulas were used to calculate such parameters.

Density and Relative Density (RD)

Density is the number of individual trees per unit area and was calculated as follows:

$$\text{Density (ind/ha)} = \frac{\text{Number of individuals of a species}}{\text{Total number of plots studied} * \text{area of plot}} \times 10000$$

Relative density is the density of a species about the overall density of all species in an area and was calculated as follows:

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

Frequency and Relative Frequency (RF)

Frequency is the dispersion of species in a community and was calculated as the proportion of sampling units in which a specific species is found as follows:

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

The relative frequency of a species is the frequency of a species about the total frequency of all species in the community.

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

Basal area and relative basal area (RBA)

The basal area is the horizontal area occupied by the stem of a species and indicates the dominance of a species (Hanson and Churchill 1961). It was calculated as follows:

Basal area (sq.cm) = $A = \pi d^2/4$

Similarly,

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

Important Value Index (IVI)

The Importance Value Index shows each species' dominance and ecological success within a community. It was calculated as follows:

IVI = Relative Density (RD) + Relative Frequency (RF) + Relative Basal Area (RBA)

Biomass estimation

Above-Ground Tree Biomass (AGTB)

Using diameter tape and clinometers, the diameter at breast height (DBH = 1.3 m) and height of individual trees more than or equal to 5 cm DBH were measured in each square plot within a 100 m^2 area. Each tree was numbered and labeled as accurately as possible with its species name. Trees on the edge of the plots were included if more than 50% of their base area fell within the plots, and were omitted if less than 50% of their basal area fell outside the plot. Trees with their trunks inside the sampling plots and branches out were omitted, whereas those with their trunks inside the plots and branches out were included. The diameter tape was wrapped around the stem precisely at the measurement place with great care.

The formula devised by Chave et al. (2005) was used to calculate AGTB:

AGTB = 0.0509 × § × D^2× h

Where, § = Specific gravity of wood (g/cm^3)

D = Tree diameter at breast height (cm)

h = Height of the tree (m)

The tree species wood specific gravity was measured and computed. Then, the biomass stock in kg/m^2 was computed by adding the sum of all the individual biomass weights (kg) of sampling plots and dividing by the area of sampling plots (100 m^2). Finally, the value was multiplied by 10 to get the ton/ha value. After multiplication with a carbon proportion of 0.47, the biomass stock was turned into carbon stock.

Below-Ground Tree Biomass (BGTB)

The root-to-shoot ratio, which has become the standard method for separating root biomass from the more easily measured shoot biomass, is one of the most popular descriptors of the relationship between roots (belowground) and shoot (aboveground) biomass. We used the root-to-shoot ratio of 1:5 to estimate BGTB, meaning that BGTB was equal to 20% of AGTB (MacDicken 1997).

Total carbon stock

By combining the carbon stocks of AGBT and BGTB, the total carbon stock of the forest was estimated.

Statistical analysis

Microsoft Excel 2007 was used to tabulate and analyze the data, which was then presented in graphs and tables.

RESULTS AND DISCUSSION

Biodiversity parameters

For the vegetation analysis of Lanta Community Forest, various biodiversity parameters were examined. In total, there were 14 tree species recorded with a total of 253 individuals from 35 sample plots of community forest in this study. The species were *Tsuga dumosa, Rhododendron arboreum, Rhododendron campanulatum, Abies spectabilis, Quercus semicarpifolia, Myrica esculenta, Daphne papyracea, Machilus* species, *Prunus cornuta, Pyrus pashia, Malus sikkimensis, Helixanthera ligustrina, Rosa sericea* and *Lyonia ovalifolia*. In addition, one species of bamboo identified, namely *Thamnocalamus* sp.

The Shannon-Wiener diversity index in the studied area was 2.20 (Table 1), which is greater than the range (0.9-1.0) reported by (Sharma et al, 2018) in Resunga Sacred Grove, Gulmi, and (1.80-1.91) reported by (Shrestha et al. 2020) in sacred groves in Kathmandu Valley, and Ganesh Community Forest and Ramnagar Community Forest in Nepal tropical (Joshi et al. 2019). However, our result is significantly lower than the range (2.69-4.53) reported by (Sahu et al. 2012) in a tropical holy forest environment in the Niyamgiri Hill Range in India Eastern Ghats. The species evenness index of our study area was 0.83, which is higher than that in Ganesh CF and Ramnagar CF (Joshi et al. 2019), indicating that the forest is more diverse and species are distributed more uniformly.

Floristic structure and composition

The average plant density in Lanta CF was 52 individuals per hectare (Table 2). The *R. arboreum* (211 ind ha^{-1}) was the most densest species, while *A. spectabilis* and *H. ligustrina* had less than 4 individuals per hectare (Table 2). The *T. dumosa*, *Q. semicarpifolia, D. papyracea,* and *R. campanulatum* were found to have 80 individuals per hectare, 71 individuals per hectare, 86 individuals per hectare, and 77 individuals per hectare, respectively. Similarly, the relative density of *R. arboreum* (29.25%) was highest and *A. spectabilis* (0.4%) had less than 1%. Similarly, the bamboo species *Thamnocalamus* was strongly growing and had a density of 3683 individuals per hectare.

Forest structure, functional diversity, ecological processes, and other ecosystem services are all influenced by tree density. The density of *R. arboreum* with 211 ind ha^{-1} is higher than Ganesh CF, which has the most densest tree species *Mallotus philippensis* (85 ind ha^{-1}), but lower than Ramnagar CF, which has the most densest tree species *Shorea robusta* (499 ind ha^{-1}) (Joshi et al. 2019). As a result, when compared to similar types of community forests in Nepal, the observed tree density in the current study might be deemed modest.

The frequency reflects how often the species appears in the forest. The *R. arboreum* (85.7%) had the highest percentage frequency, while *A. spectabilis* had the lowest (2.85%). In Lanta CF, the average basal area of trees was 79 m^2 ha^{-1} with *T. dumosa* was the most dominant species. Although it had a lower density (80 trees per hectare), it has the largest basal area (706.57 m^2 ha^{-1}) among the species due to its great girth size. Similarly, *A. spectabilis* was the recessive species with the smallest basal area (0.02 m^2 ha^{-1}).

Table 1. Biodiversity parameters in Lanta Community Forest, Jajarkot District, Nepal

Parameters	Value
Numbers of species	14
Number of individuals	253
Shannon-Wiener Index (H’)	2.20
Margalef Richness Index (D)	2.35
Evenness Index (e)	0.83

Table 2. The density, frequency and basal area of species in Lanta Community Forest, Jajarkot, Nepal

Species	Density (trees/ha)	Freq. (%)	BA (m^2 ha^{-1})
Tsuga dumosa	80	51.42	706.57
Rhododendron arboreum	211.42	85.71	99.51
Quercus semicarpifolia	71.42	22.85	218.72
Prunus cornuta	34.28	11.42	9.32
Machilus spp.	22.85	11.42	2.72
Pyrus pashia	25.71	22.85	7.85
Malus sikkimensis	11.42	5.71	1.89
Myrica esculenta	51.42	22.85	22.72
Rhododendron campanulatum	77.14	28.57	15.09
Helixanthera ligustrina	2.85	5.71	9.24
Daphne papyracea	85.71	40	1.29
Abies spectabilis	2.85	2.85	0.02
Rosa sericea	34.28	20	1.52
Lyonia ovalifolia	11.42	8.57	2.88

Note: BA: Basal area (m^2 ha^{-1})

The average basal area was found to be 78.52 m^2 ha^{-1} in present study, which was higher than the basal area of 37.28 m^2/ha reported by (Bhuju 2000) for Churia Forest in eastern Nepal and 34.20 m^2 ha^{-1} reported by (Marasini 2003) for disturbed Churia forest in Rupandehi District. In comparison to the forest of Churia, the Lanta Community Forest appears to be less disturbed. This could be related to the fact that the Lanta CF is located distant from human settlements and is not suitable for leisure visits.

Similarly, *R. arboreum* has the highest relative density (29.25%) and relative frequency (25.21%), whereas *A. spectabilis* has the lowest relative density (0.4%) and relative frequency (0.84%) (Table 3). The *T. dumosa*, the dominating species, had the highest relative dominance (64.26%), while *A. spectabilis* had the lowest (0.002 %) (Table 3). The IVI was found highest for *T. dumosa* (90.46) followed by *R. arboreum* (63.51), *Q. semicarpifolia* (36.5), *D. papyracea* (23.74), *Rhododendron campunulatum* (20.45), *M. esculenta* (15.9), *P. pashia* (10.99), *R. sericea* (10.76), *P. cornuta* (8.95), *Machilus* sp. (6.77), *L. ovalifolia*(4.36), *M. sikkimensis* (3.43), *H. ligustrina* (2.92) and the lowest IVI was obtained for *A. spectabilis* (1.24) as shown in Table 3.

Important Value Index (IVI) values express any species' dominance and ecological succession. The *T. dumosa* had the highest IVI (90.46), indicating that it takes up most space and resources. Conversely, with the lowest IVI index value (1.24), *A. spectabilis* is the most recessive species, which only consumes the least amount of area and resources.

Biomass estimation

The Lanta CF is located in temperate region of Nepal, where gymnosperms with enormous trunks present. As the result, the volume of wood would be enormous. The average wood volume in the Lanta CF is 1.090 m^3 ha^{-1}, with *T. dumosa* (10.5 m^3 ha^{-1}) having the largest volume, followed by *Q. semicarpifolia* (3.57 m^3 ha^{-1}), *R. arboreum* (0.84 m^3 ha^{-1}) and least *A. spectabilis* (0.0001 m^3 ha^{-1}) as shown in Table 4.

As shown in Table 4, the average biomass in Lanta Community Forest was found to be 2.285 t ha^{-1} , with *T. dumosa* (15.28 t ha^{-1}) having the highest biomass followed by *Q. semicarpifolia* (7.89 t ha^{-1}), *R. arboreum* (5.08 t ha^{-1}) and the least was *A. spectabilis* (0.003 t ha^{-1}). Forest biomass estimation is influenced by forest structure, such as tree density, diameter, basal area, tree height, and age. Furthermore, because biomass is closely tied to species selection and scheduled operations, such as planting, harvesting, and collecting other forest products, biomass in the forest reveals possibilities for improvements in forest management (Lal, 2005).

The present studies' mean biomass (2.285 t ha^{-1}) was lower than that of Dahal (2007) in the mid-hills of Central Nepal (233.0 t ha^{-1}) and *Eucalyptus* forest (96 t ha^{-1}) in Northeast Australia (Zerihun et al. 2006), community managed Hill Sal forest (120 Mg ha^{-1}) in central Nepal reported by Shrestha et al. (2020).

The amount of carbon sequestered in the forest varies depending on the forest type and tree density. The average carbon stock of Lanta CF was found to be 1.07 t ha^{-1}. *T. dumosa* (7.18 t ha^{-1}) was found to have the highest biomass, followed by *Q. semicarpifolia* (3.71 t ha^{-1}), *R. arboreum* (2.39 t ha^{-1}), least *A. spectabilis* (0.0014 t ha^{-1}). However, the results are not as comparable to those published by (Pandey and Bhusal 2016) from Sal forest in two different ecological areas (Hill and Terai) of Nepal, and by (Karki et al. 2016) from ICIMOD Knowledge Park, Godavari, which ranged from 234.54 to 479.29 t ha^{-1} in 2012. Forests, which store 20-100 times more carbon per unit area than croplands, play a critical role in lowering CO_2 levels in the atmosphere (Brown and Pearce 1994).

Table 3. The relative density, relative frequency, relative dominance and IVI of species in Lanta Community Forest, Jajarkot, Nepal

Species	RD (%)	RF (%)	RDo (%)	IVI
Tsuga dumosa	11.07	15.13	64.26	90.46
Rhododendron arboreum	29.25	25.21	9.06	63.51
Quercus semicarpifolia	9.88	6.72	19.9	36.5
Prunus cornuta	4.74	3.36	0.85	8.95
Machilus sp.	3.16	3.36	0.25	6.77
Pyrus pashia	3.56	6.72	0.71	10.99
Malus sikkimensis	1.58	1.68	0.17	3.43
Myrica esculenta	7.11	6.72	2.06	15.9
Rhododendron campanulatum	10.67	8.4	1.37	20.45
Helixanthera ligustrina	0.4	1.68	0.84	2.92
Daphne papyracea	11.86	11.76	0.11	23.74
Abies spectabilis	0.4	0.84	0.002	1.24
Rosa sericea	4.74	5.88	0.14	10.76
Lyonia ovalifolia	1.58	2.52	0.26	4.36

Note: RD: Relative density (%), RF: Relative frequency (%), RDo: Relative dominance (%), IVI: Importance value index

Table 4. Wood volume, living biomass and carbon stock of species in Lanta Community Forest, Jajarkot, Nepal

Species	Wood volume (m^3 ha^{-1})	Biomass (t ha^{-1})	Carbon stock (t ha^{-1})
Tsuga dumosa	10.50	15.28	7.18
Rhododendron arboreum	0.85	5.08	2.39
Quercus semicarpifolia	3.58	7.9	3.71
Prunus cornuta	0.06	0.55	0.26
Machilus sp.	0.02	0.15	0.07
Pyrus pashia	0.02	0.19	0.09
Malus sikkimensis	0.01	0.15	0.07
Myrica esculenta	0.18	1.07	0.50
Rhododendron campanulatum	0.09	1.13	0.53
Helixanthera ligustrina	0.05	0.17	0.08
Daphne papyracea	0.003	0.12	0.056
Abies spectabilis	0.0001	0.003	0.001
Rosa sericea	0.006	0.11	0.05
Lyonia ovalifolia	0.014	0.11	0.05

Table 5. Correlation matrix on the abundance between species in Lanta Community Forest, Jajarkot, Nepal

Species	T D	R A	Q S	P C	M S	P P	M S	M E	R C	H L	D P	A S	R S	L O	T S
T D	1														
R A	-0.18	1													
Q S	-0.32	0.00	1												
P C	-0.23	0.03	-0.14	1.00											
M S	0.34	0.04	-0.16	-0.06	1										
P P	-0.01	-0.05	-0.25	0.25	-0.17	1.00									
M S	-0.01	-0.02	-0.11	0.03	0.65	0.00	1.00								
M E	-0.28	-0.06	0.04	-0.14	-0.15	-0.18	-0.10	1							
R C	0.28	-0.59	-0.26	-0.06	-0.06	0.00	-0.12	-0.24	1.00						
H L	0.04	-0.02	-0.08	-0.05	-0.06	-0.09	-0.04	-0.08	0.15	1					
D P	0.02	-0.14	-0.16	-0.03	-0.10	-0.36	-0.15	0.23	0.19	0.16	1.00				
A S	0.22	-0.30	-0.08	-0.05	-0.06	-0.09	-0.04	-0.08	0.39	-0.03	0.02	1			
R S	-0.25	-0.01	-0.12	-0.11	-0.12	-0.19	-0.08	0.49	-0.16	0.12	0.37	-0.06	1.00		
L O	-0.02	0.27	-0.09	-0.09	-0.10	-0.15	-0.06	0.00	-0.05	-0.05	0.38	-0.05	-0.03	1.00	
T S	0.03	-0.12	-0.09	0.20	0.17	0.43	0.25	-0.19	-0.02	-0.03	-0.52	0.00	-0.10	-0.39	1

Note: TD: *Tsuga dumosa, RA*: *Rhododendron arboretum,* QS: *Quercus semicarpifolia,* PC: *Prunus cornuta,* MS: *Machilus* sp., PP: *Pyrus pashia,* MS: *Malus sikkimensis,* ME: *Myrica esculenta,* RC: *Rhododendron campanulatum,* HL: *Helixanthera ligustrina,* DP: *Daphne papyracea,* AS: *Abies spectabilis,* RS: *Rosa sericea,* LO: *Lyonia ovalifolia,* and TS: *Thamnocalamus* spp.

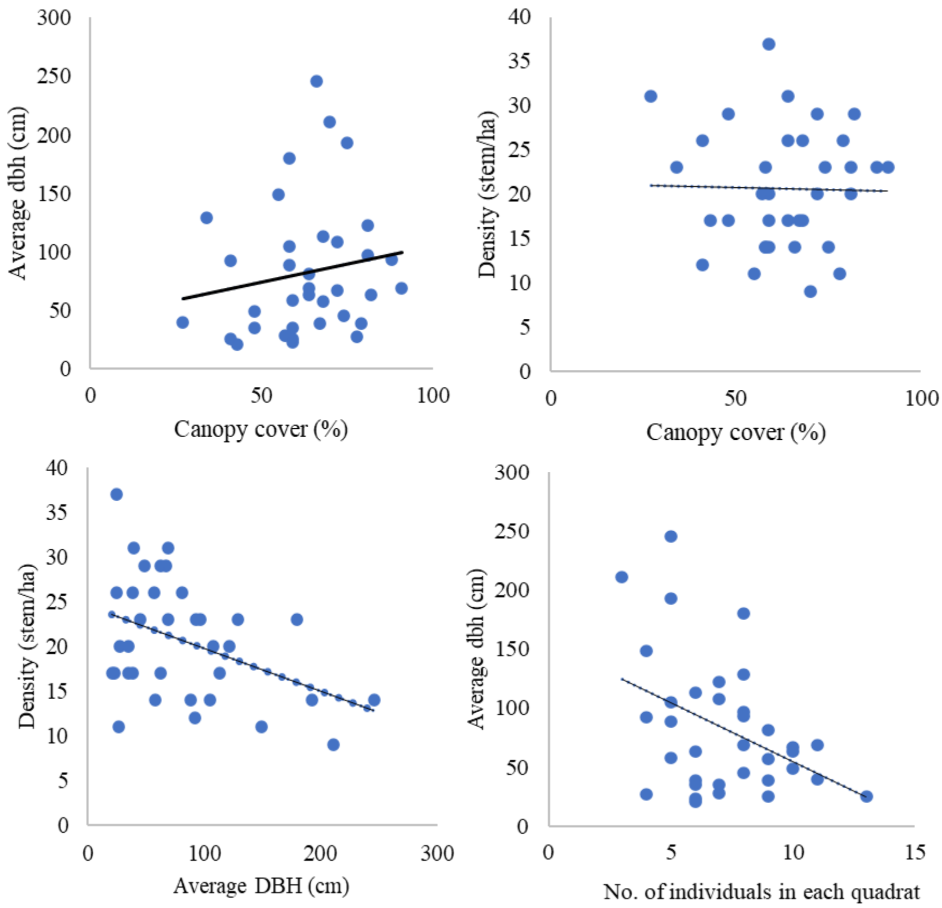

Figure 2. Correlation between structural parameters: A. Average dbh (cm) and canopy cover (%); B. density (stem/ha) and canopy cover (%); C. density (stem/ha) and average dbh (cm); and D. between average dbh (cm) and no. of individuals in a quadrat

Correlation between species

Most of the species in Lanta CF had a slightly negative relationship, while some species had a slightly positive one. However, there was a strong positive correlation between *Machilus* spp. and *M. sikkimensis* with a Pearson correlation coefficient of +0.65. Similarly, there was a strong negative correlation between *R. arboreum* and *R. campanulatum*, with a Pearson's correlation coefficient of -0.59.

The abundance of eight species in Lanta CF had a slight negative correlation with *Thamnocalamus* species, whereas the abundance of five species had a slightly positive correlation. The *D. papyracea* had a moderate negative correlation with a coefficient of -0.52 among the recorded species, whereas *P. pashia* had a moderate positive correlation with a Pearson correlation coefficient of +0.43. However, *A. spectabilis* was one of the few species with neither a positive nor a negative relationship with the *Thamnocalamus* species (r = 0).

In Lanta CF, the canopy cover was found to be positively correlated (r = 0.16) with average dbh (cm), suggesting that the present study is by the universally accepted concept, as shown in Figure 2A. The positive correlation between the average dbh of both canopy covers is because as the tree gets older, its girth size increases and also increases the branches and leaves. Conversely, there was a negative correlation between density (stem/ha) and canopy cover (r =-0.02), as shown in Figure 2B. The negative correlation between canopy cover and density might be due to the presence of large trees with widely dispersed branches which increased the canopy cover without increasing the tree number. Likewise, the average dbh (cm) was negatively correlated with density (stem/ha) (r = -0.4) and several individuals in each quadrat (r = -0.4), as shown in Figure 2C and 2D, respectively.

In conclusion, the vegetative characteristics and the biomass and carbon stock of the Lanta community forest were investigated. The observation plots in the Lanta CF recorded 14 tree species with 253 individuals and one bamboo species with 1289 individuals. The CF had a Shannon-Wiener diversity index of 2.20, a Richness Index of 2.35, and a species evenness index of 0.83. Based on the Important Value Index (IVI), *T. dumosa* was the dominant tree species in Lanta Community Forest. The total tree density was 723 trees per hectare, with the *R. arboreum* (211 individuals per hectare) being the densest. The forest's total wood volume, biomass, and carbon stock were also estimated to be 15.375 m^3 ha^{-1}, 31.99 t ha^{-1}, and 15.03 tons/ha, respectively. The amount of carbon stock differed among tree species due to tree structural factors such as density, basal area, height, and wood-specific gravity. The *R. arboreum* and *R. campanulatum* were found to have a strong negative correlation among all species, while *M. sikkimensis* and *Machilus* sp. had a high positive correlation. Similarly, the bamboo species had a negative association with *D. papyracea* and a positive association with *P. pashia*. Based on the results of the study, we recommend the following suggestions: (i) to increase the tree species richness in the forest, equal emphasis should have given to each tree species; (ii) to maintain the tree species diversity emphasis should have given to the proportionate distribution of all tree species throughout the forest; (iii) to normalize the species composition in the forest equal emphasis should have given to the less valuable species; (iv) to maintain the mean stem volume/ha, the balanced distribution of pole and trees over the entire forest area should be retained; and (v) to control the effect of limiting factor in the forest, regular and proper care should be employed during the management of the forest.

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