

**PLANT DIVERSITY, REGENERATION AND CARBON  
STOCK AT NORTHERN AND SOUTHERN ASPECT IN  
KALESHWAR, LALITPUR, NEPAL**



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REQUIREMENTS OF MASTER'S DEGREE IN BOTANY

SHARMILA SHARMA

SYMBOL No.: 561/2074

T.U. REGD. NO.: 5-2-0053-0323-2013

DEPARTMENT OF BOTANY

AMRIT CAMPUS

TRIBHUVAN UNIVERSITY

KATHMANDU, NEPAL

2023

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**Signature**

*Sharmila*.....

Sharmila Sharma

Department of Botany

Amrit Science Campus

Lainchaur, Kathmandu

**Date:** 28/01/2023



## AMRIT CAMPUS

P. O. Box No. 102, Thamel, Kathmandu, Nepal.

E-mail : amritcampus@ntc.net.np

Ref No.:

Date: 2079/07/18

Amrit Campus

### RECOMMENDATION

This is to recommend that the Master's thesis entitled "Plant Diversity, Regeneration and Carbon Stock at Northern and Southern Aspect in Kaleshwar, Lalitpur, Nepal" is carried out by Sharmila Sharma under my supervision. The entire work is based on original scientific investigations and has not been submitted for any other degree in any institutions. I therefore, recommend this thesis work to be accepted for the partial fulfillment of Master's Degree in Botany.

Supervisor

**Prof. Dr. Mukesh Kumar Chettri**

Professor in Botany

Department of Botany

Amrit Science Campus

Tribhuvan University

Kathmandu, Nepal

Date: 28/01/2023

Co-supervisor

**Gyanu Thapa Magar**

Asst. Professor

Department of Botany

Mahendra Multiple Campus

Tribhuvan University

Nepalgunj, Banke, Nepal



## AMRIT CAMPUS

P. O. Box No. 102, Thamel, Kathmandu, Nepal.

E-mail: amritcampus@ntc.net.np

Ref No.:

Date: 2079/08/28

### APPROVAL

The thesis work submitted by Sharmila Sharma entitled "Plant Diversity, Regeneration and Carbon Stock at Northern and Southern Aspect in Kaleshwar, Lalitpur, Nepal" submitted to Department of Botany, Amrit Campus, Tribhuvan University, TU Registration Number 5-2-0053-0323-2013 has been accepted for the partial fulfillment of the requirement for Master's Degree of Science in Botany.

**External Examiner**

**Dr. Narayan Prasad Ghimire**

**Assistant Professor**

Central Department of Botany

Tribhuvan University

Kathmandu, Nepal

**Expert committee**

**Internal Examiner and**

**Program Coordinator**

**Dr. Laxmi Joshi Shrestha**

**Assistant Professor**

Amrit Science Campus

Tribhuvan University

Kathmandu, Nepal

**Supervisor**

**Prof. Dr. Mukesh Kumar Chettri**

**Professor**

Amrit Science Campus

Tribhuvan University

Kathmandu, Nepal

**Co supervisor**

**Gyanu Thapa Magar**

**Assistant Professor**

Mahendra Multiple Campus

Tribhuvan University

Nepalgunj, Banke, Nepal

**Head of Department**

**Dr. Shila Singh**

**Associate Professor**

Amrit Science Campus

Tribhuvan University

Kathmandu, Nepal

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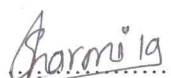
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## ABBREVIATION AND ACRONYMS

°C	:	Degree celsius
asl	:	above sea level
cm	:	centimeter
D	:	Density
DBH	:	Diameter at Breast Height
<i>et al.</i>	:	and others
F	:	Frequency
GoN	:	Government of Nepal
GPS	:	Global Positioning System
Ha	:	Hectare
IVI	:	Importance Value Index
m	:	meter
RD	:	Relative Density
RF	:	Relative Frequency
SD	:	Standard Deviation
Sd	:	Seedling
Sp	:	Sapling
sp.	:	species (singular = sp. and plural = spp.)

## ABSTRACT

Plant community structure in particular area determines the forest stage and its importance. Different topographical, climatic, edaphic and population factor affects the community composition and its life span. Thus, the present study has aimed to find out the role of different topographical features in species diversity, tree regeneration and total biological carbon stock in the Kaleshwar area of Lalitpur district, Central Nepal. A quantitative study was carried out along the altitudinal gradients at both Northern and Southern aspect of Lahuribina community forest and Gimdi community forest respectively at Kaleshwar area. The study was carried out by using stratified random sampling method. Study area was divided into 5 different altitudinal strata in both the aspects (i.e.1500m-1600m, 1700m-1800m, 1900m-2000m, 2100m-2200m and above 2300m). 10 circular plots of sizes 10m radius for trees, within it, subplots of 5m radius for shrubs including sapling and 1m radius for herbs and seedling were laid in each strata. Regeneration of tree species were calculated by counting the seedlings (height < 20 cm) with in 1 m radius and saplings (height > 20 cm) with in 5m in circular plot. Carbon stock of tree species were calculated with the help of tree DBH and height. Total of 155 plant species were enumerated from north facing aspect, with 42 species of tree, 37 species of shrubs and 76 herbs species. But in southern aspect 134 species were recorded; 32 trees, 37 shrubs and 65 herbs species. Numbers of species were slightly higher in northern aspect than in the southern aspect however, the difference was not significant. There was slight variation in species richness and evenness between two aspects. There was very low number of seedlings than that of sapling and adults along all the altitudinal strata in both the aspects. Carbon stock was higher at 1500m followed by 2100m and 2300m altitudinal strata along northern aspect and at 1700m and 1900m altitude along southern aspect. Study concluded that the altitude and aspect play significant role in plant species diversity, regeneration and carbon stock.

**Key words:** Altitude, Forest structure, Slope direction, Broad leaf forest

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# Chapter 1 Introduction

## 1.1 Background

### 1.1.1 Biodiversity

Nepal has tremendous geographic diversity ranging from Terai to high Himalaya due to this reason variation occurs in vegetation. Vegetation of Nepal has been divided into six bio-climatic zones: Topical (< 1000m), sub-tropical (1000 - 2000m), temperate (2000m – 3000m), sub-alpine (3000 – 4000m), alpine (4000 - 5000m) and nival (> 5000m) (Dobremez, 1980). Vegetation in Nepal has been influenced by different factors like rainfall, aspect, humidity, altitude and exposure (Stainton, 1972).

The variability of all life form which includes within species, between species and ecosystem is the biodiversity (Glowka *et al.*, 1994). Diversity has two components Species richness and evenness. Species richness is the number of species per unit area and evenness is the abundance distribution of species in a community (Vasilevich, 2009). Species richness plays a great role for measure biodiversity (Whittakar *et al.*, 2001) and acts as a surrogate measure for many other kinds of variation in biodiversity. Similarly, evenness can be used to define and differentiate ecological communities (Magurran, 2003). Natural and human disturbances are both considered to be the major drivers of species diversity in plant communities.

In general, frequency and magnitude of disturbance are key factors for changes in species diversity (Connell, 1978; Sousa, 1979). Under extensive disturbance species diversity normally declines, but moderate disturbance can enhance or reduce depending on the spatial scale and types of species (Chaneton & Facelli, 1991; Hamer & Hill, 2000; Dumbrell *et al.*, 2008). Human disturbances, particularly from the over exploitation of biological resources, generally have negative impact on species diversity at a global scale (Goudie, 2005; Abadie *et al.*, 2011). In addition, plant diversity, distribution, and abundance are directly affected by topography (Cantlon, 1953). In mountainous regions, topographic features such as slope orientation and elevation play a major role in structuring vegetation composition due to variation in incoming solar radiation, soil parents, and amount of rainfall (Holland & Steyne, 1975). Scherrer and Körner (2010) have shown that the mountain topography can influence temperature differences over

very short horizontal distances. Therefore, the differential distribution of solar radiation between north- and south-facing slopes may produce differences in micro-climate (e.g., temperature) and water balance (moisture) between the slopes, which result in different plant community composition and richness (Vetaas, 2000).

### **1.1.2 Regeneration of forest**

Natural plant regeneration implies the process of re-growing or reproducing new individual plants in the community (Coulter, 2019). It is a critical part of forest management, because it maintains the desired species composition and stocking after various disturbances (Khumbongmayum *et al.*, 2005). The successful regeneration of a tree species depends upon the ability of its seedlings and saplings to survive and grow (Good & Good 1972). Forest structure is both a product of forest dynamics and a template for biodiversity and ecosystem function. Moreover, size-class distributions give a better indication of long-term regeneration status than seedling counts (Vetaas, 2000). The regeneration of plant species mainly depends upon the viability of seed, dispersal of seed, vegetative growth and reproductive success (Napit, 2015).

The proportion of different life stages (seedlings, saplings and trees) of different species helps in predicting the composition and population size of the forest on near future (Malik & Bhatt, 2016). On the basis of density of seedlings, saplings and trees, different types of regeneration status (i.e. good, fair, poor and new regeneration) can be observed in different forests (Khan *et al.* 1987). According to Saxena and Singh (1984) when the seedling number counts greater than sapling and sapling greater than adult trees, reflects the good regeneration of the forest, but when seedling is greater than sapling but sapling is less than adult trees, reflects the fair regeneration, and when species is in only sapling stage in forest indicate the poor regeneration; i.e., consequentially, reflecting recent forest composition replaced by other community in near future. The rate of regeneration has been highest in species rich vegetation i.e., more stability of community having more diversity (Jayakumar & Nair, 2013). Similarly, Population structure can be defined as the number of individual present in each of the definite girth class distribution of tree species (Sarkar & Devi, 2014). The ratio of various diameter groups in a population determines the reproductive status of the population, and it indicates the future course of stability of forest communities (Odum, 1971). Factors like disturbance, competitive interactions

between trees influence the population structure and recruitment pattern of forest (North *et al.*, 2004).

### **1.1.3 Forest and carbon stock**

Storage of atmospheric carbon dioxide in green plant biomass through photosynthesis is called carbon stock in plant (Noble *et al.*, 2000). Atmospheric carbon categorizes into two main groups, as tree carbon stock and soil carbon stock (Gebrewahid & Meressa, 2020). Tree carbon stock is also divided into two groups above ground carbon stock and below ground carbon stock (Nair *et al.*, 2009). Globally, forest vegetation shares approximately 80% of terrestrial above-ground, and 40% of terrestrial below-ground biomass carbon storage (Panagiotopoulos, *et al.*, 2020). Above ground biomass is a key for quantifying carbon stock in forest, the carbon stored in the aboveground living biomass of trees is the largest pool and the most directly influenced by the deforestation and forest degradation (Gibbs, 2007). It is estimated that about 86% of the terrestrial above-ground carbon and 73% of the earth's soil carbon are stored in the forests (Rodger, 1993). The tropical forest plays a major role in the global carbon cycle, storing up to about 46% of the world's terrestrial carbon pool and about 11.55% of the world's soil carbon pool (Brown & Lugo, 1982). Tree biomass is directly influenced by species composition (Bunker *et al.*, 2005) thus higher density will have higher biomass carbon storage (Rahayu *et al.*, 2005).

Human beings are increasing the rate of emission of free CO<sub>2</sub> concentration through fossil fuels burning; land use changes and forestry activities, resulting in global warming and climate change (Upadhyaya *et al.*, 2005). Forest play a significant role in mitigation of climate change by sequestering and storing more carbon from the atmosphere (Gubena & Soromesssa, 2017).

## **1.2 Rationale of the study**

Many forests are under great anthropogenic pressure and require management intervention to maintain the overall biodiversity, productivity and sustainability (Kumar *et al.*, 2002). Understanding the species diversity and distribution patterns are important ecological parameters to evaluate the impact of solar radiation on forest resources. Present study focused on plant species composition and population structure of the forest at two different aspects (i.e. north and south). Both the sites were covered with forest and

people in these sites were highly dependent on forest for fodder and firewood collection. It is not known if different aspects do have role on plant diversity, forest structure, regeneration and carbon stock. Therefore, the present study intends to evaluate these parameters at different altitude in north and south aspects.

### **1.3 Research Questions**

1. Does Plant diversity varies with north and south aspects?
2. Does Regeneration and Population structure and carbon stock varies with different altitude at north and south aspects?

### **1.4 Objectives**

#### **General objective**

General objective of the study is to compare the plant species diversity and their population and growing structure of forest at northern and southern aspect of the Kaleshwar area, Lalitpur.

#### **Specific objectives**

- To measure the species diversity indices and similarity index of plants species at different altitude on both aspects.
- To determine the community structure of plant species along altitudinal gradient.
- To compare the carbon stock and regeneration status of trees.

### **1.5 Limitations of the study**

- Random sampling was conducted that might have chances of exclusion of important species from the study.
- Some herb species could not be identified due to the lack of their proper development of vegetative and reproductive parts during the field visit.

## Chapter 2 Literature review

### 2.1 Species diversity

Species diversity has been affected by the environmental factors (Rai *et al.*, 2016). Zeng *et al.*, (2014) studied the plant species diversity in south and north-facing slopes and found that species diversity has affected by the slope aspect and slope position of the hilly region of china. He also reported that southern slope exhibits higher shrub species diversity while northern slopes have higher herb species diversity. Maren *et al.*, (2015) studied the differences in vegetation and soil characteristics between slope aspects in high altitude semiarid environments and reported that soil properties are not affected by slope, but vegetation are affected by topography through their direct effect on radiation and moisture. Ghimire *et al.*, (2010) studied the tree diversity at two aspects of Himalayan region of the central Nepal and reported more tree species at north facing than at south facing slopes. Similarly, plant species and composition were studied on two aspects of the Annapurna mountain range and the Tibetan Plateau above 3000m and reported that there was variation between northeast and southeast facing slopes (Paudel & Vetaas, 2014). Elevation gradient have varied climates, which promote the diversification of plant species (Brown, 2001).

Pausas & Austin, (2001) studied the pattern of species richness and found that increase in species richness with temperature and water availability. Wang *et al.*, (2020) studied the soil moisture and species diversity and he concluded that soil moisture in 20-60 cm was significant related with species diversity.

Human disturbances are considered as a major driver of species diversity in plant communities (Connell, 1978). According to Shrestha (2013) lopping for fodder is one of the main practices which causes large-scale disturbance in forests. Kier *et al.*, (2005) studied patterns of species diversity around the world and conclude that higher species diversity in between tropical to temperate region. Mutke and Barthlott (2005) studied the vascular plant diversity and reported that higher vascular diversity in tropical to temperate region. Hump shaped species richness pattern with elevational gradient for different groups of plants was found from Bhabha Valley in Western Himalaya India (Chawla *et al.*, 2008). Hua (2000) studied plant species pattern along elevation gradient

and found significantly increasing trend in total species richness from 400m to 1000m asl and clear decline from 1000 m to 3105 m.

Unimodal pattern of plant species was found in Nepalese Himalaya (Grytness & Vetaas, 2002). Bhattarai and Vetaas (2003) studied the variation in plant species richness of different life forms along a subtropical elevation gradient in the east Nepal and found that shrub and trees had unimodal pattern, ferns decreased monotonically and woody climbers increased monotonically with altitude. Bhattarai *et al.*, (2004) reported fern species were maximum at 2000m altitude. But Bhattarai *et al.*, (2018) reported that the species diversity decreases with increase in altitude and species diversity was positively correlated with carbon stock.

## **2.2 Regeneration**

Regeneration can be considered as the key process for the continued existence of a species in a community. The success of regeneration can be predicted on the basis of current population structure and growth (Guedje *et al.*, 2003). Factors of abiotic and biotic interaction of the surroundings significantly influence the structure and regeneration process of forest community (Tripathi & Khan, 2007). Different type of regeneration pattern was found all over the world, Senbeta and Teketay (2001) found that inversed J-shaped curve with high number of seedling low number of sapling and very small amount of adult in central Ethiopia. Sarkar and Devi (2014) found that reversed J- shaped with good regeneration status in Assam, Northeast India. Pandey *et al.*, (2014) also reported that reversed J-shaped curved with good regeneration status at the undisturbed site but fair regeneration status showed in disturbed site at central Himalaya, India. Similarly, Paul *et al.*, (2019) also reported that reversed J-shaped curve with the density of sapling less than seedling and adults at temperate region in western Arunachal Pradesh, India. Bhakuni *et al.*, (2015) studied the quantitative status of regeneration and found that the total density of tree, sapling and seedling was 630, 260 and 490 individuals per hectare respectively at Nainital of Kumaun Himalaya around 1950m altitude.

The existence of a species in the community largely depends on its regeneration capacity under varied environmental conditions. Nepal has the tremendous geographic diversity ranging from terai to high Himalaya due to this region variation occurs in vegetation as

well as regeneration status. Giri *et al.*, (1999) studied the regeneration status of Bardia national park in *Shorea* forest and *Shorea-Terminalia* forest and reported 348.0 and 330.87 ind/ha respectively. Similarly, Chapagain *et al.*, (2021) studied the regeneration status in the sub tropical forest of Lamjung District, Nepal and reported the density of adult trees ranged from 575 Ind/ha to 1196 Ind/ha. The sapling ranged from 2533 Ind/ha to 4000 Ind/ha and seedling from 19583 Ind/ha to 37500 Ind/ha. Joshi *et al* (2021) found the reversed J-shaped population curve at the far western Terai region Nepal.

### 2.3 Carbon stock

The elevation and slope aspect play a key role in determining the temperature regime of any sites. Within one elevation, co-factors like topography, aspect, inclination of slope and soil type affect the forest composition (Shank and Noorie 1950).The micro-environment of different aspects of hill slopes is influenced by the intensity and duration of available sunlight (Yadav & Gupta 2006). Sharma *et al* (2014) compared the carbon stock in different slopes aspect at temperate region Garhwal Himalaya, India, and reported that carbon stock was higher in northern aspect (i.e 469.1 CMg ha<sup>-1</sup> than southern aspect (i.e. 118.1 CMg ha<sup>-1</sup>). Similarly, Yohannes, *et al* (2015) found out the variations of carbon stock in Ethiopia and concluded that the carbon stock was significantly affected by slope aspect and also reported that south aspect has the lowest carbon stock. Gubena and Soromessa (2017) estimated the variation of carbon stock in different aspect in Ethiopia and conclude that amount of carbon stock varies between slopes aspect and also found that higher carbon stock in northern aspect.

The carbon pools of a forest ecosystem vary with the age structure (Clark *et al.*, 2004) and forest type (Zhang *et al.*, 2013).Carbon pools in forest ecosystems are strongly affected by climate, forest type, stand age, disturbance regimes, and edaphic conditions (Somogyi *et al.*, 2007).Pandey *et.al.*, (2014) studied the carbon stock in three different district (i.e Chitwan, Gorkha and Dolakha) and reported thatthe carbon was higher in dense forests with dominant Pine vegetation (24 Mg C/ha) followed by *Schima-Castanopsis* (20 Mg C/ha), mixed broad leaf types (18.9 Mg C/ha) and *Shorea robusta* (16.9 Mg C/ha), while the lowest was found in sparse canopy of *Rhododendron-Quercus* vegetation (5.9 Mg C/ha). Bhandari and Zhang (2019) studied the effect of altitude in biomass and species richness Nepal and Tibet revealed significantly greater biomass and species richness on the southern slopes of lower zone than northern slopes. Maren and

Sharma (2021) studied the carbon stock of temperate forest of the Nepalese Himalaya and reported that the aboveground tree carbon was higher in protected forests ( $164 \pm 8$  t/ha) compared to in unprotected forests ( $114 \pm 5$  t/ha). Sharma and Kakchapati (2018) studied the carbon stock of chure area and reported that the total carbon stock in Chure forest was 76.67 t C/ha.

Nepal possesses diverse physiography as a whole and the most in Middle-hills physiography due to micro-climatic and topographic variation. Due to this reason different type of forest are found in Nepal. Forest types play an important role on total carbon sequestration. Shrestha, (2009) reported total biomass carbon in *Shorea* and *Schima-Castanopsis* forest was found 101.66 and 44.43 t ha/ha respectively in palpa district. But Tripathi *et al.*, (2017) found the carbon stock in *Schima-Castanopsis* forest at mid hills of Nepal and reported that *Schima*, for 19.56 t/ha *Castanopsis* for 18.66 t/ha and other species were found, 3.59 t/ha. Similarly, Ranabhat *et al.* (2008) studied the carbon stock in *Alnus nepalensis* forest at the midhills of Kaski district and found that total carbon stock is higher at southern aspect than at northern aspect (i.e. 39.00 t/ha and 30.20 t/ha respectively).

In Nepal, species diversity, regeneration and carbon stock of plant species were studied in different parts of Nepal and limited studies was done between northern and southern aspect. This study provides the information about species diversity, regeneration and carbon stock at northern and southern aspect of Kaleshwar, Lalitpur, Nepal.

## Chapter 3 Materials and methods

### 3.1 Study area

The Research area of Kaleshwar is located at Lalitpur district, central Nepal. It is situated in mahabharat range on  $27^{\circ}50'39''\text{N}$  &  $85^{\circ}42'2''\text{E}$  and altitude ranged from 1500-2300m asl. The northern aspect of study area falls under Lahuribina community forest located in Mahankhal Rural Municipality and southern aspect falls under Gimdi community forest of Bagmati Rural Municipality. Gotikhel is at the lowest area of northern aspect and Gimdi is at the base of Southern aspect. Kaleshwar temple is situated at the top of the study area.

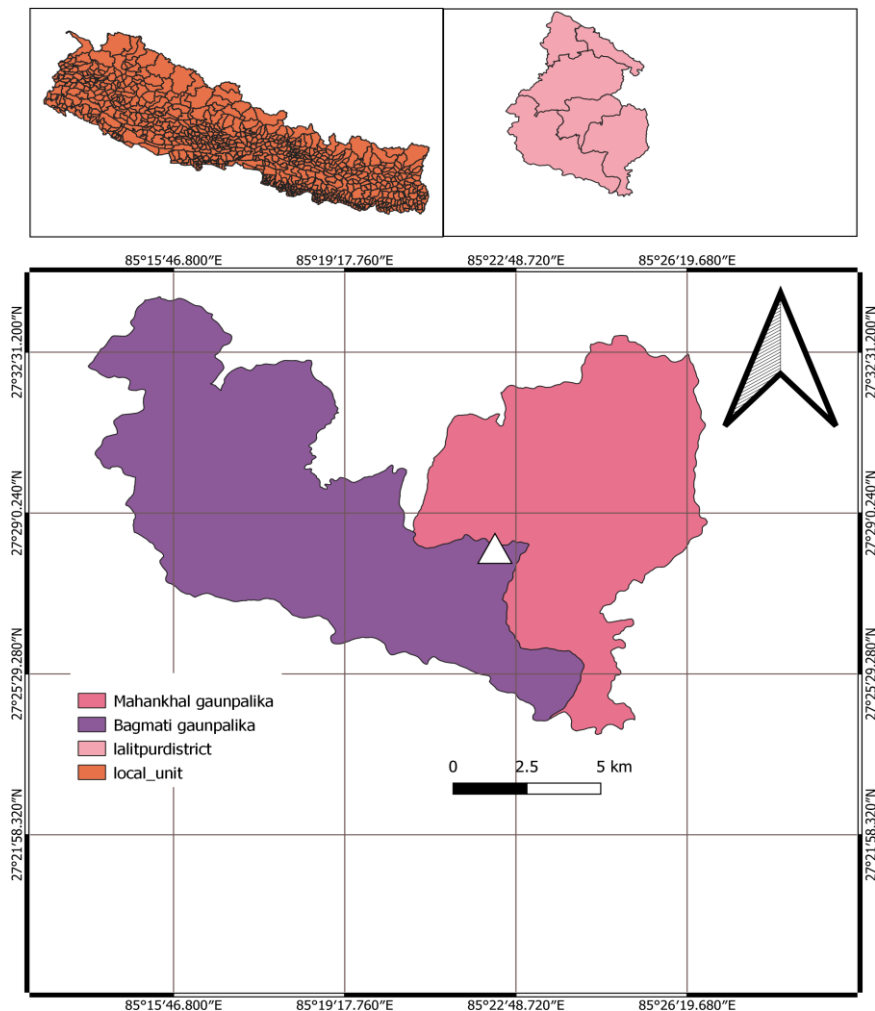


Figure 1: Map of study area

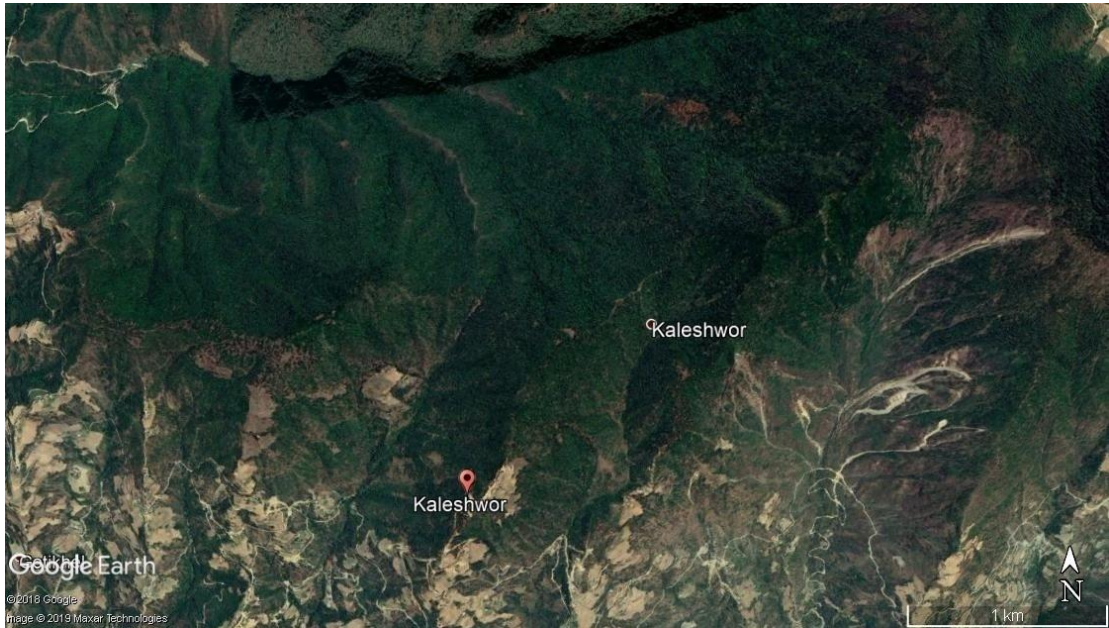


Figure 2: Satellite image of study area (Source google earth 2018)

### 3.1.1. Climate

Based on the godawari station Kaleshwar has mild climatic condition with average temperature of 34.9 °C; May was the hottest month of the year and January being the coldest one. June to September had maximum rainfall thus had moist summer. Climatic data from 2012 to 2021 showed the Yearly average maximum and minimum temperature and rainfall. But small variations occur in rainfall.

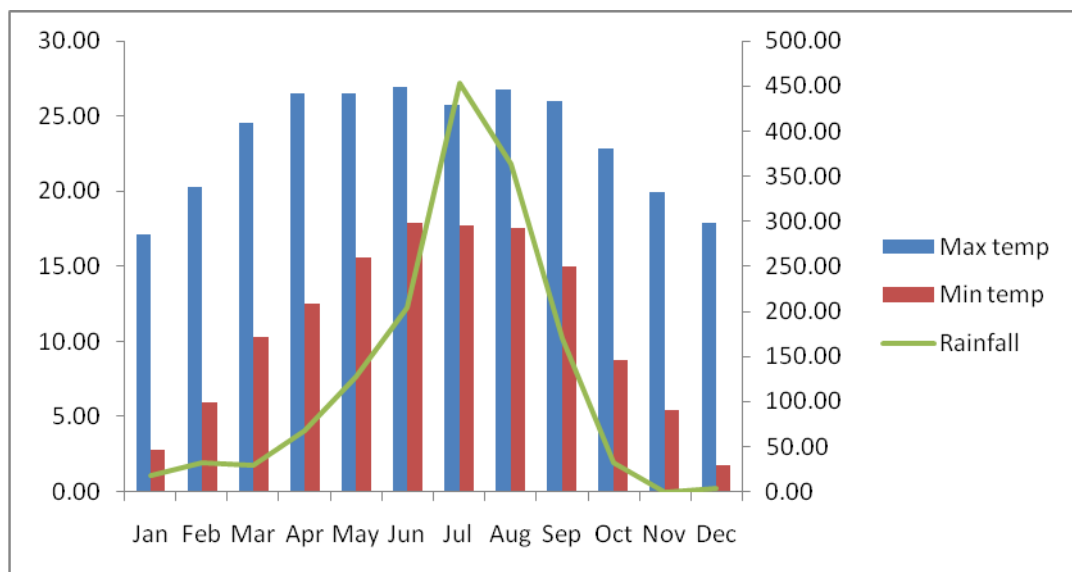


Figure 3: Average minimum, maximum temperature and rainfall recorded at Godavari weather station on 2012 to 2021. (Department of hydrology and metrology, Babarmahal, Kathmandu, Nepal, 2022) (Source: Department of Hydrology and Meteorology, 2021).

### 3.1.2 Vegetation

The lowest strata (i.e.1500-1800m), broadly consists of mixed broad leaf forest comprising *Schima wallichii*, *Castanopsis tribuloides*, *Prunus ceresoides*, *Engelhardia spicata*, *Quercus semecarpifolia* *Rhododendron arboreum* and *Alnus nepalensis* at both aspects. The forest of upper strata (i.e. 1900-2300m) is replaced by *Symplocous*, *Eurya* and *Rhododendron* species in the northern aspect however; *Leucoseptrum canum* replaced the southern aspect associated with *Macaranga indica*, *Quercus semecarpifolia*, and *Castanopsis tribuloides*.

## 3.2 Methodology

### 3.2.1. Sampling design and data collection

The field visit was done in the month of March. Study sites were selected at different elevations in both Northern and Southern slopes. Altitude of sampling site ranged from 1500 m to 2300 m above sea level, entire range of study area was categorized into five altitudinal strata i.e. 1500m-1600m, 1700m-1800m, 1900m-2000m, 2100m-2200m and above 2300m named as 1500m, 1700m, 1900m, 2100m and 2300m strata respectively. In total 100 plots were laid randomly, 50 on each aspect. The measuring tape and rope were used to draw the circular quadrat of 10m radius for trees, within those plots sub plot of 5m radius for shrubs and sapling and 1m radius for herb and seedling. Regeneration of tree species were calculated by counting the seedlings (height < 20 cm) and saplings (height > 20 cm) within 5m radius (Sundriyal & Sharma,1996) and compared it with number of tree poles of respective species.

All the species within the quadrat were recorded. Plants having diameter more than 10 cm at breast height were considered as trees and other woody plants were considered as Sapling. Diameter tape was used to measure diameter at breast height (DBH) for all individual tree. The slopes, aspects and height of each tree were measured with the help of clinometers and compass. Geographic location i.e. latitude, longitude and elevation of each quadrat was recorded using Global Positioning System (GPS) from the centre of the quadrat. Canopy cover of the tree species was visually estimated. All the species found in the plot was identified in the field as far as possible. For the species, which could not be identified in the field, herbarium specimens were prepared to identify later by experts and according to the identification keys, relevant texts and other standard literature

(Malla *et al.*, 1986; Polunin and Stainton, 1987; Watson *et al.*, 2011; Chapagain *et al.*, 2016).

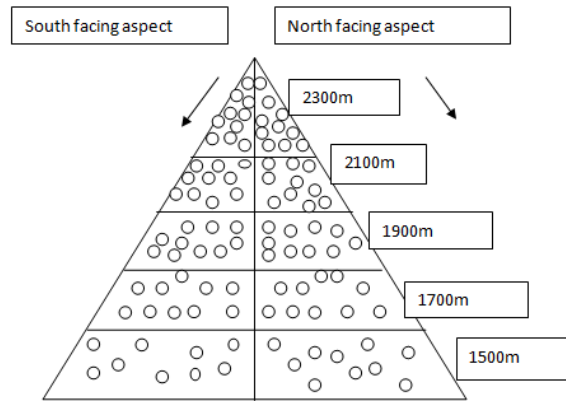


Figure 4: Sampling design on study site along both the aspects

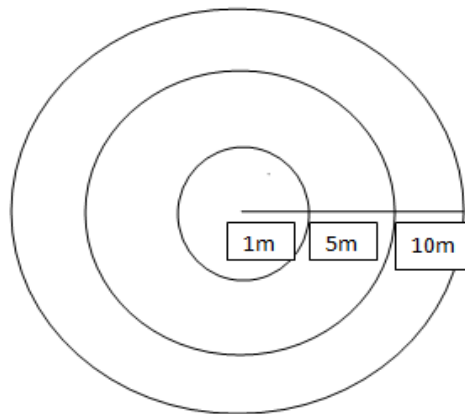


Figure 5: Sampling design within circular quadrat of different size for different life form

### 3.2.2 Data analysis

Importance Value Index of all the species reported and identified from the study area were calculated using Zobel *et al.* (1987). Among the several indices, most commonly used two indices of species diversity used were Simpson's index (Simpson 1949) and Shannon-Wiener's index (Shannon and Wiener 1949). Simpson's index (D) reflects dominance and Shannon-Wiener index (H) reflects species diversity; thus, Simpson's index is also called Index of Dominance.

### **Density and relative density**

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

$$\text{Density (D)} = \frac{\text{Total no.of individual species}}{\text{Total no.of quadrats studied}} \times \text{Area of quadrats}$$

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

$$\text{Relative Density (RD)} = \frac{\text{Density of individual species}}{\text{Total density of all species}} \times 100$$

### **Frequency and relative frequency**

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

$$\text{Frequency (F)} = \frac{\text{Number of quadrat in which species occurred}}{\text{Total number of quadrat studied}} \times 100$$

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

$$\text{Relative Frequency (RF)} = \frac{\text{Frequency of individual Species}}{\text{Total frequency of all species}} \times 100$$

### **Coverage and relative coverage**

Coverage can be expressed as the percentage of ground covered by canopy.

$$\text{Coverage (C)} = \frac{\text{Total coverage of individual species}}{\text{Total number of quadrat studied}}$$

Relative coverage is the cover of a particular species or life form as a percentage of total plant cover.

$$\text{Relative Coverage (RC)} = \frac{\text{Coverage of individual Species}}{\text{Total Coverage of all species}} \times 100$$

### **Basal area and relative basal area**

Basal area refers to the ground actually penetrated by the stems. It is one of the characters that determine the dominance. Basal area of a species in each sampling plot was obtained by the summation of Basal area of all individuals of a species.

$$\text{Basal Area (m}^2\text{)} = \frac{\pi d^2}{4}$$

$$\text{Relative dominance} = \frac{\text{Total basal area of individual}}{\text{Total basal area}} \times 100$$

### **Importance Value Index**

Importance value index (IVI) gives the overall importance of each species in the community structures. It was calculated as the sum of relative values of density, frequency and basal area for trees. Relative values were obtained by the following relations.

For herbs and shrubs,

$$\text{IVI} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Coverage}$$

For trees,

$$\text{IVI} = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Dominance}$$

### **Diversity indices**

Species diversity is the combination of species richness and species evenness. Species richness is the number of species per sampling unit. Species evenness is the distribution of individuals among the species.

$$\text{Simpson's Index of Diversity (1-D)} = 1 - \sum \frac{n(n-1)}{N(N-1)}$$

$$\text{Shannon Index (H)} = - \sum (p_i) \times (\ln p_i)$$

Where, 1- D = Simpson index of diversity

N = Total number of species

P<sub>i</sub> = Proportion of all individuals in sample that belongs to species i

H = Shannon-Wiener index

$$\text{Sorenson similarity index} = 2 \times \frac{\text{Common species}}{\text{Species of northern aspect} + \text{species of southern aspect}}$$

## Regeneration

The regeneration status of tree species was determined based on the population sizes of seedlings, saplings, and adults. Regeneration was categorized according to the methods of Shankar (2001) as follows:

Good – if seedlings > saplings > adults

Fair – if seedlings > saplings < adults

Poor- if there were saplings but no seedlings (irrespective of the relative numbers of saplings and adults)

None- if only adults were present, with no seedlings or saplings.

New- if only saplings and/or seedlings were present, with no adults.

## Biomass

Allometric equation was used to estimating above- ground tree biomass (AGTB). Allometric equations for biomass usually include information on trunk diameter at breast height DBH (in cm), total tree height H (in m), and wood-specific gravity (in g/cm<sup>3</sup>) (Chave *et al.*, 2005)

$$\text{Above ground biomass} = 0.0509 \times \text{wood specific density} \times D^2 \times H$$

Where, D= Tree diameter at breast height (cm)

H= Height of tree (m)

Tree density in g cm<sup>-3</sup>

After taking the sum of all the individual weights (in kg) from a sampling plot and dividing it by the area of a sampling plot, the biomass stock density was attained in kg m<sup>-2</sup>. This value was later converted to ha<sup>-1</sup> by multiplying it by 10.

Below ground biomass=20% of above ground biomass

Above ground carbon stock=47% of above ground biomass

Below ground carbon stock=47% of below ground biomass

Total carbon stock= above ground carbon stock+ below ground carbon stock

### **3.2.3 Statistical analysis**

Data were entered and analyzed in MS excel 7. Density, frequency, coverage, basal area and IVI for the individual species were calculated. For statistical analysis, SPSS 20 software was used and independent t-test was performed to find out the relationship between species richness and evenness along the different aspect.

## Chapter 4 Result

### 4.1 Species diversity and richness

Altogether, 155 plant species were enumerated from northern aspect, in which 42 species were tree, 37 shrubs and 76 herbs (Appendix I). Similarly, in southern aspect 134 species were recorded, in which 32 species were trees, 37 shrubs and 65 herbs (Appendix I). In northern aspect herb, shrub and tree species were found in slightly decreasing order but in southern aspect number of plant species was found in irregular pattern (Figure 6,7and 8).

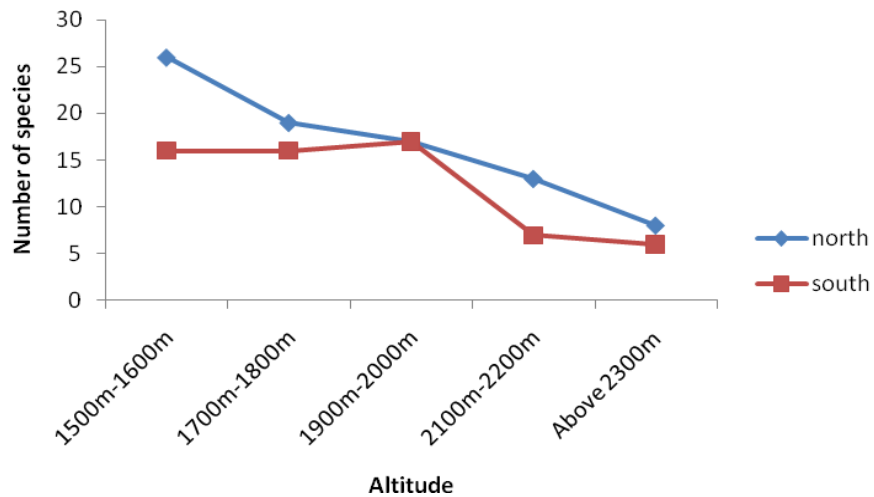


Figure 6: Tree species pattern from 1500 to 2300m

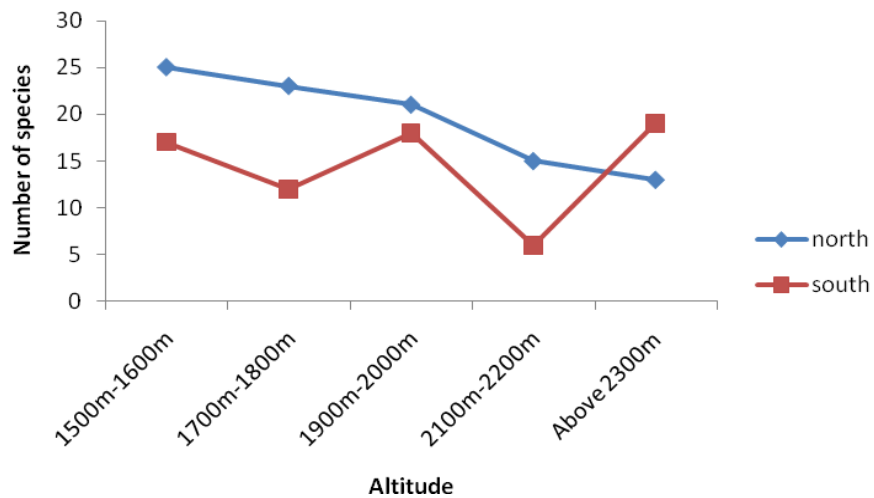


Figure 7: Shrub species pattern from 1500 to 2300m

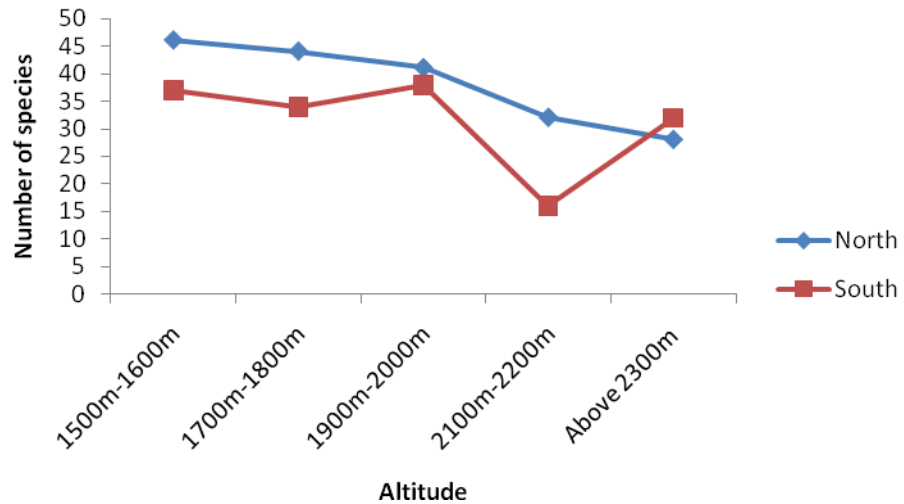


Figure 8: Herb species pattern from 1500m to 2300m

The most dominated life form was herb at both the sites in which Simpson's index diversity ranged from 0.91-0.96 in northern aspect and 0.87-0.95 in southern aspect. Similarly, value for shrub and tree ranged from 0.85-0.90 and 0.63-0.92 respectively on northern aspect and 0.73-0.88 and 0.47- 0.84 on southern aspect. Also, herbs were evenly distributed than shrubs and trees; evenness was ranged from 0.84-0.89, 0.79-0.87 and 0.63-0.85 respectively at northern aspect similarly 0.81-0.89, 0.79-0.85 and 0.51-0.87 respectively at southern aspect (table 1). Mean was compared using t-test. From the Shapiro-Wilk test of normality, at 5% level of significance, diversity of both the aspect was known to be normally distributed. At 5% level of significance the value was found to be  $>0.05$ , thus there was lack of significant difference on diversity of herb, shrub and tree species in both sides.

**Table 1:** Simpson's index and Shannon weiner index of diversity along different altitude at north and south facing aspect of Kaleshwor area

Life form/ Altitude (m)	Simpson's index		Shannon Weiner index		Evenness	
	Northern aspect	Southern aspect	Northern aspect	Southern aspect	Northern aspect	Southern aspect
<b>Trees</b>						
1500m-1600m	0.92	0.84	2.79	2.13	0.85	0.76
1700m-1800m	0.88	0.81	2.36	2.00	0.80	0.72
1900m-2000m	0.88	0.91	2.33	2.48	0.82	0.87
2100m-2200m	0.83	0.47	2.00	0.99	0.78	0.51
Above 2300m	0.63	0.51	1.31	1.00	0.63	0.56
<b>Significance*</b>	0.050				0.146	
<b>Shrubs</b>						
1500m-1600m	0.90	0.85	2.61	2.31	0.81	0.81
1700m-1800m	0.90	0.85	2.62	2.12	0.83	0.85
1900m-2000m	0.87	0.90	2.42	2.48	0.79	0.86
2100m-2200m	0.88	0.73	2.35	1.42	0.87	0.79
Above 2300m	0.85	0.88	2.13	2.47	0.83	0.84
<b>Significance*</b>	0.187				0.750	
<b>Herbs</b>						
1500m-1600m	0.96	0.94	3.41	3.15	0.89	0.87
1700m-1800m	0.95	0.94	3.32	3.11	0.88	0.88
1900m-2000m	0.95	0.92	3.26	2.96	0.88	0.81
2100m-2200m	0.95	0.87	3.14	2.39	0.91	0.86
Above 2300m	0.91	0.95	2.80	3.09	0.84	0.89
<b>Significance*</b>	0.368				0.652	

[\*Significance value (P) obtained from independent t-test shows significance in relationship]

Among the five altitudinal strata, mostly similar species of herb, shrub and tree were recorded at above 2300m asl. Nearly 50 percent of tree species were similar at the altitudinal range of 1500m-1600m and 1700m-1800m while more than 70 percent tree species were different at the altitudinal range of 1900m-2000m and 2100m-2200m.

**Table 2:** Sorenson's similarity index among northern and southern aspect

Altitude	Herb	Shrub	Tree
<b>1500m-1600m</b>	48.19	38.09	42.85
<b>1700m-1800m</b>	56.41	34.28	51.43
<b>1900m-2000m</b>	55.7	56.41	29.41
<b>2100m-2200m</b>	37.5	28.57	30
<b>Above 2300m</b>	60	75	71.43

#### 4.1.1 IVI value

##### Tree species

Altogether 26 tree species were recorded in northern aspect and 16 species were recorded in southern aspect (Appendex 2) but 9 species were common in both aspects at 1500m-1600m altitudinal range were *Schima wallichii*, *Lyonia ovalifolia*, *Ficus semicordata*, *Castanopsis indica*, *Engelhardia spicata*, *Prunus cerasoides*, *Rhododendron arboreum*, *Quercus semecarpifolia* and *Castanopsis tribuloides* (Appendex 2). At the altitudinal range of 1700m-1800m asl, 19 species were found in northern aspect and 16 species from southern aspect (Appendex 3) and 9 species were common in both aspects i.e. *Schima wallichii*, *Lyonia ovalifolia*, *Symplocos* sp, *Engelhardia spicata*, *Prunus cerasoides*, *Rhododendron arboreum*, *Alnus nepalensis*, *Syzygium cumini* and *Castanopsis tribuloides*. Equal numbers of plant species were recorded in northern and southern aspects at 1900m-2000m altitudinal range i.e. 17 species. Only 5 species were common i.e. *Schima wallichii*, *Lyonia ovalifolia*, *Rhododendron arboreum*, *Engelhardia spicata* and *Eurya acuminata* at both aspects (Appendex 4). Altogether 13 and 7 species were recorded from northern and southern aspect respectively at 2100m-2200m altitudinal range. 3 species were common along both the aspects i.e. *Purunus cerasoides*, *Symplocos ramosissima* and *Lindera* sp. Altogether 8 and 6 species were recorded from northern and southern aspect respectively at above 2300m asl. 5 species were common along both the aspects i.e. *Quercus semecarpifolia*, *Lyonia ovalifolia*, *Eurya acuminata*, *Rhododendron arboreum* and *Symplocos ramosissima*.

Highest IVI value of *Castanopsis tribuloides* was recorded among trees at the northern aspect that was replaced by *Quercus semecarpifolia* at southern aspect at 1500m-1600m altitudinal range. Similarly, at the altitudinal range of 1700m-1800m, *Alnus nepalensis* was recorded with highest IVI value among tree species at northern aspect replaced in southern aspect by *Castanopsis tribuloides*. Above 1900m altitude *Rhododendron arboreum* and *Symplocos ramosissima* were recorded with highest IVI value at northern aspect replaced in *Leucosceptrum canum* at southern aspect.

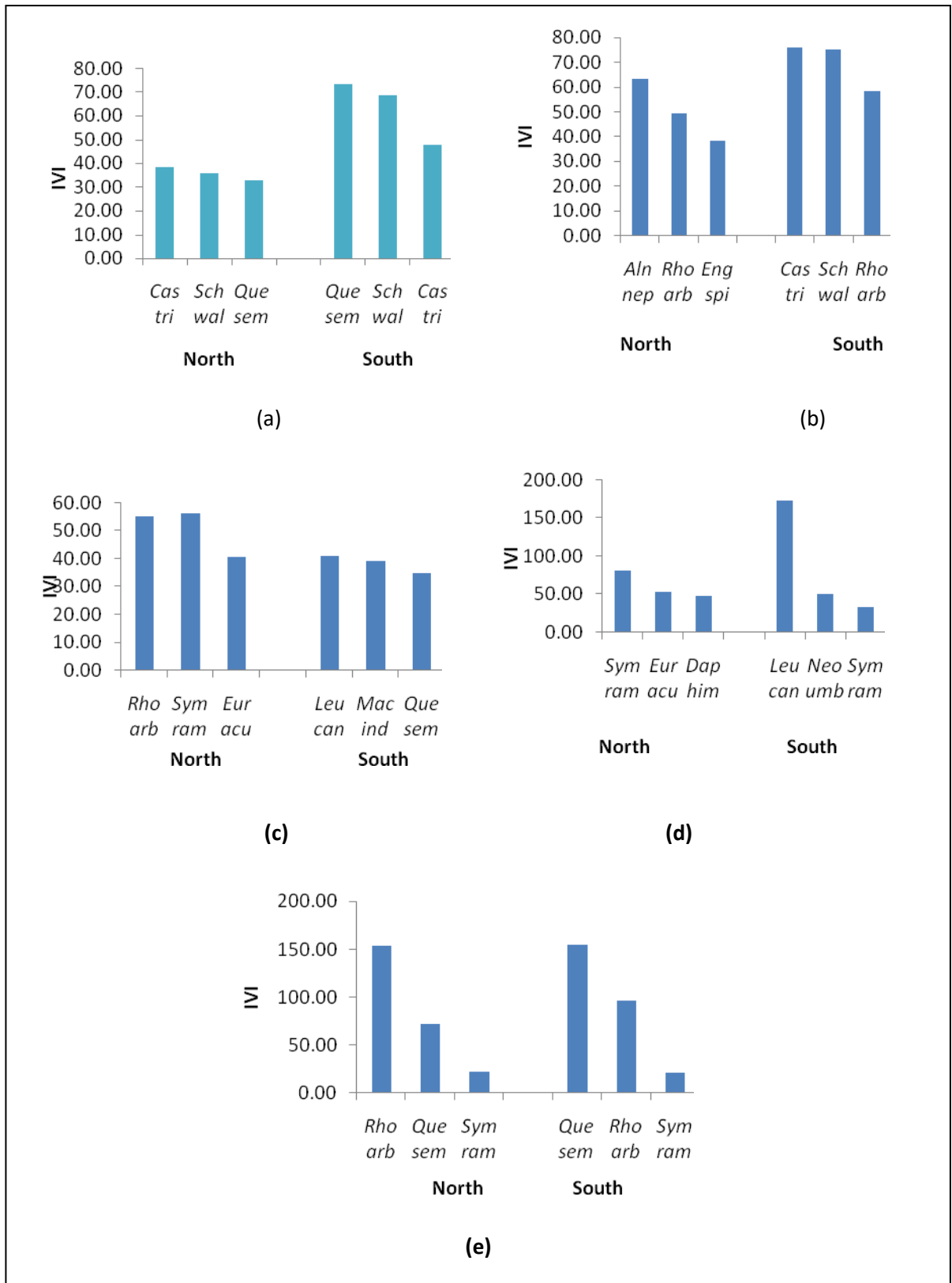


Figure 9: IVI of different tree species along the altitudinal gradient in both aspect (a) 1500m-1600m (b) 1700m-1800m (c) 1900m-2000m (d) 2100m-2200m (e) above 2300m

### **Shrub species**

A total of 25 species were collected from northern aspect and 17 species from southern (Appendex 7) and 8 species were common i.e. *Artemisia indica*, *Buddleja asiatica*, *Hypericum uralum*, *Osbeckia nepalensis*, *Osyris wightiana*, *Phyllanthus parvifolius*, *Rubus ellipticus* and *Rubus rosifolius* at 1500m-1600m altitudinal range. Altogether 23 and 12 species were collected from northern and southern aspect respectively (Appendex 8) and only 6 species were common i.e. *Berberis aristata*, *Maesa chisia*, *Osbeckia nepalensis*, *Oxyspora paniculata*, *Rubus rosifolius* and *Viburnum coriaceum* in both aspect at 1700m-1800m altitudinal range. At 1900m-2000m altitudinal range 21 and 18 species (Appendex 9) were recorded in northern and southern aspect respectively and 11 species were common i.e. *Clerodendrum indicum*, *Gaultheria hookei*, *Maesa chisia*, *Mahonia nepaulensis*, *Osbeckia nepalensis*, *Phyllanthus parvifolius*, *Pilea pumila*, *Rubus ellipticus*, *Sambucus hookeri*, *Sarcococca hookeriana* and *Viburnum coriaceum* along both aspects. At 2100m-2200m altitudinal range, altogether 15 and 6 species (Appendex 10) were recorded from northern and southern aspect respectively and 3 species were common i.e. *Sarcococca hookeriana*, *Synotis sp.* and *Mahonia nepaulensis*. Altogether 13 and 9 species were recorded in northern and southern aspect respectively and 12 species were common i.e. *Phyllanthus parvifolius*, *Rubus ellipticus*, *Rubus rosifolius*, *Sambucus hookeri*, *Sarcococca hookeriana*, *Clerodendrum indicum*, *Daphne bholua*, *Gaultheria hookei*, *Hypericum uralum*, *Inula cappa*, *Jasminum mesnei* and *Mahonia nepaulensis* at above 2300m altitude.

Highest IVI value of *Berberis aristata* was recorded in northern aspect and *Phyllanthus parvifolius* in southern aspect at 1500m-1600m altitudinal range. Highest IVI value of *Phyllanthus parvifolius* was recorded in northern aspect but *Maesa chisia* was recorded in southern aspect at 1700m-1800m altitudinal range. At the altitudinal range of 1900m-2000m, highest IVI value of *Gaultheria hookei* was recorded at northern aspect which was replaced by *Viburnum mullaha* at southern aspect. At above 2300m, highest IVI value of *Gaultheria hookei* was recorded at northern aspect whereas IVI value of *Phyllanthus parvifolius* was recorded highest at southern aspect.

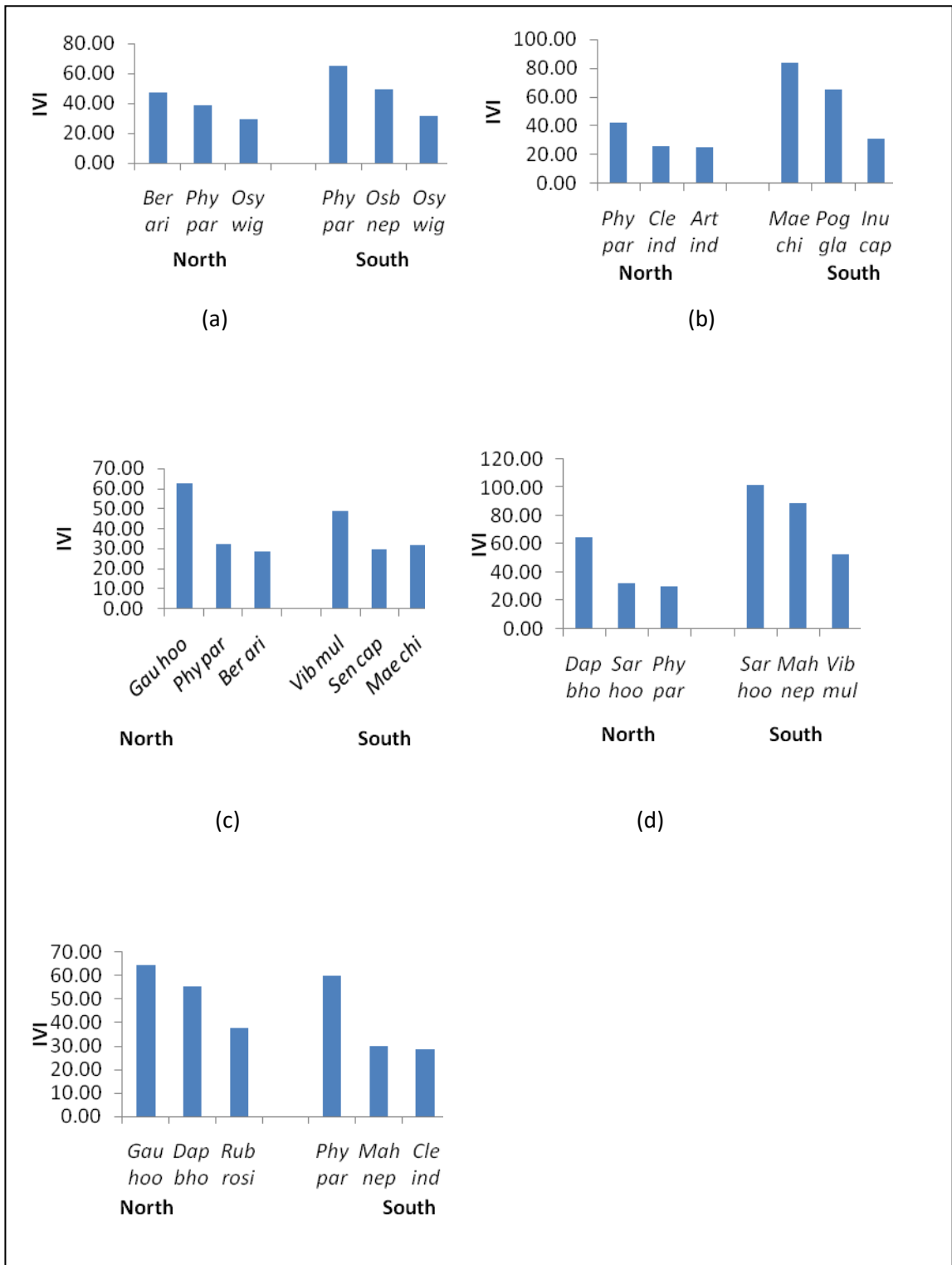


Figure 10: IVI of different shrub species along the altitudinal gradient in both aspect (a) 1500m-1600m (b) 1700m-1800m (c) 1900m-2000m (d) 2100m-2200m (e) Above 2300m

### Herb species

At 1500m-1600m altitudinal range, altogether 46 and 37 species (appendix 12) were found in northern and southern aspect respectively 22 species were common such as *Bidens pilosa*, *Capillipedium assimile*, *Cheilanthes bicolor*, *Crassocephalum crepidioides* etc along both aspects. A total of 44 and 34 species (appendix 13) were found in northern and southern aspect respectively at 1700m-1800m altitude and 23 species were common such as *Acer sikkimense*, *Allium wallichii*, *Anaphalis busua*, *Asparagus racemosus*, *Boehmeria rugulosa*. At the altitude of 1900m-2000m, 41 and 38 species (appendix 14) were collected in northern and southern aspect respectively. 20 species were common such as *Ageratina adenophora*, *Gentiana cephalodes*, *Globa recemosa*, *Hedera nepalensis*, *Imperata cylindrica* etc. 32 and 16 species were (appendix 15) collected from northern and southern aspect respectively at 2100m-2200m altitude and 9 species were common i.e. *Acer sikkimense*, *Allium wallichii*, *Boehmeria rugulosa*, *Cyperus sp*, *Drepanostachyum falcatum*, *Elatostema integrifolium*, *Globa recemosa*, *Hedera nepalensis*, *Polystichum aculeatum*. Similarly, 28 and 32 species were (appendix 16) collected from northern and southern aspect at above 2300m altitude respectively. Among them 17 species were common such as *Themeda triandra*, *Anaphalis busua*, *Polystichum aculeatum*, *Smilax elegans*, *Paspalum distichum*, *Persicaria capitata* etc.

Highest IVI value of *Capillipedium assimile* was recorded both northern and southern aspect at 1500m-1600m altitudinal range. Highest IVI value of *Eupatorium adenophorum* was recorded in northern aspect but was highest IVI value of *Drepanostachyum falcatum* was recorded in southern aspect at 1700m-1800m altitudinal range. Highest IVI value was recorded for *Cyperus* at northern aspect but *Elatostema integrifolium* at southern aspect at 1900m-2000m altitudinal range. Highest IVI value of *Smilax elegans* was recorded at northern aspect but *Elatostema* was at southern aspect at 2100m-2200m altitudinal range. Highest IVI value was recorded for *Cyperus* species while *Themeda triandra* in southern aspect at above 2300m altitude.

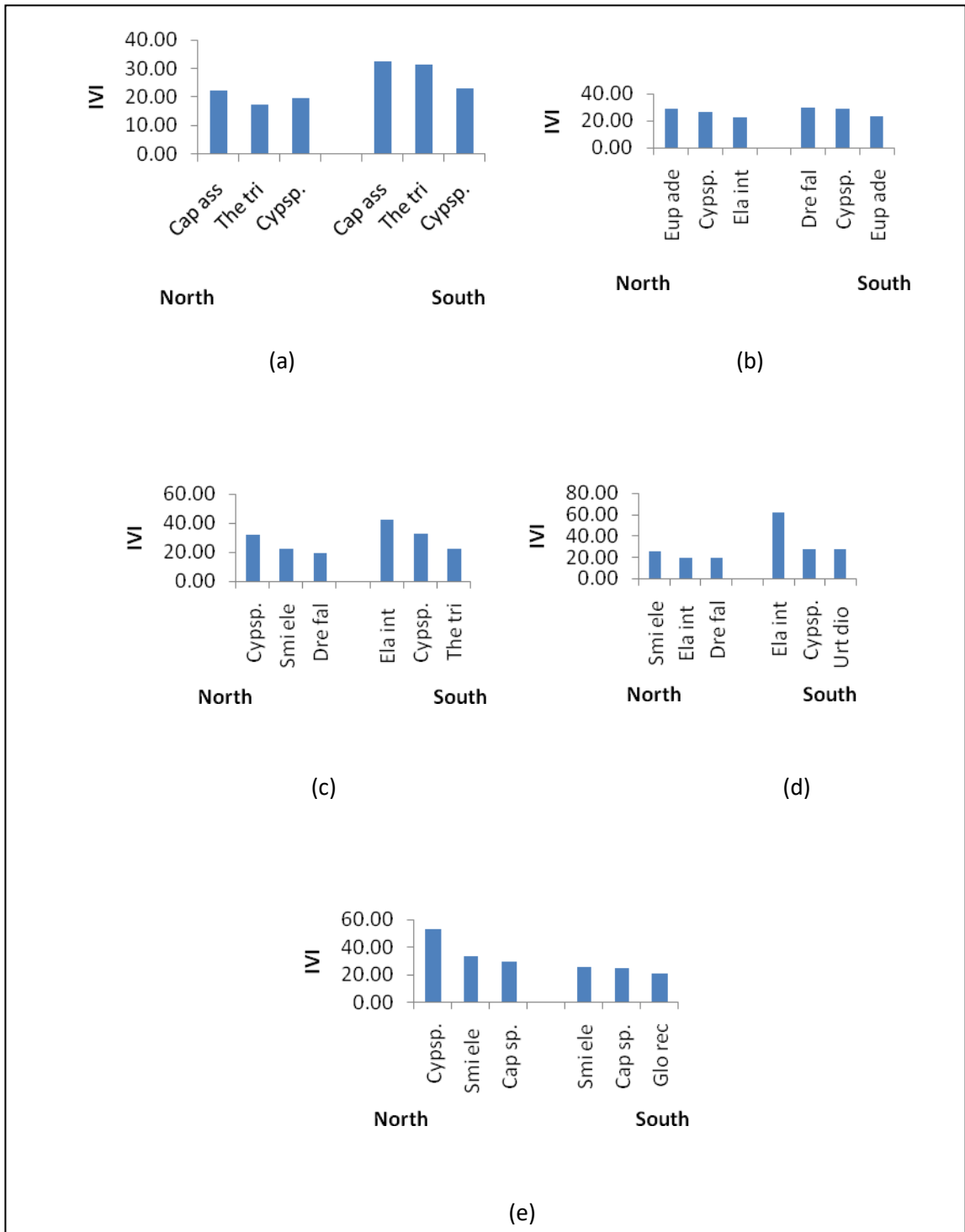


Figure 11: IVI of different herb species along the altitudinal gradient in both aspect (a) 1500m-1600m (b)1700m-1800m (c) 1900m-2000m (d) 2100m-2200m (e) Above 2300m

## 4.2 Regeneration

The total number of seedling, sapling and tree poles for all species in the northern aspect was 914.01, 1824.83 and 1748.40 ind/ha respectively (fig 12). Similarly, in southern aspect seedling, sapling and tree individual were 764.32, 1535.03 and 1477.70 ind/ha respectively (fig 12). Above result show that regeneration status of study area was poor at both northern and southern facing aspect. There was very low amount of seedling in comparison to sapling and adults At 1500m-1600m altitudinal range, the number of seedling was highest i.e. 270.79 ind/ha at northern aspect and 242.04 ind/ha at 2100m. The number of seedling was recorded very low i.e.63.69 ind/ha at 1700m-1800m altitudinal range. In contrast to seedling counts sapling was highest in the 1900m-2000m altitudes and lowest at 2100m-2200m altitudes. At southern aspect, number of seedling and sapling was highest at 1500m-1600m i.e.308.92 and 519.12 ind/ha but seedling and sapling was lowest i.e 47.77 and 165.60 at 2100m-2200m.

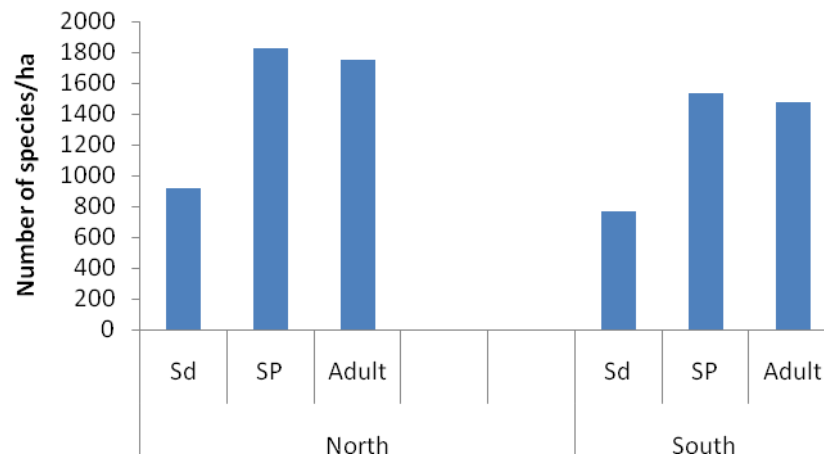


Figure 12: Regeneration status of northern and southern aspect

At the altitudinal range of 1500m-1600m, *Prunus cerasoides*, *Myrsine semiserrata* and *Rhododendron arboreum* were good regeneration (Appendex-17) rate at northern aspect while *Schima wallichii*, *Lyonia ovalifolia* and *Rhododendron arboreum* had highest regeneration rate (appendex 17) at southern aspect. The regeneration rate was highest at northern aspect for *Rhododendron arboreum* and *Lyonia ovalifolia* at 1700m-1800m altitudinal range but it was greater for *Rhododendron arboreum*, *Schima wallichii*, and *Myrica esculenta* at southern aspect. At the altitudinal range of 1900m-2000m, *Rhododendron arboreum*, *Eurya acuminata* and *Symplocos* species contribute to regeneration of forest at northern aspect. Similarly, *Leucosceptrum canum*, *Lyonia*

*ovalifolia*, *Schima wallichii*, *Rhododendron arboreum*, and *Eurya acuminata* contribute to regeneration of forest at southern aspect (appendex 19). At the altitudinal range of 2100m-2200m, regeneration rate of tree species was highest at northern aspect in comparision to southern aspect.

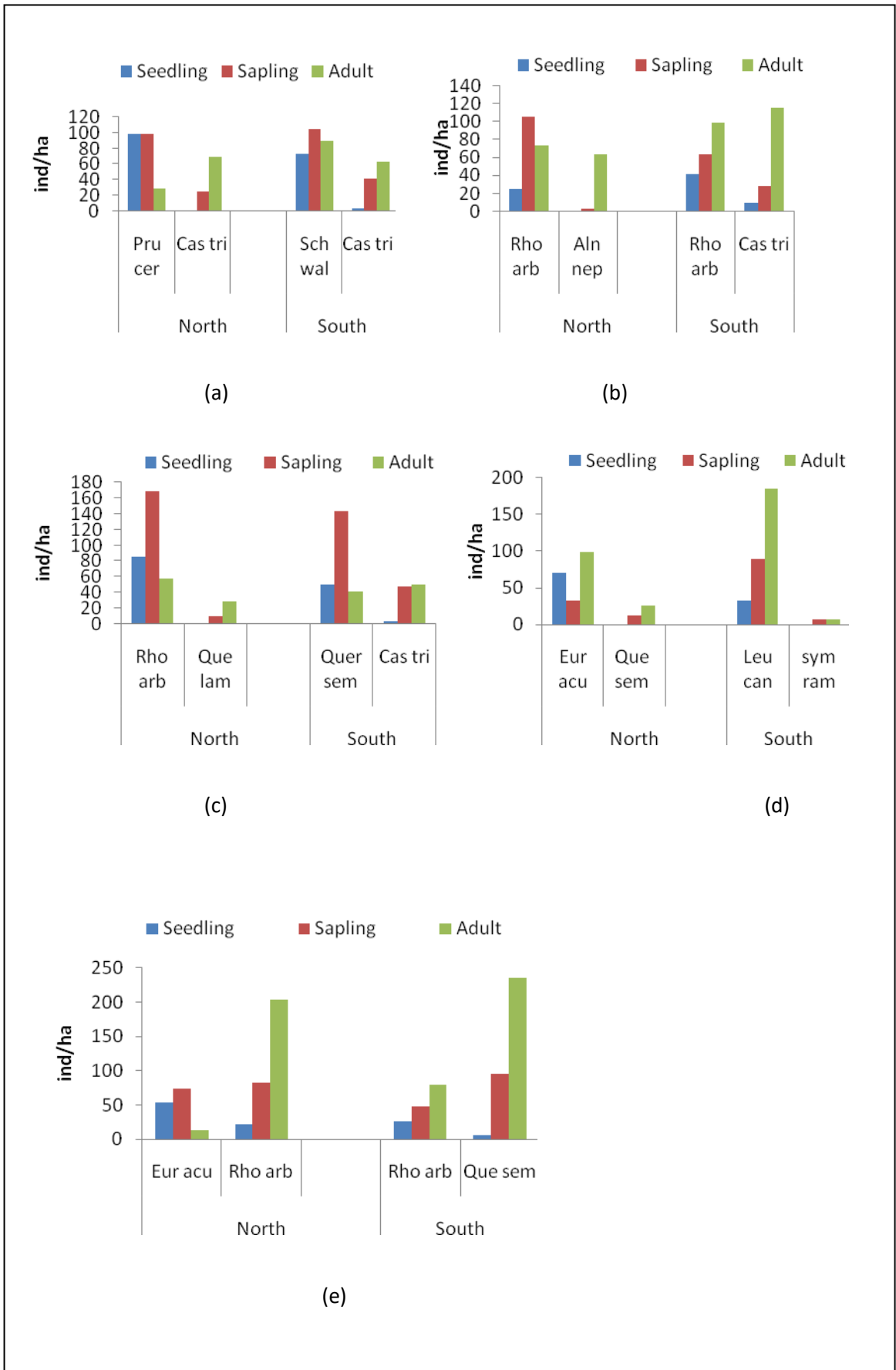


Figure 13: Regeneration status of tree species along the altitude at both aspects

Overall population structure of study area was reverse J-shaped. Tree species were gradually decreased with increased girth class. This result showed that very young trees were occurred in study area. Highest number of tree species was recorded in between 10-20 cm Dbh class in both the aspects. Older trees were more in southern aspect than of northern aspect. There were no trees in northern aspect greater than 50 cm dbh but only one percent was occurred in the southern aspect. At the altitudinal range of 1700m-1800m, highest tree species were occurred in 10-20 cm dbh class size in both aspects. There were no trees in the northern aspect greater than 50 cm dbh but only one percent occurs in the southern aspect. Dbh size was almost similar for 1500m-1600m and 1700m-1800m altitudinal range. There was lack of tree > 50cm dbh in northern aspect but 6% in southern aspect at 1900m-2000m altitudinal range. 1 and 2 percent of >50 cm dbh tree species were occurred in northern and southern aspects respectively at 2100m-2200m altitudinal range. At above 2300m altitude, only 1% tree species were occurred in >50cm northern aspect but there were lacking at southern aspect.

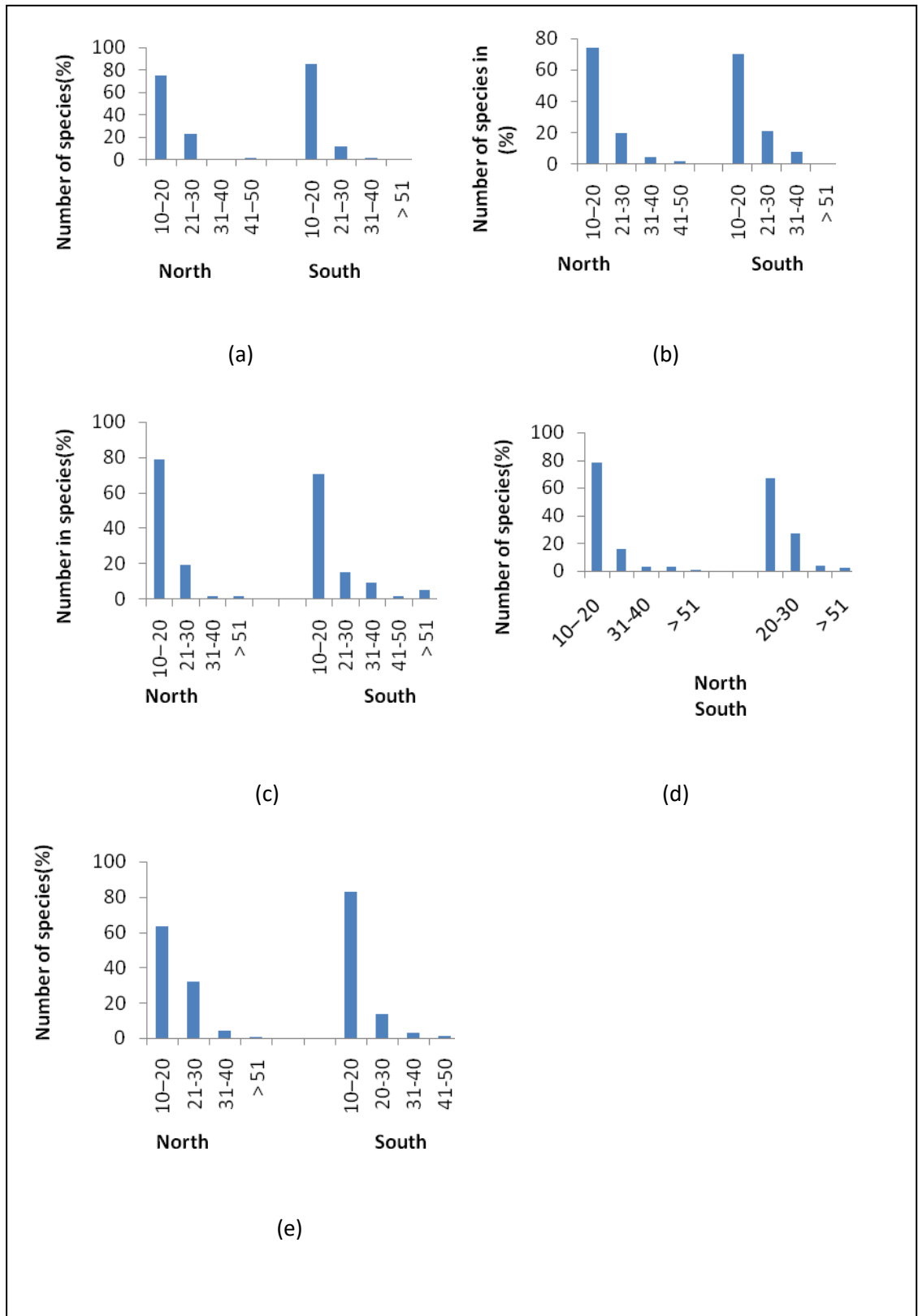


Figure 14: DBH class of tree species

### 4.3 Carbon stock

In 1500m-1600m, 2100m-2200m and above 2300m altitudinal range, carbon stock was higher at northern aspect than that of southern aspect but at 1700m-1800m and 1900m-2000m altitudinal range carbon stock was higher at southern aspect. Maximum amount of carbon stock was found in 1700m-1800m altitudinal range of southern aspect i.e.30.40T/ha and minimum amount of carbon stock was found in above 2300m altitude of southern i.e. 6.29T/ha. At the altitudinal range of 1500m-1600m, mainly 4 species contributed to production of biomass at both aspects i.e. *Schima wallichii*, *Castanopsis tribuloides*, *Quercus semecarpifolia* and *Engelhardia spicata*. At altitudinal range of 1700m-1800m, different species were occurred at two aspects. In northern aspect *Alnus nepalensis*, *Engelhardia spicata* and *Schima wallichii* contributed to production of highest biomass. Similarly, in southern aspect *Schima wallichii*, *Myrica esculenta*, *Castanopsis tribuloides* and *Rhododendron arboreum* contributed to production of biomass. Above 1900m altitude, *Symplocos*, *Euryaa cuminata*, *Daphniphyllum himalense*, *Quercus lamellosa*, *Quercus semecarpifolia* and *Rhododendron arboreum* contributed to production of biomass at northern aspect. But at the southern aspect *Leucosceptrum canum*, *Neolitsea umbrosa*, *Toona ciliata*, *Rhododendron arboreum* and *Quercus semecarpifolia* contributed to production of biomass.

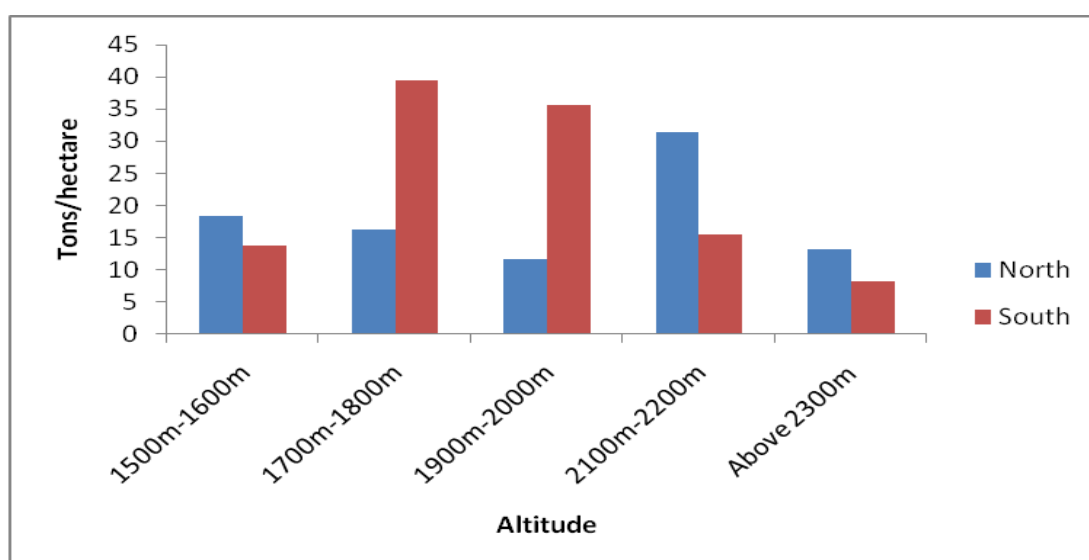


Figure 15: Carbon stock at north and south aspect

## Chapter 5 Discussion

### 5.1. Plant species diversity

The overall study showed that species diversity was high in Kaleshwor area. This might be due to forest structure and geographical conditions. Generally, highest biodiversity has recorded in broad leaved forest (Peng *et al.*, 2012). Number of species was slightly higher in northern aspect than the southern aspect but there was insignificant difference between both the aspects. There was little variation in species richness and evenness between two aspects. Generally, species richness has been dependent on the biotic interaction i.e. competition, predation, dispersal (Cornell & Lawton 1992).

Plant species diversity was slightly decreased with increase in altitude at northern aspect this might be due to decrease in temperature with increasing altitude. This type of result was also reported by Baniya *et al.*, (2010). Mainly three type of species richness pattern has been determined: a monotonic increase with elevation, a monotonic decrease with elevation and unimodal pattern (Rahbek 1995, 1997). Out of these three types, this study showed the monotonic decrease in species richness with elevation. In Nepalese Himalaya unimodal pattern has most dominant (Bhattarai and Vetaas 2003; Grytnes 2003; Bhattarai *et al.* 2004). Bhattarai and Vetaas (2003) reported that decreasing of plant species with increase in altitude is due to decrease of temperature and rate of evapo-transpiration. But in southern aspect species richness did not show any pattern which might be due to various reasons like solar radiation and disturbance due to human activities etc.

The results also showed that plant species diversity was slightly higher in northern aspect. Generally, the North aspect of hills in Nepal is moist, and the south is drier, which results in higher species richness in the North Slope aspect and was also reported by Panthi *et al.*, (2007) in Manang valley. According to Auslander *et al.*, (2003) south-facing slopes may receive six times more the amount of solar radiation than north-facing slopes in the northern hemisphere. The growth rate of plants in the south-facing aspect may be less than the North aspect due to high solar radiation and less moisture. Maren *et al.*, (2015) also observed similar results while working on north and south aspects at Manang and has been speculated due to difference in moisture content in soil. Water plays an important role in structure and density of plant communities (Kutiel and Lavee, 1999). Maren *et al.*, (2015) also suggested that human disturbance in a semiarid

environment play a significant role in reducing plant diversity as well as soil characters. North facing aspects are more moist with high canopy in the present study. Canopy is also a significant factor, probably it reduces the light intensity to reach the ground and keep the forest floor moist (Spurr and Barnes, 1973; Tilman, 1985).

Among different life forms, diversity of herb was highest at both aspects. Diversity of herb is affected by the different factors like canopy cover of the forest, soil pH, human disturbance and associated plants (Marialigeti *et al.*, 2016). Study area was rich in herb diversity, which might be due to favorable condition (i.e. light and water availability) for the growth of herb. Han *et al.*, (2011) also supported this type of result.

Similarity index of plant species were highest at 2300m a.s.l. This might be due to dispersion of seed because 2300m altitude was the peak of the study area and the chances of dispersal of seeds of most of the species might be equal on both northern and southern aspects (Fleishman *et al.*, 2001). Similarly, spatial barrier can influenced the similarity of species through environmental conditions and distance of the ecological patch (Legendre, 1993).

Among 5 belts of different altitude, almost similar species were found in 1500m-1600m and 1700m-1800m altitudinal range at both aspects but dominant species were different. This might be due to human interferences likes election of trees by humans, fire, reforestation, etc. In this way *Castanopsis tribuloides* was the dominant tree in north facing aspect but *Quercus semecarpifolia* was in south facing aspect at 1500m-1600m altitudinal range. Similarly, *Alnus nepalensis* was the dominant tree species in north facing aspect and *Castanopsis tribuloides* was in south facing aspect at 1700m-1800m altitudinal range. This might be due to different species have different favorable environments to growth and development (Austin *et al.*, 1996).

Dominant tree species were totally different at 1900m-2000m and 2100m-2200m altitudinal range at north and south facing aspects. This might be due to differences in their microclimate; light intensity, soil and air temperature, humidity, soil moisture and evaporation, and duration of growing periods Cantlon (1953) and Pook and Moore (1966). These differences are closely associated with differences in vegetation composition and structure.

The IVI value of trees changed along the elevation gradient at both aspects and there was also different IVI value among common species of two aspects. Highest IVI value of *Castanopsis tribuloides* was recorded among trees at the northern aspect that was replaced by *Quercus semecarpifolia* at southern aspect at 1500m-1600m altitudinal range. Some species like, *Aesandra butyracea*, *Bombax ceiba*, *Cinnamomum camphora*, *Grevillea robusta*, *Syzygium cumini* etc were absent in northern aspect. Similarly, *Alnus nepalensis*, *Bauhinia vahlii*, *Choerospondia saxillaris* etc were absent in southern aspect. Similarly, at the altitudinal range of 1700m-1800m, *Alnus nepalensis* was recorded with highest IVI value among tree species at northern aspect replaced in southern aspect by *Castanopsis tribuloides*. Such a different species composition along the northern and southern aspect shows variation might due to microclimatic condition, disturbances or edaphic factors (Timilsina *et al.*, 2007).

In 1900m-2000m altitudinal range mostly, different species were found in between northern and southern aspect. *Castanopsis tribuloides*, *Debregeasia salcifolia*, *Leucoseptrum canum*, *Macaranga indica*, *Neolitsea umbrosa* etc were absent in northern aspect, while were reported with highest IVI value at southern aspect. Similarly *Alnus nepalensis*, *Quercus lamellosa*, *Symplocos ramosissima*, etc were absent in southern aspect. This might be due to the historical succession of forest. Variousness of environmental condition create genetic heterogeneity through several evolutionary processes among population due to this reason variety of population has been established (Linhart and Grant 1996).

At the altitudinal range of 2100m-2200m, the IVI value was recorded highest for *Symplocos ramosissima* at northern aspect replaced by *Leucosceptrum canum* at southern aspect. At above 2300m, highest IVI value was recorded for *Rhododendron arboreum* followed by *Quercus semecarpifolia* at northern aspect while *Quercus semecarpifolia* followed by *Rhododendron arboretum* at southern aspect. Heterogeneity of species might be due to suitable habitat, ability of the species to reach the site and competitive habitat of tree species (Bezemer *et al.*, 2010)

Herb and shrub species generally get influenced by the composition of tree species (Mckenzie *et al.*, 2000). Highest IVI value of different species was recorded along the two aspects at same altitude like, *Berberis aristata* in northern aspect and *Phyllanthus parvifolius* in southern aspect at 1500m-1600m altitudinal range. Highest IVI value of

*Phyllanthus parvifolius* was recorded in northern aspect followed by *Clerodendrum indicum* and *Artemisia indica*, which were completely absent in southern aspect. Highest IVI value of *Maesa chisia* was recorded in southern aspect followed by *Pogostemon glaber* at 1700m-1800m altitudinal range. At the altitudinal range of 1900m-2000m, highest IVI value of *Gaultheria hookei* was recorded at northern aspect which was replaced by *Viburnum mullaha* at southern aspect. At above 2300m, highest IVI value of *Gaultheria hookei* was recorded at northern aspect followed by *Daphne bholua* and *rubus rosifolius* whereas IVI value of *Phyllanthus parvifolius* was recorded highest at southern aspect followed by *Mahonia nepaulensis*. Growth and development of herb and shrub species had affected by the tree species through light availability, canopy cover etc (Thomas *et al.* 1999).

Highest IVI value of *Capillipedium assimile* in both slopes followed by *Themeda triandra*, *Cyperus* and *Capillipedium* species at 1500m-1600m altitudinal range. Highest IVI value of *Eupatorium adenophorum* was recorded in northern aspect followed by *Cyperus* species and *Elatostema* species. But was highest IVI value of *Drepanostachym falcatum* was recorded in southern aspect followed by *cyperus* species and *Eupatorium adenophorum* at 1700m-1800m altitudinal range. Highest IVI value was recorded for *Cyperus* followed by *Smilax elegans* at northern aspect but *Elatostema integrifolium* followed by *cyperus* sp at southern aspect at 1900m-2000m altitudinal range. Highest IVI value of *Smilax elegans* was recorded at northern aspect but *Elatostema* was at southern aspect at 2100m-2200m altitudinal range. Highest IVI value was recorded for *Cyperus* species followed by *smilax elegans* and *capillipedium* species at northern aspect while *Themeda triandra* followed by *smilax elegans* and *capillipedium* species at above 2300m altitude. Composition of herb and shrub has been affected by canopy cover of tree species through an effect on soil nutrient and light availability (Augusto *et al.*, 2003).

## **5.2. Regeneration**

Overall study of Kaleshwor area showed rate of regeneration varied along altitudinal gradient. Different species contribute to forest regeneration in between two aspects. Species behavior of tree seedlings in different forests have shown that their growth and survival are influenced by a variety of micro- climatic and edaphic factors (Scholl and

Taylor, 2006). In the present study regeneration rate of plant species is slightly higher in north facing slopes than in south facing slopes. This could be due to high soil moisture, and less incoming solar radiation in the north slopes of Nepal (Panthi *et al.*, 2007). Light is an important factor for the forest regeneration. Besides this viability of seed, dispersal of seed, vegetative growth and reproductive growth directly affect the plant regeneration (Napit, 2015). The influence of biotic and abiotic factors of the environment affects the survival and growth of seedlings (Muller- domboset *et al.*, 1980). Seed germination, emergence, growth, survival and establishment of seedlings affect forest regeneration by influencing plant populations in forest (Osunkjoya *et al.*, 1992). Competition of seedling and sapling with the sub canopy of shrub and herb also affects the regeneration rates (Lorimer *et al.*, 1994). Above result show that regeneration status of study area was poor at both north and south facing slopes. There was very low amount of seedling in comparison to sapling and adults, this might be due to different biotic and abiotic factors like low productivity of forest, anthropogenic disturbance and less supportive microclimate conditions (like germinability, the viability of seeds, predators, dispersing agents) has been suggested by Manna and Mishra (2017). Overall population structure of study area was reverse J-shaped. Tree species were gradually decreased with increased girth class. This result showed that very young trees were occurred in study area. The overall distribution of diameter class of all the individuals at both aspects was found to be in high proportions of individuals in lower dbh class, which indicated that the forest are in regenerating phase which might be due to people awareness and forest management practices.

### **5.3. Carbon stock**

Out of five belt three belt had higher carbon stock in north facing slopes (i.e. 1500m, 2100m and 2300m altitude), which could be due to higher rate of plant diversity, moist environment, that favored the luxuriant growth of the forest. The north facing aspect had more moisture than south facing aspect because south facing aspect receive more sunlight than north facing aspect (Sharma *et al.*, 2011). Our results showing more carbon stock in north facing slopes also supports the findings of Bayat (2011), who reported higher carbon stock in north facing aspect than south facing aspects and suggested that this could be due to drier south facing aspect. Due to more moist conditions in north aspects, it forms better congenial environment for growth than the south aspects. however, two lower strata had higher carbon stock in south facing aspect (i.e. 1700m and

1900m), that might be due to high disturbance and deforestation due to road construction in northern aspect at this elevations. Similar results were also observed by Achat (2015) and Lal (2005) indicating to anthropogenic activities.

## **Chapter 6 Conclusion and Recommendations**

### **6.1 Conclusion**

Present study concluded that the species richness and species diversity is varies along the altitudinal gradient. Similarly, life form of plant species differs along the facing aspect. Species diversity was higher at north facing aspect than at south facing aspect, though the difference was not significant. The status of regeneration was better at northern aspect than at southern aspect. Different environmental variables were known to have tremendous role for the variation in carbon stock of the forest. Carbon pool differed along the different environmental gradients (altitude and aspect). Aspect plays a key role in both aboveground and belowground carbon pool account. Growth, survival and reproductive potential of the plant species was known to be affected by the natural as well as anthropogenic activities.

### **6.2 Recommendations**

Following recommendations have been suggested on the basis of the results of the present study.

- Further studies about mosses, fern should be done in the Kaleshwar area.
- Illegal tree cutting and uncontrolled forest use should be stopped in the forest.

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## Appendices

Annex 1: Total plant species at northern and southern aspect with their local name and family

North				South		
S.N	Scientific name	Family	Local name	Name of species	Family	Local name
1	<i>Acer sikkimense</i> Miq.	Aceraceae	Lahara	<i>Acer sikkimense</i> Miq.	Aceraceae	Lahara
2	<i>Achyranthes aspera</i> L.	Amaranthaceae	Datiwan	<i>Achyranthes aspera</i> L.	Amaranthaceae	Datiwan
3	<i>Achyranthus bidentata</i> Blude	Amaranthaceae		<i>Aesandra butyracea</i> (Roxb.)Baehni	Sapotaceae	Cheuri
4	<i>Adiantum capillus-veneris</i> L.	Pteridaceae	Kaniuneu	<i>Albizia spp.</i>	Leguminosae	
5	<i>Albizia sp.</i>	Leguminosae		<i>Allium wallichii</i> Kunth	Amaryllidaceae	Jimbujhar
6	<i>Allium wallichii</i> Kunth	Amaryllidaceae	Jimbujhar	<i>Alnus nepalensis</i> D.Don	Betulaceae	Uttis
7	<i>Alnus nepalensis</i> D.Don	Betulaceae	Uttis	<i>Anaphalis busua</i> (Buch.-Ham. ex Don) DC.	Asteraceae	Setoekleghans
8	<i>Anaphalis busua</i> (Buch.-Ham. ex Don) DC.	Asteraceae	Setoekleghans	<i>Anemone rivularis</i> Buch.-Ham. ex DC.	Ranunculaceae	Kangressjhar
9	<i>Anemone rivularis</i> Buch.-Ham. ex DC.	Ranunculaceae	Kangressjhar	<i>Angiopteris sp.</i>	Marattiaceae	
10	<i>Angiopteris sp.</i>	Marattiaceae		<i>Arisaema tortuosum</i> (Wall.) Schot	Araceae	Banko
11	<i>Arisaema tortuosum</i> (Wall.) Schot	Araceae	Banko	<i>Artemisia indica</i> Willd.	Asteraceae	Titepati
12	<i>Artemisia indica</i> Willd.	Asteraceae	Titepati	<i>Asparagus racemosus</i> Willd.	Liliaceae	Kurillo
13	<i>Asparagus racemosus</i> Willd.	Liliaceae	Kurillo	<i>Asplenium sp.</i>	Aspleniaceae	
14	<i>Asplenium sp.</i>	Aspleniaceae		<i>Berberis aristata</i> DC.	Berberidaceae	Chutro
15	<i>Astilbe rivularis</i> Buch.-Ham ex D. Don	Saxifragaceae	Thulo okhati	<i>Bergenia ciliata</i> (Haw.) Sternb.	Saxifragaceae	Pakhanbhed
16	<i>Bauhinia vahlii</i> Wight&Arn.	Leguminosae	Bhorla	<i>Bidens pilosa</i> L.	Asteraceae	Kalokuro
17	<i>Berberis aristata</i> DC.	Berberidaceae	Chutro	<i>Boehmeria rugulosa</i> Wedd.	Urticaceae	Gargalo
18	<i>Bergenia ciliata</i> (Haw.) Sternb.	Saxifragaceae	Pakhanbhed	<i>Bombax ceiba</i> L.	Bombacacea	Simal
19	<i>Betula alnoides</i> Buch.-Ham. ex D. Don	Betulaceae	Saur	<i>Buddleja asiatica</i> Lour.	Logaginaceae	Bhimsen pate
20	<i>Bidens pilosa</i> L.	Asteraceae	Kalokuro	<i>Capillipedium assimile</i> (Steud.) A. Camus	Poaceae	Musekharu
21	<i>Boehmeia rugulosa</i> Wedd.	Urticaceae	Gargalo	<i>Capillipedium sp.</i>	Poaceae	Thulokharu
22	<i>Brassaiopsis hainla</i> (Bach.-Ham. ex D. Don) Seem.	Araliaceae	chuletro	<i>Castanopsis indica</i> (Roxb.) Miq.	Fagaceae	Katus
23	<i>Buddleja asiatica</i> Lour.	Logaginaceae	Bhimsen pate	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	Fagaceae	Musurekatus
24	<i>Capillipedium assimile</i> (Steud.) A. Camus	Poaceae	Musekharu	<i>Cheilanthes bicolor</i> (Forss K.) Kaulf .	Pteridaceae	Kali sinki
25	<i>Capillipedium sp.</i>	Poaceae	Thulo kharu	<i>Cinnamomum camphora</i> (L.) J. Presl.	Lauraceae	Kapur
26	<i>Carex setigera</i> D. Don	Cyperaceae		<i>Clerodendrum indicum</i> (L.) Kutze	Verbenaceae	Bhargi
27	<i>Castanopsis indica</i> (Roxb.) Miq.	Fagaceae	Katus	<i>Colebrookea oppositifolia</i> Sm.	Labiatae	Dhasure
28	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	Fagaceae	Musurekatus	<i>Colocasia esculenta</i> (L.) Schott	Araceae	Karkalo
29	<i>Centella asiatica</i> (L.) Urban.	Umbelliferae	Ghortapre	<i>Commelina bengalensis</i> L.	Commelinaceae	Kanejhar
30	<i>Cheilanthes albomarginata</i> C.B. Clarke	Pteridaceae	Rani sinki	<i>Crassocephalum crepidiodes</i>	Asteraceae	anikalejhar

				(Benth.) S. Moore		
31	<i>Cheilanthes bicolor</i> (Forss K.) Kaulf .	Pteridaceae	Kali sinki	<i>Crateva unilocularis</i> Buch. - Ham.	Capparaceae	Sipligan
32	<i>Choerospondias axillaris</i> (Roxb.) B.L. Brutt. & A.W.Hiil.	Anacardiaceae	Lapsi	<i>Crotalaria cytisoides</i> Roxb.	Leguminosae	Bakhreghans
33	<i>Clerodendrum indicum</i> (L.) Kutze	Verbenaceae	Bhargi	<i>Cynoglossum zeylanicum</i> (Vahl) Thunb. ex Lehm.	Boraginaceae	Kanikekuro
34	<i>Colebrookea oppositifolia</i> Sm.	Labiatae	Dhasure	<i>Cyperus rotundus</i> L.	Cyperaceae	Mothe
35	<i>Conyza stricta</i> Willd	Asteraceae		<i>Daphne bholua</i> Buch.-Ham. ex D. Don	Thymelacaceae	Lokta
36	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Asteraceae	anikalejhar	<i>Debregeasia salicifolia</i> (D. Don) Rendle	Urticaceae	Daar
37	<i>Cuscuta reflexa</i> Roxb.	Cuscutaceae	Aakashbeli	<i>Desmodium elegans</i> DC.	Leguminosae	
38	<i>Cyperus rotundus</i> L.	Cyperaceae	Mothe	<i>Dichroaefrifuga</i> Lour	Hydrangeaceae	Ganaune pat
39	<i>Daphne bholua</i> Buch.-Ham. ex D. Don	Thymelacaceae	Lokta	<i>Digitaria ciliaris</i> (Retz) Koeler	Poaceae	Chitrevanso
40	<i>Daphniphyllum himalense</i> (Benth.) Muell.-Arg.	Daphniphyllaceae	Rakcan	<i>Dioscorea bulbifera</i> L.	Cyperaceae	Geetha
41	<i>Debregeasia salicifolia</i> (D. Don) Rendle	Urticaceae	Daar	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	Poaceae	Nigalo
42	<i>Desmodium microphyllum</i> (Thunb. ) DC.	Leguminosae	Bakhreghans	<i>Dryopteris cochleata</i> (D. Don) C. Chr.	Aspidiaceae	
43	<i>Dichroa frifuga</i> Lour.	Hydrangeaceae	Ganaune pat	<i>Elaeagnus parvifolia</i> Wall. ex Royle	Elaeagnaceae	
44	<i>Digitaria aciliaris</i> (Retz) Koeler	Poaceae	Chitrevanso	<i>Elatostema integrifolium</i> (D. Don) Wedd.	Urticaceae	Lipejhar
45	<i>Dioscorea bulbifera</i> L.	Cyperaceae	Geetha	<i>Elshotziablenda</i> (Benth.) Benth.	Labiatae	
46	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	Poaceae	Nigalo	<i>Engelhardia spicata</i> Lsch. ex Bl.	Juglandaceae	Mauwaa
47	<i>Dryathyrium boryanum</i> (Willd) Ching	Aspidiaceae	kaloniuro	<i>Erythrina stricta</i> Roxb.	Leguminosae	Faledo
48	<i>Dryopteris cochleata</i> (D. Don) C. Chr.	Aspidiaceae		<i>Eulaliopsis binata</i> (ReU.) C.E. Hubbard	Poaceae	Babiyo
49	<i>Elaeagnus parvifolia</i> Wall. ex Royle	Elaeagnaceae		<i>Eupatorium adenophorum</i> Spreng.	Asteraceae	Banmara
50	<i>Elatostema integrifolium</i> (D. Don) Wedd.	Urticaceae	Lipejhar	<i>Eurya acuminata</i> DC.	Theaceae	Jhingani
51	<i>Engelhardia spicata</i> Lsch. ex Bl.	Juglandaceae	Mauwaa	<i>Ficus nerrifolia</i> Sm.	Moraceae	Dudhiolo
52	<i>Eragrostis tenella</i> (L.) Beauvois ex Roem. & Sch.	Poaceae	Vanso	<i>Ficus semicordata</i> Buch. - Ham ex Sm.	Moraceae	Khanio
53	<i>Eriobotrya dubia</i> (Lindl.) Decne	Rosaceae	Jure kafal	<i>Galium aparine</i> L.	Rubiaceae	Kangreejhar
54	<i>Eulaliopsis binata</i> (ReU.) C.E. Hubbard	Poaceae	Babiyo	<i>Gaultheria hookei</i> C-B. Clarke	Ericaceae	Patpate
55	<i>Eupatorium adenophorum</i> Spreng.	Asteraceae	Banmara	<i>Gentiana capitata</i> Buch-Ham. ex D. don	Gentianaceae	
56	<i>Eurya acuminata</i> DC.	Theaceae	Jhingani	<i>Gentiana cephalodes</i> Edgew.	Gentianaceae	Hans phul
57	<i>Fagopyrum dibotrys</i> (D. Don) Hara	Polygonaceae	Ban Phapar	<i>Geranium</i> sp.	Geraniaceae	
58	<i>Ficus auriculata</i> Lour.	Moraceae	Timilo	<i>Girardinia diversifolia</i> (Link) Friis	Urticaceae	Allo
59	<i>Ficus lacor</i> Buch-Ham.	Moraceae	Kavro	<i>Globa recemosa</i> J.E. Smith	Zngiberaceae	Lahareghans

60	<i>Ficus nerrifolia</i> Sm.	Moraceae	Dudhiolo	<i>Gonostegia hirta</i> (Blume) Miq.	Urticaceae	Chipleghans
61	<i>Ficus semicordata</i> Buch. - Ham ex Sm.	Moraceae	Khanio	<i>Grevillea robusta</i> A. Cunn. ex B.Br.	Proteaceae	Kangio
62	<i>Flemingia marcophylla</i> (Willd.) Merr.	Leguminosae		<i>Hedera nepalensis</i> K. Koch	Araliaceae	Kathe lahara
63	<i>Frageria nubicola</i> Lindl. ex Lacaita	Rosaceae	Bhuin Ainselu	<i>Heteropogon contortus</i> (L.) Beauvois	Poaceae	Arthunge
64	<i>Fraxinus floribunda</i> Wall.	Oleaceae	Lankuri	<i>Huperzia</i> sp.	Lycopodiaceae	
65	<i>Galinsoga parviflora</i> Cav.	Asteraceae	Chitlangejhar	<i>Hypericum uralum</i> Buch. - Ham. ex D. Don	Hypericaceae	Khareto
66	<i>Galium aparine</i> L.	Rubiaceae	Kangree jhar	<i>Imperata cylindrica</i> L.	Poaceae	Siru
67	<i>Gaultheria hookei</i> C-B. Clarke	Ericaceae	Patpate	<i>Inula cappa</i> DC.	Asteraceae	Kan pate
68	<i>Gentiana cephalodes</i> Edgew.	Gentianaceae	Hans phul	<i>Ischaemum rugosum</i> Salisb.	Poaceae	Maldero
69	<i>Gerbera maxima</i> (Hook.f.) Kitam	Asteraceae		<i>Jasminum mesnei</i> Hance	Oleaceae	Jai
70	<i>Globa recemosa</i> J.E. Smith	Zngiberaceae	Lahareghans	<i>Leptodermis lanceolata</i> Wall.	Rubiaceae	BhuiChampa
71	<i>Gynura angulosa</i> (Wall.) A.DC.	Asteraceae		<i>Leucosceptum canum</i> Sm.	Iabiatae	Bhasure
72	<i>Hedera nepalensis</i> K. Koch	Araliaceae	Kathe lahara	<i>Lindenbergia indica</i> (L.) Vatke	Scrophulariaceae	Chharuwajhar
73	<i>Heteropogon contortus</i> (L.) Beauvois	Poaceae	Arthunge	<i>Lindera nacusua</i> (D.Don) Merr.	Lauraceae	
74	<i>Holboellia latifolia</i> Wall.	Lardizabalaceae	Gulpha	<i>Lyonia ovalifolia</i> (Wall.) Drude	Ericaceae	Angeri
75	<i>Huperzia</i> sp.	Lycopodiaceae		<i>Macaranga indica</i> Wight	Euphorbiaceae	Maledo
76	<i>Hypericum uralum</i> Buch. - Ham. ex D. Don	Hypericaceae	Khareto	<i>Maesa chisia</i> Buch.-Ham. ex D. Don	Myrsinaceae	Bilauney
77	<i>Ilex excelsa</i> (Wall.) Hook	Aquifoliaceae	Pvale	<i>Mahonia nepaulensis</i> DC.	Berberidaceae	Jamanemandro
78	<i>Imperata cylindrica</i> L.	Poaceae	Siru	<i>Mazus pumilis</i> (Burm. f.) Steenis	Scrophulariaceae	Taprejhar
79	<i>Inula cappa</i> DC.	Asteraceae	Kan pate	<i>Melastoma melabathicum</i> L.	Melastomaceae	Angeri
80	<i>Ischaemu nrugosum</i> Salisb.	Poaceae	Maldero	<i>Mussaenda frondose</i> L.	Rubiaceae	Dhobeni
81	<i>Jasminum mesnei</i> Hance	Oleaceae	Jai	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	Myricaceae	Kafal
82	<i>Juglans regia</i> L.	Juglandaceae	Okhar	<i>Myrsine capitellata</i> Wall.	Myrsinaceae	Setikath
83	<i>Justicia adhatoda</i> L.	Acanthaceae	Asuro	<i>Neolitsea umbrosa</i> (Nees) Gamble	Lauraceae	Putali
84	<i>Lindenbergia indica</i> (L.) Vatke	Scrophulariaceae	Chharuwajhar	<i>Nepeta hindostana</i> (Roth) Haines	Iabiatae	Niesbo
85	<i>Lindera nacusua</i> (D.Don) Merr.	Lauraceae		<i>Nephrolepis cordifolia</i> (L.) Presl.	Davalliaceae	Paniaamala
86	<i>Lithocarpus elegans</i> (Blume) Hatus ex Soep	Fagaceae	Arkhaulo	<i>Osbeckia nepalensis</i> Hak.	Melastomaceae	Setochulsi
87	<i>Litsea monopetala</i> (Roxb.) Pers.	Lauraceae	kutmero	<i>Osyris wightiana</i> Wall.	Santalaceae	Nundhiki
88	<i>Lycopodium cernum</i> L.	Lycopodiaceae	Nagbeli	<i>Oxyspora paniculata</i> (D. Don) DC.	Melastomataceae	Chulesijhar
89	<i>Lyonia ovalifolia</i> (Wall.) Drude	Ericaceae	Angeri	<i>Paspalum distichum</i> L.	Poaceae	Janaighans
90	<i>Maesa chisia</i> Buch.-Ham. ex D. Don	Myrsinaceae	Bilauney	<i>Persea odoratissima</i> (Nees) Kosterm.	Lauraceae	Kaulo
91	<i>Mahonia nepaulensis</i> DC.	Berberidaceae	Jamanemandro	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	Polygonaceae	Raktanyaulejhar

92	<i>Mazus pumilis</i> (Burm. f.) Steenis	Scrophulariaceae	Taprejhar	<i>Phoenix</i> sp.	Palmae	
93	<i>Mentha arvensis</i> L.	Labiatae	Babari	<i>Phyllanthus parvifolius</i> Buch-Ham. ex D. Don	Euphorbiaceae	Khagreto
94	<i>Myrsine semiserrata</i> Wall.	Myrsinaceae	kali kath	<i>Pilea pumila</i> (L.) A. Gray	Urticaceae	
95	<i>Nepeta hindostana</i> (Roth) Haines	Labiatae	Niesbo	<i>Plantago major</i> L.	Plantaginaceae	
96	<i>Nephrolepis cordifolia</i> (L.) Presl.	Davalliaceae	Paniaamala	<i>Pogostemon glaber</i> Benth.	Labiatae	
97	<i>Nyctanthes arbor-tristis</i> L.	Oleaceae	Parijat	<i>Polygonum verticillatum</i> (L.) All.	Polygonaceae	
98	<i>Osbeckia nepalensis</i> Hak.	Melastomaceae	Setochulsi	<i>Polystichum aculeatum</i> (L.) Schott.	Aspidiaceae	Thulonyuro
99	<i>Osyris wightiana</i> Wall.	Santalaceae	Nundhiki	<i>Prunus cerasoides</i> D. Don	Rosaceae	Painyu
100	<i>Oxalis corniculata</i> L.	Oxalidaceae	Chari amilo	<i>Pteris wallichiana</i> Agardh	Pteridaceae	Tin khuttesotar
101	<i>Oxyspora paniculata</i> (D. Don) DC.	Melastomataceae	Chulesi jhar	<i>Pyracantha crenulata</i>	Rosaceae	
102	<i>Paspalum distichum</i> L.	Poaceae	Janaighans	<i>Quercus glauca</i> Thunb.	Fagaceae	Phalat
103	<i>Persea duthiei</i> (King ex Hook f.) Kost	Lauraceae	Mahilocalo	<i>Quercus semecarpifolia</i> J.E. Smith.	Fagaceae	Kharshu
104	<i>Persea odoratissima</i> (Nees) Kosterm.	Lauraceae	Kaulo	<i>Ranunculus diffusus</i> DC.	Ranunculaceae	
105	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	Polygonaceae	Raktanyaulejhar	<i>Reinwardtia indica</i> Dumort	Linaceae	Pyauli
106	<i>Persicaria perfoliata</i> (L.) H. Gross	Polygonaceae	Bakhreankhla	<i>Rhododendron</i> sp.	Ericaceae	Gurans
107	<i>Phoenix</i> sp.	Palmae		<i>Rhus javanica</i> L.	Anacardiaceae	Bhakkimlo
108	<i>Phyllanthus parvifolius</i> Buch-Ham. ex D. Don	Euphorbiaceae	Khagreto	<i>Rubia manjith</i> Roxb. ex Fleming	Rubiaceae	Majitho
109	<i>Pilea pumila</i> (L.) A. Gray	Urticaceae		<i>Rubus ellipticus</i> Smith	Rosaceae	Ainselu
110	<i>Polystichum aculeatum</i> (L.) Schott.	Aspidiaceae	Thulonyuro	<i>Rubus rosifolius</i> Smith	Rosaceae	Ratoaainselu
111	<i>Potentilla fulgens</i> Wall. ex Hook.	Rosaceae	Bajradanti	<i>Rungia pectinata</i> (L.) Nees	Acanthaceae	Gajejhar
112	<i>Prunus cerasoides</i> D. Don	Rosaceae	painyu	<i>Sambucus hookeri</i> Rehder	Caprifoliaceae	Galeni
113	<i>Pteris wallichiana</i> Agardh	Pteridaceae	Tin khuttesotar	<i>Sarcococca hookeriana</i> Bail.	Buxaceae	Telparo
114	<i>Pyracantha crenulata</i>	Rosaceae		<i>Schima wallichii</i> (DC.) Korth.	Theaceae	Chilaune
115	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	Rosaceae	Mayal	<i>Selaginella bryopteris</i> (L.)	Selaginellaceae	
116	<i>Quercus glauca</i> Thunb.	Fagaceae	Phalat	<i>Selinum wallichianum</i> (DC.) Raizada & H. O. Saxena	Umbelliferae	
117	<i>Quercus lamellosa</i> Sm.	Fagaceae	Bajrat	<i>Senecio cappa</i> Buch.-Ham. ex D. Don	Compositae	
118	<i>Quercus semecarpifolia</i> J.E. Smith.	Fagaceae	Kharshu	<i>Smilax ovalifolia</i> Roxb.	Smilacaceae	Kukurdino
119	<i>Rhododendron arboreum</i> Smith	Ericaceae	Gurans	<i>Smilax aspera</i> L.	Smilacaceae	
120	<i>Rosa brunonii</i> Lindl	Rosaceae	Bhainsikane gulab	<i>Smilax cordifolia</i> Humb. & Bonpl. ex Willd.	Smilacaceae	
121	<i>Rubia manjith</i> Roxb. ex Fleming	Rubiaceae	Majitho	<i>Smilax elegans</i> Wall. ex Kunth	Smilacaceae	
122	<i>Rubus ellipticus</i> Smith	Rosaceae	Ainselu	<i>Spondias pinnata</i> (L.f) Kuz	Anacardiaceae	Aamaro
123	<i>Rubus rosifolius</i> Smith	Rosaceae	Ratoaainselu	<i>Stranvaesia nussia</i> (D. Don) Denche	Rosaceae	Jure mayal
124	<i>Rungia pectinata</i> (L.) Nees	Acanthaceae	Gajejhar	<i>Strobilanthes</i> sp.	Acanthaceae	
125	<i>Sambucus hookeri</i> Rehder	Caprifoliaceae	Galeni	<i>Symplocos ramosissima</i> Wall ex. D. Don	Symplocaceae	Hakula
126	<i>Sapium insigne</i> (Royle) Benth. ex Hook.f.	Euphorbiaceae	Khirro	<i>Synotis</i> sp.	Commelinaceae	

127	<i>Sarcococca hookeriana</i> Bail.	Buxaceae	Telparo	<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	Jamun
128	<i>Sauravia napaulensis</i> DC.	Sauraviaceae	Gogan	<i>Themeda triandra</i> Forssk	Poaceae	Khar
129	<i>Schima wallichii</i> (DC.) Korth.	Theaceae	chilaune	<i>Thysanolaena maxima</i> (Roxb.) O. Kuntze	Poaceae	Amriso
130	<i>Sedum rhombifolia</i> L.	Crassulaceae	Ativala	<i>Toona ciliata</i> M. Roem.	Meliaceae	Tuni
131	<i>Selaginella bryopteris</i> (L.)	Selaginellaceae		<i>Triumfetta pilosa</i> Roth	Tiliaceae	Dallekuro
132	<i>Smilax ovalifolia</i> Roxb.	Smilacaceae	Kukurdino	<i>Urtica dioica</i> L.	Urticaceae	Sisnoo
133	<i>Smilax aspera</i> L.	Smilacaceae		<i>Viburnum coriaceum</i> Blume	Caprifoliaceae	Ghodekhari
134	<i>Smilax cordifolia</i> Humb. & Bonpl. ex Willd.	Smilacaceae		<i>Viburnum mullaha</i> Buch-Ham. ex D. Don	Sambucaceae	Mallo
135	<i>Smilax elegans</i> Wall. ex Kunth	Smilacaceae				
136	<i>Spatholobus parviflorus</i> (Roxb.) Kuntze	Leguminosae				
137	<i>Stephania glandulifera</i> Miers.	Menispermaceae	Batule lahara			
138	<i>Symplocos ramosissima</i> Wall ex. D. Don	Symplocaceae	Hakula			
139	<i>synotis</i> sp.	Commelinaceae				
140	<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	Jamun			
141	<i>Taraxacum officinale</i> Weber	Asteraceae				
142	<i>Taxus baccata</i> L.	Taxaceae	Dhegresalla			
143	<i>Terminalia chebula</i> Relz.	Combretiaceae	Harro			
144	<i>Themeda triandra</i> Forssk	Poaceae	Khar			
145	<i>Thysanolaena maxima</i> (Roxb.) O. Kuntze	Poaceae	Amriso			
146	<i>Toona ciliata</i> M. Roem.	Meliaceae	Tuni			
147	<i>Valeriana hardwickii</i> wall	Valerianaceae	Nakkalijatamani			
148	<i>Viburnum continifolium</i> D. Don	Sambucaceae	Gharghure			
149	<i>Viburnum coriaceum</i> Blume	Caprifoliaceae	Ghodekhari			
150	<i>Viburnum mullaha</i> Buch-Ham. ex D. Don	Sambucaceae	Mallo			
151	<i>Vicia hirsute</i> (L.) S.F. Gray	Leguminosae	Ankara			
152	<i>Viola canescens</i> Wall. ex Roxb	Violaceae				
153	<i>Viscum album</i> L.	Loranthaceae	Miselto			
154	<i>Woodfordia fruticosa</i> (L.) Kurz	Lythraceae	Dhaiyaro			
155	<i>Zizyphus incurve</i> Roxb.	Rhamnaceae	hade bayer			

#### Annex 2: Importance value index of tree species at 1500m-1600m altitude

S.N	Name of species	IVI at North aspect	IVI at South aspect
1	<i>Aesandra butyracea</i> (Roxb.) Baehni	0.00	3.28
2	<i>Alnus nepalensis</i> D. Don	10.53	0.00

3	<i>Bauhinia vahli</i> iWight&Arn.	3.76	0.00
4	<i>Betula alnoides</i> Buch.-Ham. ex D. Don	11.43	0.00
5	<i>Bombax ceiba</i> L.	0.00	3.29
6	<i>Brassaiopsi shainla</i> (Bach.-Ham. ex D. Don) Seem.	3.13	0.00
7	<i>Castanopsis indica</i> (Roxb.) Miq.	2.83	3.22
8	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	38.26	47.69
9	<i>Choerospondias axillaris</i> (Roxb.) B.L. Brutt. &A.W.Hiil.	8.21	0.00
10	<i>Cinnamomum camphora</i> (L) J. Presl.	0.00	3.55
11	<i>Debregeasia salicifolia</i> (D. Don) Rendle	2.98	0.00
12	<i>Engelhardia spicata</i> Lsch. ex Bl.	18.99	13.54
13	<i>Eurya acuminata</i> DC.	17.83	0.00
14	<i>Ficus auriculata</i> lour.	9.54	0.00
15	<i>Ficus lacor</i> Buch-Ham.	3.04	0.00
16	<i>Ficus nerrifolia</i> Sm.	2.51	0.00
17	<i>Ficus semicordata</i> Buch. - Ham ex Sm.	2.91	3.30
18	<i>Fraxinus floribunda</i> Wall.	4.85	0.00
19	<i>Grevillea robusta</i> A. Cunn. ex B.Br.	0.00	9.72
20	<i>Lithocarpus elegans</i> (Blume) Hatus ex Soep	7.28	0.00
21	<i>Litsea monopetala</i> (Roxb.) Pers.	5.09	0.00
22	<i>Lyonia ovalifolia</i> (Wall.) Drude	17.02	10.87
23	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	0.00	9.65
24	<i>Myrsine capitellata</i> Wall.	0.00	11.55
25	<i>Myrsine semiserrata</i> Wall.	3.77	0.00
26	<i>Nyctanthes arbor-tristis</i> L.	2.80	0.00
27	<i>Prunus cerasoides</i> D. Don	20.35	4.24
28	<i>Quercus lamellose</i> Sm.	4.07	0.00
29	<i>Quercus semecarpifolia</i> J.E. Smith.	32.87	73.16
30	<i>Rhododendron arboreum</i> Smith	18.96	28.50
31	<i>Saurauia napaulensis</i> DC.	11.05	0.00
32	<i>Schima wallichii</i> (DC.) Korth.	35.92	68.37
33	<i>Syzygium cumini</i> (L.) Skeels	0.00	6.09

Annex 3: Importance value index of tree species at 1700m-1800m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Aesandra butyracea</i> (Roxb.)Baehni	0.00	4.26
2	<i>Alnus nepalensis</i> D.Don	63.37	3.26
3	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	10.85	75.77

4	<i>Engelhardia spicata</i> Lsch. ex Bl.	38.54	13.57
5	<i>Eurya acuminata</i> DC.	3.14	0.00
6	<i>Fraxinus floribunda</i> Wall.	6.11	0.00
7	<i>Lyonia ovalifolia</i> (Wall.) Drude	31.69	6.25
8	<i>Macaranga indica</i> Wight	0.00	12.16
9	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	0.00	7.58
10	<i>Myrsine capitellata</i> Wall.	0.00	7.49
11	<i>Persea duthiei</i> (King ex Hook f.) Kost	3.05	0.00
12	<i>Persea odoratissima</i> (Nees) Kosterm.	3.06	0.00
13	<i>Prunus cerasoides</i> D. Don	3.99	8.48
14	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	11.71	0.00
15	<i>Quercus semecarpifolia</i> J.E. Smith.	0.00	9.91
16	<i>Rhododendron arboreum</i> Smith	49.44	58.31
17	<i>Sapium insigne</i> (Royle) Benth. ex Hook.f.	3.35	0.00
18	<i>Schima wallichii</i> (DC.) Korth.	29.23	75.19
19	<i>Spondias pinnata</i> (L.f) Kuz	0.00	4.35
20	<i>Stranvaesis nussia</i> (D.Don) Denche	0.00	6.58
21	<i>Symplocu sramosissima</i> Wall ex. D.Don	2.94	3.57
22	<i>Syzygium cumini</i> (L.) Skeels	3.56	3.29
23	<i>Taxus baccata</i> L.	13.86	0.00
24	<i>Terminalia chebula</i> Relz.	5.20	0.00
25	<i>Toona ciliata</i> M. Roem.	3.35	0.00
26	<i>Zizyphus incurve</i> Roxb.	6.27	0.00

Annex 4: Importance value index of tree species at 1900m-2000m altitude

S.N.	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Aesandra butyracea</i> (Roxb.)Baehni	0.00	7.06
2	<i>Alnus nepalensis</i> D.Don	23.60	0.00
3	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	0.00	30.11
4	<i>Daphniphyllum himalense</i> (Benth.) Muell.-Arg.	4.61	0.00
5	<i>Debregeasia salicifolia</i> (D. Don) Rendle	0.00	21.50
6	<i>Engelhardia spicata</i> Lsch. ex Bl.	15.00	3.38
7	<i>Eriobotrya dubia</i> (Lindl.) Decne	3.95	0.00
8	<i>Erythrina stricta</i> Roxb.	0.00	3.79
9	<i>Eurya acuminata</i> DC.	40.53	4.94
10	<i>Ficus nerrifolia</i> Sm.	0.00	3.41
11	<i>Fraxinus floribunda</i> Wall.	4.09	0.00
12	<i>Leucosceptrum canum</i> Sm.	0.00	40.84
13	<i>Lindera nacusua</i> (D.Don) Merr.	7.55	0.00
14	<i>Lyonia ovalifolia</i> (Wall.) Drude	27.03	10.79
15	<i>Macaranga indiba</i> Wight	0.00	39.01
16	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	0.00	13.61
17	<i>Myrsine semiserrata</i> Wall.	3.88	0.00
18	<i>Neolitsea umbrosa</i> (Nees) Gamble	0.00	27.06
19	<i>Persea odoratissima</i> (Nees) Kosterm.	0.00	8.35
20	<i>Prunus cerasoides</i> D. Don	4.00	0.00
21	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	4.25	0.00
22	<i>Quercus glauca</i> Thunb.	6.09	0.00
23	<i>Quercus lamellose</i> Sm.	34.82	0.00
24	<i>Quercus semecarpifolia</i> J.E. Smith.	0.00	34.76
25	<i>Rhododendron arboreum</i> Smith	55.10	23.54
26	<i>Schima wallichii</i> (DC.) Korth.	3.82	15.72
27	<i>Symplocu sramosissima</i> Wall ex. D.Don	56.06	0.00
28	<i>Toona ciliata</i> M. Roem.	0.00	12.13
29	<i>Zizyphus incurve</i> Roxb.	5.61	0.00

Annex 5: Importance value index of tree species at 2100m-2200m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Alnus nepalensis</i> D.Don	2.98	0.00
2	<i>Crateva unilocularis</i> Buch. - Ham.	0.00	14.02
3	<i>Daphniphyllum himalense</i> (Benth.) Muell.-Arg.	47.73	0.00
4	<i>Eurya acuminata</i> DC.	53.54	0.00
5	<i>Ilex spp.</i>	3.26	0.00
6	<i>Juglans regia</i> L.	5.44	0.00
7	<i>Leucosceptrum canum</i> Sm.	0.00	173.29
8	<i>Lindera nacusua</i> (D.Don) Merr.	5.95	7.63
9	<i>Lyonia ovalifolia</i> (Wall.) Drude	27.18	0.00
10	<i>Neolitsea umbrosa</i> (Nees) Gamble	0.00	50.61
11	<i>Prunus cerasoides</i> D. Don	3.02	13.91
12	<i>Quercus glauca</i> Thunb.	0.00	6.59
13	<i>Quercus lamellose</i> Sm.	16.18	0.00
14	<i>Quercus semecarpifolia</i> J.E. Smith.	12.99	0.00
15	<i>Rhododendron</i> sp.	39.01	0.00
16	<i>Schima wallichii</i> (DC.) Korth.	3.90	0.00
17	<i>Symplocous</i> sp.	81.55	33.95

Annex 6: Importance value index of tree species at above2300m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Aesandra butyracea</i> (Roxb.)Baehni	0.00	4.96
2	<i>Eurya acuminata</i> DC.	10.40	11.74
3	<i>Lyonia ovalifolia</i> (Wall.) Drude	20.62	11.91
4	<i>Prunus cerasoides</i> D. Don	8.21	0.00
5	<i>Quercus glauca</i> Thunb.	5.02	0.00
6	<i>Quercus lamellose</i> Sm.	7.87	0.00
7	<i>Quercus semecarpifolia</i> J.E. Smith.	72.07	154.55
8	<i>Rhododendron</i> sp.	153.13	96.00
9	<i>Symplocous</i> sp.	22.69	20.85

Annex 7: Importance value index of shrub species at 1500m-1600m

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Achyranthus bidentata</i> Blude	2	0
2	<i>Albizia</i> spp.	0.00	10.38
3	<i>Artemisia indica</i> Wild	24.43	6.09
4	<i>Berberis aristata</i> DC.	47.16	0.00
5	<i>Buddleja asiatica</i> Lour.	15.24	3.65
6	<i>Clerodendrum indicum</i> (L.) Kutze	5.96	0.00
7	<i>Colebrookea oppositifolia</i> Sm.	2.14	0.00
8	<i>Desmodium elegans</i> DC.	0.00	20.51
9	<i>Desmodium microphyllum</i> (Thunb. ) DC.	16.96	0.00
10	<i>Dichroa febrifuga</i> Lour.	4.16	0.00
11	<i>Gaultheria hookei</i> C-B. Clarke	12.39	0.00
12	<i>Hypericum uralum</i> Buch.- Ham. ex D. Don	13.01	7.01
13	<i>Inula cappa</i> DC.	0.00	8.20
14	<i>Jasminum mesnei</i> Hance	8.96	0.00
15	<i>Justicia adhatoda</i> L.	4.39	0.00
16	<i>Maesa chisia</i> Buch.-Ham. ex D. Don	0.00	8.67
17	<i>Melastoma melabathicum</i> L.	0.00	27.82
18	<i>Mussaenda frondosa</i> L.	0.00	3.03
19	<i>Osbeckia nepalensis</i> Hak.	5.57	49.00
20	<i>Osyris wightiana</i> Wall.	29.61	31.54
21	<i>Oxyspora paniculata</i> (D. Don) DC.	8.85	0.00
22	<i>Phyllanthus parvifolius</i> Buch-Ham.ex D. Don	38.91	64.75
23	<i>Pogostemon glaber</i> Benth.	0.00	13.19
24	<i>Reinwardtia Indiba</i> Dumort	0.00	6.11
25	<i>Rosa brunonii</i> Lindl	4.99	0.00
26	<i>Rubus ellipticus</i> Smith	15.60	4.88
27	<i>Rubus rosifolius</i> Smith	9.22	16.88
28	<i>Sarcococca hookeriana</i> Bail.	13.65	0.00
29	<i>Spatholobus parviflorus</i> (Roxb.) Kuntze	3.13	0.00
30	<i>Viburnum continifolium</i> D.Don	2.64	0.00
31	<i>Viburnum coriaceum</i> Blume	0.00	18.38
32	<i>Viburnum mullaha</i> Buch-Ham. ex D.Don	2.13	0.00
33	<i>Viscum album</i> L.	2.38	0.00
34	<i>Woodfordia fruticosa</i> (L.) Kurz	4.14	0.00

Annex 8: Importance value index of shrub species at 1700m-1800m altitude

S.N.	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Achyranthus bidentata</i> Blude	14.28	0.00
2	<i>Artemisia indica</i> Willd.	24.94	0.00
3	<i>Berberis aristata</i> DC.	23.98	4.28
4	<i>Buddleja asiatica</i> Lour.	3.08	0.00
5	<i>Clerodendrum indicum</i> (L.) Kutze	26.27	0.00
6	<i>Desmodium elegans</i> DC.	0.00	24.36
7	<i>Elaeagnus parvifolia</i> Wall. ex Royle	3.82	0.00
8	<i>Flemingia marcophylla</i> (Willd.) Merr.	21.26	0.00
9	<i>Gaultheria hookei</i> C-B. Clarke	18.93	0.00
10	<i>Hypericum uralum</i> Buch.- Ham. ex D. Don	4.53	0.00
11	<i>Inula cappa</i> DC.	0.00	30.80
12	<i>Justicia adhatoda</i> L.	12.55	0.00
13	<i>Maesa chisia</i> Buch.-Ham. ex D. Don	2.31	83.94
14	<i>Mahonia nepaulensis</i> DC.	13.32	0.00
15	<i>Osbeckia nepalensis</i> Hak.	15.30	12.34
16	<i>Osyris wightiana</i> Wall.	17.45	0.00
17	<i>Oxyspora paniculata</i> (D. Don) DC.	2.76	5.47
18	<i>Phyllanthus parvifolius</i> Buch-Ham.ex D. Don	42.23	0.00
19	<i>Pilea pumila</i> (L.)A. Gray	22.96	0.00
20	<i>Pogostemong glaber</i> Benth.	0.00	64.88
21	<i>Reinwardtia Indiba</i> Dumort	0.00	4.61
22	<i>Rosa brunonii</i> Lindl	8.32	0.00
23	<i>Rubus ellipticus</i> Smith	0.00	21.24
24	<i>Rubus rosifolius</i> Smith	1.62	13.85
25	<i>Sambucus hookeri</i> Rehder	0.00	10.43
26	<i>Spathologus parviflorus</i> (Roxb.) Kuntze	1.99	0.00
27	<i>Viburnum continifolium</i> D.Don	10.76	0.00
28	<i>Viburnum coriaceum</i> Blume	1.99	11.09
29	<i>Viscum album</i> L.	2.52	0.00

Annex 9: Importance value index of shrub species at 1900m-2000m altitude

S.N.	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Albizia spp.</i>	10.52	0.00
2	<i>Artemisia indica</i> Willd.	2.20	0.00
3	<i>Berberis aristata</i> DC.	28.45	0.00
4	<i>Clerodendrum indicum</i> (L.) Kutze	23.00	10.34
5	<i>Dichroa febrifuga</i> Lour	0.00	23.58
6	<i>Elaeagnus parvifolia</i> Wall. ex Royle	0.00	8.07
7	<i>Gaultheria hookei</i> C-B. Clarke	62.62	8.96
8	<i>Hedera nepalensis</i> K. Koch	0.00	3.24
9	<i>Hypericum uralum</i> Buch.- Ham. ex D. Don	10.67	0.00
10	<i>Inula cappa</i> DC.	9.03	0.00
11	<i>Jasminum mesnei</i> Hance	8.43	0.00
12	<i>Maesa chisia</i> Buch.-Ham. ex D. Don	3.20	31.88
13	<i>Mahonia nepaulensis</i> DC.	27.62	22.10
14	<i>Osbekia nepalensis</i> Hak.	12.93	15.21
15	<i>Osyris wightiana</i> Wall.	9.87	0.00
16	<i>Oxyspora paniculata</i> (D. Don) DC.	2.14	0.00
17	<i>Phyllanthus parvifolius</i> Buch-Ham.ex D. Don	32.14	19.99
18	<i>Pilea pumila</i> (L.)A. Gray	2.89	20.62
19	<i>Pogostemong glaber</i> Benth.	0.00	5.41
20	<i>Pyracantha crenulata</i>	2.36	0.00
21	<i>Rhus javanica</i> L.	0.00	12.27
22	<i>Rubus ellipticus</i> Smith	4.56	14.19
23	<i>Rubus rosifolius</i> Smith	25.35	0.00
24	<i>Sambucus hookeri</i> Rehder	5.87	5.16
25	<i>Sarcococca hookeriana</i> Bail.	4.55	16.00
26	<i>Senecio cappa</i> Buch.-Ham. ex D- Don	0.00	29.88
27	<i>Viburnum coriaceum</i> Blume	11.57	4.26
28	<i>Viburnum mullaha</i> Buch-Ham. ex D.Don	0.00	48.77

Annex 10: Importance value index of shrub species at 2100m-2200m altitude

S.N.	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Albizia</i> spp.	13.41	0.00
2	<i>Berberis aristata</i> DC.	7.65	0.00
3	<i>Daphne bholua</i> Buch.-Ham. ex D.Don	64.61	0.00
4	<i>Elshotzia blanda</i> (Benth.) Benth.	0.00	15.25
5	<i>Gaultheria hookei</i> C-B. Clarke	27.34	0.00
6	<i>Hedera nepalensis</i> K. Koch	0.00	5.13
7	<i>Hypericum uralum</i> Buch.- Ham. ex D. Don	13.16	0.00
8	<i>Mahonia nepaulensis</i> DC.	30.05	89.19
9	<i>Osbekia nepalensis</i> Hak.	4.64	0.00
10	<i>Phyllanthus parvifolius</i> Buch-Ham.ex D. Don	30.45	0.00
11	<i>Pyracantha crenulata</i>	15.87	0.00
12	<i>Rubus rosifolius</i> Smith	29.44	0.00
13	<i>Sambucus hookeri</i> Rehder	6.38	0.00
14	<i>Sarcococca hookeriana</i> Bail.	32.60	101.77
15	<i>Synotis</i> spp.	9.68	36.23
16	<i>Viburnum coriaceum</i> Blume	11.21	0.00
17	<i>Viburnum mullaha</i> Buch-Ham. ex D.Don	0.00	52.46
18	<i>Viscum album</i> L.	3.43	0.00

Annex 11: Importance value index of shrub species at above 2300m altitude

S.N.	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Artemisia indica</i> Wild	0.00	19.37
2	<i>Berberis aristata</i> DC.	0.00	16.33
3	<i>Clerodendrum indicum</i> (L.) Kutze	3.37	28.58
4	<i>Colebrookea oppositifolia</i> Sm.	0.00	7.88
5	<i>Crotalaria cytisoides</i> Roxb.	0.00	3.65
6	<i>Daphne bholua</i> Buch.-Ham. ex D.Don	54.97	5.73
7	<i>Desmodium elegans</i> DC.	0.00	2.12
8	<i>Gaultheria hookei</i> C-B. Clarke	64.09	6.38
9	<i>Hypericum uralum</i> Buch.- Ham. ex D. Don	22.26	19.33
10	<i>Inula cappa</i> DC.	7.27	19.20
11	<i>Jasminum mesnei</i> Hance	23.38	21.62
12	<i>Mahonia nepaulensis</i> DC.	17.47	29.97
13	<i>Osyris wightiana</i> Wall.	0.00	3.65
14	<i>Phyllanthus parvifolius</i> Buch-Ham.ex D. Don	4.81	59.58
15	<i>Rubus ellipticus</i> Smith	15.72	23.95
16	<i>Rubus rosifolius</i> Smith	37.53	5.04
17	<i>Sambucus hookeri</i> Rehder	13.82	6.69
18	<i>Sarcococca hookeriana</i> Bail.	27.06	14.21
19	<i>Synotis</i> spp	0.00	6.64
20	<i>Viscum album</i> L.	8.18	0.00

Annex 12: Importance value index of herb species at 1500m-1600m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Acer sikkimense</i> Miq.	0.00	2.97
2	<i>Adiantum capillus-veneris</i> L.	1.48	0.00
3	<i>Allium wallichii</i> Kunth	3.23	0.00
4	<i>Anaphalis busua</i> (Buch.-Ham. ex Don) DC.	0.00	10.60
5	<i>Anemone rivularis</i> Buch.-Ham. ex DC.	1.66	0.00
6	<i>Asparagus racemosus</i> Willd.	5.87	0.00
7	<i>Asplenium</i> sp.	6.89	0.00
8	<i>Bidens pilosa</i> L.	3.48	2.05
9	<i>Boehmeria</i> sp.	6.24	1.11
10	<i>Capillipedium assimile</i> (Steud.) A. Camus	22.20	32.45
11	<i>Capillipedium</i> sp.	20.54	19.95
12	<i>Centella asiatica</i> (L.) Urban.	2.26	0.00
13	<i>Cheilanthes albomarginata</i> C.B. Clarke	2.89	0.00
14	<i>Cheilanthes bicolor</i> (Forss K.) Kaulf .	13.97	12.45
15	<i>Colocasia esculenta</i> (L.) Schott	0.00	0.97
16	<i>Commelina bengalensis</i> L.	0.00	6.15
17	<i>Conyza stricta</i> Willd	3.21	0.00
18	<i>Crassocephalum crepidiodes</i> (Benth.) S. Moore	2.46	0.88
19	<i>Cyperus</i> sp	19.52	22.98
20	<i>Digitaria ciliaris</i> (Retz) Koeler	5.07	0.00
21	<i>Dioscorea bulbifera</i> L.	2.53	4.98
22	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	7.55	1.32
23	<i>Dryothyrium boryanum</i> (Willd) Ching	6.91	0.00
24	<i>Dryopteris cochleata</i> (D. Don) C. Chr.	0.00	1.18
25	<i>Eragrostis tenella</i> (L.) Beauvois ex Roem. & Sch.	4.53	0.00
26	<i>Eulaliopsis binata</i> (ReU.) C.E. Hubbard	2.02	0.00
27	<i>Eupatorium adenophorum</i> Spreng.	12.64	15.98
28	<i>Fagopyrum dibotrys</i> (D. Don) Hara	1.93	0.00
29	<i>Fragaria</i> sp.	4.59	0.00
30	<i>Galinsoga parviflora</i> Cav.	1.29	0.00
31	<i>Galium aparine</i> L.	14.19	0.00
32	<i>Gentiana cephalodes</i> Edgew.	0.00	9.92
33	<i>Globa recemosa</i> J.E. Smith	3.01	1.27
34	<i>Gonostegia hirta</i> (Blume) Miq.	0.00	1.58
35	<i>Huperzia</i> sp.	0.00	1.87
36	<i>Imperata cylindrica</i> L.	12.18	12.36
37	<i>Ischaemum rugosum</i> Salisb.	0.00	9.28
38	<i>Lindenbergia indica</i> (L.) Vatke	11.30	1.60
39	<i>Nepeta hindostana</i> (Roth) Haines	1.48	0.00
40	<i>Nephrolepis cordifolia</i> (L.) Presl.	21.10	2.75
41	<i>Oxalis corniculata</i> L.	5.12	0.00
42	<i>Paspalum distichum</i> L.	2.46	7.69

43	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	5.78	2.74
44	<i>Polystichum aculeatum</i> (L.) Schott.	1.87	2.51
45	<i>Pteris wallichiana</i> Agardh	1.14	15.29
46	<i>Ranunculus diffusus</i> DC.	0.00	1.79
47	<i>Rubia manjith</i> Roxb. ex Fleming	4.96	6.84
48	<i>Rungia pectinata</i> (L.) Nees	0.00	10.02
49	<i>Sedum</i> sp.	1.29	0.00
50	<i>Selaginella bryopteris</i> (L.)	5.52	0.00
51	<i>Selinum wallichianum</i> (DC.) Raizada & H. O. Saxena	0.00	3.37
52	<i>Smilax ovalifolia</i> Roxb.	4.96	1.51
53	<i>Smilax aspera</i> L.	4.06	0.00
54	<i>Stephania glandulifera</i> Miers.	7.20	0.00
55	<i>Strobilanthus</i> sp.	0.00	15.08
56	<i>Themeda triandra</i> Forssk	17.53	31.13
57	<i>Thysanolaena maxima</i> (Roxb.) O. Kuntze	4.70	6.11
58	<i>Triumfetta pilosa</i> Roth	0.00	3.96
59	<i>Vicia hirsute</i> (L.) S.F. Gray	1.29	0.00
60	<i>Viola canescens</i> Wall. ex Roxb	2.15	0.00

Annex 13: Importance value index of herb species at 1700m-1800m altitude

S.N	Name of species	IVI at North aspect	IVI at South aspect
1	<i>Acer sikkimense</i> Miq.	4.29	5.23
2	<i>Achyranthes aspera</i> L.	2.16	0.00
3	<i>Allium wallichii</i> Kunth	2.58	6.71
4	<i>Anaphatis busua</i> (Buch.-Ham. ex Don) DC.	2.38	2.66
5	<i>Arisaema tortuosum</i> (Wall.) Schot	0.00	1.16
6	<i>Asparagus racemosus</i> Willd.	1.25	2.50
7	<i>Asplenium</i> sp.	0.00	13.60
8	<i>Astilbe rivularis</i> Buch.-Ham ex D. Don	1.90	0.00
9	<i>Bergenia ciliata</i> (Haw.) Sternb.	2.21	0.00
10	<i>Bidens pilosa</i> L.	2.76	0.00
11	<i>Boehmeria</i> sp.	19.72	21.51
12	<i>Capillipedium assimile</i> (Steud.) A. Camus	4.77	2.54
13	<i>Capillipedium</i> sp.	20.14	16.05
14	<i>Cheilanthes albomarginata</i> C.B. Clarke	2.97	0.00
15	<i>Cheilanthes bicolor</i> (Forss K.) Kaulf .	2.43	0.00
16	<i>Conyza stricta</i> willd	0.95	0.00
17	<i>Cuscuta reflexa</i> Roxb.	2.76	0.00
18	<i>Cyperus</i> sp.	26.43	29.07
19	<i>Digitaria ciliaris</i> (Retz) Koeler	0.00	5.16
20	<i>Dioscorea bulbifera</i> L.	3.92	4.86
21	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	7.36	29.26
22	<i>Dryopteris cochleata</i> (D. Don) C. Chr.	0.00	10.21
23	<i>Elatostema integrifolium</i> (D. Don) Wedd.	22.27	4.50
24	<i>Eragrostis tenella</i> (L.) Beauvois ex Roem. & Sch.	5.08	0.00
25	<i>Eupatorium adenophorum</i> Spreng.	28.69	22.88
26	<i>Galinsoga parviflora</i> Cav.	1.42	0.00
27	<i>Galium aparine</i> L.	10.51	0.00
28	<i>Gentiana cephalodes</i> Edgew.	2.85	5.73
29	<i>Globa recemosa</i> J.E. Smith	1.69	1.64
30	<i>Imperata cylindrica</i> L.	6.71	4.11
31	<i>Ischaemum rugosum</i> Salisb.	0.00	4.61
32	<i>Lindenbergia indica</i> (L.) Vatke	4.35	21.23
33	<i>Mentha</i> sp.	2.46	0.00
34	<i>Nepeta hindostana</i> (Roth) Haines	5.84	8.25
35	<i>Nephrolepis cordifolia</i> (L.) Presl.	2.93	0.00
36	<i>Oxalis corniculata</i> L.	3.46	0.00
37	<i>Paspalum distichum</i> L.	10.16	9.60
38	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	7.56	2.44
39	<i>Polystichu maculeatum</i> (L.) Schott.	10.64	19.39
40	<i>Potentilla fulgens</i> Wall. ex Hook.	2.09	0.00
41	<i>Rubia manjith</i> Roxb. ex Fleming	3.20	12.06
42	<i>Rungia pectinata</i> (L.) Nees	4.12	0.00

43	<i>Selaginella bryopteris</i> (L.)	10.86	0.00
44	<i>Selinum wallichianum</i> (DC.) Raizada & H. O. Saxena	0.00	2.57
45	<i>Smilax ovalifolia</i> Roxb.	9.76	6.92
46	<i>Smilax aspera</i> L.	12.96	0.00
47	<i>Smilax cordifolia</i> Humb. & Bonpl. ex Willd.	0.00	1.84
48	<i>Stephania glandulifera</i> Miers.	7.66	0.00
49	<i>Taraxacum officinale</i> Weber	1.25	0.00
50	<i>Tectaria macrodonata</i> (Fee.) C. Chr.	0.00	3.57
51	<i>Themeda triandra</i> Forssk	7.00	4.04
52	<i>Thysanolaena maxima</i> (Roxb.) O. Kuntze	0.00	5.07
53	<i>Viola canescens</i> Wall. ex Roxb	1.66	0.00

Annex 14: Importance value index of herb species at 1900m-2000m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Acer sikkimense</i> Miq.	3.46	6.76
2	<i>Achyranthes aspera</i> L.	0.00	3.04
3	<i>Allium wallichii</i> Kunth	0.00	2.48
4	<i>Anaphalis busua</i> (Buch.-Ham. ex Don) DC.	0.00	19.55
5	<i>Anaphatis busua</i> (Buch.-Ham. ex Don) DC.	18.78	0.00
6	<i>Anemone rivularis</i> Buch.-Ham. ex DC.	0.00	1.35
7	<i>Angiopteris</i> sp.	5.27	0.00
8	<i>Arisaema tortuosum</i> (Wall.) Schot	1.09	0.00
9	<i>Asparagus racemosus</i> Willd.	1.46	2.02
10	<i>Asplenium</i> sp.	1.25	4.64
11	<i>Astilbe rivularis</i> Buch.-Ham ex D. Don	8.01	0.00
12	<i>Bergenia ciliata</i> (Haw.) Sternb.	2.33	0.00
13	<i>Bidens pilosa</i> L.	0.00	1.31
14	<i>Boehmeria</i> sp.	5.94	6.59
15	<i>Capillipedium assimile</i> (Steud.) A. Camus	0.00	3.03
16	<i>Capillipedium</i> sp.	10.83	10.27
17	<i>Cheilanthes albomarginata</i> C.B. Clarke	3.90	0.00
18	<i>Cheilanthes bicolor</i> (Forss K.) Kaulf .	0.00	1.80
19	<i>Crassocephalum crepidiodes</i> (Benth.) S. Moore	0.00	1.35
20	<i>Cynoglossum zeylanicum</i> (Vahl) Thunb. ex Lehm.	0.00	5.69
21	<i>Cyperus</i> sp.	31.65	32.49
22	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	19.27	4.82
23	<i>Dryopteris cochleata</i> (D. Don) C. Chr.	18.90	8.64
24	<i>Elatostema integrifolium</i> (D. Don) Wedd.	13.14	41.95
25	<i>Eragrostis tenella</i> (L.) Beauvois ex Roem. & Sch.	1.62	0.00
26	<i>Eupatorium adenophorum</i> Spreng.	16.52	9.43
27	<i>Galium aparine</i> L.	15.08	0.00
28	<i>Gentiana capitata</i> Buch-Ham.exD.don	0.00	3.60
29	<i>Gentiana cephalodes</i> Edgew.	5.15	10.13
30	<i>Geranium</i> spp.	0.00	2.92
31	<i>Girardinia diversifolia</i> (Link) Friis	0.00	2.65
32	<i>Globa recemosa</i> J.E. Smith	2.82	14.52
33	<i>Hedera nepalensis</i> K. Koch	8.40	2.07
34	<i>Heteropogon contortus</i> (L.) Beauvois	0.00	2.20
35	<i>Holboellia latifolia</i> Wall.	3.06	0.00
36	<i>Imperata cylindrica</i> L.	2.59	20.77
37	<i>Ischaemum rugosum</i> Salisb.	8.75	13.48
38	<i>Leptodermis lanceolata</i> Wall.	0.00	1.91
39	<i>Lindenbergia indica</i> (L.) Vatke	0.00	2.25
40	<i>Lycopodium cernum</i> L.	4.03	0.00
41	<i>Paspalum distichum</i> L.	8.28	8.55
42	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	3.16	5.27

43	<i>Persicaria perfoliata</i> (L.) H. Gross	2.59	0.00
44	<i>Polystichum aculeatum</i> (L.) Schott.	1.53	2.06
45	<i>Potentilla fulgens</i> Wall. ex Hook.	2.43	0.00
46	<i>Rubia manjith</i> Roxb. ex Fleming	0.00	5.32
47	<i>Selaginella bryopteris</i> (L.)	5.86	6.53
48	<i>Smilax ovalifolia</i> Roxb.	9.16	0.00
49	<i>Smilax aspera</i> L.	5.26	0.00
50	<i>Smilax cordifolia</i> Humb. & Bonpl. ex Willd.	1.53	0.00
51	<i>Smilax elegans</i> Wall. ex Kunth	21.94	0.00
52	<i>Strobilanthus</i> sp.	0.00	1.54
53	<i>Themeda triandra</i> Forssk	3.08	22.27
54	<i>Valeriana hardwickii</i> wall	8.08	0.00
55	<i>Viola canescens</i> Wall.exRoxb	2.59	0.00

Annex 15: Importance value index of herb species at 2100m-2200m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Acer sikkimense</i> Miq.	10.02	20.13
2	<i>Achyranthes aspera</i> L.	0.00	24.30
3	<i>Allium wallichii</i> Kunth	7.48	13.05
4	<i>Anaphatis busua</i> (Buch.-Ham. ex Don) DC.	4.30	0.00
5	<i>Anemone rivularis</i> Buch.-Ham. ex DC.	7.51	0.00
6	<i>Angiopteris</i> sp.	22.66	0.00
7	<i>Astilbe rivularis</i> Buch.-Ham ex D. Don	1.25	0.00
8	<i>Boehmeria</i> sp.	7.50	16.36
9	<i>Capillipedium</i> sp.	1.59	0.00
10	<i>Carex setigera</i> D. Don	2.57	0.00
11	<i>Centella asiatica</i> (L.) Urban.	1.76	0.00
12	<i>Cheilanthes albomarginata</i> C.B. Clarke	1.51	0.00
13	<i>Cynoglossum zeylanicum</i> (Vahl) Thunb. ex Lehm.	0.00	2.86
14	<i>Cyperus</i> sp.	14.43	27.59
15	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	19.21	4.99
16	<i>Dryopteris cochleata</i> (D. Don) C. Chr.	0.00	21.34
17	<i>Elatostema integrifolium</i> (D. Don) Wedd.	19.45	61.73
18	<i>Eragrostis tenella</i> (L.) Beauvois ex Roem. & Sch.	5.08	0.00
19	<i>Galium aparine</i> L.	1.63	0.00
20	<i>Gentiana cephalodes</i> Edgew.	3.73	0.00
21	<i>Gerbera maxima</i> (Hook.f.) Kitam	17.48	0.00
22	<i>Girardinia diversifolia</i> (Link) Friis	0.00	9.41
23	<i>Globa recemosa</i> J.E. Smith	5.61	2.86
24	<i>Hedera nepalensis</i> K. Koch	15.50	14.60
25	<i>Heteropogon contortus</i> (L.) Beauvois	1.94	0.00
26	<i>Huperzia</i> sp.	1.51	0.00
27	<i>Paspalum distichum</i> L.	8.08	0.00
28	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	0.00	18.82
29	<i>Polygonum verticillatum</i> (L.) All.	0.00	3.97
30	<i>Polystichum aculeatum</i> (L.) Schott.	24.15	4.62
31	<i>Potentilla fulgens</i> Wall. ex Hook.	1.41	0.00
32	<i>Rubia manjith</i> Roxb. ex Fleming	9.60	0.00
33	<i>Selaginella bryopteris</i> (L.)	12.79	0.00
34	<i>Smilax aspera</i> L.	1.19	0.00
35	<i>Smilax elegans</i> Wall. ex Kunth	24.94	0.00
36	<i>Themeda triandra</i> Forssk	2.22	0.00
37	<i>Urtica dioica</i> L.	0.00	27.45

Annex 16: Importance value index of herb species at above 2300m altitude

S.N	Name of species	IVI at north aspect	IVI at south aspect
1	<i>Acer sikkimense</i> Miq.	0.00	1.84
2	<i>Achyranthes aspera</i> L.	0.00	1.15
3	<i>Anaphalis busua</i> (Buch.-Ham. ex Don) DC.	8.53	17.75
4	<i>Anemone rivularis</i> Buch.-Ham. ex DC.	0.00	1.34
5	<i>Angiopteris</i> sp.	6.64	1.93
6	<i>Asplenium</i> sp.	0.00	2.19
7	<i>Astilbe rivularis</i> Buch.-Ham ex D. Don	1.61	0.00
8	<i>Bergenia ciliata</i> (Haw.) Sternb.	9.62	6.64
9	<i>Bidens pilosa</i> L.	0.00	7.78
10	<i>Boehmeria</i> sp.	0.00	4.44
11	<i>Capillipedium assrmille</i> (Steud.) A. Camus	0.00	3.84
12	<i>Capillipedium</i> sp.	29.33	24.70
13	<i>Cheilanthes albomarginata</i> C.B. Clarke	2.83	0.00
14	<i>Cheilanthes bicolor</i> (Forss K.) Kaulf .	0.00	10.31
15	<i>Cyperus</i> sp.	53.12	12.62
16	<i>Drepanostachyum falcatum</i> (Munro) Keng f.	16.20	19.36
17	<i>Eragrostis tenella</i> (L.) Beauvois ex Roem. & Sch.	2.43	0.00
18	<i>Eulaliopsis binata</i> (ReU.) C.E. Hubbard	0.00	5.83
19	<i>Eupatorium adenophorum</i> Spreng.	5.61	20.66
20	<i>Galium aparine</i> L.	5.54	15.69
21	<i>Gentiana cephalodes</i> Edgew.	0.00	3.47
22	<i>Gerbera maxima</i> (Hook.f.) Kitam	5.08	0.00
23	<i>Globa recemosa</i> J.E. Smith	15.41	20.51
24	<i>Gynura angulosa</i> (Wall.) A.DC.	1.61	0.00
25	<i>Hedera nepalensis</i> K. Koch	7.98	0.00
26	<i>Huperzia</i> sp.	2.07	4.06
27	<i>Lindenbergia indica</i> (L.) Vatke	0.00	4.87
28	<i>Mazus pumilis</i> (Burm. f.) Steenis	10.53	3.47
29	<i>Paspalum distichum</i> L.	4.70	7.14
30	<i>Persicaria capitata</i> (Buch.-Ham.) H. Gross	5.51	4.95
31	<i>Phoenix</i> sp.	2.43	1.30
32	<i>Polystichum aculeatum</i> (L.) Schott.	13.76	7.57
33	<i>Rubia manjith</i> Roxb. ex Fleming	4.60	0.00
34	<i>Selaginella bryopteris</i> (L.)	3.49	0.00
35	<i>Smilax aspera</i> L.	0.00	1.49
36	<i>Smilax elegans</i> Wall. ex Kunth	32.98	24.99
37	<i>Themeda triandra</i> Forssk	11.43	29.98

Annex 17: Regeneration status of tree species at northern and southern aspect in 1500m-1600m

S.N	Name of species	North aspect in per hectare			South aspect in per hectare		
		seedling	sapling	adult	seedling	sapling	Adult
1	<i>Quercus semecarpifolia</i> J.E. Smith.	0	9.5541	47.7705	12.7388	82.8022	85.9869
2	<i>Schima wallichii</i> (DC.) Korth.	3.1847	54.1399	57.3246	73.2481	105.0951	89.1716
3	<i>Betula alnoides</i> Buch.-Ham. ex D. Don	6.3694	0	19.1082			
4	<i>Saurauia napaulensis</i> DC.	6.3694	28.6623	12.7388			
5	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	0	25.4776	70.0634	3.1847	41.4011	63.694
6	<i>Lyonia ovalifolia</i> (Wall.) Drude	3.1847	28.6623	19.1082	57.3246	54.1399	9.5541
7	<i>Rhododendron arboreum</i> Smith	22.2929	85.9869	31.847	57.3246	66.8787	35.0317
8	<i>Prunus cerasoides</i> D. Don	98.7257	98.7257	28.6623	0	0	0
9	<i>Engelhardia spicata</i> Lsch. ex Bl.	12.7388	0	19.1082	25.4776	73.2481	15.9235
10	<i>Eurya acuminata</i> DC.	15.9235	41.4011	28.6623	0	3.1847	0
11	<i>Myrsine semiserrata</i> Wall.	60.5093	15.9235	3.1847	0	0	0
12	<i>Litsea monopetala</i> (Roxb.) Pers.	15.9235	3.1847	6.3694	0	0	0
13	<i>Alnus nepalensis</i> D. Don	0	3.1847	15.9235	0	0	0
14	<i>Ficus nerrifolia</i> Sm.	15.9235	28.6623	3.1847	0	0	0
15	<i>Ficus lacor</i> Buch-Ham.	0	3.1847	3.1847	0	0	0
16	<i>Zizyphus incurve</i> Roxb.	6.3694	0	0	0	3.1847	0
17	<i>Phyllanthus emblica</i> L.	0	6.3694	0	0	0	0
18	<i>Castanopsis indica</i> (Roxb.) Miq.	0	3.1847	3.1847	3.1847	9.5541	3.1847
19	<i>Aesandra butyracea</i> (Roxb.) Baehni	0	3.1847	0	3.1847	6.3694	3.1847
20	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	3.1847	3.1847	0	22.2929	31.847	9.5541
21	<i>Grevillea robusta</i> A. Cunn. ex B.Br.	0	0	0	47.7705	22.2929	12.7388
22	<i>Syzygium cumini</i> (L.) Skeels	0	0	0	3.1847	15.9235	9.5541
23	<i>Sapium insigne</i> (Royle) Benth. ex Hook.f.	0	0	0	0	3.1847	0

Annex 18: Regeneration status of tree species at north and south aspect in 1700m-1800m

S.N	Name of species	North aspect in per hectare			South aspect in per hectare		
		seedling	sapling	adult	seedling	Sapling	Adult
1	<i>Schima wallichii</i> (DC.) Korth.	0	31.847	35.0317	15.9235	38.2164	89.1716
2	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	0	19.1082	12.7388	9.5541	28.6623	114.6492
3	<i>Lyonia ovalifolia</i> (Wall.) Drude	6.3694	47.7705	41.4011	3.1847	6.3694	6.3694
4	<i>Rhododendron arboreum</i> Smith	25.4776	105.0951	73.2481	41.4011	63.694	98.7257
5	<i>Prunus cerasoides</i> D. Don	3.1847	19.1082	3.1847	3.1847	6.3694	6.3694
6	<i>Engelhardia spicata</i> Lsch. ex Bl.	0	3.1847	57.3246	9.5541	12.7388	19.1082
7	<i>Alnus nepalensis</i> D. Don	0	3.1847	63.694	0	0	0
8	<i>Zizyphus incurve</i> Roxb.	9.5541	19.1082	6.3694	0	0	0
9	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	0	15.9235	12.7388	0	0	0
10	<i>Ficus nerrifolia</i> Sm.	12.7388	19.1082	0	0	0	0
11	<i>Saurauia napaulensis</i> DC.	0	3.1847	0	0	0	0
12	<i>Myrsine semiserrata</i> Wall.	6.3694	6.3694	0	0	0	0
13	<i>Quercus semecarpifolia</i> J.E. Smith.	0	0	0	31.847	31.847	15.9235
14	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	0	0	0	15.9235	28.6623	9.5541
15	<i>Aesandra butyracea</i> (Roxb.) Baehni	0	0	0	3.1847	0	6.3694
16	<i>Eurya acuminata</i> DC.	0	0	0	6.3694	19.1082	0

Annex 19: Regeneration status of tree at north and south aspect in 1900m-2000m

S.N	Name of species	North aspect in per hectare			South aspect in per hectare		
		seedling	sapling	adult	seedling	sapling	adult
1	<i>Schima wallichii</i> (DC.) Korth.	6.3694	0	3.1847	28.6623	28.6623	15.9235
2	<i>Lyonia ovalifolia</i> (Wall.) Drude	25.4776	70.0634	25.4776	38.2164	22.2929	12.7388
3	<i>Rhododendron arboreum</i> Smith	85.9869	168.7891	57.3246	9.5541	9.5541	35.0317
4	<i>Prunus cerasoides</i> D. Don	3.1847	12.7388	3.1847	0	0	0
5	<i>Engelhardia spicata</i> Lsch. ex Bl.	6.3694	0	9.5541	9.5541	22.2929	3.1847
6	<i>Eurya acuminata</i> DC.	50.9552	66.8787	44.5858	6.3694	3.1847	6.3694
7	<i>Myrsine semiserrata</i> Wall.	6.3694	0	3.1847	0	0	0
8	<i>Quercus glauca</i> Thunb.	0	15.9235	6.3694	0	0	0
9	<i>Symplocous</i> sp.	15.9235	31.847	31.847	3.1847	0	0
10	<i>Zizyphus incurve</i> Roxb.	0	6.3694	3.1847	0	0	0
11	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	3.1847	28.6623	3.1847	0	0	0
12	<i>lindera</i> sp.	3.1847	6.3694	9.5541	0	0	0
13	<i>Quercus semecarpifolia</i> J.E. Smith.	0	3.1847	0	50.9552	143.3115	41.4011
14	<i>Alnus nepalensis</i> D. Don	0	25.4776	15.9235	0	0	0
15	<i>Quercus lamellosa</i> Sm.	0	9.5541	28.6623	0	0	0
16	<i>Leucosceptrum canum</i> Sm.	0	0	0	25.4776	22.2929	44.5858
17	<i>Aesandra butyracea</i> (Roxb.) Baehni	0	0	0	3.1847	9.5541	6.3694
18	<i>Erythrina stricta</i> Roxb.	0	0	0	3.1847	47.7705	3.1847
19	<i>Ficus nerrifolia</i> Sm.	0	0	0	0	6.3694	3.1847
20	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	0	0	0	9.5541	6.3694	12.7388
21	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	0	0	0	3.1847	47.7705	50.9552
22	<i>Crateva uniloculari</i> sBuch. - Ham.	0	0	0	3.1847	15.9235	0
23	<i>Debregeasia salicifolia</i> (D. Don) Rendle	0	0	0	6.3694	28.6623	28.6623

Annex 20: Regeneration status of tree species at north and south aspect in 2100m-2200m

S. N	Name of species	North aspect in per hectare			South aspect in per hectare		
		seedling	Sapling	adult	Seedling	Sapling	Adult
1	<i>Lyonia ovalifolia</i> (Wall.) Drude	9.5541	73.2481	47.7705	0	0	0
2	<i>Rhododendron arboreum</i> Smith	28.6623	63.694	60.5093	0	0	0
3	<i>Eurya acuminata</i> DC.	70.0634	31.847	98.7257	3.1847	15.9235	0
4	<i>Symplocous</i> sp.	50.9552	41.4011	143.3115	0	6.3694	6.3694
5	<i>Lindera</i> sp.	19.1082	35.0317	9.5541	3.1847	9.5541	6.3694
6	<i>Daphniphyllum himalense</i> (Benth.) Muell.-Arg.	41.4011	35.0317	50.9552	0	0	0
7	<i>Quercus semecarpifolia</i> J.E. Smith.	0	12.7388	25.4776	0	0	0
8	<i>Myrsine semiserrata</i> Wall.	0	22.2929	0	0	0	0
9	<i>Quercus lamellose</i> Sm.	9.5541	41.4011	19.1082	0	0	0
10	<i>Ilex</i> sp	9.5541	3.1847	3.1847	0	0	0
11	<i>Quercus glauca</i> Thunb.	3.1847	9.5541	0	0	0	0
12	<i>Prunus cerasoides</i> D. Don	0	0	0	0	3.1847	3.1847
13	<i>Aesandra butyracea</i> (Roxb.)Baehni	0	0	0	6.3694	15.9235	0
14	<i>Crateva unilocularis</i> Buch. - Ham.	0	0	0	3.1847	25.4776	9.5541
15	<i>Leucosceptrum canum</i> Sm.	0	0	0	31.847	89.1716	184.7126

Annex 21: Regeneration status of tree species at north and south aspect in above 2300m

S.N	Name of species	North aspect in per hectare			South aspect in per hectare		
		Seedling	sapling	Adult	seedling	Sapling	Adult
1	<i>Lyonia ovalifolia</i> (Wall.) Drude	9.5541	0	19.1082	0	0	0
2	<i>Rhododendron arboreum</i> Smith	22.2929	82.8022	203.8208	25.4776	47.7705	79.6175
3	<i>Eurya acuminata</i> DC.	54.1399	73.2481	12.7388	28.6623	41.4011	9.5541
4	<i>Symplocous</i> sp.	15.9235	44.5858	19.1082	0	9.5541	19.1082
5	<i>Quercus lamellose</i> Sm.	0	3.1847	6.3694	3.1847	0	0
6	<i>Quercus semecarpifolia</i> J.E. Smith.	25.4776	28.6623	108.2798	6.3694	95.541	235.6678
7	<i>Lindera</i> sp.	3.1847	38.2164	0	3.1847	0	0
8	<i>Aesandra butyracea</i> (Roxb.)Baehni	0	3.1847	0	0	3.1847	0
9	<i>Grevillea robusta</i> A. Cunn. ex B.Br.	0	0	0	0	3.1847	0

Annex 22: Total biomass of tree species at north aspect in 1500m-1600m

S.	Name of	Above	Above ground	Above ground	Below ground	Total
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N	species	ground biomass (kg)	biomass(kg/m <sup>2</sup> )	biomass(tons/hectare)	biomass(tons/hectare)	biomass
1	<i>Quercus lamellosa</i> Sm.	148.23	0.05	0.47	0.09	0.57
2	<i>Quercus semecarpifolia</i> J.E. Smith.	1279.86	0.41	4.07	0.81	4.89
3	<i>Schima wallichii</i> (DC.) Korth.	1297.52	0.41	4.13	0.83	4.95
4	<i>Betula alnoides</i> Buch.-Ham. ex D. Don	584.64	0.19	1.86	0.37	2.23
5	<i>Saurauia napaulensis</i> DC.	163.50	0.05	0.52	0.10	0.62
6	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	1583.63	0.50	5.04	1.01	6.05
7	<i>Lyonia ovalifolia</i> (Wall.) Drude	233.80	0.07	0.74	0.15	0.89
8	<i>Rhododendron arboreum</i> Smith	232.47	0.07	0.74	0.15	0.89
9	<i>Choerospondias axillaris</i> (Roxb.) B.L. Brutt. & A.W. Hill.	1001.91	0.32	3.19	0.64	3.83
10	<i>Prunus cerasoides</i> D. Don	373.52	0.12	1.19	0.24	1.43
11	<i>Engelhardia spicata</i> Lsch. ex Bl.	1476.11	0.47	4.70	0.94	5.64
12	<i>Bauhinia vahlii</i> Wight & Arn.	157.44	0.05	0.50	0.10	0.60
13	<i>Eurya acuminata</i> DC.	509.48	0.16	1.62	0.32	1.95
14	<i>Myrsine semiserrata</i> Wall.	113.66	0.04	0.36	0.07	0.43
15	<i>Ficus semicordata</i> Buch. - Ham ex Sm.	85.18	0.03	0.27	0.05	0.33
16	<i>Litsea monopetala</i> (Roxb.) Pers.	32.73	0.01	0.10	0.02	0.12
17	<i>Ficus auriculata</i> Lour.	203.94	0.06	0.65	0.13	0.78
18	<i>Alnus nepalensis</i> D. Don	164.15	0.05	0.52	0.10	0.63

19	<i>Brassaiopsis hainla</i> (Bach.-Ham. ex D. Don) Seem.	27.81	0.01	0.09	0.02	0.11
20	<i>Nyctanthes arbor-tristis</i> L.	10.41	0.00	0.03	0.01	0.04
21	<i>Fraxinus floribunda</i> Wall.	316.45	0.10	1.01	0.20	1.21
22	<i>Lithocarpus elegans</i> (Blume) Hatus ex Soep	54.54	0.02	0.17	0.03	0.21
23	<i>Ficus nerrifolia</i> Sm.	10.54	0.00	0.03	0.01	0.04
24	<i>Castanopsis indica</i> (Roxb.) Miq.	59.80	0.02	0.19	0.04	0.23
25	<i>Ficus lacor</i> Buch-Ham.	60.18	0.02	0.19	0.04	0.23
26	<i>Debregeasia salicifolia</i> (D. Don) Rendle	34.92	0.01	0.11	0.02	0.13

Annex 23: Total biomass of tree species at north aspect in 1700m-1800m

S. N	Name of species	biomass (kg)	biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass
1	<i>Schima wallichii</i> (DC.) Korth.	1243.09	0.40	3.96	0.79	4.75
2	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	163.61	0.05	0.52	0.10	0.62
3	<i>Lyonia ovalifolia</i> (Wall.) Drude	470.62	0.15	1.50	0.30	1.80
4	<i>Rhododendron arboreum</i> Smith	717.51	0.23	2.28	0.46	2.74
5	<i>Prunus cerasoides</i> D. Don	145.64	0.05	0.46	0.09	0.56
6	<i>Engelhardia spicata</i> Lsch. ex Bl.	1690.65	0.54	5.38	1.08	6.46
7	<i>Eurya acuminata</i> DC.	22.14	0.01	0.07	0.01	0.08
8	<i>Alnus nepalensis</i> D. Don	3706.72	1.18	11.79	2.36	14.15
9	<i>Fraxinus floribunda</i> Wall.	25.61	0.01	0.08	0.02	0.10
10	<i>Toona ciliata</i> M. Roem.	32.04	0.01	0.10	0.02	0.12
11	<i>Persea odoratissima</i> (Nees) Kosterm.	12.72	0.00	0.04	0.01	0.05
12	<i>Sapium insigne</i> (Royle) Benth. ex Hook.f.	41.82	0.01	0.13	0.03	0.16
13	<i>Taxus baccata</i> L.	161.13	0.05	0.51	0.10	0.62
14	<i>Persea duthiei</i> (King ex Hook f.) Kost	16.61	0.01	0.05	0.01	0.06
15	<i>Zizyphus incurve</i> Roxb.	60.96	0.02	0.19	0.04	0.23
16	<i>Syzygium cumini</i> (L.) Skeels	81.49	0.03	0.26	0.05	0.31
17	<i>Symplocos ramosissima</i> Wall ex. D. Don	14.08	0.00	0.04	0.01	0.05
18	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	373.22	0.12	1.19	0.24	1.43
19	<i>Terminalia chebula</i> Relz.	119.59	0.04	0.38	0.08	0.46

Annex 24: Total biomass of tree species at north aspect in 1900m-2000m

S. N	Name of species	biomass (kg)	biomass(kg/m <sup>2</sup> )	Above groundbiomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass
1	<i>Schima wallichii</i> (DC.) Korth.	18.32	0.006	0.058	0.012	0.070
2	<i>Lyonia ovalifolia</i> (Wall.) Drude	348.16	0.111	1.108	0.222	1.329
3	<i>Rhododendron arboreum</i> Smith	635.75	0.202	2.023	0.405	2.427
4	<i>Prunus cerasoides</i> D. Don	31.91	0.010	0.102	0.020	0.122
5	<i>Engelhardia spicata</i> Lsch. ex Bl.	317.50	0.101	1.010	0.202	1.212
6	<i>Eurya acuminata</i> DC.	876.04	0.279	2.787	0.557	3.345
7	<i>Myrsine semiserrata</i> Wall.	26.92	0.009	0.086	0.017	0.103
8	<i>Alnus nepalensis</i> D. Don	286.05	0.091	0.910	0.182	1.092
9	<i>Fraxinus floribunda</i> Wall.	21.38	0.007	0.068	0.014	0.082
10	<i>Quercus glauca</i> Thunb.	34.87	0.011	0.111	0.022	0.133
11	<i>Symplocos ramosissima</i> Wall ex. D. Don	2167.38	0.690	6.896	1.379	8.275
12	<i>Zizyphus incurve</i> Roxb.	187.24	0.060	0.596	0.119	0.715
13	<i>Pyrus pashia</i> Buch.-Ham. ex D. Don	40.60	0.013	0.129	0.026	0.155
14	<i>Quercus lamellose</i> Sm.	1319.09	0.420	4.197	0.839	5.037
15	<i>Eriobotrya dubia</i> (Lindl.) Decne	11.08	0.004	0.035	0.007	0.042
16	<i>Lindera nacusua</i> (D. Don) Merr.	82.19	0.026	0.262	0.052	0.314
17	<i>Daphniphyllum himalense</i> (Benth.) Muell.-Arg.	130.38	0.041	0.415	0.083	0.498

Annex 25: Total biomass of tree species at north aspect in 2100m-2200m

S. N	Name of species	biomass (kg)	biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass
1	<i>Quercus semecarpifolia</i> J.E. Smith.	211.878	0.067	0.674	0.135	0.809
2	<i>Schima wallichii</i> (DC.) Korth.	42.467	0.014	0.135	0.027	0.162
3	<i>Lyonia ovalifolia</i> (Wall.) Drude	637.094	0.203	2.027	0.405	2.433
4	<i>Rhododendron</i> sp.	1142.724	0.364	3.636	0.727	4.363
5	<i>Prunus cerasoides</i> D. Don	22.340	0.007	0.071	0.014	0.085
6	<i>Eurya acuminata</i> DC.	2760.432	0.878	8.783	1.757	10.540
7	<i>Alnus nepalensis</i> D. Don	11.010	0.004	0.035	0.007	0.042
8	<i>Symplocous</i> sp.	5670.867	1.804	18.044	3.609	21.652
9	<i>Quercus lamellose</i> Sm.	188.770	0.060	0.601	0.120	0.721
10	<i>Lindera nacusua</i> (D. Don) Merr.	369.584	0.118	1.176	0.235	1.411
11	<i>Daphniphyllum himalense</i> (Benth.) Muell.-Arg.	6015.837	1.914	19.141	3.828	22.970
12	<i>Juglans regia</i> L.	342.832	0.109	1.091	0.218	1.309
13	<i>Ilex</i> sp.	62.422	0.020	0.199	0.040	0.238

Annex 26: Total biomass of tree species at north aspect in above 2300m

S.N	Name of species	biomass (kg)	biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass
1	<i>Lyonia ovalifolia</i> (Wall.) Drude	326.333	0.104	1.038	0.208	1.246
2	<i>Rhododendron</i> sp.	5481.749	1.744	17.442	3.488	20.930
3	<i>Prunus cerasoides</i> D. Don	48.033	0.015	0.153	0.031	0.183
4	<i>Eurya acuminata</i> DC.	96.630	0.031	0.307	0.061	0.369
5	<i>Quercus glauca</i> Thunb.	31.710	0.010	0.101	0.020	0.121
6	<i>Symplocous</i> sp.	250.066	0.080	0.796	0.159	0.955
7	<i>Quercus lamellose</i> Sm.	28.120	0.009	0.089	0.018	0.107
8	<i>Quercus semecarpifolia</i> J.E. Smith.	1153.129	0.367	3.669	0.734	4.403

Annex 27: Total biomass of tree species at south aspect in 1500m-1600m

S. N	Name of species	Above ground biomass (kg)	Above ground biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass(tons/hectare)
1	<i>Rhododendron</i> sp.	514.38	0.16	1.64	0.33	1.96
2	<i>Quercus semecarpifolia</i> J.E. Smith.	1803.76	0.57	5.74	1.15	6.89
3	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	243.21	0.08	0.77	0.15	0.93
4	<i>Shima wallichii</i> (DC.) Korth.	3221.31	1.02	10.25	2.05	12.30
5	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	961.95	0.31	3.06	0.61	3.67
6	<i>Lyonia ovalifolia</i> (Wall.) Drude	345.84	0.11	1.10	0.22	1.32
7	<i>Engelhardtia spicata</i> Lsch. ex Bl.	231.04	0.07	0.74	0.15	0.88
8	<i>Myrsine capitellata</i> Wall.	69.86	0.02	0.22	0.04	0.27
9	<i>Aesandra butyracea</i> (Roxb.) Bae hni	10.78	0.00	0.03	0.01	0.04
10	<i>Prunus cerasoides</i> D. Don	90.06	0.03	0.29	0.06	0.34
11	<i>Bombax ceiba</i> L.	8.78	0.00	0.03	0.01	0.03
12	<i>Grevillea robusta</i> A. Cunn. ex B.Br.	86.00	0.03	0.27	0.05	0.33
13	<i>Ficus semicordata</i> Buch. - Ham ex Sm.	12.65	0.00	0.04	0.01	0.05
14	<i>Cinnamomum camphora</i> (L) J. Presl.	20.83	0.01	0.07	0.01	0.08
15	<i>Castanopsis indica</i> (Roxb.) Miq.	16.08	0.01	0.05	0.01	0.06
16	<i>Syzygium</i>	86.30	0.03	0.27	0.05	0.33

	<i>cumini</i> (L.) Skeels					
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Annex 28: Total biomass of tree species at south aspect in 1700m-1800m

S. N	Name of species	Above ground biomass (kg)	Above ground biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass(tons/hectare)
1	<i>Macaranga indica</i> Wight	1035.77	0.33	3.30	0.66	3.95
2	<i>Rhododendron</i> sp.	2095.86	0.67	6.67	1.33	8.00
3	<i>Quercus semecarpifolia</i> J.E. Smith.	169.94	0.05	0.54	0.11	0.65
4	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	3744.48	1.19	11.91	2.38	14.30
5	<i>Schima wallichii</i> (DC.) Korth.	8412.68	2.68	26.77	5.35	32.12
6	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	5046.70	1.61	16.06	3.21	19.27
7	<i>Lyonia ovalifolia</i> (Wall.) Drude	94.64	0.03	0.30	0.06	0.36
8	<i>Engelhardtia spicata</i> Lsch. ex Bl.	450.24	0.14	1.43	0.29	1.72
9	<i>Myrsine capitellata</i> Wall.	125.27	0.04	0.40	0.08	0.48
10	<i>Aesandra butyracea</i> (Roxb.) Bakhni	34.04	0.01	0.11	0.02	0.13
11	<i>Prunus cerasoides</i> D. Don	444.96	0.14	1.42	0.28	1.70
12	<i>Stranvaesia nussia</i> (D. Don) Denche	73.08	0.02	0.23	0.05	0.28
13	<i>Syzygium cumini</i> (L.) Skeels	54.75	0.02	0.17	0.03	0.21
14	<i>Spondias pinnata</i> (L.f) Kuz	68.17	0.02	0.22	0.04	0.26
15	<i>Alnus nepalensis</i> D. Don	50.57	0.02	0.16	0.03	0.19

16	<i>Symplocous</i> sp.	67.76	0.02	0.22	0.04	0.26
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Annex 29: Total biomass of tree species at south aspect in 1900m-2000m

S. N	Name of species	Above ground biomass (kg)	Above ground biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass(tons/hectare)
1	<i>Leucosceptrum canum</i> Sm.	1665.77	0.53	5.30	1.06	6.36
2	<i>Neolitsea umbrosa</i> (Nees) Gamble	1412.60	0.45	4.49	0.90	5.39
3	<i>Debregeasia salicifolia</i> (D. Don) Rendle	324.67	0.10	1.03	0.21	1.24
4	<i>Aesandra butyracea</i> (Roxb.)Baehni	50.27	0.02	0.16	0.03	0.19
5	<i>Eurya acuminata</i> DC.	103.68	0.03	0.33	0.07	0.40
6	<i>Persea odoratissima</i> (Nees) Kosterm.	76.13	0.02	0.24	0.05	0.29
7	<i>Macaranga indiba</i> Wight	10589.00	3.37	33.69	6.74	40.43
8	<i>Toona ciliata</i> M. Roem.	2284.21	0.73	7.27	1.45	8.72
9	<i>Erythrina stricta</i> Roxb.	35.01	0.01	0.11	0.02	0.13
10	<i>Rhododendron</i> sp.	522.40	0.17	1.66	0.33	1.99
11	<i>Ficus nerrifolia</i> Sm.	11.99	0.00	0.04	0.01	0.05
12	<i>Quercus semecarpifolia</i> J.E. Smith.	1331.39	0.42	4.24	0.85	5.08
13	<i>Myrica esculenta</i> Buch.-Ham. ex D. Don	80.14	0.03	0.25	0.05	0.31
14	<i>Schima wallichii</i> (DC.) Korth.	269.65	0.09	0.86	0.17	1.03
15	<i>Castanopsis tribuloides</i> (Sm.) A. DC.	636.22	0.20	2.02	0.40	2.43
16	<i>Lyonia ovalifolia</i> (Wall.) Drude	441.64	0.14	1.41	0.28	1.69

17	<i>Engelhardia spicata</i> Lsch. ex Bl.	18.28	0.01	0.06	0.01	0.07
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Annex 30: Total biomass of tree species at south aspect in 2100m-2200m

S. N	Name of species	Above ground biomass (kg)	Above ground biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass(tons/hectare)
1	<i>Leucosceptrum canum</i> Sm.	3673.45	1.17	11.69	2.34	14.03
2	<i>Neolitsea umbrosa</i> (Nees) Gamble	765.13	0.24	2.43	0.49	2.92
3	<i>Symplocos</i> sp.	3796.75	1.21	12.08	2.42	14.50
4	<i>Quercus glauca</i> Thunb.	66.17	0.02	0.21	0.04	0.25
5	<i>Lindera</i> sp.	55.09	0.02	0.18	0.04	0.21
6	<i>Prunus cerasoides</i> D. Don	239.91	0.08	0.76	0.15	0.92
7	<i>Crateva unilocularis</i> Buch. - Ham.	91.11	0.03	0.29	0.06	0.35

Annex 31: Total biomass of tree species at south aspect in above 2300m

S. N	Name of species	Above ground biomass (kg)	Above ground biomass(kg/m <sup>2</sup> )	Above ground biomass(tons/hectare)	Below ground biomass(tons/hectare)	Total biomass(tons/hectare)
1	<i>Lyonia ovalifolia</i> (Wall.) Drude	82.08	0.03	0.26	0.05	0.31
2	<i>Rhododendron</i> sp.	2103.65	0.67	6.69	1.34	8.03
3	<i>Eurya acuminata</i> DC.	79.31	0.03	0.25	0.05	0.30
4	<i>Quercus semecarpifolia</i> J.E. Smith.	2082.83	0.66	6.63	1.33	7.95
5	<i>Aesandra butyracea</i> (Roxb.) Bakhni	9.82	0.00	0.03	0.01	0.04
6	<i>Symplocos</i> sp.	185.66	0.06	0.59	0.12	0.71

## Photos Plates



Data collection of trees



Measuring dbh



Measuring dbh



Making quadrat



Data collection of herb and shrub



