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RESEARCH ARTICLE

Edge Effects in Tree Diversity and Carbon Stock in South Slope at Phulchoki Forest, Lalitpur Nepal

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Highlights

- The density (ind/ha) and richness of trees were significantly variation in gradient.
- The diversity of forest changes with gradient
- The carbon stock varies in gradient

Abstract

The floral community changes in elevation. Due to the more diverse ecological characteristics, the diverse flora, and the number of landscape elements, there is a change in diversity called the edge effect. This study examines the role of altitude (1400–1800 m, 1800–2400 m, and above 2400 m) and how floral diversity changes with altitude variation. The aim of this study is to examine the carbon stock at which altitudinal range it is higher and why. One tree species (oak) was found at highest altitude (2650 m) followed by intermediate altitude (2100 m) further with greatest number of tree species at low altitude (1600 m). Higher species diversity(Shanon Index: 2.1863) and density (5575 individuals per hectares) was found at altitudinal range I (1400 to 1800 m) composed by Rhododendrum arborium, Quercus glauca, Myrica esculenta, and Myrsine capitellat. Whereas Rhododendron arboretum, Castanopsis tribuloides, and Quercus incana dominate altitudinal range II (1800m to 2400m) with diversity (Shannon Index: 1.759) and an average density (2150 individuals per hectare). In Altitudinal Area III (2400 m and above), the forest is dominated by Quercus semicarpifolia. The highest carbon stock was found in the altitudinal range (1800m to 2400m) compared to altitudinal ranges I and III. Edge effects shaped the community composition and affected tree diversity and carbon stock. In conclusion, the floral community and carbon stock were affected by forest edges, which led to conservation actions and mitigation of climate change in surprisingly different ways.

Keywords: *Elevation, Diversity, Density, Richness, Carbon stock*

Introduction

Understanding spatial patterns in biodiversity along environmental gradients is an important theme in ecology [1, 2]. Nepal, a Himalayan country, rises from the Indo-Gangetic plain about 60m in the south to worlds highest peak, thus, it encompasses variations in topographical features, with high mountains and with low land Tarai, such habitat heterogeneity contributes to the maintenance of high biodiversity [3]. An attitude is important factor in habitat diversity because it present changes in the availability of resources, such as heat and water [4a]. Many researchers explored altitudinal biodiversity patters of plants and classified that altitudes have a role in regulating species richness patterns [5].

The abrupt shift in vegetation and temperature from the mountain's base to its summit is a basic feature of mountain ecosystems.

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Elevation gradients cause soil differentiation and distinct climates, which in turn encourage the diversification of plant species [6]. Plant diversity is not directly impacted by elevation alone as an ecological factor [4]. Rather, variables that affect plants growing at different elevations are either directly related to elevation (temperature, air pressure, etc.) or have a more complex relationship with elevation (available surface area, precipitation, etc.). Numerous interrelated factors, including plant productivity, competition, geographic location, historical or evolutionary development, regional species dynamics, regional species pool, environmental variables [7].

Elevation diversity gradient (EDG) is an ecological pattern where levels in biodiversity occur at different elevations. The species richness trends to increase as elevation increase up to a certain level point), calling a "diversity bulge" at middle elevations and decrease richness with increase elevation. The biodiversity in elevation gradients is an important study to know distribution pattern of species diversity [3, 4]. The elevation gradient change can be compared with latitudinal gradient [8]. Many studies have been related to climate change and forests management prospect. This research studied for analysis of vegetation diversity changes for example richness, heterogeneity etc change in elevation gradient. The study was taken on the basis of change in Richness, Heterogeneity, Density, and Biomass, Importance value Index (IVI), Dominance and Evenness of trees with change in the elevation.

Materials and Methods

Study Area

The study was carried out at Phulchoki hill (27^0 33'N, 85^0 22'E), 10 km southeast of Kathmandu. It is a part of sub-Himalayan Mahabharat region with an altitudinal range of 1400 to 2715 m with extensive diverse forests mostly dominated by broad leaved evergreen trees. The climate of this area is sub- tropical to temperate. The maximum precipitation in the period was 1871 mm. The average was temperature 10.5oC. The vegetation of Phulchoki Hill is characterized by three distinct evergreen broad leaved forest types: mixed *Schima Castanopsis* forest at the base (1400 m to 1800 m), Oak- Laurel

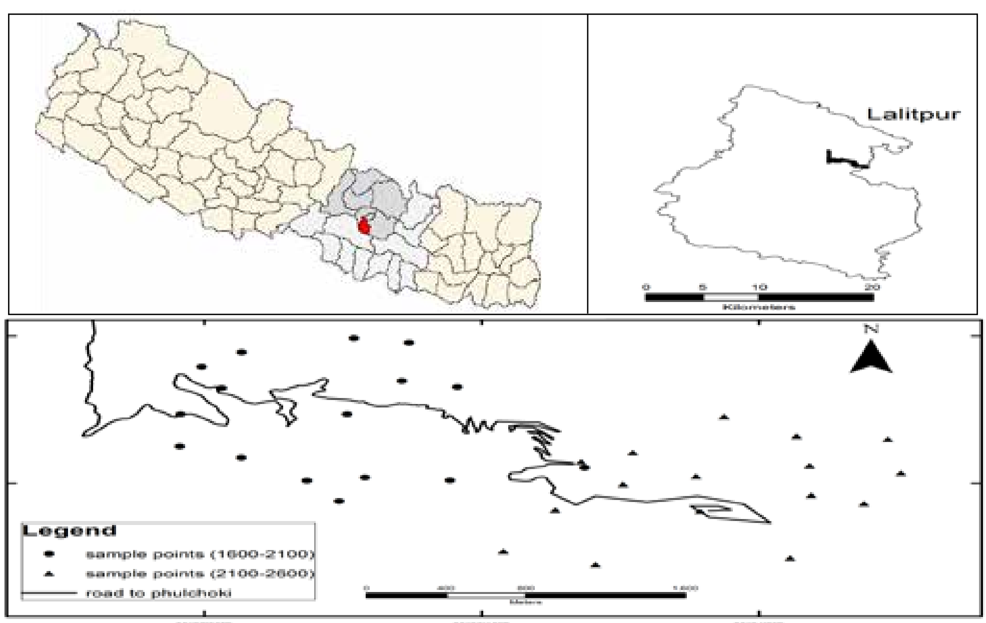

Fig 1. Map of Study Area

Forest (1800 m to 2400 m) and evergreen oak forest (2400 m and above). Mean temperature ranges between 2.6 to 18.7 C in winter and 15.8 to 28.2 C in summer. Relative humidity is greater than 90 percent in July, with a minimum of 63 percent in April [9]. 529 species of trees were enumerated by [10]

Methods

The vegetation investigation was conducted during May and June, 2023, at three different altitudinal area in the Phulchoki forest. The arrangement and floral makeup of tree species at varying elevations Elevation was measured using specific guidelines as recommended by [11] in 45 randomly selected 9.8 m × 9.8 m square plots. A total shift in the composition of the vegetation served as the basis for the selection of three distinct elevations: 1600 m, 1950 m, and 2650 m [9]. Four samplings were conducted in each of the four directions from the chosen elevation, centered on the wholesome tree composition, following the recommendation of [12]. In order to distinguish trees from shrubs and other woody plants, the following variables were noted in each sample plot: species, number, diameter, and cut stumps in study plots. Clinometers were used to measure each tree's height and diameter.. [3] defined trees as woody plants with a stem diameter of 6 cm or more and higher than 3m. The herbarium specimens were collected and identified in National Herbarium and Plant Laboratories, Godawari (Nepal). From the collected information, various vegetation parameters like Shannon-Weiner Diversity Index (H'), Evenness Index, Density and Relative Density, Frequency and Relative Frequency, Basal Area and Relative Basal Area and Importance Value Index (I.V.I.) were measured. From the measured data above ground tree was measured using equation suggested by [13]. Dry forest stand was selected and below ground biomass was taken as 20% of Above Ground Tree Biomass.

Density and Relative Density

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

$$\text{Density}\left(\frac{\text{no}}{\text{ha}}\right) = \frac{\text{No. of individuals of species}}{\text{Total no.of plots studied x area of each plot}}\ \text{x10000}$$

The proportion of density of species with respect to total density of all the species within an area is referred to as relative density.

$$\text{Relative density (R.D.)(\%)} = \frac{\text{Density of species A}}{\text{Total densities of all species}}\ \text{x100}$$

Frequency and Relative Frequency

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

$$\text{Frequency(\%)} = \frac{\text{No. of plots in which species A occured}}{\text{Total no. of plots sampled}}\ \text{x100}$$

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

$$\text{Relative Frequency (R.F.)(\%)} = \frac{\text{Frequency of species A}}{\text{Total frequency of all the species}}\ \text{x100}$$

Basal Area and Relative Basal Area

Basal area refers to the ground actually penetrated by the stems [14]. It is one of the characters that determine the dominance.

$$\text{Basal area (sq.m)} = \frac{(3.1416)\text{x}\ (\text{dbh})^2}{4}$$

Similarly,

$$\text{Relative basal area (R.B.A)(\%)} = \frac{\text{Basal area of species A}}{\text{Total basal area of all species}}\ \text{x100}$$

Importance Value Index (I.V.I.)

It is calculated by adding the relative values of the three parameters density, frequency and basal area [15].

I.V.I. = Relative Density (R.D.) + Relative Frequency (R.F.) + Relative Basal Area (R.B.A.)

Density is calculated to represent the quantitative strength of the species in the community. Density (ind./hec) = (I / (A/N)) x 10000

Where,

I = Total number of individuals, A= Area of each sampling plot and N= Total number of plots

Shannon-Wiener Diversity Index (H')

Shannon-Wiener's Index [16] was calculated to measure species diversity.

$H' = -\sum (ni/N) \ln (ni/N) = -\sum pi \ln pi$.

Where,

N= Total no of species

ni= no. of individuals of species

Pi= ni/N $\frac{\sum pi \ln pi}{\ln S}$ $\frac{\sum pi \ln pi}{\ln S}$ $\frac{\sum pi \ln pi}{\ln S}$

Where,

H = index number, s = total number of species, pi = proportion of all individuals in the sample i, and ln is the symbol of the natural log.

Index of Dominance (c)

Index of dominance (c) is calculated to know the dominant cover type of the ecosystem studied. Index of dominance can be calculated by following formula:

$$c = \sum\left(\frac{ni}{N}\right)^2 \sum\left(\frac{ni}{N}\right)^2 \text{ [14]}$$

Where,

ni = number of individuals of each species

N = total of individuals

Evenness Index (e)

Evenness of plant species is found using the Shannon evenness index to understand the relationship of species to each other.

Shannon Evenness Index, e= H/log S.

Where,

H =Shannon wiener's index of species diversity and S = number of species.

Evenness expresses how evenly the individuals in the community are distributed over the different species. Evenness index (e) is calculated as:

$$e = H'/ \log S \frac{\overline{H} \quad \overline{H} \quad \overline{H}}{\log S \log S \log S} \text{ [8]}$$

Where,

S= Number of species

$\overline{H}\ \overline{H}\ \overline{H}$ = Shannon-Wiener Diversity Index

Species richness

Species richness is the number of species per sampling unit.

Species richness (SR) = Number of species occurred in the study area

Biomass Estimation

Above Ground Tree Biomass (AGTB)

The dbh and height of individual tree greater than or equal to 5 cm dbh were measured in each square plots using diameter tape and clinometers. Each tree was marked individually to prevent double counting. Each tree were numbered and recorded with its species name. Trees on the border were included if >50% of their basal area falls within the plots and excluded if < 50% of their basal area falls outside the plot. Trees overhanging to the plots were excluded, but with their trunk inside of the sampling plots and branches out were included. The studied forest falls under dry forest stand [13].

$$AGTB = 0.112 \times (\S D^2 H)^{0.916}$$

Where,

AGTB = aboveground tree biomass (kg)

§ = wood specific gravity (kg m^{-3})

D = tree diameter at breast height (dbh) (cm);

H = tree height (m) [17]

The specific wood gravity of vegetation species were taken and calculated. After taking the sum of all the individual biomass weights (in kg) of a sampling plots and dividing it by the area of sampling plots the biomass stock was obtained in kg m^{-2}. This value was then converted to t/ha by multiplying it by 10. The biomass stock was converted into carbon stock after multiplication with the IPCC [18] default carbon fraction of 0.47.

Below Ground Biomass (BGB)

One of the most common descriptors of the relationship between roots (belowground) and shoot (aboveground) biomass is the root-to-shoot ratio, which has become the standard method for root biomass from the more easily measured shoot biomass.. To simplify the process for estimating Below Ground Biomass (BGB), it is recommended to follow [19] root-to-shoot ratio value of 1:5 that is to estimate Below Ground Biomass as 20% of Above Ground Tree Biomass [17].

Statistical Analysis

Microsoft Excel was used for the data recording and database preparation with R software. Parameters such as standard deviation and standard error were calculated using the respective formula.

Results and Discussion

Vegetation parameters on altitudinal area I

The observed number of trees was 225 on altitudinal area I with twelve different species such as *Castonopsis indica, Schima wallichiana, Rhododendron arborium, Quercus lanata* etc. Some other important vegetation parameters analyzed are presented in Table 1.

Regarding tree species, The richness was found 12 on site I. similarly, Heterogeneity was found 1.025, Mean dbh was found 24.97cm and mean height was found 9.47m. The above ground and below ground biomass were found on site I was 215.24 tons/hectare.

Table 1. Vegetation Parameters in Phulchoki site I forests

Parameters	Altitudinal Area I	Altitudinal Area II	Altitudinal Area II
Species richness	12	7	3
Shannon- Wiener	1.02	0.704	0.2
Diversity Index (H')			
Evenness Index (e)	0.41	0.36	0.18
Basal Area	637.79	1847.45	1526.76
Density	320	389	202
Mean dbh	24.97	30.91	62.434
Mean height	9.47	11.65	22.552
AGTB (tons/ha)	179.89	274.88	163.49
BGTB (tons/ha)	35.35	54.78	34.6

Importance value index in altitudinal area I

The relative density, relative basal area and relative frequency were calculated to determine the Importance Value Index (I.V.I.). The I.V.I. of different species in two forests is shown in Table 2. The forest consists of broad leaved trees. Regarding tree species, *Quercus lanata* was the most widely distributed tree with high frequency of occurrence value (80%) occurring in all the sampled plots followed by *Schima wallichiana* (75%), Rhododendron arboretum (70%). The highest value of IVI was calculated in *Quercus lanata* (37.35) followed by *Schima wallichiana* (35.74) and the minimum IVI was calculated in *Persea duthiei* (table 2).

Table 2. I.V.I. of different species in altitudinal area I

S.N	Name of species	Importance Value Index (IVI)
1	*Rhododendron arboretum*	32.65
2	*Schima wallichi*	35.74
3	*Eurya acuminate*	22.43
4	*Eugethardia spicata*	18.78
5	*Carpinus viminea*	26.46
6	*Lindera pulcharima*	18.12
7	*Quercus lanata*	37.35
8	*Castanopsis indica*	31.54
9	*Myrsine capitellata*	19.84
10	*Persea duthiei*	17.76
11	*Quercus glauca*	15.88
12	*Myrica esculenta*	23.45

Size class distribution

The number of trees decreased with increase within size increase. The mean height was 9.47m. With mean dbh was 24.97cm.

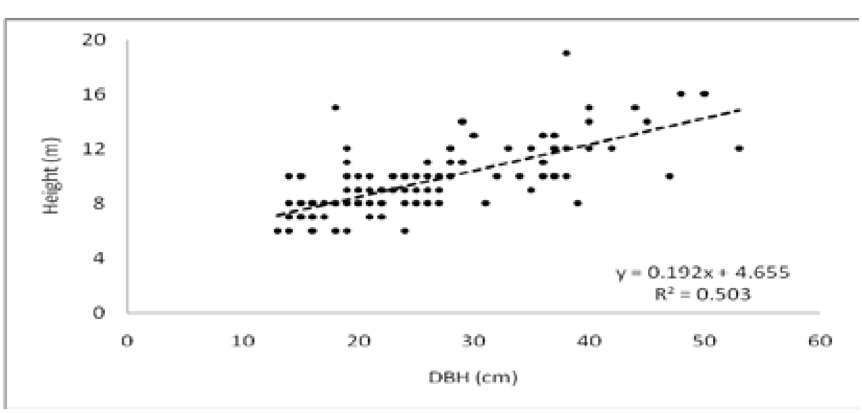

Fig 2. Relationship between heights (m) to DBH (cm) in altitudinal area I

Vegetation parameters on altitudinal area II

The observed no of trees was 146 trees on site II had the altitude 2050m to 2150m. Some other important vegetation parameters analyzed are presented in Table 1. The richness was observed seven (7) on site II. Similarly, heterogeneity was found 0.704, Mean dbh was found 30.91cm and mean height was found 11.65m. The totals above ground and below ground biomass were found on site I was 328.66 tons/hectare.

Importance Value Index (IVI) in altitudinal area II.

The I.V.I. of different species in forests is shown in Table 3. The forest consists of broad leaved trees. Regarding tree species, *Quercus lanata* was the most widely distributed tree with high frequency of occurrence value (65%) occurring in all the sampled plots followed by *Quercus glauca* (60%), *Rhododendron arboretum*(50%).

Table 3. I.V.I. of different species in altitudinal area II

S.N	Name of species	Importance Value Index (IVI)
1	*Rhododendrom arborium*	36.5
2	*Quercus lanata*	83.4
3	*Quercus glauca*	82.6
4	*Persea duthai*	40.3
5	*Myrica esculanta*	25.6
6	*Lyonia avalifolia*	18.3
7	*Eurya acuminate*	13.3

The highest value of IVI was calculated in *Quercus lanata* (83.4) followed by *Quercus glauca* (82.6) and the minimum IVI was calculated in *Rhodendrom arborium* and *Persea duthiei*.

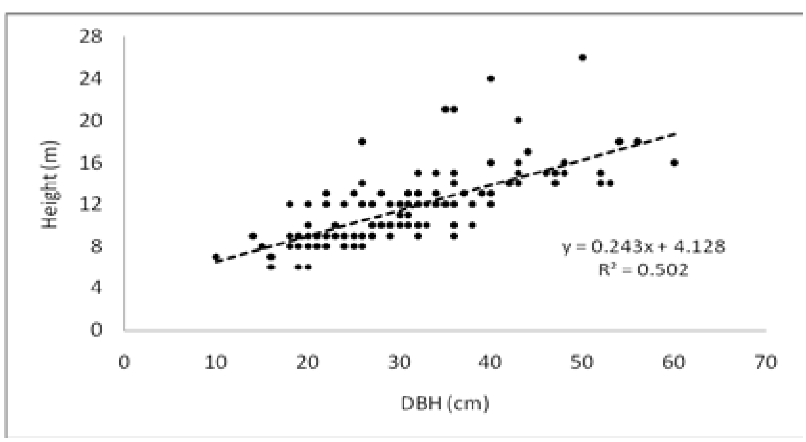

Fig 3. Relationship between heights (m) and DBH (cm) in altitudinal area II

The above figure 3 showed that the dbh (cm) increase with increase of height (m).The average height of tress in this site was 11.65m and average dbh was 30.91cm.

Vegetation parameters on altitudinal area III

The observed no of trees was 75 trees on site III had the altitude 2650m. Some other important vegetation parameters analyzed are presented in Table 1. Similarly, Heterogeneity was found 0.2, index of dominance was found 0.89, Evenness or equitability value was calculated 0.18. The density of trees per hectare was found 202.

Importance value Index in altitudinal area III

In area III, the richness was found three species. They were *Quercus semecarpifolia*, Ilex *dipyrens* and *Salix sp*. Among them, the value of IVI of *Quercus semicarpifolia* was calculated 225 followed by *Ilex dipyrens* and *Salix sp.* 40 and 35 respectively.

Table 4. I.V.I. of different species in altitudinal area III

S.N	Name of specie	IVI
1	*Quercus semecarpifolia*	225
2	*Ilex dipyrena*	40
3	*Salix* sp.	35

Relationship between height and dbh in altitudinal area III

The figure 4 gives the information of size and height of trees that the dbh increase to increase the height. The mean height was measured 22.55m and mean dbh was 62.43cm.

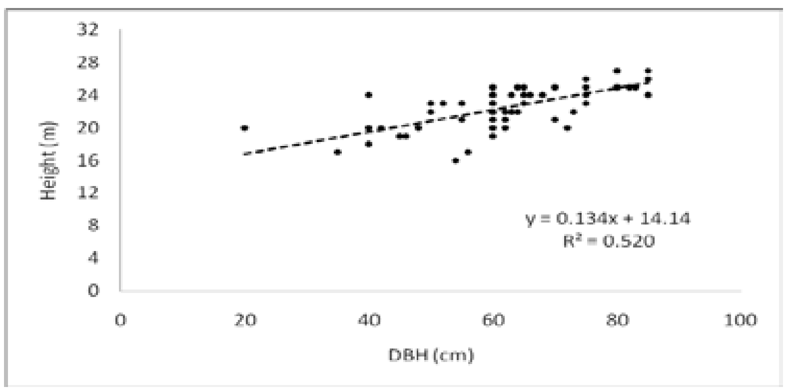

Fig 4. Relationship between heights (m) and DBH (cm) in altitudinal area III

[20] explored that altitudinal biodiversity patterns of plants that altitudes has a role in regulating vegetative composition patterns.

At lower altitude (area -I) *Quercus lanata* is dominant tree species with IVI value 37.35. The major associate tree species are *Schima wallichiana* (35.74) *Rhododendrom arboretum* (32.65)*, Myrica esculenta, myrsine capitellate* etc. The density of trees per hectare was 320 per hectare which was higher than high altitude. The higher density comparison to site III means this site is more favorable environment than area III but less in area-I. Similarly, the basal area was found 637.79m^2 where as richness was found 12 that was higher than other sites. Richness higher may be due to more heterogeneity more favorable for growing different species. Evenness index was fore in site I means that more species were found there. Evenness or equitability means the distribution of individual among the species. Evenness is maximum in when all the species have nearly equal number of individuals. The biomass was 179.89tons/hectare in area I mean it is regenerated species. The relationship between dbh and height be also suggest regeneration on this site.

At altitudinal area II, *Quercus glauca*, *Quercus lanata*, *Rhododendron abroreum* and *Castanopsis tribuloides* were mainly dominant and associated species are *Quercus incana, Quercus glauca, Castonopsis indica, Myrsine remiserata*. The density on site II was higher than site I and site III. The density of trees per hectare was 389no of tress per hectare. The higher density than other sites means this site is more favorable environment than site I and site-III means that this site is in boundary [21]. That may be due to influences of microclimatic conditions. The basal area was found higher that was 1847.45m^2 mean that in this site more favorable for growing trees and we can calculate that heterogeneity also higher in this site so this is transitional boundary between lower elevation and higher elevation where as richness was found 7 that was higher than site III means environmental constrains is low effect than higher elevation. Richness higher may be due to more heterogeneity more favorable for growing different species. Evenness or equitability means the distribution of individual between the vegetation community. Here evenness found 0.18 it is lower than 0.5 means here is evenly distributed species. The biomass was 274.78 tons/hec in site which was higher than other species. The relationship between dbh and height be also suggesting the trees is going to mature that passed the regeneration time.

The density on area-III was lowest than other two sites. The density of trees per hectare was 202 trees per hectare. The lower density comparison to other sites means this site is worse effect for plant growth. Similarly, the basal area was found 1526.76m^2 where as richness was found lower that was 3. Richness higher may be due to more heterogeneity more favorable for growing different species but in this site its value is 3 means few species are more favorable to grow. Evenness or equitability means the distribution of individual among the species. Evenness is maximum when all the species have nearly equal number of individuals. The biomass was 163.49 tons/hec. The relationship between dbh and height was higher means it is in mature stage.

Species richness along the elevation gradient confirms the results of studies by [23] has found the highest diversity of species and families between 1523-2135m in China. As well, species richness and diversity along the gradient show patterns which are similar to these of studies in eastern India, mountain areas in China [24, 25] diversity depends more on the heterogeneity of the dominant conditions than to the number of sampled areas. Notice that the greatest absolute diversity was found in subtropical zone than other zone. [26] had reported that when the sampling size is same although richness and diversity changes in some rhythm it's due to altitudinal change. The elevation positions of the lower/upper sampling limits are clearly linked to the observed diversity patterns and elevations of diversity peaks which generally are higher at mid-latitudes for major taxonomic groups for example within tropical mountain ranges, temperature generally increase in diversity within elevation but then decline at the highest elevations. Also, differences in elevation diversity peaks among plants and animals and among their sub groups probably reflect differences both in physiological tolerance and niche partitioning among species groups [27]. In general, less inclusive groups are less likely to present unimodal patterns because their constituent species usually have narrower distribution elevation ranges and more specialized habitat preferences. Therefore, we would expect smaller groups to demonstrate varied elevation patterns, as has been demonstrated across latitudinal gradients [7]. The patterns of distribution of plant species were not uniform accordingly to altitude due to variation in microclimate. At lower altitude *Schima wallichiana* is dominated among tree species. Generally high altitude forest has less number of biodiversity compared to broadleaved. The reason for the low tree density in the broadleaf forest could be attributed to the mature forest's nearly stratified canopy and larger trees. The similarity between two stands is more influenced by the most prevalent and common species [28]. The most crucial element in establishing the index of similarity is therefore variation in altitudinal ranges [3]. The different topography and edaphic factors could also be the cause. The way that species react to their microenvironment is known as floral similarity [29].

I.V.I. value expresses the dominance and ecological succession of any species with the single value. In Pulchoki Forest on area-I *Quercus lanata* was dominated with the value of 37.35 followed by *Schima wallichiana, Rhododendrom arboreum* had the value of 35.74, 32.65. This showed *Quercus lanata* that is dominant species on the basis of I.V.I. value in this site I. Similarly, other tree species associated *Eugethardia spicata, Quercus glauca* are suitable on that altitude. Similarly, in Site II with altitude higher than Site I the *Quercus lanata* and *Quercus glauca* were dominated species with the IVI vale 83.4 and 82.6 respectively followed by *Rhododendron arboretum*. The Site III the most dominant species was *Quercus semecarpifolia* with the IVI vale 225. I.V.I. value expresses the dominance and ecological succession of any species with the single value. In Pulchowki forest *Quercus glauca, Quercus lanata* had the highest value of I.V.I. followed by *Rhododendron arborium*. Similarly, other tree species associated *Eugethardia spicata, Lyonia avalifolia* are suitable on that altitude. Whereas in area III the species found that was *Quercus semicarfolia* was most dominated followed by *Ilex dipyrena* and *Sorbus sp*.

Trees are the plants that can develop a large biomass and capture a large amount of carbon over a growth cycle of many decades. So, forest can capture and retain a large volume of carbon for a long period of time. The total carbon sink and storage in the forest are important factor to mitigate climate change. Biomass of tree is variation in age, size of tree, forest composition as well as tree density. The total biomass on studied sites was in average of Phulchoki forest was 250.33 t/ha. The biomass on area I was calculated 215.24t/hec on elevation 1600m, the biomass on area II was calculated 338.66t/hec on 2100m and similarly the biomass on Site III was value 197.09t/hec. The biomass found lowest in high altitude was less tree density. The area I was middle biomass due to regeneration species or not mature trees while area II found highest biomass may be mature trees. In area I, The fig 4 showed that the species having DBH (10-20) cm and height 4-9) m had high frequency of occurrence in the sampling plots because there was old trees in the areas. The aboveground carbon stock was found 34.30-97.86 t/ha in different forest types [30]. In study sites, the mean carbon stock was found 250.33t/hec which was more than carbon stock value estimated by [3]. Various factors affect ecosystem carbon stocks, including net primary productivity of plant and biomass decomposition. Net primary productivity differs according to vegetation type, age of the stand, and the surrounding environment [31]. Mishra (2010) found the biomass carbon of the Chapako Community forest near Pulchoki as 119.742 t/ha. This is less than the biomass carbon found in this study. Biomass estimation of any forest depends on forest structure i.e. density of trees, diameter, basal area, tree height, age of trees etc. The above ground biomass of tree species in our study site-I was 179.89t/ha. A higher value of 86.02 tons/ha biomass was recorded by [32, 33] in degraded Chirpine forest at Lalitpur district. Simillarly, [34] estimated above ground tree biomass of *Pinus roxburghii* forest and mixed broad leaf forest of Palpa district to be 269.205 t/ha and 76.65 t/ha respectively. Pulchowki forest showed higher above ground tree biomass than the findings in other forest. The higher value of above ground biomass in the present study is indication of good protection of the forest. The above ground biomass also depends on trees size and canopy opening. Similarly, the total estimated carbon stock of the Gokarna forest was found to be 298.26 t/ha which was more comparable to values recorded by [35]. In Lalitpur district of Nepal (128 t/ha) more than the value estimated in Gadhanta-Bardibash CFM (208.363 t/hec). This value was higher than Singh (2002), who estimated the total carbon sequestration potential of Kusunde community forest, was 57.90 t/hec. The result of higher carbon content is signified by tree density and tree size (diameter and height) which was higher in this forest as compared to Kusunde community forest. Plant roots plays significant role in carbon transfer from the atmosphere into the soil [37]. The difference in such amount of carbon may be due to the reason of less aged trees than the forest of this study. So, this was also one of the reasons to have more carbon stock in study forest. The variability among the findings of the studies might be due to various factors which are responsible for the variation in biomass as stated above. While comparing with other studies, mean total carbon stock of present study was higher than the total carbon stocks findings of [38,39] who reported a value of 161.8t/hec in the world's forests and (126 t/hec) in sub tropical pine *Pinus roxburghii* forests of Pakistan (Ne but lower than accounted values (303 t/hec) in tropical seasonal forest of Southwestern China [40,41] and 283.80 t/ha in natural forest of Bangladesh [42]. This dissimilarity in carbon stock might be dense forest as well as trees with higher density, species composition and DBH of tree [43, 44].

Conclusions

The study forest consists of mixed forest at 2300 meter altitude below while altitude greater than 2300m means high altitude broadleaf type forest were found (*Quercus semicarfopilia*). The lower altitude was found higher diversity than higher altitude in the studied forest. Evenness index was found grater in lower altitude than higher (0.70 to 0.36) while similar result was found for heterogeneity like (1.025 to 0.7). The total biomass was found higher in middle altitude (338t/hec) while lower 215.24t/hec and higher 197.09 t/hec. Similar results was found for tree density (1847 trees density, 328 and 203tree density).

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