1. INTRODUCTION

1.1 Background

Nepal, a country having peculiar diverse fauna and flora, lies between China on the north and India on the east, south and west. Its shape is long, rectangular with eastern line shorter than on the west. It stands on latitude of 26º 22’ to 30º 27’ north and its longitude is between 80º 4’ to 88º 12’ east. The east-west length of the country is 800 km parallel to the Himalayan axis and the average north-west width is 140 km. Its total area is about 147,181 sq km. Its altitude varies from 60-220m in the south rising to 8848m at the north. Within this small area the country has all possible land form features of the earth except the volcanic and coral islands and marine. The physiographic of the land is very interesting. The country has plain area in the south, hills and valleys in the middle and lofty Himalayas in the north.

Nepal can be divided into following regions (Sharma, 1991):

(1) Terai Plain (2) Churia hills or Siwaliks (3) Mahabharat ranges (4) Midland or Central Hills (5) Higher or Greater Himalayas.

Ecologically, Nepal can best be divided into three regions (Sharma, 1991):

(a) Lowland including Terai, Bharbar, Churia and Mahabharat ranges up to 915 m.

(b) Midland including Mahabharat range 915m as well as middle hill complex up to 2,749m

(c) Highlands or Greater Himalayas including all remaining region above 2,745m.

Nepal’s great variation in topography-altitudes over a small distance has resulted in a great diversity of climate and vegetation ranging from subtropical to cold desert. Nepal has been endowed with a rich variety of plants and animals. The different biological species play a role not only in establishing symbiotic relationships among themselves but also have great economic value. People's relationship with their surroundings has changed over time, affecting the biodiversity of the landscape. With an area of only 0.1% of the global surface area (147,181 km^2), Nepal hosts some of the most spectacular natural areas in the world. Nepal possesses over 2% of the world's flowering plants, about 9% of the world's bird species and about 4% of the world's mammalian species. In terms of species richness, Nepal is in 11th position in Asia and 25th position at the global level. Nepal has 118 types of forest ecosystems spread over four physiographic regions, 181 species of mammals, 844 species of birds, 185 species of fish, 143 species of reptiles and amphibians, over 5884 species of flowering plants and about 2287 species of fungus and lichens (CBS 2003).

Over 400 species of agro-horticultural crops have been reported in Nepal including 200 species of vegetables (NAA 1995). Of these, around 50 species have been domesticated for commercial and household consumption. Fifteen fruits with more than 100 varieties, 50 vegetables with 200 varieties and 10 varieties of potatoes are cultivated commercially.

Sixteen protected areas (together with six Buffer Zones) have been established for the protection of flora and fauna. These protected areas are in the form of national park (9), conservation area (3), wildlife reserves (3) and hunting reserves (1) and are intended to provide protection to diverse species of plants and animals in climate ranging from subtropical to cold desert. The protected areas make up about 17% of the country's total area of which the Sagarmatha National Park and the Royal Chitwan National Park have been included in the World Natural Heritage List; and the Koshi Tappu Wildlife Reserve, Bishajari Tal (Chitwan), Jagdishpur

Jalasha Reservoir (Kapilbastu), and Ghodaghodi Tal (Kailali) have been designated as Ramsar sites.

1.1.1 Biogeography in the Himalaya

The Himalaya is well known for eternal snow, for the mysterious abode of the abominable snowman and for adventures offered by its majestic heights. The Himalayan mountain chain links and locks two great land masses of Asia, the Tibetan plateau and the Indian sub-continent (Shrestha, 1989). Himalayan Systems is grouped into two major divisions: Cis-Himalyan and Trans-Himalayan. The Cis-Himalayan ranges are situated south of the main range, the great Himalaya. The Cis-Himalayan ranges comprise the Siwalik Ranges and lesser Himalayan ranges. The Trans-Himalayan ranges are situated to the north of the Great Himalaya and include Zaskar, Ladakh and Karakoram.

The Himalayan region covers approximately 23% of the country along northern border with Tibet (LRMP, 1986). Hagan (1969) has suggested 10 physiographic divisions in northern-south profile of the Himalayas.

1. Tibetan plateau.
2. Tibetan Marginal range
3. Valleys of inner Himalaya
4. Great Himalaya
5. Fore-Himalaya
6. Midlands
7. Mahabharat lekh
8. Dun valleys
9. Siwalik Range and
10. Terai

1.2 Forests and Vegetation of Nepal

Forests play an important role in the maintenance of ecological balance and economic development. Pristine forests are the centers of ecotourism. Forests are also the source of energy, fodder, timber and several non-timber forest products of vital significance contributing to rural subsistence. Forest catchments are the source of water for hydroelectric power, irrigation, drinking and other household uses. Their importance can be seen explicitly in the energy system of Nepal. Fuel wood alone supplies about 80% of the total energy requirement, 88% of the rural energy requirement and 98% of the residential sector energy requirement of the country (WECS, 1997).

Forests are the largest natural resources of Nepal in terms of land area coverage. Latest data available reveal that the country has 29% forest spread over 4.26 million hectare and 10.6 % shrub land or so called degraded forest occupying 1.559 million hectares area. Distribution of forests in Nepal is not uniform and the far Western Region has the highest area under forest (FRISP, 1999). Forest area in Nepal has declined considerably as compared to the past and the annual deforestation rate is estimated to be 1.7% (DFRS, 1999).

Forests of Nepal are of diverse types. Stainton (1972) classified Nepalese forests into 35 types, which are categorized into ten major groups (Lekhak 2003).

1. Tropical forest
2. Subtropical broad leaved forest
3. Subtropical conifer forest
4. Lower temperate broad-leaved forest
5. Lower temperate mixed broad-leaved forest
6. Upper temperate broad-leaved forest

7. Upper temperate mixed broad-leaved forest
8. Temperate conifer forest
9. Sub-alpine forest
10. Alpine forest

Owing to a wide variation of physiographic, climate and edaphic conditions, the ecosystem and habitat of Nepal changes abruptly, and almost all climatic zones of the world are represented in a comparatively small area with different vegetation types. For example Schweinfurth (1957) and Banerji (1963) proposed three divisions of Nepal corresponding to three river systems: Karnali, Gandaki and Koshi.Stear (1960) divided Nepal into three major regions using climatological, floristic and ecological data. Stainton (1972) described forests of Nepal on the basis of ecology and vegetation composition under six divisions. Dobremez (1972) proposed four phyto-geographical sub-divisions.

The vegetation of Nepal has been described on the basis of range of altitude and climate under the following three zones (Chaudary, 1999).

1.2.1 The Tropical and sub-tropical zones

Including the Terai, Siwalik Hills, Dun valleys and the Southern slope of Mahabharat range, these zones extend from East to West. Tropical zone falls below 1000m asl and is characterized by warm and humid climate *Shorea robusta* is the dominant species. Other associated species are *Adina cardifolia*, *Terminalia chebula*, *T. bellirica* etc. Sub-tropical zone lies at the elevation of 1000-2000m asl and range between Siwalik Hills and Southern slope of Mahabharat range. The zone is characterized by *Schima-castonopsis* in eastern and central region while in western region it is replaced by *Pinus roxburghii*.

1.2.2 Temperate zone

This zone falls at an elevation range of 2000-3100m asl which includes mainly the Mahabharat range, lying almost parallel and North to Siwalik Hills from East to West. The zone is characterized by laurel, mixed broad-leaved deciduous evergreen Oak and Rhododendron forest in eastern and central parts, while evergreen coniferous forest in Western parts of country.

1.2.3 Sub-alpine and alpine zone

This zone include outer and inner Himalayas and Tibetan marginal land in northern part of country at an altitude above 3100m asl. Here, climate is cold, dry and windy. Sub-alpine zone falls at an altitude of 3100-4100m asl and it is characterized by coniferous forest of fir (*Abies spectabilis*) at lower elevations and Birch-Rhododendron (*Betula utilis – Rhododendron campanulatum)* at upper elevations. The alpine zone is characterized by moist alpine scrub and dry alpine scrub at an altitude above the timberline.

1.3 Selection of the study area

In selecting a suitable area for the study, several criteria were considered so that it is representative of the high altitude region of the Himalayas in general. Special emphasis was placed on issues such as inaccessibility, marginality and fragility which confront the whole Himalayan area (Shrestha, 1992).

High altitude people have unique cultural identities including different language dress habits and social systems. The economy revolves around farming with limited potential for expansion, intensification and diversification due to adverse natural conditions (altitude, climate, topography, etc) and limited access to external resources for economic development. These areas have generally no access to motor able roads and no modern means of communication. Most areas are accessible only by foot and often it takes days and even weeks to reach there. The environment is fragile and the combined effects of slope, altitude, geological, edaphic and biotic factors make the alpine environment highly vulnerable to soil erosion, landslides, glacial lake outbursts and avalanches. CHAME forest meets many of the above criteria. Besides, being District head, it has suffered from human activities such as deforestation for infrastructure development, collection of timber & non-timber products, collection of fodder for animal husbandry, disposal of waste as it is main route for tourists etc. So it is a good location for studying and observing the vegetation in term of different aspects including anthropogenic and natural disturbances.

ANNAPURNA CONSERVATION AREA

King Mahendra Trust for Nature Conservation was formed in 1982. The mission of KMTNC is to promote, conserve and manage nature in all its diversity balancing human needs with the environment on a sustainable basis for posterity ensuring maximum community participation with due recognition of the linkages between economics, environment and ethics through a process in which people are both the principal factors and beneficiaries (KMTNC, 1997). The objective of ACAP is to conserve cultural heritage, sustainable social and economic development, natural resource conservation, development and management of sustainable tourism, local resident's full involvement in the management of natural resources and community development and finally, empowerment and equity of women (KMTNC, 1997). ACAP is spread out in five districts of the western development regions and covers 55 Village Development Committees. It encompasses the hill and mountain climatic regions

1.4 Rationale

In Nepal, forest resources are being degraded gradually. Deforestation is the biggest environmental problem to conserve the diversity of trees as well as other plant and animal species in natural ecosystem (Mishra, 1998). Because of the dearth of intensively undertaken ecological research projects in the Nepalese forests, quantitative information concerning the ecology of most forest types in Nepal is largely undocumented to date (KC, 1997). Therefore this research stands to make an additional contribution by documenting the detailed ecology of an important forest type in the Himalayan region and it would be helpful to know the effect of altitude and other environmental factors in vegetation composition. The study will establish important baseline ecological data which should assist in subsequent research work

1.5 Objectives

- To study the forest vegetation around CHAME quantitatively.
- To determine the diversity, abundance and species composition of tree and shrub
- To study the vegetation distribution with edaphic, climatic and biotic factors.

1.6 Limitations of the study

Because of difficult terrain, inaccessibility, bad climate and adverse political condition of the country, through study could not be made. However as far as possible, study was carried out in two seasons accompanied with plant collection, soil collection, and quantitative study and with the help of existing literature.

2 LITERATURE REVIEW

Beaman (1965) studied the ecology of alpine flora of Mexico. The result of the study showed the reduction in number of species as well as number of individual plants with the increase in altitude (3700m-4300m).

Stainton (1972) extensively explored the vegetation of Nepal. He reported that the variations in the vegetation of Nepal are greatly influenced by different environmental factors such as rainfall, aspect, slope, altitude, soil, and exposure.

Bhatt and Shrestha (1973) studied the environment of Shuklaphanta Wildlife Reserves of western development region. They reported that the soil factors like texture, pH and soil erodability markedly affected the vegetation of that area.

Ohsawa *et al*. (1973) studied the vegetation of cool temperate zone the humid Himalayas in eastern Nepal. They found decreasing tendency of tree height and basal area with increasing altitude. They didn’t observe any intimate relation of species diversity with elevation gradient indicating thereby the species diversity is controlled not only by habitat condition but also by the inter-relationship of the component species.

Shrimali and Vyas (1977) carried out the work in the forest of Udaypur, India and reported that the northern and eastern aspects were found to have richer species composition compared to southern and western aspects. They also found that the protected stands possessed higher basal cover of tree species.

Shrestha (1982) made an extensive study on the ecology and vegetation of North West Nepal and started that altitude is the most important factor that determines the vegetation type. Variation in altitude is indicated by change in vegetation distribution and floristic composition.

Bankaoti *et al*. (1986) analyzed the vegetation along an altitudinal gradient of Kumaun Himalaya between 600m-2250m elevations and identified eight forest types based on importance value index (IVI). There was a positive correlation between the total basal area cover and tree species diversity.

Joshi (1990) carried out vegetation analysis of temperate forest in the Annapurna Conservation area. He found 190 plant species and concluded that species diversity and density decreases as the altitude goes up.

Raya-Chhetry (1991) analyzed the vegetation of Chandragiri in relation to soil characters along with altitude, slope and aspects. He identified four district forest types on the basis of species composition within the elevation range of 1380 m to 2150m. He also reported that the species diversity was higher at lower altitude than that of higher altitude.

Lata and Bishta (1991) conducted a quantitative analysis of woody vegetation in moist temperate forest of Garhwal Himalaya. They reported that maximum number of species and basal cover of forest were found at an altitude of 2500m on S-W aspect. *Rubus* sp. and *Berberis* sp were the most common among shrub species.

Singh and Singh (1992) studied the structure; function and impact of human being on forest in Himalayas of India including Central Himalayas of Nepal and reported that density, total basal areas, above ground biomass and leaf litter were higher on undisturbed site than the disturbed one.

Gurung (1995) studied the vegetation pattern in the Tahr grazing area of Annapurna South and reported that the plant density increased with elevation whereas species richness generally decreased. He also reported that medium disturbance created by human and livestock had positive role in terms of species diversity compared to height and low disturbances.

Lokna (1995) carried out a work in the oak forest of Langtang National Park, Nepal using ordination technique and reported that altitudinal gradient and soil had greatest impact on the vegetation.

Manandhar (1996) studied species compositions and regeneration along a disturbance gradient of high altitude forest in Western Nepal. She categorized forest into three types as relatively undisturbed, moderately disturbed and disturbed sites. The density, basal area and alpha and beta diversity was found highest in relatively undisturbed forest.

Subedi (1996) studied the natural vegetation and human impacts in Langtang valley of Nepal and described the prominent flora and dominant vegetation found in different bio-climatic zones at an elevation from 1500 m to 4800 m a.s.l. He also suggested some conservation measures for the management of the national in relation to the flow of tourists and their impacts in the park.

Vetaas (1997) conducted a study on the effect of canopy disturbance on species richness in Central Himalayan Oak forest. The result indicated that a small –scale lopping regime would enhance the habitat diversity and species richness of vascular plants. However large-scale canopy disturbance will reduce diversity and changes the species composition that becomes dominated by weedy ruderals.

Julia (1997) analyzed the plant species richness in grazed and ungrazed site of south west Finland. According to her, species richness decreased significantly with an increase in biomass or height of vegetation. The richness was higher in grazed plot than in ungrazed plot.

Obou (1997) made an ecological study on the impact of ecotourism in Kibale National Park, Uganda and reported that development of camp sites within the park had influenced in the removal of vegetation, loss of woody species and reduction of species composition in protected areas.

MFSC (1998) conducted the vegetation study of western Development Region applying altitudinal concepts and identified six bio-climatic zones with different forest types and its associated species. They reported that Upper Mixed hardwood forest (46%) was the most dominant type followed by lower mixed hardwood forest (22%). The number of stems over 10cm dbh is 570 stems/ha.

Yadav and Sah (1998) studied the quantitative vegetation (trees and shrubs) of North-East slope and South-West slope of Nagarjun hill and concluded that there was variation in species composition and vegetation structure along the altitudinal gradients. Species diversity was maximum at lower altitudes on NE slope (1610m) than that of SW slope (1840m) in contrast to total tree density.

Bailey *et al*. (1998) stated that the total herbaceous cover and species richness were greater in thinned or old growth stands. Part of the increased richness was caused by the presence of exotic species and also more native grasses and nitrogen fixing species on thinned stands than unthinned stands. Both cover and frequency of grasses in thinned stands were greater.

Brockway (1998) studied the forest plant diversity in the Cascade Mountain of South-West Washington and reported that the old growth forests were known to support high level of diversity. He also pointed that evenness among the plant species was greatest at higher elevations where severe climate limits the ability of any single or group of species to dominate

Ferriera and Prance (1998) studied species richness and floristic composition in upland forest of Jau National Park in central Amazonia. They calculated and compared different parameters such as basal area, relative density, relative dominance, relative diversity and importance value index among four one-hector plots.

Pucheta *et al*. (1998) studied the floristic composition and above ground net plant production in grazed and protected sites in a grassland of Argentina. They analyzed that the species richness was maximum at the grazed site and decreased significantly after protection. Diversity decreased significantly only after 15 years of protection. No alien or weedy species were found at protected sites. Grazing exclusion produced a shift from grazing tolerant species with a graminoid or prostrate growth form to taller species with a tall tussock growth form.

Aiba and Kitayam (1999) worked on forest structure, composition and tree species diversity in an altitude- substrate matrix of rain forest tree communities from 799m to 3100m of Mount Kinabalu (Borneo). They found that the forest status, mean leaf area and tree diversity decreased with altitude.

De Oliveira *et al*. (1999) studied the bio diversity and conservation of plant community. They concluded that the high species richness can only develop in areas with soils and relatively high rainfall. It was suggested that such high species richness was the result of combination of habitat heterogeneity and geological history.

Dlugosch and Moral (1999) conducted a study on vegetation heterogeneity along altitudinal gradient and suggested that the heterogeneity in plant cover increases with elevation. They also suggested that percentage similarity decreases with elevation.

Einarsson and Milberg (1999) carried out the vegetation study of southern Sweden. They reported that the herbaceous species composition varied significantly with light availability. Species richness increased with light availability

Hahs *et al*. (1999) analyzed the quantitative characters of vegetation in relation to edaphic factors and altitudinal gradients at Shivapuri watershed. They observed the variations in the quantitative characters of plant along the altitudinal gradient.

Pandit (1999) worked on altitudinal impacts on vegetation distribution in Chhimkeswori hill (300- 2200m) Makwanpur, Nepal. He found six forest types on different altitudinal range. The plant diversity, basal area and tree density decreased with the increase in elevation.

Sharma (2000) studied the biodiversity in relation to altitudinal gradient of Shivapuri (near Baghdwar to Sundarijal) and observed that diversity of trees decreased with the rise in altitudes due to topographic features, soil and climate, soil nutrient, Organic Matter, pH and moisture content of soil were found to have inverse relation with altitude.

Nepal (2001) studied vegetation (trees and shrubs) along an altitudinal gradient in Annapurna conservation area. He found 46 tree species in SW slope and 44 species in NE slope and number of shrubs 27 in SW and 19 in NE slope. In spite of variation in species composition a significant change in the forest vegetation between two different slopes was not found in Ghandruk forest.

Pandey (2001) studied on vegetation distribution and composition of Brashbang Hill, Dhading and revealed seven forest types from 900m to 1700m and also reported that plant diversity, density, average basal area, coverage, IVI decreased in their values with increase in altitude.

Carpenter (2001) studied the patterns of tree species richness in the forests of eastern Nepal and reported that tree species richness declined with elevation, although human disturbance obscures this pattern at lower elevations. He also reported that under storey plant species richness was inversely correlated to elevation, although, epiphytic species richness become maximum at upper temperate elevation (2500m-3000m).

Shrestha (2001) studied species diversity and distribution along altitudinal gradients in Landruk village of Annapurna region, Nepal. He found prominent variation of forest vegetation along altitudinal gradient.

Pandey (2001) did quantitative vegetation analysis as per aspect and altitude and regeneration behavior of tree species in Garhwal

Himalaya forest. He found that density ranged between 792.2 pl/ha to 1111 pl/ha, total basal area ranged between 56.42 m2/ha 126 m2/ha and diversity index ranged between 1.80-2.33 for trees and 2.23-2.57 for shrubs.

Wesche (2001) studied the altitudinal variation in climate and vegetation in two transects along the most western side and the dry eastern side of Mt Elgon (Kenya). Ha found out that fire frequency is of crucial importance for the vegetation distribution. Fires were the main factors responsible for the heterogeneous structure of the lower Afro alpine region.

Gurung *et al*. (2002) carried out a study in Mardi watershed in Nepal to estimate the stem volume and biomass and analyzed the factors responsible for their variations in different forest types. They found out that distance, altitude and slope explained up to 93% of the total variation in Oak Forest biomass.

Fekedulgen *et al*. (2003) made a detailed study at Appalachian watershed, USA and examined relationship between radial growth, growth, topographic aspect and precipitation for four hardwood species- *Liriodendron* sp; *Quercus rubra*, *Q. prinus* and *Acer rubum*. The main objective of the study was to determine variation in growth between northeast and southwest aspects. The study found that all species except *Quercus rubra*, showed significant differences in growth between the northeast and southwest aspect.

Rubino *et al*. (2003) made a detailed at Ohio, USA. They investigated the influence of topography (slope, aspect, percent slope and slope position as calculated from a landrom index (Li) and plot characteristics (Tree height, age and canopy cover) on the distribution of trees (dbh >10cm), saplings (dbh < 10cm). In all the 3 structural layers, slope aspect and LI were consistently important in explaining individual taxa distributions. Total tree density was significantly negatively correlated with slope position (r=-0.469), slope aspect (r=-0.328) and canopy cover (r=-0.391) and total sapling density was significantly negatively correlated with height of the dominant tree in each plot (r = -0.283).

Grytnes (2003) studied species richness patterns of vascular plants along seven altitudinal transect in Norway. Altitudinal richness patterns were investigated along altitudinal gradients located in northern Norway (two transects) and along a west-east gradient in southern Norway (five transects). In five transects species richness peaked at mid altitude, whereas in two northern transects species richness decreased with altitude.

Theurillat *et al*. (2003) carried out study of vascular plant and bryophyte diversity along elevation gradients in Alps. They found that vascular plant species richness decreased consistently with increasing elevation and the distribution of vascular plants along elevation gradients is primarily governed by temperature – related processes alongside a gradual change in the physical environment.

Khatri *et al.* (2004) studied altitudinal variation in structural compositions of vegetation in Satpura National Park, India, three major communities at three elevations. The density decreased with increasing altitude and diversity index was higher on lower elevation.

Coroi *et al.* (2004) studied vegetation diversity and stand structure in streamside forests in the south of Ireland and found that plant species richness in the broadleaved stands was almost double of that of conifer plantations. Plant species richness and total vegetation cover decreased with distance from the stream, which is likely to be the reduced levels of light, water and soil nutrients away from the stream bank.

Adhikari (2004) carried out a study at Bosan community forest at Chandragiri. He found out that total plant density, frequency, average basal area, importance value index, species richness and species diversity of both trees and shrubs/saplings were found higher on north face in comparison to south face.

Khadka (2004) analyzed the vegetation in Pisang, Manang. He concluded that topographical and climatic features are important factors in determining the vegetation in the Himalayas.

Bhattarai and Vetaas (2004) studied the variation in plant species richness of different life forms along a subtropical elevation gradient in the Himalayas and reported significant relationship of woody life forms with climate and no any significant relationship of herbaceous life forms with climate.

Ghimire (2005) concluded altitude and site factor play a great role in composition and distribution of vegetation in high altitude Himalayan region.

Shrestha *et al.* (2005) studied vegetation pattern of trans-himalayan zone in the North-West Nepal, and they classified six vegetation types on the basis of vegetation composition, they were Xerophile formation, Alpine scrubs, Alpine meadows, Scree vegetation, Nival formation and Agriculture boarder.

Rawat (2005) studied density of woody vegetation and soil characteristics along an altitudinal gradient from 1700 to 2100m in a mountain flank of Garhwal Himalaya. Maximum total tree density was recorded for the upper slope followed by middle and lower slopes respectively whereas in case of shrub maximum density was recorded for lower slope followed by middle and upper slope respectively. Organic carbon and potassium were positively correlated and soil pH showed negative correlation with the altitudinal gradient. However phosphorus showed non-significant correlation.

Subedi (2006) studied the distribution pattern of plant species of Manang along Himalayan elevation gradient of Nepal and showed hump shaped distribution with optimum species at 3500m asl.

Nishimura (2006) reported that the stem breakage is a major cause of tree death in coniferous cool temperate forest that is subjected to typhoons and heavy snowfall.

Norman and Taylor (2006) reported that type conversions of vegetation are often triggered by changes in one or more limiting environmental factors and such changes are particularly evident along montane forest-meadow ecotones where historical changes in fire, grazing and climate have occurred.

Kala (2006) studied community and species diversity in the Valley of Flowers and Khiron valley using stratified random quadrate of 0.22m². TWINSPAN was used for identifying the plant communities and Shannon-wiener Index was used for species diversity.

Goris *et al* (2007) studied that an old pine plantation can develop spontaneously into well structured pine forest with an under storey of oak and pine. However, under storey recruitment in these forest types is not a continuous process and in this case a single allogenic canopy disturbance triggered its establishment.

Wang (2007) studied effects of altitude an plant species diversity and productivity in an alpine meadow, Qinghai, Tibetan Plateau and reported that soil organic matter content and available nitrogen and phosphorus were negatively and closely related to plant diversity (species richness, Shannon-wiener diversity index and Pielou evenness index) and biomass declined significantly with increasing altitude.

3. STUDY AREA

3.1 An Overview of Manang District

Manang district is one of the most sparsely settled districts among 75 districts in Nepal with a total population of 9587 (CBS 2002). It lies within the Annapurna Conservation Area in Central Nepal. Its total area is 2246 sq. Km, with total hosehold of 1772 in number. It is situated in Gandaki zone with district borders of Lamjung and Kaski on south, Tibet on North, Mustang on west and Gorkha on east. Southern part of Manang is formed by chain of Himalayas such as Manaslu, Annapurna I, II, III and IV which are the major tourist attractions. It lies bewteen 28º 77’ N to 28º 43’ N latitude and 83º 44’ E to 84º 34’ E longitude with an altitude varying from 1830m asl in Tal to 8156 m asl at the peak of Mt Manaslu. Whole Manang district is drained by Marsyandi River with its tributaries such as Jhar khola, Nar khola and Dudh Khola. The Manang valley is divided into two main villages i.e. Upper U-valley or Nyseshange Gaun and Lower V-valley or Gyansumdo or Teen Gaun.

3.2 Study Area

The present study was conducted on both south and north facing slopes of V-valley (Chame, headquarter of Manang), located between Bagarchhap and Pisang ranging from 2400m to 2800m asl. The study was taken in all possible aspect in Chame. The studied area varied from gentle to sharp sloppy ranging form 18º to 45º in inclination.

3.3 Vegetation

Due to decreasing influence of the monsoon and increasing altitude, there occurs a change in vegetation types from subtropical to temperate, xerophilous and alpine formations (Phole, 1990). In general, Manang district possesses following five types of vegetation.

a) Dry Alpine Scrub

The northern part of manang is tree less and dominated by alpine scrubs from an altitude of 3600m a.s.l to above. Dry alpine scrub is characterized by the occurrence of dwarf and prostrate *Juniperus* sp replacing dwarfs Rhododendron sp three species of *Juniperus* namely *Juniperus indica, J. recurva, J. squamata* form a scrub vegetation with other dry loving plants such as Ephendra gerardiana, Potentilla *fructicosa, Verbascum thapsus, Berberis sp.* and many species of *Anaphalis, Potentilla, Saxifraga and Cruciferae.*

b) Moist Alpine scrub

Moist Alpine scrub is dominated by rhododendron and a number of dwarf shrub *Juniperus indica, Lonicera ovodata* etc. Along the riverine areas or in shady river gullies *Salix* sp. dominates the vegetation. The associated species are *Astragalus* sp., *Berbeis* sp., *Caragana* sp., *Lonicera* sp., *Hippophae* sp. etc. The herb layer consists of *Bistorta* sp, *Geranium* sp, *Primula* sp, *Aconitum* sp, *Pediculais* sp and different species of Orchids

c) Birch Rhododendron Forest

Birch rhododendron association is ubiquitous as tree-line vegetation. Extensive stands of birch are found on north facing shady slopes and ravines with an understory of Rhododendron sp. etc. Birch forests are often mixed with fir trees (*Abies spectabilis*) that rise above the birch canopy.

Birch rhododendron forests are supplemented by blue pine (*Pinus wallichiana*) in drier valleys that are sheltered from the full force of the monsoon. More blue pines association than rhododendron is found in some parts, which makes the forest tend to be dominated by blue pine. Other species of dry habitats such as *Juniperus indica*, *Caragana* sp., *Hippophae* sp., are often mixed with tree-line vegetation of the trans-Himalayan region (Miehe, 1982).

d) Fir Forest

Fir trees appear at about 2800 m and ascend to 3800m. However, pure forests of firs are frequently found at 3000m to 3500m (Smidt- Vogt, 1990). Fir trees are widespread in north facing slopes. In dry valleys and parts of the trans-Himalayan regions, fir trees are suppressed by blue pine and Juniper. The shrub layer is dominated by *Rhododendron sp., Lonicera sp., Berberis sp* etc.

e) Temperate forest

The temperate zone (lower part of Manang, 2000m to 3000m) is mostly rich in forest type and mainly dominated by conifer and oak, in which blue pine (*Pinus wallichiana*) is the most dominant one. The other associated tree species are spruce (*Picea smithiana*), hemlock (*Tsuga dumosa*) as pure coniferous forests or as mixed forests with khasru oak (*Quercus semecarpifolia*).

3.4 Climate

The most influencing factor of climate of Central Nepal is two great mountain ranges, the Great Himalaya and the Siwalik range. The

Great Himalaya blocks monsoon resulting to the north of Himalaya arid and to the south humid climate. The northern side of Himalayas belongs to Tibetan plateau forming the southern fringe of vast highland. But the climate of these regions is slightly modified by deep gorges formed by the rivers which permit summer monsoon to go upstream to varying extent. The influence of monsoon is almost completely shut by gorge of Kali Gandaki and the landscape changes suddenly from humid to semiarid and arid zone. But the influence of monsoon is not completely shut off as the Thonje gateway and Pisang gateway let monsoon enter upper Manang.

Great variations in altitude and aspect together with different geomorphological conditions within the Manang valley result in a great range of climates. In general Manang district has temperate, cool temperate to alpine type of climate. The mountain ranges of Annapurna, Lamjung and Manaslu shield the monsoon causing the valleys atmosphere dry. In this valley wind blows daily upstream, clearing the clouds from the center of the valley and sharply reducing rainfall. Dry winds sucked into and funneling through some of these valleys create arid conditions (Schaller, 1977). The microclimate is much warmer on the south-facing slopes than on the north facing slopes. Most downpour fall occurs during the monsoon period from June to September. There is a pronounced dry period in April and May. Snow is common during winter. In January the mean temperature ranges from 16.1ºC to -1.5ºC. During the warmest months, the temperature of Manang ranges from 7.0ºC to 21.3ºC in June (DHM, 2006)

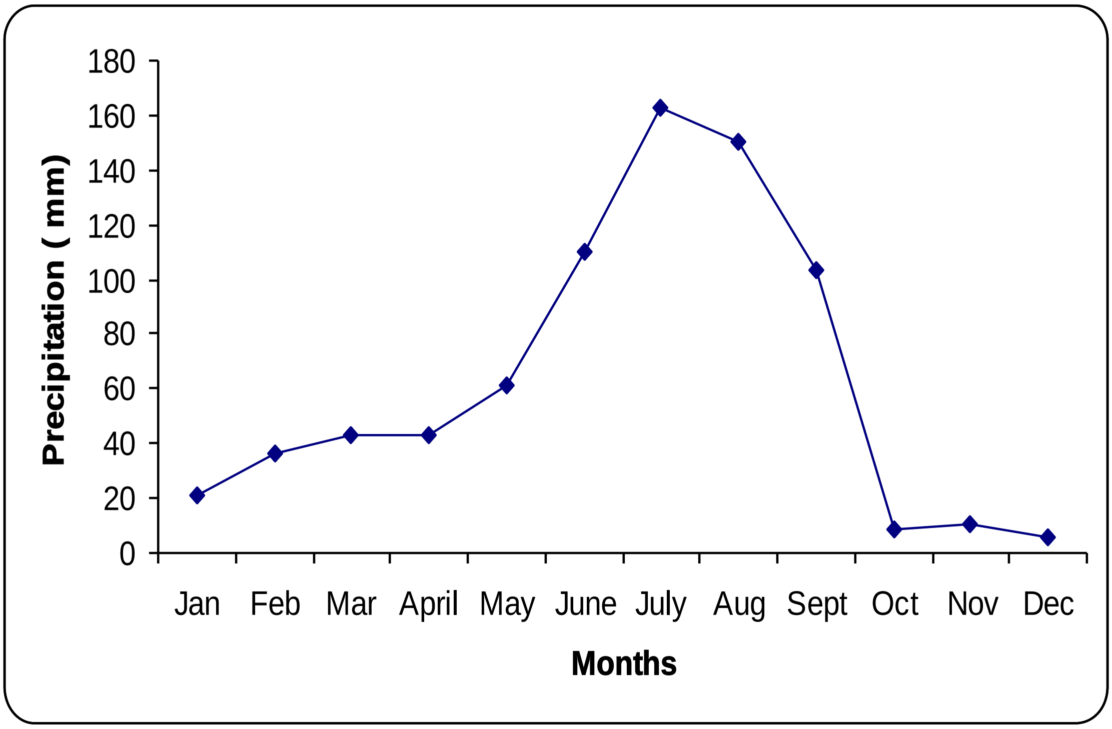

Figure1. Average Monthly precipitation of Chame (1998-2006)

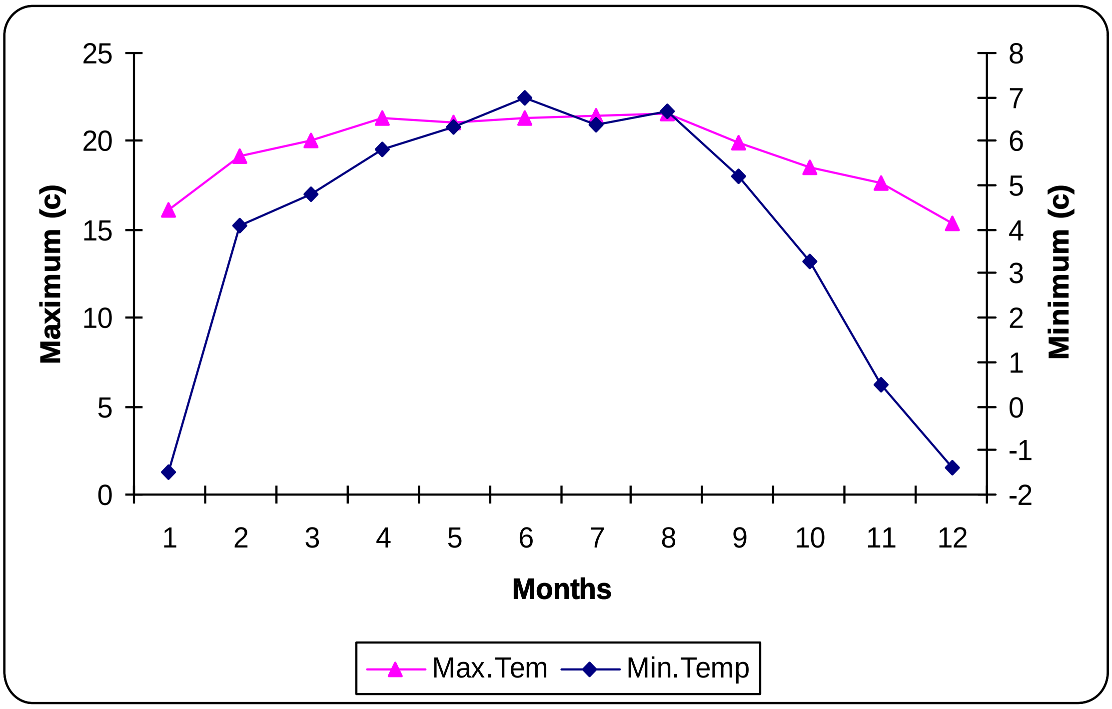

Figure2. Monthly average maximum and minimum temperature of Chame (2006)

3.5 Land use Pattern

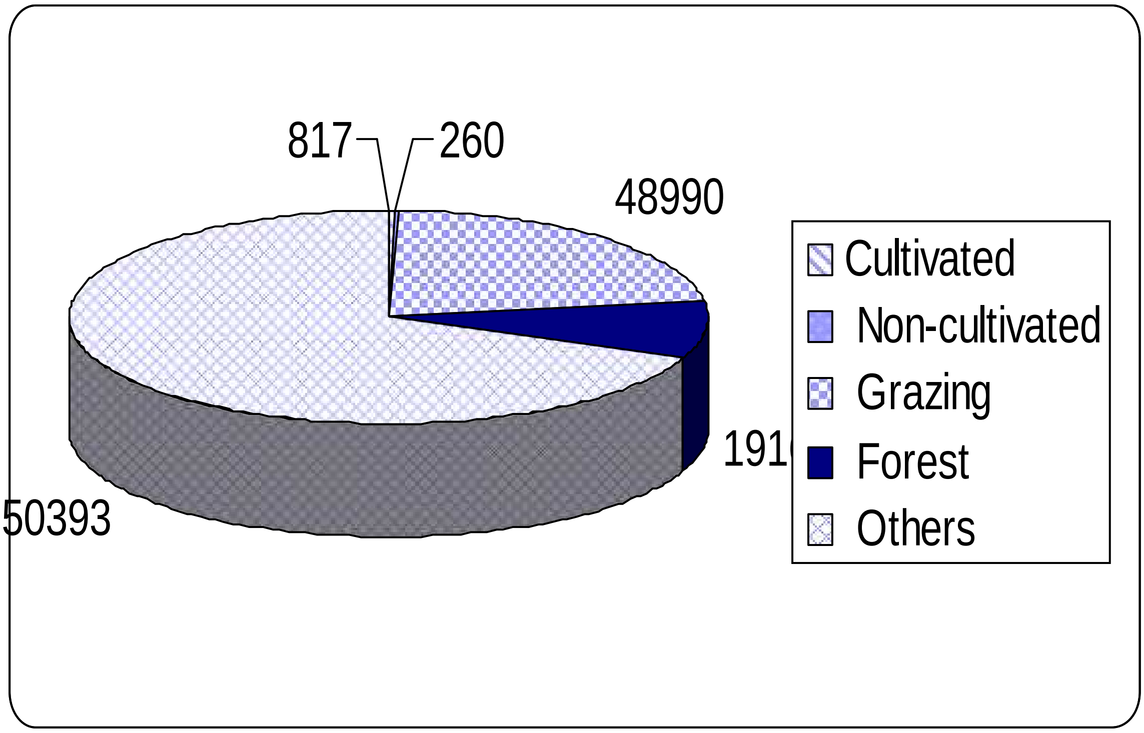

Figure3. Land use pattern in Manang (ha)

4. MATERIALS AND METHODS

The fieldwork was carried out to obtain a detailed quantitative data on the vegetation of the forest area of the two slopes facing north and south. Considering the aims and objectives of the survey, field data forms were prepared. They were designed so that the information on sample site conditions, environmental data, vegetation composition and quantitative data of all trees, shrubs and saplings, herbs were included and soil status was noted on the data sheets.

4.1 Reconnaissance

The reconnaissance of the study site was undertaken in July and October 2006. A thorough observation was made as far as possible; and difference in vegetation, slopes, aspects and altitudinal variation were studied along with the disturbances and human interferences.

4.2 Primary Data Collection

The field study was made by setting a baseline at 2400 m altitude to maximum 2800 m in north and south facing slopes as well as ecotone was taken under study.

Altogether 49 quadrate (10 m X 10 m) for trees and shrubs were laid down as shown in **figure 4**. Most of the species were identified in the field and their local names were also recorded during the field visit for easy identification. The unidentified species were collected and tagged. These specimens were identified consulting herbarium in the central Department of Botany (TUCH). Correct scientific names and their citation were made with the help of Hara et al. (1978), Hara and Williams (1979), Shrestha (1998) and Press et al (2000).

4.3 Quantitative Analysis

The vegetation of the study areas was analyzed on the basis of quantitative characters. Quantitative characters for vegetation sampling such as frequency, density, basal area and their relative values were calculated by using the following formulae:

4.3.1 Frequency and Relative Frequency

The frequency of a species is a measure of the chance of finding it with any one quadrate in a given area. In general, frequency is a useful measure of abundance where comparison of one species in relation to that of total plant species.

$$Frequency(F)\% = \frac{Number\ of\ quadrate\ in\ which\ species\ 'A'\ occur}{Total\ number\ of\ quadrates\ sampled} \times 100$$

$$\text{Re}lative\ Frequency(F)\% = \frac{Frequency\ of\ a\ species}{Total\ frequency\ of\ all\ species} \times 100$$

4.3.2 Density and Relative Density

Density is the number of individual per unit area, which gives the numerical strength of species. In general density is the total number of individual of a species relative to the total area examined. Relative density is a proportion of total number of individuals of a species with the total number of individual of all species with an area.

$$Density(D)\ Pl/ha = \frac{Total\ number\ of\ individuals\ of\ species\ 'A'\ in\ all\ quadrates}{Total\ number\ of\ quadrates\ sampled \times size\ of\ quadrates} \times 10{,}000$$

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

4.3.3 Basal Area

Basal area is the aerial space covered per unit area by plant stem estimated by measuring diameter at breast height (dbh). It is one of the chief characteristics to determine dominance. Relative basal area is the proportion of basal area of species to the sum of the basal area of all species (Mishra, 1968)

Basal area = πr^2

$$BA = \frac{\pi d^2}{4}$$

$$BA = \frac{c^2}{4\pi}$$

Where,

r = radius

D = Diameter at breast height

C = circumference at breast height

Π = 3.1416

Total Basal Area (m^2/ha) = Sum of basal area of each species

$$\text{Relative Basal area } \% = \frac{\text{BA of individual species}}{\text{Total BA of all species}} \times 100$$

4.3.4 Importance Value Index (IVI)

Importance Value Index (IVI) was introduced by Curtis and McIntosh (1951) as an index of vegetational importance within a stand. It is the function of relative density, relative frequency and relative basal area of each species. This index provides a quantitative basis for the classification of community. The IVI value of any species in a community ranges between 0-300.

Importance Value Index = Relative Density + Relative Frequency + Relative Basal Area

3.3.5 Diversity Index

Diversity Index is defined as a function of the number of species present in a given area of the evenness with which the individuals were distributed among the species. It is the combined effects of species richness and abundance. For the calculation of diversity index both Simpson's (1949) index (C) and Shannon's and Weiner's (1963) index (H) were analyzed.

Diversity Index (C) = 1 - $\sum Pi^2$

Where,
Pi = Relative density (%)

$$Diversity\ \ Index\ (H) = 3.3219\ \left\{ \frac{N \log_{10} N - \sum ni \log ni}{N} \right\}$$

Where,

N = Total number of individual of all species

Ni = Total number of individual of a species

4.3.6 Species Richness and Evenness

Species richness is considered as a number of species per sampling unit (Whittaker, 1960, Pielou, 1975). Evenness (J) as stated by Magurran (1988) as another component of diversity, generally expressed as the ratio of observed diversity to maximum diversity.

$$Species\ evenness\ (J) = \frac{H}{H_{\max}}$$

Where, H = observed diversity H_{max} = maximum possible diversity

H_{max} = 3.3219 log10K, where K = number of species

4.3.7 Index of Similarity (IS)

This index is the simplest method to compare samples only in terms of species presence or absence. It gives the degree of similarity between any two stand which depends on the quantitative phyto-sociological characters of species common to both stands. This index is designed to equal one in case of complete similarity and zero if the set is dissimilar and has no species in common. It was calculated by applying formula given by Sorenson's index modified by Greg smith (1964).

$$IS = \frac{2C}{A + B} \times 100$$

Where A = total number of species that occurred in a set of sample

B = total number of species in another sample

C = total number of common species in both the sample.

4.3.8 Radiation Index (RI)

Radiation Index (RI) was calculated for all the plots with a formula

RI = Cos (180-Ω).Sin β. SinΦ+ Cosβ. SinΦ

(Oke, 1987)

Radiation Index expresses relative radiation intensity at as a function of latitude (Ω), Aspect (Ω) and slope (β).

4.4 Soil Analysis

Soil is one of the most important ecological factors which are the reservoir of biogenic salts and mineral which are essential for the living organisms. It is a stratified mixture of inorganic and organic materials. Almost all of the nutrients, laid in soil, are absorbed by the plant from the soil.

Soil samples were collected by following Tribedi and Goel (1984). For the collection of soil, about 200gm of soil was taken from four corners and midpoint of each plot from the depth of 10cm after removing the humus. The samples were blended homogenously and packed in a clean polythene bag. From each composite sample (i.e. 27 samples) different soil parameters were analyzed in Central Department of Botany, TU and Agriculture Technical Center, Lalitpur.

4.4.1 Soil moisture

Soil moisture is defined as the amount of water content in unit weight of soil. Soil moisture was measured by the use of the instrument called soil pH and moisture tester (Model DM 15, Takemura Electric Works Ltd, Japan) at the field. The instrument contains the grade from one to eight and above.

Soil is a mixture of various organic and inorganic chemicals and shows some significant chemical properties. Some chemical parameters are calculates as follows:

4.4.2 Soil pH

The pH value is the measure of the hydrogen ion activity of the soil water system and expresses the acidity and alkalinity of soil. The pH is a very important property of soil a so it determines the availability of nutrients, microbial activity and physical condition of the soils.

Soil pH was measured by soil pH and moisture Tester (Model DM 15), Takemura Electric Works Ltd, Japan at the field.

4.4.3 Organic matter (OM)

Organic matter influences physical and chemical properties of soil by keeping the soil fertile, increases water holding capacity and makes soil porous. It plays vital role in plant nutrition and in meeting micro-organism body requirements. It is determined by Walkey – Black method in the laboratory of Central department of Botany, TU.

$$OM\ (\%) = \frac{(B - S) \times N}{Weight\ of\ dry\ soil} \times 0.067 \times 100$$

Where,

B = Vol. of FAS used up for blank titration.

S = Vol. of FAS used up for sample titration.

N = Normality of FAS from blank titration

FAS = 0.5N Ferrous ammonium sulphate

4.4.4 Nitrogen

Nitrogen is an integral component of many compounds essential for plant growth processes including chlorophyll and many enzymes. It is an essential component of amino acids and related proteins, which are critical not only as building blocks for plants but also in the cell nuclei and protoplasm in which hereditary control is vested. Total Nitrogen present in the soil was determined by Kjeldahl's method (PCARR, 1980) in the Ecology Laboratory of Department.

$$Nitrogen\ \ content\ \ (\%) = \frac{(T - B\ \ ) \times N}{S} \times 1\,4 \times 100$$

Where,

T = Sample titration (ml) of standard acid
B = Blank titration (ml) of standard acid
N = Normality of standard acid
S = Oven dry weight of sample

4.4.5 Total Phosphorus (P)

Phosphorus has been called "the key to life' because it is an essential component of deoxyribonucleic acid (DNA), the seat of genetic inheritance in plants as well as animals and of the various forms of ribonucleic acid (RNA) needed for protein synthesis. Obviously, phosphorus is essential for numerous metabolic processes such as photosynthesis, nitrogen fixation, maturation, root development etc. Phosphorus occurs in the soil in both organic and inorganic forms. Available phosphorus was determined by using Olsen's modified carbonate method (Carr, 1980).

Phosphorus (kg/ha) = R×F

Where,

F = Coefficient factor, calculated from blank solution
R = Reading in spectrophotometer (co-efficient factor = 3615.15)

4.4.6 Total Potassium (K)

Potassium is known as third fertilizer element. It plays many essential roles in plants. It is an activator of dozens of enzymes responsible for such plant processes as energy metabolism, starch synthesis, nitrate reduction and sugar degradation. It increases crop resistant to certain diseases and by, encouraging strong root and stem system. Plants absorb large amounts of potassium, all of it in the form of the K+ ion.

It was measured by flame photometer method.

Potassium kg/ha = R20 × 1.2 × 2 where, R = Reading in photometer

4.5 Statistical Analysis

Correlation coefficient was calculated between community characters and soil parameters such as pH and soil moisture. Besides correlation coefficient was also calculated between species richness and radiation index. All the statistical analysis was done from the Computer Program SPSS (Statistical Package for the Social Science, 2001).

5. RESULTS

5.1 Species Composition

Altogether 14 species of trees, 34 species of shrubs and tree saplings, 55 species of herbs were recorded in the studied area ranging from 2400m to 2800m asl. .Among tree species, *Pinus wallichiana* was most dominant followed by *Picea smithiana.*

Altitude wise number of species were high in altitude between 2500-2600m and 2700-2800m asl. But due to lack of flower, fruits or any other distinguishing characters, some of the species are left unidentified especially for herbaceous species. List of plant species recorded in studied area are listed in Appendix I.

5.2 Quantitative Analysis

5.2.1 Frequency, Density and Basal Area of Trees

Pinus wallichiana was most frequent species with a frequency of 100% and its relative frequency is 47.12%.It is followed by *Picea smithiana* with frequency of 66.3% and its relative frequency is 30.78%. On the other hand, least frequent species are *Juglan, Ficus, Cotoneaster* and *Betula* with a frequency of 2.04% and relative frequency of 0.96%.

Species wise *Pinus wallichiana* had highest density of 720 pl/ha with relative density of 74.67p pl/ha. Second most dense species was *Picea smithiana* with a density of 144.89 pl/ha and relative density of 15.02 pl/ha. But total tree density ranged from 720 pl/ha to 924 pl/ha.

The total basal area of tree species ranged from 25m²/ha to 956m²/ha. But when species wise is considered, highest basal area was of *Pinus wallichiana* i.e. 13.974m²/ha followed by *Picea smithiana* (3.1m²/ha) and least was of *Ficus clavata* and *Cotoneaster sp* i.e. 0.01m²/ha.

Table1: Frequency, density and Basal Area of tree species

Species	Density (pl/ha)	Frequency (%)	Basal Area (m^2/ha)
Pinus wallichiana	720.4	100	13.9700
Taxus buccata	20.4	10.20	0.2400
Picea smithiana	144.9	65.30	3.1000
Tsuga dumosa	10.2	6.12	0.0420
Juglan regia	2.04	2.04	0.0750
Acer cambellii	10.2	6.12	0.4760
Desmodium sp	2.04	2.04	0.0200
Populas sp	6.12	4.08	0.0640
Coriaria nepalensis	36.12	4.08	0.2580
Abies spectabilis	6.12	4.08	0.0230
Ficus clavata	2.04	2.04	0.0113
Cotoneaster sp	2.04	2.04	0.0176
Betula utilis	2.04	2.04	0.0200

5.2.2 Importance Value Index

As shown by IVI of different species in Table 1, *Pinus wallchiana* was found to be most important species with IVI value of 198.509. Another important species was *Picea smithiana* (62.988) where as least important species was *Ficus clavata*..

Table 2: IVI of the tree species

Species	RD (%)	RF (%)	RBA (%)	IVI
Pinus wallichiana	74.679	47.57	76.26	198.509
Taxus buccata	2.114	4.85	1.31	8.274
Picea smithiana	15.02	31.068	16.9	62.988
Tsuga dumosa	1.057	2.911	0.229	4.197
Juglan regia	0.2114	0.97	0.409	1.59
Acer campbellii	1.057	2.911	2.598	6.566
Desmodium sp	0.2114	0.97	0.109	1.29
Populas sp	0.634	1.94	0.349	2.923
Coriaria nepalensis	3.744	1.94	1.408	7.092
Abies spectabilis	0.634	1.94	0.125	2.699
Ficus clavata	0.2114	0.97	0.062	1.24
Cotoneaster sp	0.2114	0.97	0.096	1.28
Betula utilis	0.2114	0.97	0.109	1.27

5.3 Shrub and Saplings of trees.

5.3.1 Frequency and Density

Plot wise total shrub density ranged from 0 to 3618pl/ha in the studied area, as shown by **table 3**. But among the shrub and saplings of tree, *Pinus wallichiana* and *Taxus buccata* were the most frequent species with the frequency of 87.7% and 55.1% respectively.This was followed by *Sarcococca* with the frequency of 53.06% with relative frequency of 7.26%.

On the other hand the studied area was densely populated by *Pinus wallichiana* with a density of 9.91 pl/ha and relative density of 22.52% followed by *Taxus buccata* with density of 2.28 pl/ha and relative density of 5.19%.

Table 3: Density, R.Density, Frequency and R.frequency

Species	Density (pl/ha)	R.density (%)	Frequency (%)	R.frequency
Taxus buccata	2.2857	5.19	55.1	7.54
Pinus wallichiana	9.91	22.52	87.7	12
Juniperus indica	0.16	0.36	20.4	2.79
Tsuga dumosa	0.34	0.77	18.36	2.51
Caragana brevispina	0.1016	0.23	6.12	0.837
Berberis aristata	2.4	5.45	46.9	0.642
Cotoneaster microphyllum	2.93	6.66	28.57	3.91
Daphne bholua	3.28	7.45	51.0	6.98
Berberis asiatica	0.69	1.56	16.32	2.23
Picea smithiana	5.48	12.45	73.46	10.05
Rosa macrophylla	0.69	1.56	20.4	2.79
Xanthoxylum armatum	1.26	2.86	28.57	3.91
Sarcococca saligna	8.1	18.40	53.06	7.26
Xylosoma sp	0.61	1.386	16.32	2.23
Abies spectabilis	1.02	2.318	34.69	4.75
Acer cambellii	0.061	0.138	6.122	0.83
Lonicera angustifolia	0.14	0.318	6.122	0.83
Desmodium sp	2.04	4.636	53.06	7.26

Rubus sp	0.22	0.5	8.16	1.12
Leguminous sp	0.22	0.5	16.32	2.23
Bambusa sp	0.1	0.227	6.122	0.83
Mahonia nepalensis	0.04	0.091	4.08	0.558
Unidentified	0.02	0.045	2.04	0.279
Cotoneaster sp	0.08	0.182	8.16	1.12
Unidentified	0.04	0.091	4.08	0.558
Niellia rubriflori	0.42	0.964	12.24	1.675
Ficus clavata	0.12	0.273	2.04	0.279
Salix sp	0.02	0.045	2.04	0.279
Jasminum humile	0.78	1.77	18.36	3.63
Berberis mucrifolia	0.06	0.136	2.04	0.279
Piptanthus sp	0.04	0.091	2.04	0.279
Juniperus squamata	0.1	0.227	4.08	0.558
Coriaria nepalensis	0.2	0.454	4.08	0.558
Populus sp	0.02	0.045	2.04	0.279
Prunus sp	0.02	0.045	2.04	0.279

5.4 Size Class Distribution

Different tree species recorded in the studied area were of different size with different diameter. So all the tree species were divided into different classes based on DBH of 10cm intervals according to **table 4.**

Table 4. DBH Classes of Tree Species

DBH Class	DBH in cm
1	10-19
2	20-29
3	30-39
4	40-49
5	50-59
6	60-69
7	70-79
8	80-89
9	90-100

In the studied area, total 14 tree species were recorded with different diameter. As shown in figure 1, among them highest number of tree species were in lower size classes i.e. Class 1, 2, and 3. There was no tree species with diameter of class 9. Highest number of trees were in class 1 i.e. 309, followed by class 2 (90). Least number of species were in class 6 & 7 i.e. 1.

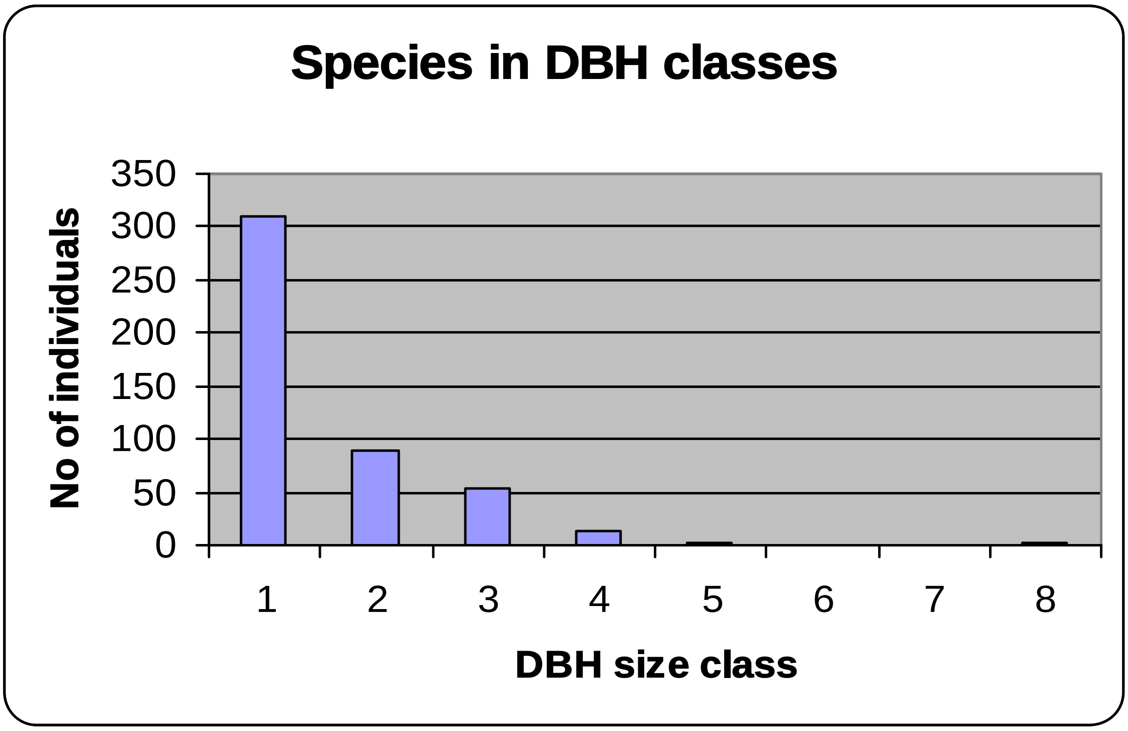

Figure 4: Tree size classes

5.5 Species Richness, Evenness, Diversity and Similarity

Species richness, evenness and plant species diversity for tree and shrub/tree saplings according to altitudinal gradient are shown by **table 5** & **table 6**.

Number of species in an area (Species richness), Simpson's and Shannon-Wiener indices of diversity and species evenness were calculated for trees and their saplings along with shrubs in different sites. Maximum tree species richness was found in site III (2600m-2700m) and minimum was found in site I (2400m -2500m). In case of shrub/saplings, it was maximum in site II & IV and minimum in site I .However highest tree species evenness was found in site IV (2700m-2800m) and for shrub/saplings was in site IV. Similarly highest species diversity for trees and shrub/saplings both were recorded in site IV.

Table 5: Species Richness, Diversity and Evenness

Habit	Site I (2400m-2500m)				Site II (2500m-2600m)			
	S	C	H	J	S	C	H	J
Tree layer	5	0.148	0.667	1.689	6	0.118	1.654	1.123
Shrub/sapling	14	0.145	1.922	0.606	22	0.097	2.35	0.796

Table 6: Species Richness, Diversity and Evenness

Habit	Site III (2600m-22700m)				Site IV (2700m-2800m)			
	S	C	H	J	S	C	H	J
Tree layer	9	0.093	2.36	1.52	6	0.066	2.805	2.06
Shrub/sapling	18	0.087	2.423	0.82	22	2.05	2.66	0.9723

S: - Species Richness **C: - Dominance index**
H: - Diversity index **J: - Species evenness**

Table 7: Index of Similarity between different sites

Sites	Index of Similarity
I & II	22.22%
I & III	21%
I & IV	66.66%
II & III	53.3%
II & IV	26.66%
III & IV	22.2%

5.6 Soil Analysis

5.6.1 Soil pH

The pH of soils samples collected from different plots in different altitude did not show much variance. It lies between the ranges of pH 6-7 except in plat 1, 3,7,8,9 where pH value ranged between 5-6. However as a whole pH ranged from 5.5 to 6.9.

5.6.2 Total Organic Matter

Total average organic matter in soil samples collected from the site was 4.1%. Plot wise plot 16 had highest organic matter content i.e. 5.92% and least organic matter content was found in plat 6 i.e. 1.23%.

5.6.3 Total Nitrogen

Total nitrogen content in soil samples ranged from 0.06 % to 1.43% with an average value of 0.67%.

5.6.4 Total Potassium

The highest value of Potassium content was found in plot 24 (312 Kg/ha) and minimum value was 72 kg/ha which was recorded in plot 21.

5.6.5 Total Phosphorus

Total average phosphorus content in soil samples ranged from 55.42 kg/ha in plot 28 to 4.1 kg/ha in plot 21.

Table8: Summary of soil characters

Soil Characters	Range of Value	Average value
Soil pH	5.50-6.90	6.38
Soil Nitrogen (%)	0.06-1.43	0.67%
Soil Phosphorus(kg/ha)	4.10-55.42	17.33
Soil Potassium(kg/ha)	72-312	191.75
Soil Organic matter (%)	1.23-5.92	4.1%

5.7 Statistical Analysis (Correlation Coefficient)

The correlation analysis is used to show the relations between different variables. The correlation analysis showed there was no significant correlation between soil pH and soil moisture. Neither there was any correlation between soil moisture with tree density, shrub density and species richness. However there was positive correlation between species richness and light intensity (r = 0.463, p=0.05) indicating that the number of species increases with the increase in light intensity.

Total tree density showed positive correlation with total tree species (r= 0.578, p=0.01). Similarly total tree density showed positive correlation with total tree basal area (r= 0.43, p=0.01). But there was negative correlation between species diversity of herbs and shrub species diversity (r=-0.523, p=0.01). Similarly total shrub density was negatively co-related with herb species richness (r=-0.33, p=0.05) but positively correlated with shrub species diversity.

Table 9: Correlation between Community Characters and Soil Parameters

	Total Tree Species Richness	Total Tree Density	Total Tree Basal Area	Shrub Species Richness	Herb Species Richness	Total Shrub Density	Soil pH
Total Tree Density	0.578(**)						
Total Tree Basal Area	0.253	0.430(**)					
Shrub Species Richness	0.159	-0.121	-0.169				
Herb Species Richness	-0.009	0.233	0.224	-0.523(**)			
Total Shrub Richness	0.063	0.021	0.104	0.577(**)	-0.330(*)		
Soil pH	-0.120	-0.053	0.128	0.107	-0.138	0.141	
Soil Moisture	0.037	-0.057	-0.004	0.028	-0.037	-0.036	-0.057

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed)

Table 10: Descriptive Statistics

Attributes	Range of values	Mean±SD
Total Tree Species Richness	1-7	2.41±1.24
Total Tree Density	720-924	810±71
Total Tree Basal Area	25-965	301±218
Shrub Species Richness	0-18	7.57±2.8
Herb Species Richness	1-24	12.57±4.4
Total Shrub Density	0.00-3618	2505±720
Soil pH	5.50-6.90	6.38±0.33
Soil Nitrogen	0.06-1.43	0.72±0.35
Soil Phosphorus	4.10-1504	113±348
Soil Potassium	72-312	191.75±62.7
Soil Organic Matter	1.23-5.92	4.40±1.23

Table 11: Spearman's Correlations Coefficient of Species Richness with RI and LI

		Radiation Index	
Species Richness	Correlation Coefficient	0.242	
	Sig. (2-tailed)	0.215	
	N	28	
Light Index	Correlation Coefficient	0.328	0.463(*)
	Sig. (2-tailed)	0.088	0.013
	N	28	28

* Correlation is significant at the 0.05 level (2-tailed).

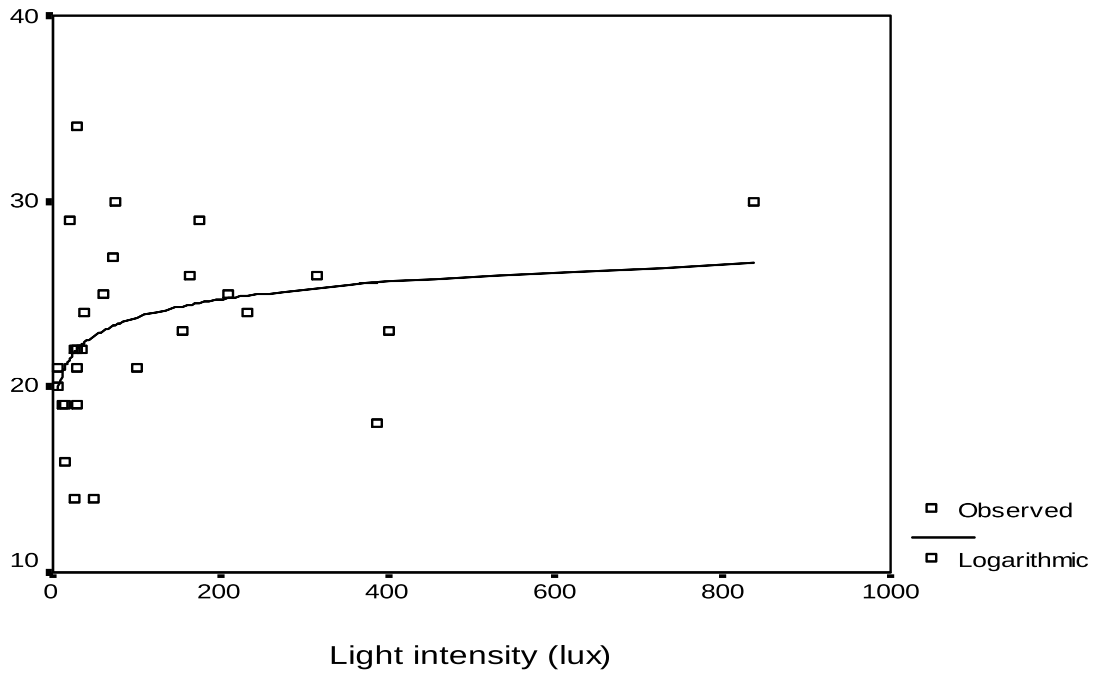

Figure 5:- Relation between Species Richness and Light Intensity

6. DISCUSSION

6.1 Vegetation Analysis

Various factors like soil, altitude, vegetation type and anthropogenic activity influence the plant density and diversity in the forest of Chame. In the studied site the total tree density ranged from 720 pl/ha to 924 pl/ha. This value is lower than the findings of Singh and Yadav (1991) that estimated 2825 pl/ha in natural forest of Manipur. However the value is much lower than the value 1509.93 pl/ha to 7184 pl/ha estimated by Khadka (2004) in the forest of Pisang, Manang. Likewise the value was close to the value reported in natural sites of Godawari hills by Khadka et al (1984-85) ranging from 390 pl/ha to 1460 pl/ha .Similarly the total tree density value was close to the value given by Balkrishna Ghimire (2005) in sub alpine region i.e. 375 pl/ha to 2625 pl/ha and to the value 350 pl/ha to 1640 pl/ha in low altitude central Himalayan forest proposed by Saxena and Singh (1982). But lower than the value 1200pl/ha to 1800 pl/ha reported by Sah et al. (1994) from Garhawal Himalaya. Similarly the findings was lower than the value given by Gewali (1999) in Biruwa Community forest i.e. 1193.64 pl/ha, value 1413 pl/ha to 2070 pl/ha reported by Sigdel (2002).

Among individual tree species, *Pinus wallichiana* had the highest density in the studied area. The density of *Pinus wallichiana* was 720.4 pl/ha which is close to the value reported in forest of Pisang by Khadka (2004) i.e. 476.6 pl/ha to 900pl/ha.

The density of shrub and saplings of trees ranged from 0 to 3618 pl/ha which was lower than the value 2817 pl/ha to 7184.4 pl/ha reported by Khadka (2004) and value ranging from 1061.04 pl/ha to 9726 pl/ha reported by Shrestha (1996) in Riyale, 2300 pl/ha to17275 pl/ha as reported by Applegate and Gilmour (1987) in Sindhupalchok but higher than the density of shrubs and tree saplings 977.62 pl/ha reported by Gewali (1999) in Kulekhani. It is closer to the value 1350 pl/ha to 5289 pl/ha as reported by Adhikari et al (1995) in central Himalayan Oak forest and higher than the value 490 pl/ha to 1730 pl/ha reported by Singh and Singh (1992) in Himalayan region of India.

Considering density species wise, Pinus wallichiana saplings had highest density i.e. 9.91 pl/ha followed by *Picea smithiana* which density was 5.28 pl/ha. Density of saplings of *Pinus wallichiana* was much lower than the value reported by Khadka (2004) and Ghimire (2005).

Basal area of plant depends upon the fertility and productivity of soil along with its genetic quality to grow. Total tree basal area ranged from 25 m^2/ha to 965m^2/ha. The value is much higher than the value given by Khadka (2004) in Pisang and Shrestha (1997) in Chitrepani. The value is also higher than the value 5.38 m^2/ha to 19.04 m^2/ha reported by Ghimire (2005) in sub-alpine region, value 3.8 m^2/ha to 59.64 m^2/ha as reported by Shrestha (1997) in Chitrepani, 12.41 m^2/ha to 19.56 m^2/ha as reported by Nepal (2001) in Ghandruk, the value 73 m^2/ha as reported by Adhikari et al (1995) in oak forest of Central Himalaya, 114 m^2/ha as reported by Pandit (1999) in Rhododendron-Lyonia forest of Makwanpur and 7.25 m^2/ha to 48.65 m^2/ha as reported by Yadav and Sah (1998) in Nagarjun hill forest.The present value was higher than the value 0 to 4 m^2/ha as reported by Shrestha (1996) in Riyale, 31.28 m^2/ha as reported by Cao et al (1996) in South West China, and 34.2 m^2/ha to 36.14 m^2/ha by Marasini (2003) in Churia forest of Rupendehi district. Large basal area value of trees may be due to high density, large trunk followed by highly productive soils accompanied by favourable climate.

The highest basal area was of *Pinus wallichiana* 13.97 m^2/ha followed by *Picea smithiana* i.e.3.1 m^2/ha. This value is higher than the value given by Khadka (2004) in forest of Pisang and the value reported by Yadav and Sah (1998) in Nagarjun hill. The present value is closer to the value 11.87 m^2/ha reported by Ghimire (2005) in sub alpine region, central Nepal.

The IVI of different species shows the most dominant and important species for particular area. According to the table 2, the studied area is highly favorable for *Pinus wallichiana* with IVI value of 190.77 followed by *Picea smithiana*. Same result was obtained by Khadka (2004) in forest of Pisang and Ghimire (2005) in lower belts of his study.

6.2 Species richness, Diversity Index and Index of Similarity

Species richness is the total number of species within the geographical area and it is expressed as an enumeration of the species occurring within a particular area (Chaudhary, 1998). Moisture and vegetation cover are the best explanatory variables for species richness. Regarding the species richness, tree species was less than of shrub species. Same result was obtained by Khadka (2004) in Pisang and Ghimire (2005) in sub alpine region. However, Manandhar (1996) found higher richness of tree species than shrub in Kaski. These variations may due to high altitude and associated environmental factors.

Species richness is a simple interpretable indicator of biological diversity that represents the total number of species within an area (Hulbert 1971; Whittaker 1977). Between four different site having different altitudes, species richness was found higher in site III for trees and II & III for shrub/saplings. Both species richness and diversity for tree and shrub/sapling is lowest in site I. It may due to human interference such as cutting, clearing as well as grazing by livestock etc. But species evenness was found highest for both trees and shrub/sapling in site IV.

Index of similarity was calculated to compare the number of common species present in the sites. Among the trees, site I & IV were similar with in comparison to other sites (66.66%) and for shrub/saplings (76.92%).

In present study, species richness showed positive relation with light intensity (r= 0.463, p=0.05) indicating having other factors constant, species increases in number with increase in light intensity. But species richness did not show significant relation with altitude and radiation index.

Total tree species relation showed positive relation with total tree density (r=0.578, p=0.01). Besides tree density was also positively co-related with basal area (r= 0.43, p=0.01).

It was found that number of herb species decreased with increase in number of shrub species or vice versa as they are negatively correlated with each other (r= -0.523, p=0.01). It is so because of competition for light, space and nutrients between them. Also herb species number was negatively correlated with shrub density (r=-0.33, p=0.05). But shrub density was positively correlated with shrub species number (r=0.577, 0.01).

6.3 Soil Analysis

The pH of the soil revealed that the whole study area possess slightly acidic soils as the pH value ranged from 5.5 to 6.9. The value 6.54 to 6.74 was less than the reported by Khadka (2004) in Pisang forest but closer to value 4.4 to 5.8 as reported by Juwa (1989) in Nagarkot hill and pH value reported by Sing and Sing (1989) in central Himalayan. This value is also closer to value reported by Sah *et al*. (1994) in the *Pinus roxburghii* forest soil of Gaharwal Himalaya which was 5.9 to 6.42. This value was also close to that as proposed by Howell (1988) 5.5 to

6.06 for mountain forest soil. But the value was less than the value reported by Ghimire (2005) in sub-alpine region (6-7). Both soil ph and moisture did not show any relation with species number and density may be they were not the significant factor for determining the vegetation of the study area.

Organic matter in soil ranged from 1.23% to 5.92% which is closer to the value reported by Khadka (2005) in Pisang forest and Pandey (2001) in Dhading. The total nitrogen content ranged from 0.06% to 1.43% which is higher than the value proposed by Ghimire (2005) in sub alpine region but similar to value 0.17% to 1.23% reported by Khadka (2004) in Pisang forest.

The total potassium content in soil ranged from 72kg/ha to 312kg/ha which is closer to the value 57.93 kg/ha to 263.91 kg/ha reported by Ghimire (2005) but lower than the value 241 kg/ha to 688 kg/ha as reported by Pandey (2001) Brashbang Hill, Dhading.

Total phosphorus content ranged from 4.1 kg/ha to 15.04 kg/ha which is closer than the value 6.12 kg/ha to 36.69 kg/ha reported by Ghimire (2005) but lesser than the value 41.15 kg/ha to 46.42 kg/ha reported by Khadka (2004). Similarly the estimates value was lower than the value 22.59 to 44.28 kg/ha as reported by Shrestha (1996) in Chhitrepani, 50.34 kg/ha to 113.56 kg/ha as reported by Pandey (2001) and by Adhikari (2004) in Bosan forest in which the value ranged between 17.5 kg/ha and 17.36 kg/ha.

7. CONCLUSION AND RECOMMENDATIONS

7.1 Conclusion

The study has been undertaken to assess quantitative analysis of trees, shrubs and saplings of trees and herbs in all possible aspect in the forest of Chame, Manang district, Central Nepal. The study comprises the analysis of soil parameters and their and species composition and diversity with in a study area. Altitudinal range of the study area was 2400m asl – 2800m asl. Altogether 13 species of trees, 34 species of shrubs/saplings and 55 species of herbs were recorded from four sites.

Diversity Index showed that species diversity was high in site II (2500m-2600m) and III (2600m-2700m) in comparison to site I (2400m-2500m) and IV (2700m-2800m). But species evenness was high in Site IV. It is so because site I is very closer to human settlements which regularly disturbs the vegetation but site II & III were little more far away. Though, these sites are not regularly disturbed but not totally away from disturbances. Slight disturbance is good for species diversity. And site IV was completely virgin from disturbance as result species evenness is high.

Among tree species *Pinus wallichiana* was the most dominant species with highest frequency, density, and important value index followed by *Picea smithiana*. Among shrubs and saplings of trees, again *Pinus wallichiana* was most frequent species with high density followed by *Picea smithiana*. However other shrub species like *Cotoneaster, Daphne and Sarcococca* were also important in the study area.

The pH of the soil revealed that the whole study area possess slightly acidic soils may due to dominance of the area by *Pinus wallichiana*. But the moisture is comparatively high due humid climate. Besides, dense vegetation protects loss of water from soil by evaporation. The size class distribution of the study site showed larger number of trees in smaller size classes indicating that the forest is in a state f regular reproduction. Because of limitation of present study, quantitative range of soil parameters could not be related with species composition of vegetation.

Usually moderate level of disturbances, altitude and soil characters like pH , nutrients (NPK), moisture play an important role in the maintenance of species diversity. However present study could not detect the specific factor that influenced the vegetation composition in the study area. The vegetation of an area might be affected by various geological, physical, chemical and biological factors, which interact among themselves and finally determine the disturbance pattern of various plant species.

7.2 Recommendations

Himalayan region is a critical area in the context of global bio-diversity and fragile habitat. Degradation of natural resources and loss of bio-diversity in the mountain ecosystems in terms of extensive deforestation, intensive cultivation in steep slopes, heavy population pressure and adverse impacts of large development projects has drawn major concern. In this relation, sustainable management of biological resources along with conservation of biodiversity has emerged as a major challenge (Shengji and Sharma 1998). The mountain specificities such as inaccessibility, fragility, marginality accompanied with natural and cultural diversity represent both constraints and opportunities. The latter parameter of mountain area represent a comparative advantage over the plains for ecotourism and an integrated participatory approach is needed for solving the interrelated constraints and harnessing the opportunities (Bhatia et al 1998).

High altitude Himalayan are geodynamically very active and are most sensitive to natural disturbances such as different forms of mass wasting such as landslides, slumps, rock falls and Glacial lake outburst floods (GLOF) due to torrential monsoon rainfall that occurs within a short span of time and human activities such as deforestation, overgrazing, production intensification, shifting cultivation with in a shortened cycle, development work etc.

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

- Since study area is famous for ecotourism, high quantity of energy is needed to fulfill the requirements of tourists which results in unsustainable collection of timber and firewood. Hence in order to cut the overburden on forests, alternative energy sources like solar energy, wind energy, micro hydropower should be developed.
- Protecting ecosystems that supply water for drinking, irrigation and hydroelectricity

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Appendix I
LIST OF THE PLANT SPECIES

Plant Species	Family
1. **Abies spectabilis (**D.Don) Mirb	Pinaceae
2. **Acer cambellii** Hook. f. & Thoms.	Aceraceae
3. **Adiantum sp**	Polypodiaceae
4. **Anaphilis contorta** (D.Don) Hook f.	Compositae
5. **Anaphilis triplinervis** (Sims) C.B.Clarke	Compositae
6. **Anaphilis margaritacea**(L) Benth	Compositae
7. **Anemone virtifolia** Buch-Ham ex DC	Ranunculaceae
8. **Asparagus filicines** Buch-Ham ex D.Don	Liliaceae
9. **Aster himalyaius** C.B Clarke	Compositae
10.**Arisima sp**	Araceae
11.**Argarolobium sp**	Leguminosae
12.**Artimecia dubia** Wild	Compositae
13.**Bambosa sp**	Gramineae
14.**Betula utilis** D.Don	Betulaceae
15.**Berberis asiatica** DC	Berberidaceae
16.**Berberis aristata DC**	Berberidaceae
17.**Berberis mucrifolia** Ahrendt	Berberidaceae
18.**Caragana brevispina** Royle	Leguminosae
19.**Calanthe sp**	Orchidaceae
20.**Circium falconer** Hook.f.	Compositae
21.**Clematis buchananiana** DC	Ranunculaceae
22.**Cotoneaster sp**	Rosaceae
23.**Cotoneaster microphyllus** Wall. Ex Lindl	Rosaceae
24.**Coraria nepalensis Wall**	Corariaceae
25.**Daphne bholua** Buch-Ham ex D.Don	Thymelaceae
26.**Desmodium sp**	Leguminoseae
27.**Dipsacus innermis** Wall	Dipsacaceae
28.**Elsholtzia fruticosa (D.Don) Rehder**	Labiatae
29.**Erigeron multiradiatus (** Lindl ex Dc) CB Clarke	Compositae
30.**Euphorbia stracheyi** Bioss	Euphorbiaceae
31.**Ficus sp**	Moraceae
32.**Fagaria nabicula** Lindl. Ex Lacaita	Rutaceae
33.**Geranium pretense** L.	Geraniaceae
34.**Gnaphalium affina** D.Don	Compositae
35.**Gnalium hirtifolia**	Compositae
36.**Gynura sp**	Compositae
37.**Hedera sp**	Araliaceae
38.**Inula hookeri** C.B Clarke	Compositae
39.**Jasminium humile** Linn	Oleaceae
40.**Juniperus squamata** Buch-Ham.ex.D.Don	Cupressaceae

41.**Juniperus indica** Bertol	Cupressaceae
42.**Juglan regia** Linn	Juglandaceae
43.**Lonicera angustifolia** Wall	Caprifoliaceae
44.**Lonicera sp**	Caprifoliaceae
45.**Maharanga sp**	Boraginaceae
46.**Mentha sp**	Labiatae
47.**Mohonia nepaulensis** DC	Berberidaceae
48.**Nepeta sp**	Labiatae
49.**Pinus wallichiana** A.B. Jacks	Pinaceae
50.**Picea smithiana** (Wall.) Boiss	Pinaceae
51.**Piper** sp	Piperaceae
52.**Piptanthus sp**	Leguminosae
53.**Pedicularis longiflora** (Klotzsch) Tsoong	Scrophulaceae
54.**Pedicularis pectinata** Wallich ex Benth	Scrophulaceae
55.**Pedicularis oederi** Vahl	Scrophulaceae
56.**Polygonatum verticellatum** (L) All.	Liliaceae
57.**Potentilla sp**	Rosaceae
58.**Populas sp**	Saliaceae
59.**Prunus sp**	Rosaceae
60.**Orobankia sp**	Orobanchaceae
61.**Origanum vulgare Linn**	Labiatae
62.**Taxus bucatta linn**	Taxaceae
63.**Tsuga dumosa** (D.Don) Eichler	Pinaceae
64.**Rosa macrophyllum** Lindl	Rosaceae
65.**Rubus biflorus** Buch-Ham ex Smith	Rosaceae
66.**Sarcococca sp**	Buxaceae
67.**Salix sp**	Saliaceae
68.**Satyricum sp**	Orchidaceae
69.**Swertia macrosperma (**C.B. Clarke) C.B. Clarke	Gentianaceae
70.**Swertia angustifolia** Buch-Ham D.Don	Gentianaceae
71.**Swertia petiolata** D.Don	Gentianaceae
72.**Senecio cappa** Buch-Ham ex D.Don	Compositae
73.**Senecio diversifolius** wall ex DC	Compositae
74.**Salvia hians** Royle ex Benth	Labiatae
75.**Smilacina sp**	Liliaceae
76.**Thallictrum alpinum** L.	Ranunculaceae
77.**Thallictrum cultratum**Wall	Ranunculaceae
78.**Thallictrum squamiferum** Lecoyer	Ranunculaceae
79.**Xylosoma sp**	Flacourtiaceae
80.**Xanthoxylum armatum** DC	Rutacea

Appendix II
Average monthly temperature and precipitation of Chame from 1998 to 2005

Month	!998			1999		
	Temp (Max) ºC	Temp (Mini) ºC	Precip mm	Temp (Max) ºC	Temp (Mini) ºC	Precip mm
January	10.5	-1.7	0	10	-4	16
February	11.5	-0.1	87	14	4	55
March	12.1	0.9	166	17	6	8
April	18.5	5.0	33	20	8	5
May	22.1	7.9	39	21	11	115
June	23.4	10.8	73	20	11	183
July	20.5	12.1	167	20	13	116
August	19.8	12.2	108	20	12	133
Sept	20.9	11.3	39	19	11	88
Oct	17.9	8.4	9	16	8	32
Nov	15.3	2.1	10	14	4	0
Dec	13.9	-1.4	1	8	-4	6

Month	2000			2001		
	Temp(Max) ºC	Temp(Min) ºC	Precip mm	Temp(Max) ºC	Temp(Min) ºC	Precip mm
January	6.9	-4.5	11	9.9	-1.2	6.2
February	7.6	-2.5	25	14	1.2	28.6
March	10.3	2.5	19	17.1	5	23.8
April	18.9	7.5	31	19.3	8.3	23
May	20.5	8.1	20	20.1	9.2	25.2
June	20.5	9.0	116	19.7	7.2	112.6
July	19.8	8.9	136	19.3	7.6	121.8
August	18.8	8.8	140	19.0	7.1	146.4
September	17.4	7.4	76	19.8	7.9	34.0
October	16.2	6.7	0	18.2	5.6	6.2
November	13.3	4.1	18	17.4	5.2	2.2
December	8.8	-1.3	0	14.5	-1.4	0

Source: Department of Hydrology and Metrology.

Average monthly temperature and precipitation of Chame from 1998 to 2005

Month	2002			2003		
	Temp(Max) ºC	Temp(Min) ºC	Ppt mm	Temp(Max) ºC	Temp(Min) ºC	Ppt mm
January	13	-5	6.7	6.7	-4.4	40.0
February	14	-1	35	11.4	1.2	49.0
March	17.9	4.5	32.8	17.6	5.0	115.5
April	19.6	8.2	74.0	18.9	7.9	72
May	19.9	9.1	87.2	21.2	9.0	40.2
June	20.2	9.0	97.6	21.1	10.3	137.8
July	21.7	10.2	80.2	20.6	9.1	113.0
August	20.2	9.2	152.5	19.6	7.5	203.8
Sep	20.0	8.9	253.1	18.7	7.4	149.4
Oct	18.5	7.5	0.0	18.5	6.5	7.0
Nov	4.4	4.1	34.0	16	4.2	32.0
Dec	8.2	-3.4	0.0	15.1	-2.2	43.0

Month	2004			2005		
	Temp(Max) ºC	Temp(Min) ºC	Ppt mm	Temp(Max) ºC	Temp(Min) ºC	Ppt mm
January	115.5	-2.6	27.6	13.5	-2.9	84
February	17.5	3.1	22	15.6	-2.6	28
March	20	6.5	5	-		10
April	20.7	7.2	49.2	20.6	5.1	104
May	21	7.1	46.6	20.4	7.6	80
June	20.4	7.2	168	21.1	6.8	60
July	19.8	6.4	258.4	28.2	5.5	231.4
August	19.7	6.5	186	-	-	-
Sep	19.7	6.2	185	21.6	10.2	21
Oct	18.1	2.4	26	-	-	-
Nov	18.5	0.5	0	15.1	1.1	0
Dec	17.6	-3.1	0	15.6	-3.8	0

Source: Department of Hydrology and Metrology.

Appendix III
Field Data Sheet

Site
Plot No
Date
Altitude
Aspect
Slope
Intensity
Latitude
Longitude

pH						

Tree Species	DBH (cm)							
Shrub/Sapling	Number of Species							
Herbs								

Appendix IV
Plot wise Tree Density and Basal Area

Quadrate No	No of tree spp	Total tree Density(pl/ha)	Total Tree basal Area (m^2/ha)
1	3	885.69	364.748
2	2	751	52.628
3	2	865.29	467.317
4	2	865.29	486.935
5	2	865.29	210.312
6	2	865.29	366.785
7	1	720.4	32.337
8	4	895.9	177.362
9	1	720.4	73.503
10	2	865.29	25.250
11	4	737.33	185.770
12	1	720.4	112.978
13	4	74549	256311
14	1	745.49	176.252
15	3	720.4	271.284
16	5	741.41	241.321
17	2	778.14	47.281
18	2	865.29	695.221
19	2	865.29	83.120
20	2	730.6	107.303
21	2	740.8	88.786
22	3	737.33	110.955
23	2	720.4	237.467
24	2	865.29	95.212
25	2	865.29	220.189
26	2	740.8	140.598
27	1	720.4	382.877
28	1	720.4	338.802
29	2	726.52	132.669
30	7	865.29	262.460
31	2	865.29	482.990
32	2	865.29	371.604
33	2	865.29	421.010
34	2	865.29	143.280
35	2	865.29	267.999
36	2	865.29	252.946
37	1	720.4	206.121
38	2	730.7	465.023
39	2	865.29	367.934
40	3	871.41	281.495
41	2	757.13	664.639
42	2	865.29	789.420
43	1	720.4	161.7342
44	3	871.41	637.248
45	3	871.41	580.580
46	4	881.61	257.994
47	3	881.61	755.494
48	6	924.46	241.636
49	38	902.02	965.327

Appendix V
Plot wise No of shrubs, Density and No of Herb Species

No of shrub sp per 100m²	No of herb sp per 100m²	Total shrub Density(pl/ha)
8	11	2122.416
6	11	1581.596
3	14	1610.196
6	18	2563.246
2	16	1008.156
7	11	2189.766
9	10	2755.068
8	13	2059.172
5	14	2265.296
4	20	2367.336
6	15	2087.74
13	10	3618.326
18	11	1726.5
8	9	2906.086
9	11	2948.946
8	12	3257.126
8	16	2371.396
8	11	3177.516
9	14	2273.426
9	9	3185.696
8	9	2742.846
9	9	2983.666
9	5	3259.126
11	6	2916.306
7	5	3126.516
10	7	3438.736
0	13	0
7	9	2402.016
9	1	1614.276
7	10	1628.956
8	11	3160.406
9	15	3332.636
8	11	2548.906
5	15	2267.336
3	13	1255.086
5	16	2373.446
7	16	2944.876
7	12	2536.666
7	20	2932.626
7	20	2818.306
8	24	2518.296
6	17	2099.966
9	20	1934.608
9	13	3273.746
9	10	3006.046
7	18	2287.726
7	14	2418.296
11	9	3567.256
8	12	3281.576

Appendix VI
Plot wise Soil Characters

N (%)	P(kg/ha)	K(kg/ha)	OM (%)	PH	Moisture
0.728	15.15	220.8	5.39	5.8	6.1
0.91	10.2	124.8	2.25	6	7.2
0.91	10.28	172.8	4.21	5.98	5.5
0.784	10.45	172.8	5.921	6.1	5.6
0.602	15.15	192.2	2.85	6.3	5.2
0.224	15.35	206.4	5.39	6.3	4.5
0.574	20.32	268.8	5.63	5.5	6
0.616	18.16	240	4	5.8	4.1
0.644	15.65	201.6	5.73	5.8	5.1
0.462	10.15	134.4	5.5	5.9	4.05
1.246	11.2	249.6	4.8	6	6.2
0.336	6.2	159.4	5.24	6.8	6.4
0.868	15.08	254.4	3.8	6.2	7
1.428	10.25	144	1.23	6.5	3.5
0.672	1102	144	5.79	6.1	4.86
0.574	10.35	163.2	4.9	6.4	6.2
0.336	5.1	81.6	4.95	6.2	6.5
0.63	10.65	177.6	4.68	6.8	5.5
0.056	4.1	72	4.25	6.5	4.9
1.092	40.1	312	3.8	6.1	5.2
0.184	5.8	120	2.59	6.8	7.2
1.33	30.35	312	2.8	6.5	5.5
1.218	30.32	268.8	3.1	6.4	1.5
0.434	15.65	240	4.9	6.8	4.5
0.698	25.5	152.6	4.74	6.6	4.5
0.868	55.42	189.9	5.2	6.6	6.2
0.952	40.1	201.7	5.3	6.5	6
				6.4	4
				6.9	5.5
				6.8	4.1
				6.4	7.2
				6.6	7.5
				6.5	6.5
				6.8	3
				6.5	7
				6.2	6
				6.5	5.2
				6.8	5
				6.4	5.1
				6.8	4.5
				6.6	3.5
				6.8	5
				6.4	4.2
				6.2	3.5
				6.4	6.1
				6.7	5.5
				6.4	6.5
				6.1	4.5
				6.3	4.8

Appendix VI
Materials and Equipments

- Map of Manang district
- Plastic bags and rubber bands
- Zipper bags
- Iron pegs
- DBH Tape
- Measuring tap
- Altimeter
- A pH meter
- Clinometers
- Trowel
- Plant cutter
- Field Observation sheets
- Nylon string and plant press.
- Luxmeter