Floristic Composition, Vegetation Structure and Regeneration Status of Kimphe Lafa Natural Forest, Oromia Regional State, West Arsi, South East Ethiopia

By: KEDIR ALIYI

A Thesis Submitted to Jimma University Graduate Program in Partial Fulfillment of the Requirement for the Degree of Master of Science in Biology (Botanical Sciences Stream)

September, 2013
Jimma, Ethiopia

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Acknowledgement

First of all, I would like to thank almighty Allah for his help in all aspects of my life. Next, I have heartfelt thanks, appreciation and respect for my advisors Dr. Kitessa Hundera and Dr. Gemedo Dalle for their guidance and constructive comments for the success of my work. Thank you very much. The way you approach, comment and advice is really appreciated. Next, Dr. Tesfaye Awas, thank you a lot for your help in plant identification at Ethiopian Institution of Biodiversity and thank you all the staff members of the Institute.

I would also like to thank Fajaru Redi, Gemedo Hemeda, Sultan Adem, my brother, Milkesso and all my families for you tired alot with me during data collection.

I also thank Biology Department of Jimma University for financially supporting my study.

Acronyms

ANDFEDO: Arsi Negele District Finance and Economic Development Office

DBH: Diameter at Breast Height

EFAP: Ethiopia Forestry Action Plan

EPA: Environmental Protection Authority

FRA: Forest Rights Act

FDREMWR: Federal Democratic Republic of Ethiopia Ministry of Water Resources

GPS: Geographical Positioning System

IUFRO: International Union for Forestry Research Organization

IVI: Important Value Index

KLNF: Kimphe Lafa Natural Forest

MoA: Ministry of Agriculture

ORSG: Oromia Regional State Government

RD: Relative Density

RF: Relative Frequency

RDo: Relative Dominance

SEPAND: Socio-economic Profile of Arsi Negele District

Ss: Sorensen`s similarity coefficient

UNEP: United Nations Environmental Programme

WBISPP: Woody biomass Inventory and Strategic Planning Project

WHYCOS: World Hydrological Cycle Observing System

WRI: World Resource Institution

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ABSTRACT

Scientific study on floristic composition, vegetation structure and regeneration status of a forest is needed for understanding of forest status to take appropriate conservation measures based on the outcome of studies.This study was conducted on Kimphe Lafa natural forest, which is Dry ever green montane Forest, located in Arsi Negele woreda, West Arsi Zone, Oromia Regional State southeast Ethiopia. The objective of the study was to assess floristic composition, vegetation structure and regeneration status of Kimphe Lafa Natural forest. Systematic sampling method was used to collect vegetation data from one hundred thirty four plots which were 20 m x 20 m for woody plant species and within a plot, 5 m x 5 m was used for seedlings and saplings and 1 m x 1 m was used for herbaceous plants. The sampling plots were placed at every 200 m intervals along the seventeen transect lines laid at 200 m a part. The vegetation analysis was performed using PC – ORD software package. A total of 130 plants species belonging to 100 genera and 56 families were recorded and identified. Fabaceae was the most dominant family represented by eighteen species followed by Asteraceae with ten species and Euphorbiaceae with six species. Six plant communities: Vernonia urticifolia-Croton macrostachyus, Calpurnia aurea-Maytanus abuscura, Ficus sur-Podocarpus falcatus, Justicia schimperiana-Dodonaea angustifolia, Ehretia cymosa-Pterolobium stellatum and *Maytanus arbotifolia-Caucanthus auricalatus were recognized. The densities for mature woody species, seedlings and saplings were 515.7, 1091.8 and 834.7 individuals ha^{-1} respectively. The basal area of the forest was 114.4 m^2 ha^{-1}. Both seedling and sapling of plant species like Ximenia americana, Cordia monoica, Cussonia arborea and Rhus glutinosa were totally absent from the area. The plant species of the forest were prioritized for conservation using population structure and important value indices. Phytogeographical comparison was made among some forests of Ethiopia and Sorenson's similarity coefficients were below 0.5 for all forests in comparison, indicating the presence of low similarities among the forests. The population structure and regeneration status of the forest indicated that there are anthropogenic disturbances in the area and immediate conservation actions have to be implemented for sustainable utilization of the forest.*

Key words/Phrases: *Kimphe Lafa Natural Forest, Dry ever green montan forest, floristic composition, plant community, population structure, phytogeographical comparison, regeneration, Floristic composition, Vegetation structure*

1. INTRODUCTION

Globally, about 30 percent of the land is covered by forests which account about 3952 million hectares (FAO, 2007). However, gradually deforestation continued at rate of 12.9 million ha/year. This is mainly as a result of conversion of forests to agricultural land, expansion of human settlements, utilization of forests for infrastructure and unwise logging practices also exposed the world forest for deforestation (FAO, 2007). In the 1990s, gross deforestation was slightly higher, at 13.1 million ha/year. In Africa, forest cover is estimated to be 650 million ha, constituting about 16.5 percent of the world's forests (FAO, 2001). The major forest types are dry tropical forests in the Sahel, Eastern and Southern Africa, moist tropical forests in Western and Central Africa, subtropical forest and woodland formations in Northern Africa and the southern tip of the continent and mangroves in the coastal zones. These types of forests have a number of international biodiversity hotspots (UNEP, 2012). African forests provide many goods and services. A study in Madagascar has estimated the value of forest products to the local villages to be US$ 200,000. In Ghana, it is estimated that 16-20 percent of the local population's food supply is met from forest products (UNEP, 2012).

East African countries are naturally endowed with variety of plant and animal species. Especially the most diversified plant species is found in East African Mountains. Over 50% of African land is covered by Afromontane vegetation, which is a type of vegetation found on highlands of Africa (Coetzee, 1978). Tropical montane forests are well known among the most hot spot ecosystem on Earth. This diversified ecosystem is under severe condition for they are highly suitable for agricultural purposes (Rodrigues *et al*., 2004).

Ethiopia is found in east Africa between 3°24´and 14°53´ N and 32°42´ and 48°12´ E with a total area of 1,120,000 Kms (MoA, 2000). The altitudinal variation of the country ranges from Afar depression (Kobar Sink), which is 110 m below sea level to Ras Dejen which is 4620 m above sea level. The country's ecological setting is diversified in altitude, climate and ecological features. The flora of Ethiopia is estimated to contain about 6,500- 7,000 species of higher plants, out of which about 12% are endemic species (Gebregziabher, 1991). It has Afromontane vegetation types on the highland areas which cover about 110 million hectare (Bekele, 1993). The relatively early and extensive deforestation in Ethiopia, coupled with cultivation of steep marginal lands, overgrazing and socio-political instability, has resulted in severe land degradation over large areas of the country (WBISPP, 2004).

Actually, having different topographical features and environmental factors enabled the country to have different vegetation types, part from afromontane forest. Forests in Ethiopia are believed to have once covered 40% of the country's land area (FDREMWR, 2001). In the 1990 the coverage of forests was 15.1 million ha and after a decade, in 2000, it was reduced to 13.7 million ha. In 2005, the problem was further aggravated and the forest coverage was reduced to 13 million ha with annual average loss of 140,000 ha. Nowadays, estimated forest cover of the country is 12.3 million ha of which 4.12 million ha or 3.37% is natural forest (FAO, 2010).

The distribution of forests greatly varies within the regions of Ethiopia. Only Oromia Regional State, Southern Nations Nationalities and Peoples Region and Gambella Region account for 95% of the total coverage of the forest (WBISPP, 2004). Of the 95% of the forest coverage contributed by the three regions, Oromia accounts for 50% of the forest. However, the region is estimated to have lost about 31% of its forest due to mainly agricultural expansion (WBISPP, 2004).

Use of forests and forest products should be in a way that could not compromise or harm the coming generation. But, contrarily, as human needs became wider and wider, clearing of forest resources is accelerated. Agricultural expansion, timber production, fuel wood, charcoal and construction materials are among the factors responsible for clearing of forests. This multipurpose clearing of forest have resulted in soil erosion, land degradation, biodiversity loss and ecosystem disturbances which is disturbing the whole ecosystems of the world today (Teketay, 1996). High level of dependency on agriculture, high rate of population growth and non-integrated investment activities are also factors that aggravated deforestation in Ethiopia (Kelbessa and Soromessa, 2008).

The destruction of vegetation and environmental degradation has become issues of national and global concern in recent years. This is because of the fact that declining vegetation cover and depletion of natural resources are closely associated with drought and food shortages that have become major threat affecting the life of millions of people. Unless conservation measures are taken, few remained forest patches will be extinct (Bekele, 1994). Losses of forest resources at an alarming rate have an implication regarding biodiversity, climate, environment and socio-economic status of a country. So, as a conservation method, scientific studies on floristic composition, vegetation structure and regeneration status of a given forest patch is needed for determination of a forest status to take appropriate conservation measures.

Kimphe Lafa Natural Forest is one of the National Forest Priority Areas of Ethiopia under Munessa Shashemene forest and it is one of the remnant Dry ever green montane forests in the country. Ecological assessments of this forest would serve as a base for the planning, sustainable utilization and conservation of this valuable natural resource. For effective management and conservation of this ecosystem of the country, there is an urgent need to develop a successful management plan and this in turn requires detailed baseline information regarding the ecology of the area. The general biodiversity, floristic composition, regeneration and structural analysis of Kimphe Lafa Natural Forest have not yet been investigated. Thus, the current work on floristic composition, diversity, structural analysis and regeneration of the vegetation in the area is believed to contribute a lot for the effective conservation and management of the forest.

1.2. Objectives

1.2.1. General Objective

- To Assess the floristic composition, structure and regeneration status of plant species in Kimphe Lafa Natural Forest

1.2.2. Specific Objectives

- To document the plant species in the study area
- To identify plant community types and diversity, species richness and evenness
- To analyze the structure of the Forest
- To assess the regeneration status of trees
- To assess conservation status of the forest

2. LITERATURE REVIEW

2.1. Forests and Biodiversity

Forests are the most biodiversity rich habitats on Earth and they are critically important for maintaining biological diversity (FAO, 2001). Forests of the world maintained over 50% of the world's biodiversity and of this, natural forests have the highest species diversity and endemism of any ecosystem type (Liaison, 2013). In addition to deforestation, Forest fragmentation has also aggravated the impacts on biodiversity by blocking migration routes and making access easier for further exploitation by humans and entry by invasive species (WRI, 2000). According to Vanclay *et al*., (2001) forest protected areas are one of the keys to the conservation of biological diversity globally. Forests are biologically diverse ecosystems; however, they are increasingly threatened as a result of deforestation, fragmentation, and other stressors that can be linked to human activities (Liaison, 2013).

2.2. Vegetation of Ethiopia

Vegetation is a group of plants in an area (Jennings *et al*., 2003). Having various climate and ecological system enabled Ethiopia to have the most diverse plant and animal species found in forests and woodlands of the country. Many research studies conducted by many researchers have tried to describe the vegetation types of Ethiopia and contributed alot for the current description and categories. Few of them are White (1983), Nigatu and Tadesse (1989), Friis and Tadesse (1990), Kelbessa *et al*., (1992), Friis (1992), Bekele (1994), Demissew *et al*., (1996), Woldu (1999), Friis and Demissew (2001), Woldemariam (2003), Demissew *et al*., (2004), Soromessa *et al*., (2004), Senbeta (2006) and Kelbessa and Soromessa (2008) who described and classified vegetation types of Ethiopia. Based on the results of the studies conducted, various vegetation types of Ethiopia have been grouped into eight general categories. These are Desert and Semidesert Scrubland, Acacia-Commiphora Woodland, Moist evergreen Montane Forest, Low land semi-evergreen forest, Combertum-Terminalia Woodland, Dry evergreen Montane Forest, Afroalpine and Sub-Afroalpine Vegetation and Riparian and Wetland Vegetation. (Kelbessa *et al*., 1992; Demissew *et al*., 1996; Friis and Demissew, 2001; Demissew *et al*., 2004; Demissew and Friis, 2009).

2.3. Forest Biodiversity and its threats in Ethiopia

Forests have great significance in maintaining biological diversities throughout the world. However, this biodiversity rich ecosystem is under severe due to human activities such as agricultural expansion, forest clearance for fire wood, construction materials and timber and charcoal production (Yeshitela, 2001; Yemishaw, 2001; Tesfaye and Teketay, 2005). These temporary benefit oriented deforestation is followed by land degradation and soil erosion which result in biological diversity loss (Woldemariam and Teketay, 2001; Senbeta, 2006; Senbeta and Denich, 2006; Woldemariam, 2008).

In addition, the policy of contemporary Ethiopian government is expanding agro-industry investment and re-settling the population as a mechanism of poverty reduction, thinking that the montane forest land as suitable for agriculture which causes great harm on the few remained forests of the country (Stellmacher and Eguavoen, 2011). At the same time, investors are converting few remained forest of the country to other land use systems like coffee and tea plantation (Bekele and Berhanu, (2001). Studies reported by Teketay, (2001); Yemishaw, (2001); FAO, (2007) indicated that as there is continuous deforestation and land degradation in Ethiopia. Plant biodiversity needs special attention to conserve them from losses for the attention given to the conservation and sustainable use of forest resources are inadequate due to low level of awareness about role of forests in ecosystem services (Denu, 2007). Adequate awareness regarding wise use of natural resources should be given to the whole society so that some very important plant species will be saved from extinction. For example, Hundera and Gadissa (2008) reported that traditional indigenous knowledge on medicinal is forgotten following disappearance of plants with forests.

2.4. Species Diversity, Richness, Evenness and Similarity

Floristic description of given vegetation is described by analysis of species diversity, richness, evenness and similarity. Species richness and species evenness are the two important factors that should be considered while evaluating species diversity. The description of plant communities involves the analysis of species diversity, evenness and similarity (Kent and Coker, 1992). The relative variation within forest communities is interpreted by species diversity (Kent and Coker, 1992). Species richness is the total number of species in a community and can be expressed in a mathematical index to compare diversity between sites and species evenness is the relative abundance of species in a community. These two components of species diversity may be examined separately or combined into some forms of index called diversity index. It is a measure of species diversity in a community.

A commonly used index for measuring the species diversity is the Shannon diversity index (Kent and Coker, 1992). It is essential in investigating taxonomic and ecological values of a habitat (Mueller-Dombois and Ellenberg, 1974). Species evenness index is a function of the frequencies or proportions pertaining to the species; and an index increases when the proportions tend to be equal and decreases when one species tend to dominate the other species in an area. The interpretation of evenness is totally dependent on the richness (Frosini, 2006). Species diversity index provides information about species endemism, rarity and commonness (Frosini, 2006). Diversity indices provide information on community composition and relative abundance of species (Kent and Coker, 1992; Frosini, 2006). The Shannon Weiner diversity index (H') varies between 1.5 and 3.5 and rarely, exceeds 4.5 (Kent and Coker, 1992). It is the most appropriate and the most widely used index for combining species richness and evenness (Krebs, 1999). This diversity index is important for conservation of plant species for it describes ecological processes and come up with appropriate conservation measures (Senbeta, 2006).

2.5. Floristic Composition and Population Structure

Vegetation composition of a given forest ecosystem is different based on the density, height and growth forms of plant species. Population structure is a random distribution of individual species to provide overall regeneration profile of the study species (Shibru and Balcha, 2004). It can be roughly grouped in to three types: Type I, II and III. Type I shows the case in which diameter or height size class distribution of the species displays a greater number of smaller trees than big trees and reductions in number from one size class to the next (Shibru and Balcha, 2004; Eshete *et al.*, 2005). Type II, is characteristic of species that show discontinuous, irregular and periodic recruitment. In this type, the frequency exhibited, for instance, in diameter/height size class causes discontinuities in the structure of the population as the established seedlings and saplings grow in to larger size classes. Type III, reflects a species whose regeneration is severely limited for some reasons (Peters, 1996). Relevant information regarding population structure is useful for determination of past environmental condition the plant species passed through and used to predict the future action of population species of an area (Peters, 1996). Hence, knowledge about the category in which the study of species falls is important issue before planning to utilize the resources.

So, analysis of population structure has something to do with the future management of the key and untapped resources of Ethiopia. Information on population structure helps to respect the healthy regeneration of the species under utilization (Gebrehiwot, 2003). Various vegetation types support high endemism and often support high biomass of plant communities (IUCN, 1999). Vegetation data is often voluminous and seemingly disorganized. Thus, the complete data set cannot be easily interpreted unless summarized; retaining the information in the given data. Application of precise numerical techniques to a data matrix having vegetation and other environmental data is required for vegetation analysis (Eshete *et al.*, 2005).

2.6. Plant Community Types

Classification of plant community types is the basic science for many years for understanding of plant composition, distribution and classification into different plant community types (Kormondy, 2005). Many authors have defined plant communities. According to Kent and Coker (1992), Plant communities are an assemblage of functionally similar species populations that occur together in time and space. For the size of the community is not standard and fixed, it ranges from small sized area to large ecosystem like grass land or forest ecosystem (Reiss and Chapman, 2008). Plant community structure is composed of several important features such as number of species, relative abundance, and types of species comprising a plant community. The structural components of plant community are determined by attributes such as physical environment, community size, and longevity of species.

Generally for understanding detail information regarding the vegetation of an area, it is important to understand basic concepts like plant species distribution, floristic composition and vegetation structure. These concepts are estimated based on the plant community types (Mueller-Dombois and Ellenberg, 1974). They also stated that the floristic composition of vegetation includes species occurring within a plant community. However, most plant communities consist of so many different species which are not unique to a given community. Hence, it is common to use the dominant species in naming plant communities (Kent and Coker, 1992).

2.7. Frequency and Plant Important Value Index

Frequency is the probability of finding species in quadrats. According to (Eshete *et al.,* 2005) frequency is a measure of revealing the distribution of species of an area which also indicate habitat preference of species. It indicates how the species are dispersed and is an ecological meaningful parameter. In other words, it gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992). The important value index (IVI) permits a comparison of species in a given forest type and depict the sociological structure of a population in its totality in the community. It often reflects the extent of the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992; Gebrehiwot, 2003; Shibru and Balcha, 2004). It is also important to compare the ecological significance of a given species. Therefore, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices.

Important Value Index compares species a given forest and deal with the dominance, occurrence and abundance of a given species in relation to other species in an area (Kent and Coker, 1992). Hence, it is significant index for summarization of vegetation characteristics and ranking species for management and conservation methods. Species with lower important value index needs high conservation measures and those with higher important value index needs measure like monitoring management.

2.8. Techniques of Plant Data Collection

The community classification approaches include physiognomic approach, dominance types, Braun-Blanquet associated approach and numerical approach (Oksanen, 2003). Quantitative community ecology is one of the most challenging branches of modern environmetrics. Community ecologists sometimes could need to analyze the effect of multiple environmental factors on dozens of species simultaneously. Thus vegetation ecologists have employed a variety of multivariate approaches to study the complex nature of plant communities with the general objectives of summarizing large complex data sets obtained from community samples, aiding in the interpretation of the data and the generation of hypotheses about community structure and variation (Gauch and Whittaker, 1972; Gauch, 1982). The descriptive nature and functional characteristics of vegetation, results from the interaction between the properties of the plant species it contains and the environment in which they occur.

Many studies pointed out that among the multivariate approaches classification is one of the main methods. Classification continues to contribute materially to the elucidating of the complexities within communities. Therefore, the choice of the method to be used depends on the ecological question to be answered (Gauch and Whittaker, 1972; Gauch, 1982).Classification is the placement of species and/or sample units in to groups. It aims at grouping individual stands into categories. The members of each category have in common a constellation of attributes, which serve to set them apart from members of another category (Greig-Smith, 1979). Stands which are closely similar with one another form one class, which is separated from other classes that also consist of similar stands (Greig-Smith, 1979). Classification or putting samples into hierarchical classes is often useful when one wishes to assign names to, or to map, ecological communities. In classification similar samples are combined in the same category, but in ordination the objective is to consider sample differences rather than similarities so as to dispose the samples in a linear or multi dimensional network that reveals the relationships between the samples and their environment (Kumar, 1981).Vegetation classification attempts to identify discrete, repeatable classes of relatively homogenous vegetation communities or association about which reliable statements can be made. Classification assumes either that natural vegetation groupings (communities) do occur or that it is reasonable to separate a continuum of vegetation in vegetation composition and/or structure in to a series of arbitrary classes.

2.9. Regeneration of Woody Plant Species

Analyzing regeneration status of a forest area is important for prediction of both current and future status of forests. The population structure characterized by the presence of sufficient population of seedlings, saplings and adults indicates successful regeneration of forest lands, and the presence of saplings under the canopies of adult trees also indicates the future composition of a community (Teketay, 2002). The study of regeneration of forest trees has important implications for the conservation and management of natural forests, and is one of the thrust areas of forestry (Tesfaye and Berhanu, 2006).

Regeneration of seedling population from the available seed relies on environmental factors. As a result, a good understanding of natural regeneration of any plant community requires information on the presence and absence of persistent soil seed banks or seedling banks, quantity and quality of seed rain, durability of seeds in the soil, losses of seeds to predation and deterioration, triggers for germination of seeds in the soil and sources of re growth after disturbances (Teketay, 2002). According to (Watkinson, 1997; Tesfaye and Berhanu, 2006) in order to understand plant population or species, it is necessary to characterize the strategies adapted in both regenerative (immature) and established (mature) stages in their life cycle. Forest plants have been reported to possess various pathways of regeneration. Studies on natural regeneration and seedling ecology can also provide options to forest development through improvement in recruitment, establishment and growth of the desired seedlings. Also, studies on tree seedling density, their rate of mortality and damage help in the understanding the status of species and natural regeneration (Hubbel *et al.*, 1986).

3. MATERIALS AND METHODS

3.1. Location and Description of the Study Area

The study was conducted on Kimphe Lafa natural forest, located in Arsi Negele district, West Arsi Zone, Oromia Regional state, in south Eastern part of Ethiopia. The forest is found at 230 kms away from Addis Ababa to the southeast and found at 30 Kms to the Northeast from the capital district town, Arsi Negele and located at the border of Lake Langano on the east direction. It is approximately located between 38^{0}4' and 8^{0}32'E and 7^{0}3' and 2^{0}20'N (Figure 1) and extends over an altitudinal range from 1557-1650 m with the total area of 449.6 ha.

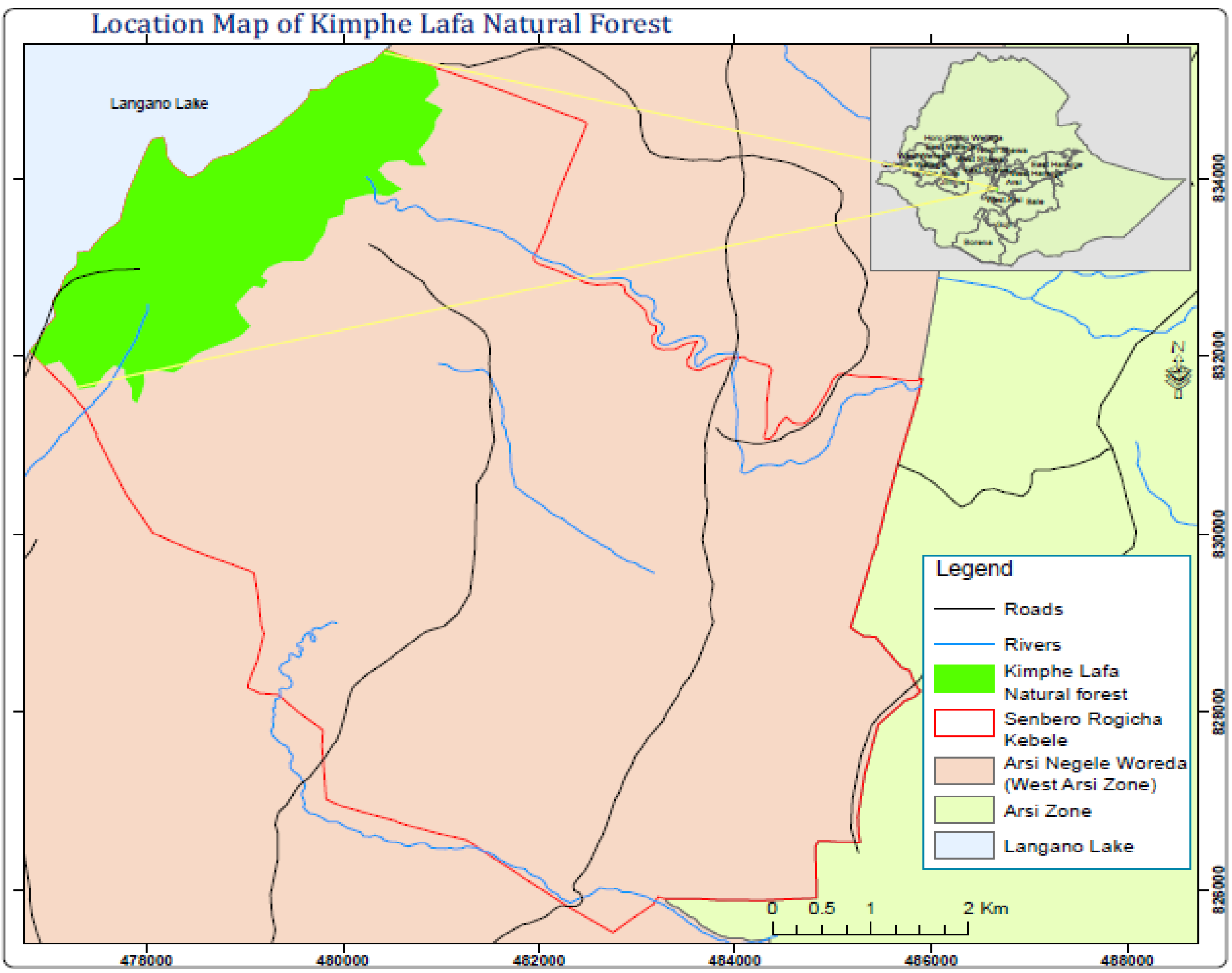


Figure 1: Map of Arsi Negele District and the Kimphe Lafa Natural Forest

3.1.1. Climate and Topography

Arsi Negele district is divided into 3 major climatic zones based on altitude. These are low, mid and high altitude climatic zones. The high altitude climatic zone occupies the largest area followed by mid and low altitude climatic zones. Average annual temperature varies from 16-25^{o}C while rainfall varies between 500-1500 mm (ORS, 2012). About 80% of the district is sub-tropical, while 20% belongs to the temperate agro-climatic zone (SEPAND, 2011). The topography is slightly undulating in the highlands and almost flat in the lowlands. Except the southeastern part, in which Duro mountain is found, which is 3095 m, most of the district's elevation is between 1500 and 2300 m (SEPAND, 2011).

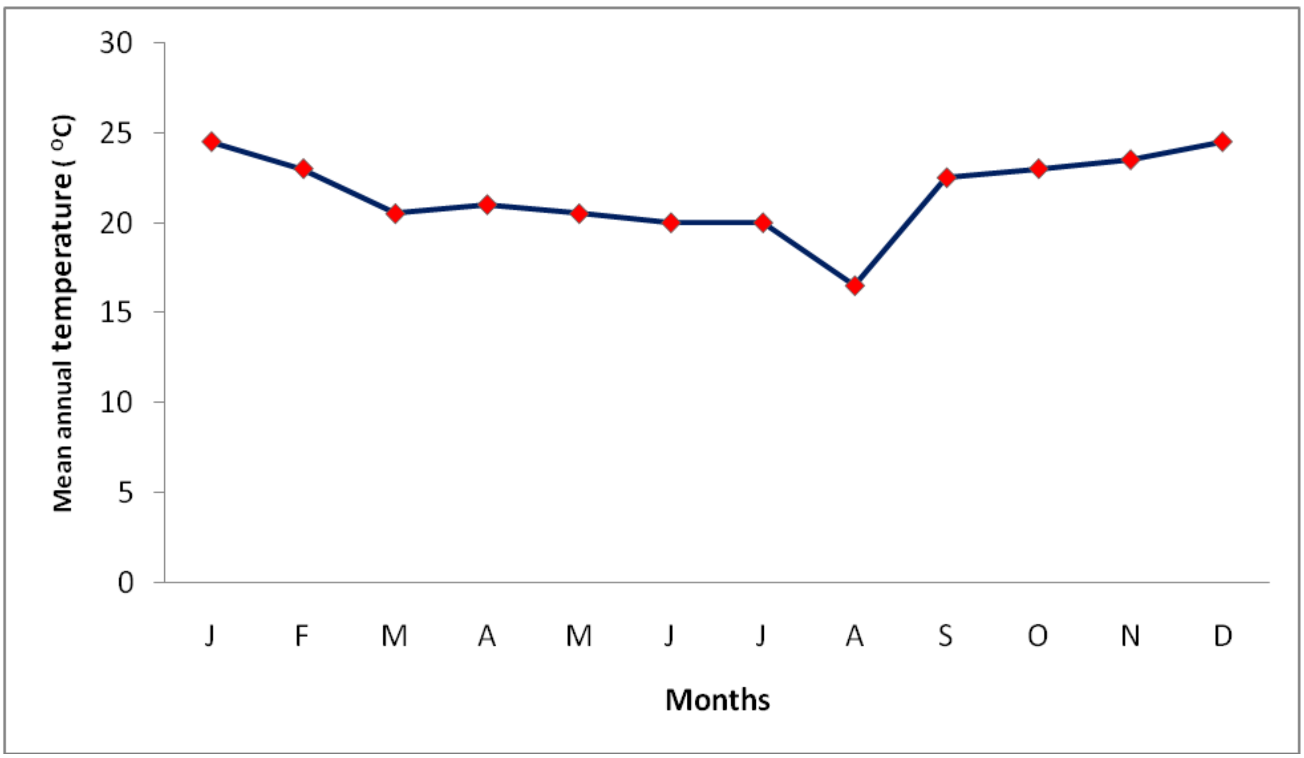


Figure 2: Distribution of Mean Annual Temperature of Five Years in the Study site (From 2008-2012). (Arsi Negele meteorological service agency, Kersa station, 2013).

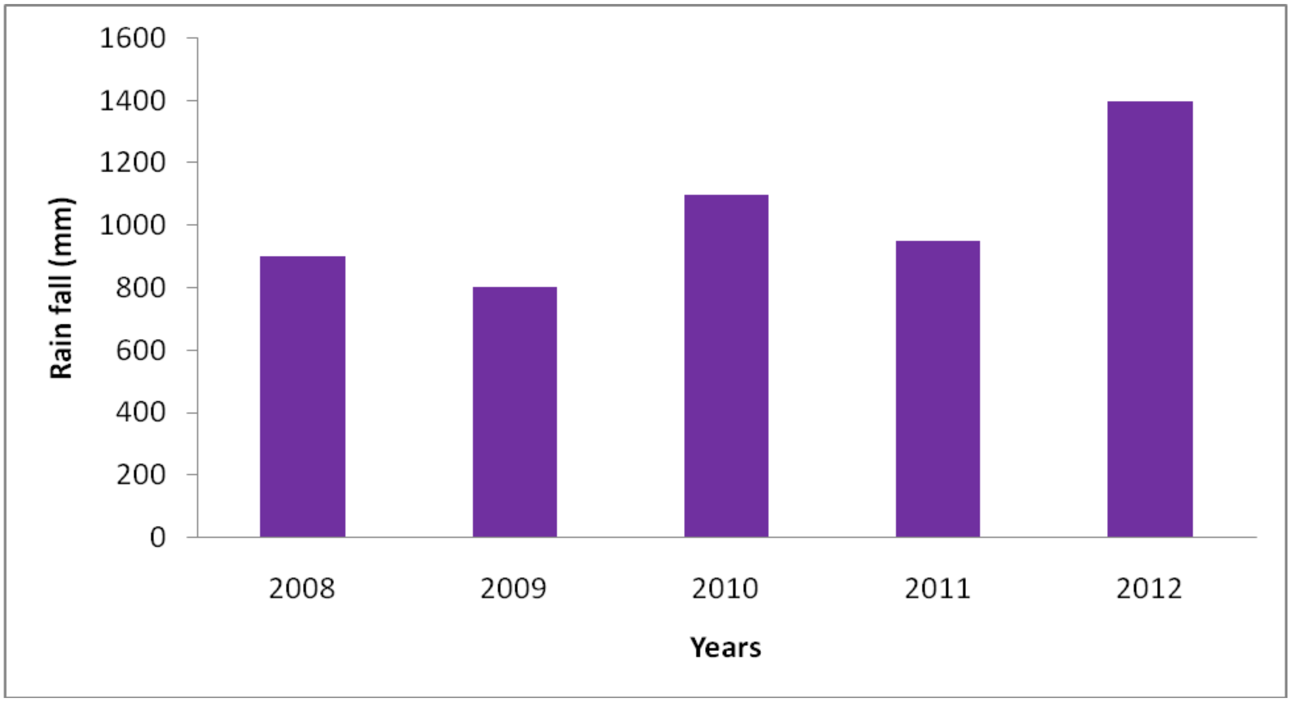


Figure 3: Distribution of Rainfall of Five Years in the Study site (mm)
(From 2008-2012). (Arsi Negele meteorological service agency, Kersa station, 2013).

3.1.2. Geology and Soil

Rift Valley is one of the defining geological features of the district which pass through the middle of the country from Red Sea to Kenya. Sand, soda ash, diatomite and salt are found in the low altitude climatic zone. These construction and industrial materials are being mined for different purposes. From construction materials, sand is the most exploited while soda ash is the widely exploited industrial mineral in the district. Andosol soil type covers about 52.2% of Arsi Negele, while Nitosols cover the remaining 47.8% (ORS, 2012).

3.1.3. Vegetation

According to some oral tells from elders, hundred years ago most parts of West Arsi zone was covered with dense natural forests. Nowadays, due to increase demands for farm land, fire woods, charcoal production and construction materials as a result of population growth, the forests almost have been lost. Currently, there are only Kofele, Munessa and very little natural forests are found in the zone.

3.1.4. Population

The district has a total population of 310,537. Of this 51 percent of the populations are females while the rest 49 percent are males. According to the District Information Desk, the district has 43 Rural Kebeles and 4 Urban Kebeles .The urban population of the district is 70,862 (22.8%) and 239,675 (77.2%) is rural population (Arsi Negele Health Bureau, 2013).

The ethnic groups in Arsi Negele are the Oromo (85.92%), the Amhara (7.69%), the Kambata (2.73%), and the Soddo Gurage (1.08%) and other ethnic groups are 2.58% of the population. 83.65% the population speaks Oromiffa language, 11.89% speak Amharic, 2.44% speak Kambata language and the remaining 2.02% speak other languages. 68.86% the population follow Islamic religion, 20.2% follow Ethiopian Orthodox Christianity, 8.99% follow Protestant and 1.04% follow Catholic religion (ANDFEDO, 2013).

3.1.5. Land Use and Agriculture and livestock rearing Practices

The total area of the district is about 1838 km^2 of which 52% is arable, 30% water bodies, 5% forest and 13% grazing and others. Arsi Negele is characterized by crop-livestock based farming systems. Maize, wheat and teff are the most important cereal crops grown in the district (ORS, 2012). The population of the area, especially that of rural depends on animal husbandry and crop production. Most farming activities (Ploughing, trashing and transporting) are done by means of livestock in the woreda. The woreda has different livestock population. The major livestock's feeds are grazing land and crop residual. There is declining of pastureland mainly due to the expansion of farm land.

Table 1: Livestock Population of Arsi Negele woreda

Serial no.	Types of Livestock	Numbers	Percent
1	Cattles	239,067	40.8
2	Sheep	65,300	11.1
3	Goat	124,839	21.3
4	Donkeys	39,540	6.7
5	Horses	14,764	2.5
6	Mules	646	0.1
7	Camels	48	0.008
8	Poultry	102,050	17.4

Source: Arsi Negele district Agriculture and Rural Development Offices, (2013)

3.2. Reconnaissance Survey

Reconnaissance survey was conducted for three days, from February 7-10, 2013 across Kimphe Lafa Natural forest in order to get an impression of vegetation patterns and determine representative sampling sites. Vegetation data collections were made from February 11 to March 21, 2013.

3.3. Sampling Design

Systematic sampling design was used to collect vegetation data from the study site. Appropriate transect lines and sampling plots were made based on the total area of the study site for vegetation data collection. Vegetation data was collected from a total of one hundred thirty four plots. The sampling plots were placed at every 200 m intervals along the seventeen transect lines laid at 200m apart. The first sampling plot was established systematically which was 20 m x 20 m (400 m^2) to collect data on woody plant species. From each established sample plot, five subplots, two at each corners and one at the center of a plot each having 5 m x 5 m (25 m^2) established to collect data for seedlings and saplings for regeneration analysis and another five subplots having 1 m x 1 m were also established following the same procedure for data collection of herbaceous plants (Singhal, 1996).

3.4. Floristic Data Collection

All plant species including trees, shrubs, herbs, lianas, epiphytes and ferns in each quadrat were recorded. Additionally, plant species occurring outside quadrats but inside the forest were also recorded only as a list, but not used for data analysis. In the study area, physiographic variables such as altitude, latitude and longitude were measured for each quadrat using GPS. The plant specimens collected were dried in the dryer, kept in a deep freezer for 72 hours and identified referring to the volumes of Flora of Ethiopia and Eritrea and comparing with authentically identified specimens (Hedberg and Edwards, 1989 and 1995; Edwards *et al.*, 1995, 1997, 2000; Hedberg *et al.*, 2003, 2006; Tadesse, 2004) at the Ethiopian Institute of Biodiversity and finally brought to Jimma University and deposited in Jimma University herbarium.

3.5. Structural Data Collection

Each individuals of the woody species in the plots were counted, circumference at breast height of all trees and shrubs having circumference greater than 7 cm was measured and later changed into diameter at breast height (DBH) and plant species that have height ≥ 2 m were measured, recorded and grouped into height classes. For analysis of regeneration, seedlings and saplings were also counted. Seedling, sapling and mature individual are defined as plants that have height < 1 m, 1-3 m and > 3 m respectively (Singhal, 1996).

3.6. Data Analysis

Of the total 130 plant species recorded from the study area, eight species were collected outside the sampling plots. Hence, one hundred twenty two plant species were used for structural data analysis.The Diameter at Breast Height (DBH), Basal area, Tree Density, Height, Frequency and Important Value Index were used for description of vegetation structure.

3.6.1. Diameter at Breast Height (DBH): DBH measurement was taken at about 1.3 m from the ground using a measuring tape for woody plant species that have circumferences greater than 7 cm (DBH ≥ 2.5 cm). DBH is calculated by the formula:

$$DBH = \frac{CBH}{\pi}$$

Where CBH is Circumference at Breast Height and Π is 3.14

3.6.2. Basal Area is the cross-sectional area of all of the stems in a stand at breast height (1.3 m above ground level). This basal area per unit area is used to explain the crowdedness of a stand of forests. It is expressed in square meter/hectare (Mueller-Dombois and Ellenberg, 1974). Its area is also used to calculate the dominance of species.

Basal area = $\sum (d/2)^2$ where D is diameter at breast-height

$$Relative\ Dominance = \frac{Dominance * of\ tree\ species}{Dominance\ of\ all\ species} X\ 100$$

Where Dominance* is mean basal area per tree times the number of tree species

3.6.3. Woody Species Density: Density is defined as the number of plants of a certain species per unit area. It is closely related to abundance but more useful in estimating the importance of a species. The number of individuals of each trees and shrubs (woody species) was counted in the total plots of 20 m x 20 m. All the dominant trees and shrubs were counted. The number of samples within which a species found (frequency) and the number of individuals of a species in a sample (abundance) was calculated for all trees and shrubs species recorded in the plots. Finally, the average number of individuals of each tree and shrub species was converted into individuals per hectare for each community as indicated in Kent and Coker (1992).

$$Density = \frac{Total\ Number\ of\ all\ trees}{Sample\ Size\ in\ Hectare} \times 100$$

$$Relative\ Density = \frac{Number\ of\ Individuals\ of\ Tree\ Species}{Total\ Number\ of\ Individuals} \times 100$$

3.6.4. Frequency: Frequency is defined as the probability or chance of finding a plant species in a given sample area or quadrat (Kent and Coker, 1992). It is calculated with the formula:

$$Frequency = \frac{Number\ of\ plots\ in\ which\ species\ occur}{Total\ number\ of\ plots} X\ 100$$

The frequencies of the tree and shrub species in all one hundred thirty four quadrats were computed. The higher the frequency the more important the plant is in the community. A better idea of the importance of a species with the frequency can be obtained by comparing the frequency of occurrences of all the tree species present. This gives relative frequency and is calculated by the formula:

$$Relative\ Frequency\ = \frac{frequency\ of\ tree\ species}{frequency\ of\ all\ tree\ species} x100$$

3.6.5. Importance Value Index (IVI): Importance value index combines data for three parameters (relative frequency, relative density and relative abundance). It is used to compare the ecological significance of species (Lamprecht, 1989). The importance value index (IVI) for each woody plant species was calculated using the formula indicated below (Kent and Coker, 1992).

Importance Value Index = Relative density + Relative frequency + Relative dominance

3.6.6. Height: is a straight forward parameter used for direct measurement purposes. The Tree heights were classified into different classes based on their height. The height of trees and shrubs in the area was classified into seven height classes as. Class I) 2-5 m, Class II) 6-10 m, Class III) 11-15 m Class IV) 16-20 m, Class V) 21-25 m, Class VI) 26-30 m, Class VII) >30 m.

3.7. Plant Community Analysis

Hierarchical cluster analysis (classification) was made using PC-ORD windows version 5 (McCune and Mefford, 1999; McCune and Grace, 2002) based on the abundance of the species (number of individuals). The identified groups were tested for the hypothesis of no difference between the groups using the multi-purpose permutation procedure (MRPP). Species indicator value calculated is used to detect environmental conditions for different species (Dufrene and Legendre, 1997).

3.8. Plant Diversity Analysis

Shannon - Wiener (1949) index of species diversity was applied to quantify species diversity richness, and evenness. This method is the most widely used approaches in measuring the diversity of species. The two main techniques of measuring diversity are species richness and evenness. Richness is a measure of the number of different species in a given site and can be expressed in a mathematical index to compare diversity between sites. Species richness index has a great importance in assessing taxonomic, structural and ecological value of a given habitat. Evenness is a measure of abundance of the different species that make up the richness of the area. Species diversity shows the product of species richness and evenness. Species diversity indices provide information about species endemism, rarity and commonness (Mueller-Dombois and Ellennberg, 1974).

Shannon-Wiener diversity index is calculated as follows.

$$H' = -\sum_{i-1}^{s} pilnpi$$

Where,

H' = Shannon diversity index

S = the number of species

Pi = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of total cover and ln = log base n

Evenness (J) which is equal to H/Hmax is a measure of the relative abundance of the different species making up the richness of an area. Evenness compares the similarity of the population size of each of the species present. Where, H=evenness, H max=lnS.

3.9. Phytogeographical Comparison

The comparison of Kimphe Lafa Natural Forest with other ten forests in Ethiopia was made and the Sorensen's similarity coefficient (Ss) was used for it is used to measure similarities between two forests. Sorensen's coefficient is calculated using the formula:

Ss =2a / 2a + b + c

Where a = number of species common to both habitats in comparison

b = number of species present in the first habitat and absent from the second

c = number of species present in the second habitat and absent from the first

3.10. Regeneration of woody species in the Forest

For determination of regeneration status of KLNF, counting method was used and all the seedlings and saplings found in each established quadrats were counted and recorded. The ratio of seedlings to adult individuals of woody species, seedling to saplings and sapling to mature individuals was calculated. The total density of seedling of woody species as well as the densities of tree, shrub and liana species was also calculated. For setting priority, some selected tree species in the study area were grouped into different groups. For each woody species, regeneration pattern was expressed and analyzed. Based on the number of seedlings and saplings of woody plant species counted from the total plots, they were divided into five classes. This is done for prediction of which plant species could be the dominant in the future, which plant species need special conservation measures and which plant species is in risk of extinction.

4. RESULTS AND DISCUSSIONS

4.1. Floristic Composition

A total of 130 plant species were identified and documented (Appendix 1). Of the total plant specimen, forty five species (34.62%) were trees, twenty three species (17.69%) were shrubs, thirty three (25.38%) species were herbs, fourteen (10.77%) species were climbers, six species (4.62%) were lianas, eight species (6.15%) were epiphytes and one species (0.77%) was fern (Figure 4).

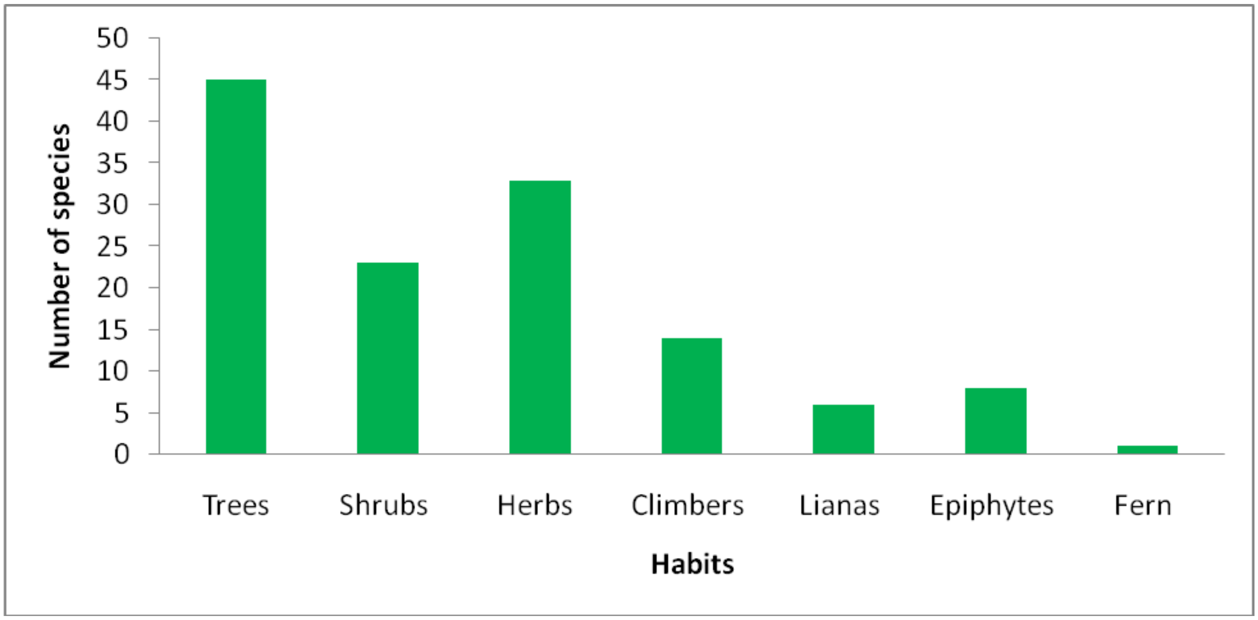


Figure 4: Growth forms and number of plants species in KLNF

The identified plant species belong to 100 genera and 56 families (Appendix 2). Eight plant species were collected outside the sampling plots and they were used only to complete the floristic list. These were: *Balanites aegyptiaca, Crepis foitida, Drynaria volkensii, Maerua triphylla, Momordica foetida, Oxalis radicosa, Ranunculus maltifidus and Guizotia abyssinica.*

Fabaceae was the most dominant family in the forest, represented by 18 species (32.14%) followed by Asteraceae with 10 species (17.86%), Euphorbiaceae 6 species (10.71%), Celasteraceae, Capparidaceae, Boraginaceae, Moraceae and Solanaceae each with 5 species (8.93% each), Conlolvulaceae and Orchidaceae each with 4 species (7.14% each) (Table 2) and the rest families were represented by 1 or 2 species.

The forest has low number of species compared to similar forests like Denkoro forest (Ayalew *et al*., 2006), Egdu forest (Tilahun, 2009) and Gedo forest (Kebede, 2010), which reported 174, 219 and 235 species respectively. This may be due to high disturbance of the forest as a result of anthropogenic effects.

Table 2: The most dominant families and plant species in KLNF

Families	**No. of species**	**Percentage (%)**
Fabaceae	18	32.14
Asteraceae	10	17.86
Euphorbiaceae	6	10.71
Celasteraceae	5	8.93
Capparidaceae	5	8.93
Boraginaceae	5	8.93
Solanaceae	5	8.93
Moraceae	5	8.93
Conlolvulaceae	4	7.14
Orchidaceae	4	7.14

Out of 130 identified plant species, 74 were woody plant species encountered on 134 sample plots (5.36 ha). These 74 woody plant species with DBH ≥ 2.5 cm belong to 34 families and 54 genera. Family Fabaceae was the most dominant with 15 species (20.27%); Capparidaceae, Moraceae and Celasteraceae; Boraginaceae, Euphorbiaceae and Oleaceae were the second and the third dominant woody plant species each with 5 species (6.76% each) and 3 species (4.05% each) respectively from study area.

4.2. Vegetation Community Classification

Based on the cluster analysis, six plant community types were recognized from data matrix of 122 species and 134 sample plots (Figure 5). Species having high indicator value (P*<0.05) were considered as indicator species in their community types and were used to name community types (Table 3). This indicator species are those that can be observed easily being widely distributed throughout the forest. The six plant communities obtained from the study site were: I) *Vernonia* *urticifolia-Croton macrostachyus*, II) *Calpurnia aurea-Maytanus abuscura*, III) *Ficus sur-Podocarpus falcatus*, IV) *Justicia shimperiana-Dodonaea angustifolia*, V) *Ehretia cymosa-Pterolobium stellatum* and VI) *Maytanus arbotifolia-Caucanthus auricalatus* (Table 3).

Table 3: Species in their Communities and their P*value

(Bold P*value indicate indicator species at P*<0.05).

Community Types	Species Name	P* Value
Community I	*Mimusops kummel*	0.1514
	Vernonia urticifolia	**0.0002**
	Croton macrostachyus	**0.0096**
	Hypoestes forskaolii	**0.0346**
Community II	*Calpurnia aurea*	**0.0002**
	Celtis africana	0.068
	Maytenus abscura	**0.0258**
Community III	*Podocarpus falcatus*	**0.0008**
	Ficus sur	**0.0004**
	Euphorbia depauperata	0.1724
Community IV	*Justicia schimperiana*	**0.0002**
	Dodonaea angustifolia	**0.0004**
	Achyranthes aspera	**0.0192**
	Tragia brevipes	**0.013**
Community V	*Pterolobium stellatum*	**0.0424**
	Ehretia cymosa	**0.0468**
	Neckera remota	0.1798

Table 4: Continued…

Community VI	*Caucanthus auricalatus*	**0.0318**
	Maytenus arbutifolia	**0.0002**
	Acalypha crenata	**0.0004**
	Cynoglosum geometricum	**0.0144**

4.2.1. *Vernonia urticifolia-Croton macrostachyus* Community type

This community is located between the altitudinal ranges of 1559 and 1650 m a.s.l. It was represented by 46 plots and 34 species (Appendix 3). Among the indicator plant species used in the naming of the community; *Vernonia urticifolia* and *Croton macrostachyus* were the dominant species in the shrub and tree layer of the community respectively and *Hypoestes forskaolii* was the dominant species in herb layer. Some of the plant species found in the community were; *Olea auropaea, Albizia grandibracteata, Mimusops kummel, Maytenus senegalensis, Vernonia urticifolia, Acacia tortolis, Croton macrostachyus, Ficus vasta, Acacia abyssinica, Acacia seyal, Phytolacca dodecandra* and *Capparis sepiaria.*

4.2.2. *Calpurnia aurea-Maytanus abscura* Community types

This community type was found between altitude of 1587 and 1608 m a.s.l. and represented by 14 plots and 24 species (Appendix 3). *Calpurnia aurea* and *Maytenus abscura* were the dominant shrub layer of the community type. The common plant species found in this community type were *Cordia africana, Ilex mitis, Solanum giganteum, Celtis africana, Bersama abyssinica, Croton dichogomas, Currisa spinarum, Syzygium guineense, Ficus sycomorus, Ficus* sp., *Cordia monoica, Hibiscus macranthus, Cadaba farinose, Nephrolepis exaltata, Zehneria scabra, Lannea schimperi, Senna didymebotry, Pappea capensis, Aerangis brachycarpa, Helinus mystacinus* and *Tridactyle bicaudata*.

Plate 1: *Calpurnia aurea* dominating the lower layer of the forest in the community (Photo by Kedir Aliyi, 2013).

4.2.3. *Podocarpus falcatus- Ficus sur* Community type

The community was found between 1597 and 1619 m a.s.l. and represented by 23 plots and 15 species (Appendix 3). *Podocarpus falcatus and Ficus sur* were the dominant tree species of this community types. *Sonchus asper, Senna petersiana, Ziziphus mucronata, Acacia senegal, Sesbania sesban, Acokanthera schimperi, Acacia mellifera, Phoenix reclinata, Acacia etbaica, Datura stramonium, Stephania abyssinica, Euphorbia depauperata* and *Ipomoea obscura* were the common plant species in the community.

Plate 2: *Podocarpus falcatus* community type from the edge of the forest
(Photo by Kedir Aliyi, 2013).

4.2.4. *Justicia schimperiana-Dodonaea andustifolia* Community type

This community was distributed between 1588 and 1600 m a.s.l. and contained 14 plots and 17 plant species (Appendix 3). *Justicia schimperiana* and *Dodonaea angustifolia* were the dominant shrub layer of the community; *Achyranthes aspera* was the dominant species in the herb layer and *Tragia brevipes* was the dominant species in the climber layer of the community. The other plant species comprised in this community types were; *Ocimum urticifolium, Englerina woodioides, Carduus schimperi, Psydrax schimperiana, Dombeya torrida, Ficus thonningii, Olea capensis, Pittosporum viridiflorum, Dolichos sericeus,Vernonia amygdalina, Rytigynia neglecta, Anagallis arvensis* and *Rubus apetalus.*

4.2.5. *Ehretia cymosa- Pterolobium* Community type

The community was distributed between altitudinal range of 1590 and 1616 m a.s.l. and had 28 plots and 17 plant species (Appendix 3). The plant species distributed in the community were; *Ricinus communis, Solanum incanum, Grewia bicolor, Grewia ferruginea, Ehretia cymosa, Delonix* *elata, Opuntia ficus-indica, Nicandra physaloides, Neckera remota, Cucumis dipsaceus, Kalanchoe marmorata, Ipomoea eriocarpa, Amaranthus caudatus, Ocimum lamiifolium, Pterolobium stellatum, Microcoelia globulosa* and *Sonchus oleraceus.*

4.2.6. *Maytanus arbutifolia- Caucanthus auricalatus*

This community was found between altitudinal variation 1592 and 1638 m a.s.l. and contained 9 plots and 15 plant species (Appendix 3). *Maytenus arbutifolia* was the dominant species in the shrub layer, *Caucanthus auricalatus* was the dominant species in the climber layer and *Acalypha crenata* and *Cynoglosum geometricum* were the dominant species in the herb layer. The other plant species found in this community were; *Rhoicissus tridentata, Desmodium dichotomum, Diospyros abyssinica, Cynoglossum lanceolatum, Convolvulus arvensis, Hippocratea africana, Rhus glutinosa, Teclea simplicifolia, Cussonia arborea, Usnea africana* and *Persicaria senegalensis.*

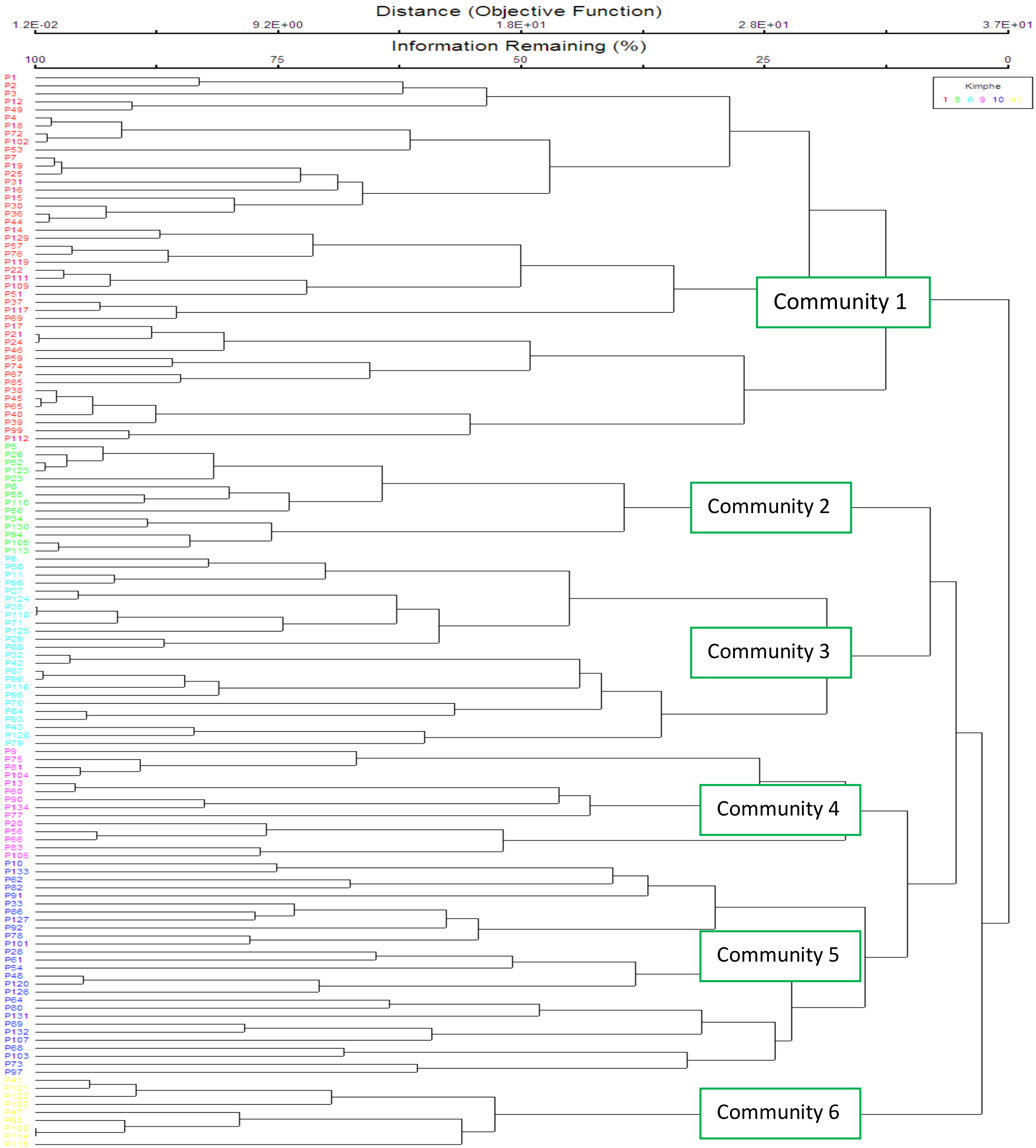


Figure 5: Dendrogram of the vegetation data obtained from the hierarchical cluster analysis

4.3. Species Diversity of the Plant Community Types

The Shannon-Weiner diversity index computed for the six community types (Table 4) indicates that community type 6 is the most diverse and has the most even distribution of species which implies that the community has relatively less anthropogenic intervention. Community type III has the least diversity index with the least number of species. Community type I has the highest number of species but with the least species evenness for the community type was dominated by only *Vernonia urticifolia* and *Croton macrostachyus*. According to Kent and Coker (1992), the Shannon-Weiner index is the most frequently used for the combination of species richness and relative abundance. Shannon-Weiner diversity index usually lies between 1.5 and 3.5 even though there are cases where the value could have more than this values (Pielou, 1969). Hence, the value of Shannon -Wiener diversity index of study area was found in between 1.73 and 2.37, which was inline with the given ranges (Table 4). The higher the value of J, the more evenness of species distribution in its community. Thus, community type VI has the highest even distribution whereas community type I has the least even distribution of species.

Table 5: Shannon-Weiner Diversity Index (H') and evenness (J) for the six community types of KLNF

Communities	Altitude (m)	Number of Species	Diversity index (H')	H'max	Species evenness (J)
1	1559-1650	34	2.17	3.53	0.61
2	1587-1608	24	2.31	3.18	0.73
3	1597-1619	15	1.73	2.71	0.65
4	1588-1600	17	2.27	2.83	0.80
5	1590-1616	17	2.31	2.83	0.82
6	1592-1638	15	2.37	2.71	0.87

4.4. Vegetation structure

4.4.1. Tree density

The density of trees and shrubs is expressed as number of tree or shrub individuals per unit area. Density parameter is an important parameter for forest evaluation and also helpful for determining regeneration status of a forest (Quackenbush *et al*., 2000). The total density of individual trees and shrubs of Kimphe Lafa Natural Forest with DBH ≥ 2.5 cm was 533.2 ha^{-1} and those with DBH below 10 cm, between 10 and 20 cm and above 20 cm were 213.99, 183.96 and 135.26 ha^{-1} respectively (Table 5).

Table 6: Density of individual tree and shrub species with DBH <10 cm, between 10 and 20 cm, and ≥ 20 cm and their percentage coverage in the forest

DBH (cm)	Density $^{-1}$	Percentage (%)
< 10	213.99	40.13
10-20	183.96	34.50
≥ 20	135.26	25.37

According to Grubb *et al*., (1963) the ratio of density of woody trees and shrubs with DBH between 10 cm and 20 cm and greater than 20 cm is taken as a measure of size class distribution of plants. Tree and shrub individuals with DBH between 10 and 20 cm represents medium-sized tree and shrub species and individuals with DBH greater than 20 cm represents large-sized tree and shrub species. According to this, the ratio of medium-sized to large sized (183.96:135.26) was 1.36 for Kimphe Lafa Natural forest. This shows that the proportion of medium-sized individuals (DBH between 10 and 20 cm) of trees and shrubs is greater than large-sized individual trees and shrubs which in turn indicate that Kimphe Lafa Natural Forest is not in a good conservation status as a result of anthropogenic disturbances to the forest. The reason behind this is that relatively, local communities prefer cutting of large-sized trees and shrubs as they are more needed for multipurpose, especially for timber production and construction materials.

Tree densities with DBH greater than 10 and 20 cm in Kimphe Lafa Natural Forest were compared with that of some forests in Ethiopia (Table 6).

Table 7: Comparison of tree/shrub densities with DBH between 10 and 20 cm and > 20 cm of KLNF with other ten forests in Ethiopia

Forest	10<DBH>20(X)	DBH>20(Y)	X/Y	Authors
Menagesha	529	198	2.67	Beche (2011)
Dodola	521	351	1.5	Hundera *et al*., (2007)
Alata- Bolale	365	219	1.7	Enkossa (2008)
Gedo	832	464	1.79	Kebede (2010)
Magada	608	332	1.8	Bekele (2005)
Egdu (MAM)	155	197	0.8	Tilahun (2009)
Denkoro	526	285	1.9	Ayalew *et al.*, (2006)
Bibita	500	265.6	1.9	Denu (2007)
Chato	333	194	1.71	Abdena (2010)
Chilimo	372.8	252	1.47	Alemu (2011)
Kimphe Lafa	**183.96**	**135.26**	**1.36**	**(Present study)**

The ratio of tree and shrub densities (X/Y) shows that there are similarities between Dodola, Chilimo and Kimphe Lafa Natural Forest. Based on the value of density ratio, Kimphe Lafa Natural Forest has higher number of medium-sized individual trees and shrubs than Egdu (Menadesh Amba Mariam). All the rest forests in comparison have trees and shrubs density value greater than that of Kimphe Lafa Natural Forest which means that the forests are dominated by trees and shrubs with DBH of lower classes. The possible reason why Kimphe Lafa Natural Forest is lower in tree and shrub individuals in lower DBH class than almost all forests under comparison is that the forest is used as a grazing land for all livestock of the area. While being overgrazed by cattle or any other domestic animals, the number of seedlings and saplings that will be grown into mature trees and shrubs might be damaged at the seedling and sapling stages. The major factor exposed the forest for highly overgrazing is the topography of the forest. As it is found on the border of Lake Langano, all livestock of the area come to this forest for the sake of water.

4.4.2. Diameter at Breast Height (DBH)

A total of 2858 individuals of woody plant species whose DBH and height is ≥ 2.5 cm and ≥ 2 m respectively were recorded from Kimphe Lafa Natural Forest. The DBH was classified in to nine classes for data analysis of the forest. Class I includes individuals with DBH <10 cm, class II includes individuals with DBH 10-20 cm, class III individuals with DBH 20.01-40 cm, class IV individuals with DBH 40.01-60 cm, class V individuals with DBH 60.01-80 cm, class VI individuals with DBH 80.1-100 cm, class VII individuals with DBH 100.01-120 cm, class VIII individuals with DBH 120.1-140 cm and class IX individuals with DBH >140 cm (Figure 7).

Table 8: Distribution of DBH classes, density ha^{-1} and percentage of tree and shrub species in KLNF

DBH class	DBH Range(cm)	Density ha^{-1}	Percentage (%)
I	<10	213.99	40.13
II	10-20	183.96	34.50
III	20.01-40	38.81	7.28
IV	40.01-60	21.83	4.09
V	60.01-80	17.54	3.29
VI	80.01-100	20.91	3.92
VII	100.01-120	11.94	2.24
VIII	120.01-140	9.70	1.82
IX	>140	14.55	2.73

The general pattern of DBH class distribution of the forest was calculated and showed inverted J-shaped distribution of individuals in the nine DBH classes which is a case in undisturbed natural montane forests (Figure 6). This pattern of DBH classes indicates a good potential of reproduction and recruitment of the forest. Similar results were reported by Ayelew *et al.*, (2006); Senbeta, (2006); Yinger *et al.*, (2008); Abdena, (2010); Gurmessa, 2010; Fisaha *et al.*, (2013).

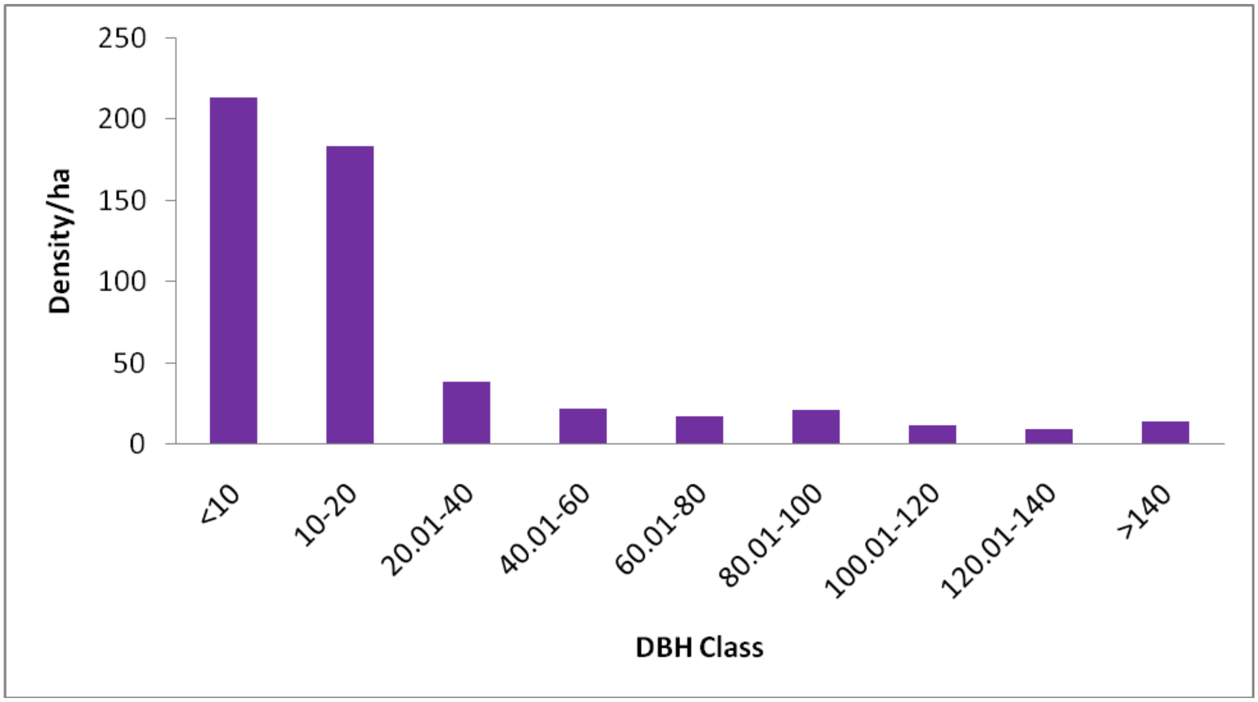


Figure 6: Distribution of DBH (cm) Class and Density of Woody plant species in KLNF

The DBH analysis revealed that individuals of woody plant species decreased significantly from the lower size classes to the higher size class except class VI and XI in which slight increase of individuals was seen (Figure 6). Generally distribution of all individuals in different DBH size classes showed an inverted J-shaped distribution. This pattern indicates that the majority of the species had the highest number of individuals in lower DBH class which in turn shows that the forest vegetation has good reproduction and recruitment potential. This is similar with the work reported by Ayalew *et al.*, (2006), Fisaha *et al.*, (2013), Kebede (2010) and Senbeta (2006).

The highest number of individuals of woody plant species of the forest was distributed in the DBH class I with 213.99 individuals ha^{-1} (40.13%). The distribution of trees in DBH class II was 183.96 individuals ha^{-1} (34.50%), class III 38.81 individuals ha^{-1} (7.28%), class IV 21.83 (4.09%), class V 17.54 (3.29%), class VI 20.91 individual ha^{-1} (3.92%), class VII 11.94 individuals ha^{-1} (2.24%) class VIII 9.70 individuals ha^{-1} (1.82%) and class IX 14.55 individuals ha^{-1} (2.73%) (Table 7).

4.4.3. Basal area

Basal area is cross-sectional area of all of the stems in a stand at breast height that is at 1.3 m above ground level. It is used to explain the crowdedness of forests. The total basal area of Kimphe Lafa Natural Forest was about 114.4 m^2 $ha^{-1}$for woody plant species that have DBH ≥ 2.5 cm. For the basal area is calculated from the DBH, there is a considerable decrease in number of individuals of trees and shrubs as the DBH of trees and shrubs increase. Basal area is an important parameter for measuring relative importance of plant species (Bekele, 1994). Hence, plant species with larger basal area in a forest is considered as the most important species in that forest.

Based on the basal area calculated for each species of the forest, *Ficus sur* was the most important plant species of the forest with basal area 71.21 m^2 ha^{-1} which is about four times greater than the second most important plant species, *Podocarpus falcatus*, with basal area 17.38 m^2 ha^{-1}.Naturally, *Ficus sur* is not used for construction materials as well as for timber production. So, the basal area of this plant is extremely high relative to the other species of the study area. The second plant species with high basal area was *Podocarpus falcatus* which was 17.38 m^2 ha^{-1}. This may be due to high number of plant species as a result of climate of the area. Other plant species are *Croton macrostachyus* with 5.38, Ficus vasta with 3.51, *Cordia africana* with 2.16, *Maytenus abscura* with 2.13, *Mimusops kummel* with 2.07, *Ficus sycomorus* with 1.2, and *Ficus* sp. with 1.08 basal area in m^2 ha^{-1} (Table 8).

Table 9: Basal area and Relative basal area of top ten plant species in KLNF

Species	Basal area	Relative BA
Ficus sur	71.21	62.22
Podocarpus falcatus	17.38	15.19
Croton macrostachyus	5.38	4.7
Ficus vasta	3.51	3.07
Cordia africana	3.01	2.63
Celtis africana	2.16	1.89
Maytenus abscura	2.13	1.86
Mimusops kummel	2.07	1.81

Table 8: Continued…

Ficus sycomorus	1.2	1.05
Ficus sp.	1.08	0.95

The basal area of Kimphe Lafa Natural Forest is less than Menagesha Suba (Beche, 2011) and Dodola (Hundera *et al*., 2007). On the other hand, the basal area for Kimphe Lafa Natural Forest is greater than all basal areas of the forests under comparison. From the total basal area of twelve forests of Ethiopia, only two of them, Menagesha Suba and Dodola are greater than that of Kimphe Lafa Natural Forest with basal area 158.68 and 129.0 m^2 ha^{-1} respectively and all the rest forests have basal area lower than Kimphe Lafa Natural Forest. This may be due to the presence of plant species with larger stems than the mentioned forests (Table 9).

Table 10: Comparison of the Basal Area of KLNF Forest with Basal Areas of other Forests in Ethiopia in m^2 ha^{-1}

Forest	BA	Author
Menagesha Suba	158.68	Beche (2011)
Dodola	129.0	Hundera *et al*., (2007)
Kimphe Lafa	**114.4**	**Present study**
Wof-Washa	64.32	Fisaha *et al*., (2013)
Menna Angetu	94.22	Lulekal *et al*., (2008)
Menagesha Amba Mariam	84.17	Tilahun (2009)
Masha Anderacha	81.9	Yeshitela and Bekele (2003)
Bibita	69.9	Denu (2007)
Magada	68.52	Bekele (2005)
Dindin	49.0	Shibiru and Balcha (2004)
Denkoro	45.0	Ayalew *et al*., (2006)
Menagesha –Suba	36.1	Bekele (1994)
Senka Meda	34.70	Bantiwalu (2010)

4.4.4. Frequency

It was found that *Vernonia urticifolia* was the most frequent species with frequency of 52.24 followed by *Podocarpus falcatus, Calpurnia aurea, Celtis africana, Cordia africana, Croton macrostachyus, Mimusops kummel, Ficus sur, Bersama abyssinica and Maytenus abscura* with frequency of 44.03, 38.81, 35.82, 35.82, 34.33, 31.34, 31.34, 30.61 and 25.37% respectively (Table 10).

According to Lambrecht (1989), frequency is an indicator of homogeneity and heterogeneity of a given vegetation type. The higher number of species in higher frequency classes and lower number of species in lower frequency classes show homogeneity and high number of species in lower frequency classes and low number of species in higher frequency classes show heterogeneity of species. The frequency and percentage frequency of each woody species of Kimphe Lafa Natural Forest was calculated.

Table 11: List of most frequent trees and shrubs in KLNF

S.no.	Species name	Frequency (%)	Relative frequency
1	*Vernonia urticifolia*	52.24	5.32
2	*Podocarpus falcatus*	44.03	4.48
3	*Calpurnia aurea*	38.81	3.95
4	*Celtis africana*	35.82	3.64
5	*Cordia africana*	35.82	3.64
6	*Croton macrostachyus*	34.33	3.50
7	*Mimusops kummel*	31.34	3.19
8	*Ficus sur*	31.34	3.18
9	*Bersama abyssinica*	30.61	3.11
10	*Maytenus abscura*	25.37	2.57

Based on the frequency value the woody plant species of the area were classified into five frequency classes. These were: class I) 0.75-12.24, II) 12.24-22.24, III) 22.24-32.24, IV, 32.24-42.24 and V) 42.24-52.24 (Figure 7). Plant species distributed in frequency class five were *Vernonia urticifolia* and *Podocarpus falcatus* which account 4.65%. Plant species distributed in frequency class four were *Calpurnia aurea*, *Celtis africana*, *Cordia africana* and *Croton macrostachyus* which account 9.3%. Those species distributed in frequency class three were *Mimusops kummel*, *Ficus sur*, *Bersama abyssinica* and *Maytenus abscura* with 9.3%. The remaining species were distributed in frequency class two and one having 11.63% and 65.12% respectively. From the pattern of woody plant species distribution in the five frequency classes, it was shown that there were high number of species in lower frequency classes and low number of species in higher frequency classes. As a result, Kimphe Lafa Natural Forest has high degree of floristic heterogeneity.

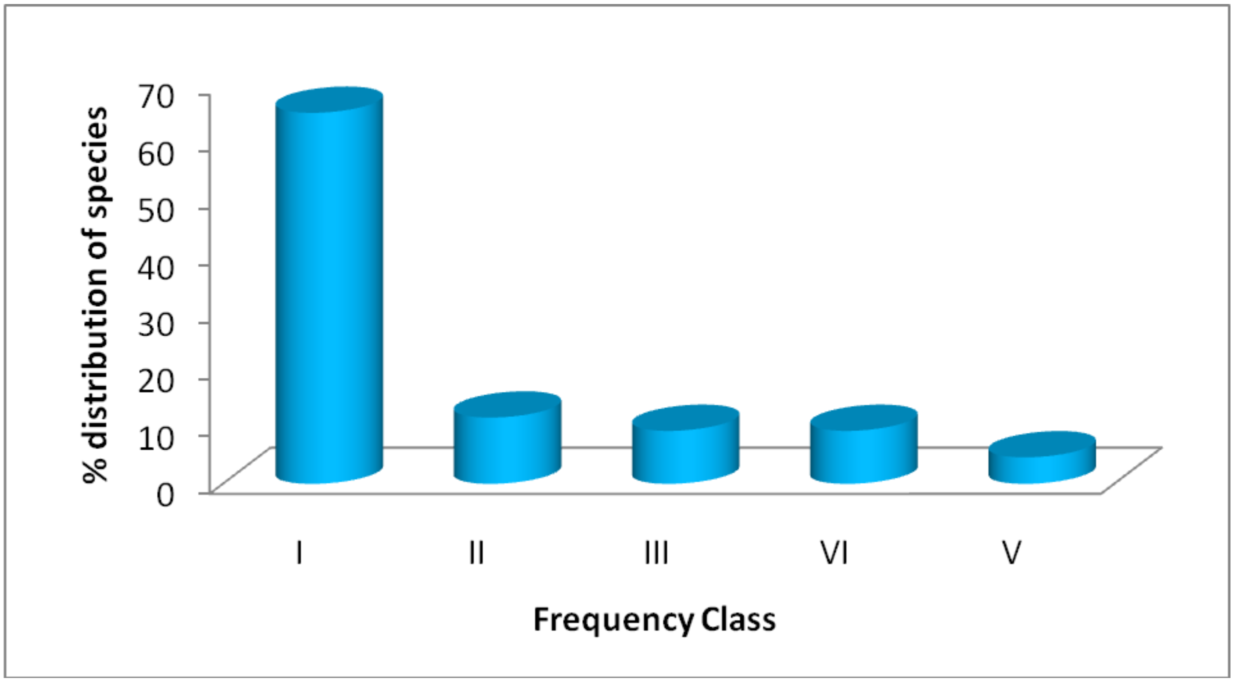


Figure 7: Frequency distribution of woody species in KLNF

4.5.5. Important Value Index (IVI)

Important value index indicates the structural importance of a species among species of a given forest and calculated by summing up of the relative frequency, relative density and relative dominance of a species. Lamprecht (1989) pointed out that the Important Value Index is used to compare the ecological significance of each species. High value of IVI indicates high sociological structure of species in a community. On the other hand, the highest Important Value Index of a species the most dominant the species is in an area (Shibru and Balcha, 2004).

IVI is also used for setting priority for conservation and management practices as well as to know sociological status of a certain plant community as dominant or rare species (Kent and Coker, 1992). All woody plant species of the study area were classified into seven IVI classes for the sake of setting priority (Table 12). Class I) <0.5, II) 0.5-1, III) 1.01-15, IV) 15.01-25, V) 25.01-35, VI) 35.01-45 and class VII, >45. Those plant species with lower IVI were grouped under the lower IVI classes and those with higher IVI were grouped under the higher classes of IVI (Table 13). Based upon this classification system, those plant species grouped under lower IVI classes, particularly those under class one requires high conservation measures while those grouped under higher IVI classes, particularly under seventh class requires monitoring management.

The top ten plant species leading with greatest importance value and dominance in Kimphe Lafa Natural Forest were *Ficus sur, Vernonia urticifolia, Podocarpus falcatus, Calpurnia aurea, Croton macrostachyus, Maytenus abscura, Celtis africana, Mimusops kummel, Cordia africana* and *Bersama abyssinica* in relative to other species of the area. Contrarily, top ten plant species that need high priority for conservation in the forest were *Ximenia americana, Acacia tortolis, Acasia abyssinica, Acacia seyal, Dombeya torrida, Grewia ferruginea, Cussonia arborea*, *Grewia bicolor, Pittosporum viridiflorum* and *Pappea capensis* based on their IVI (Table 11).

Table 12: The IVI for 40 tree and shrub species of the forest with their corresponding relative frequency, relative density and relative dominance in KLNF

(RF= Relative frequency, RD= Relative density, RDO= Relative dominance, IVI= Important value index)

S.no.	**Species**	**RF (%)**	**RD (%)**	**RDO (%)**	**IVI**
1	*Olea auropaea*	0.23	0.62	0.02	0.87
2	*Ilex mitis*	0.31	0.86	0.01	1.18
3	*Grewia bicolor*	0.15	0.37	0.003	0.52
4	*Grewia ferruginea*	0.15	0.25	0.0009	0.40
5	*Maytenus senegalensis*	0.91	2.47	0.006	3.38
6	*Celtis africana*	3.64	19.6	1.9	25.14

Table 11: Continued...

7	*Dichrostachys cinerea*	0.53	1.53	0.11	2.17
8	*Diospyros abyssinica*	0.3	0.86	0.3	1.46
9	*Ziziphus mucronata*	0.15	0.62	0.03	0.8
10	*Psydrax schimperiana*	0.23	0.62	0.09	0.94
11	*Albizia grandibracteata*	0.46	1.12	0.19	1.77
12	*Bersama abyssinica*	3.11	16.03	0.93	20.07
13	*Acacia seyal*	0.15	0.25	0.005	0.40
14	*Mimusops kummel*	3.19	19.24	1.81	24.24
15	*Maytenus abscura*	2.58	22.07	1.86	26.51
16	*Maytenus arbutifolia*	1.21	6.01	0.54	7.76
17	*Croton dichogomas*	1.44	8.01	0.03	9.48
18	*Ehretia cymosa*	0.61	1.23	0.02	1.86
19	*Syzygium guineense*	0.68	1.85	0.16	2.69
20	*Dombeya torrida*	0.15	0.25	0.0004	0.40
21	*Ximenia americana*	0.08	0.12	0.009	0.20
22	*Ficus thonningii*	1.29	2.96	0.33	4.58
23	*Teclea simplicifolia*	0.46	1.11	0.035	1.60
24	*Olea capensis*	1.75	5.8	0.24	7.79
25	*Pittosporum viridiflorum*	0.23	0.37	0.03	0.63
26	*Vernonia urticifolia*	5.32	75.21	0.44	80.97
27	*Calpurnia aurea*	3.95	43.77	0.18	47.9
28	*Acacia tortolis*	0.08	0.12	0.05	0.25
29	*Cussonia arborea*	0.15	0.25	0.09	0.49
30	*Podocarpus falcatus*	4.48	32.8	15.19	52.47

Table 11: Continued…

31	*Croton macrostachyus*	3.5	32.8	4.7	41
32	*Ficus sycomorus*	0.76	2.09	1.06	3.91
33	*Ficus sur*	3.19	20.34	62.22	85.75
34	*Ficus vasta*	0.15	0.37	3.07	3.59
35	*Ficus* sp.	0.23	0.5	0.95	1.68
36	*Cordia monoica*	0.3	0.62	0.03	0.95
37	*Maytenus undata*	0.76	0.12	0.005	0.88
38	*Pappea capensis*	0.23	0.5	0.03	0.76
40	Acasia abyssinica	0.08	0.12	0.13	0.33

The percentage contribution of seven IVI classes was 16.67, 21.43, 38.09, 7.14, 4.76, 2.38 and 9.53% from class 1-7 respectively. The highest percentage was contributed by IVI class III (about 38.09) which contained sixteen species and the lowest was by class VI (about 2.38%) which contained a single species. The highest value of IVI was 267.09 which attained in class VII while the lowest is 2.47 attained in class I (Table 12).

Table 13: IVI Classes and number of species in each class in KLNF

IVI class	Value	No of species	Percentage	Total IVI
I	<0.5	7	16.67	2.47
II	0.5-1	9	21.43	7.60
III	1.01-15	16	38.09	56.60
IV	15.01-25	3	7.14	68.21
V	25.01-35	2	4.76	51.56
VI	35.01-45	1	2.38	41.00
VII	>45	4	9.53	267.09

Table 14: List of species under Each IVI priority classes

Class I	**Class II**
Ximenia americana L. *Acacia tortolis* (Forssk.) Hayne Acacia abyssinica Hochst.ex Benth. *Acacia seyal* Del. *Dombeya torrida* (J.F. Gmel.) P. Bamps *Grewia ferruginea* Hochst. Ex A. Rich *Cussonia arborea* A. Rich.	*Grewia bicolor* Juss. *Pittosporum viridiflorum* Sims *Pappea capensis* Eckl. And Zeyh. *Ziziphus mucronata* Willd. *Olea auropaea* L. *Maytenus undata* (Thunb.) Blackelock *Psydrax schimperiana* (A. Rich.) Bridson *Cordia monoica* Roxb.
Class III	**Class IV**
Ilex mitis (L.) Radlk *Diospyros abyssinica* (Hiern) F. White *Teclea simplicifolia* (Engl.) Verdoorn. *Aeschynomene elaphroxylon* (Guill. And Perr.) Taub *Albizia grandibracteata* Taub. *Ehretia cymosa* Thonn. *Dichrostachys cinerea* (L.) Wight and Arm *Syzygium guineense* (Willd.) DC. *Maytenus senegalensis* (Lam.) Exell *Ficus vasta* Forssk. *Ficus sycomorus* L. *Ficus thonningii* Blume	*Bersama abyssinica* Fresen. *Cordia africana* Lam. *Mimusops kummel* A.DC.
Maytenus abscura (A. Rich.) Cuf.	

Table13: Continued

Olea capensis L. *Cordia monoica* Roxb **Class V** *Celtis africana* Burm.f. *Maytenus abscura* (A. Rich.) Cuf.	**Class VI** *Croton macrostachyus* Del.
Calpurnia aurea (Ait.) Benth *Podocarpus falcatus* (Thumb.) R.B.ex.Mirb. *Vernonia urticifolia* A. Rich. *Ficus sur* Forssk.	

4.5. Height distribution of Woody Plant Species in Kimphe Lafa Natural Forest

About 42 plant species with 2858 individuals were used for description of plant structure in Kimphe Lafa Natural Forest. The height of trees and shrubs in the area was classified into seven height classes as follows. Class I) 2-5 m, Class II) 6-10 m, Class III) 11-15 m Class IV) 16-20 m, Class V) 21-25 m, Class VI) 26-30 m, Class VII) >30 m (Figure 8).

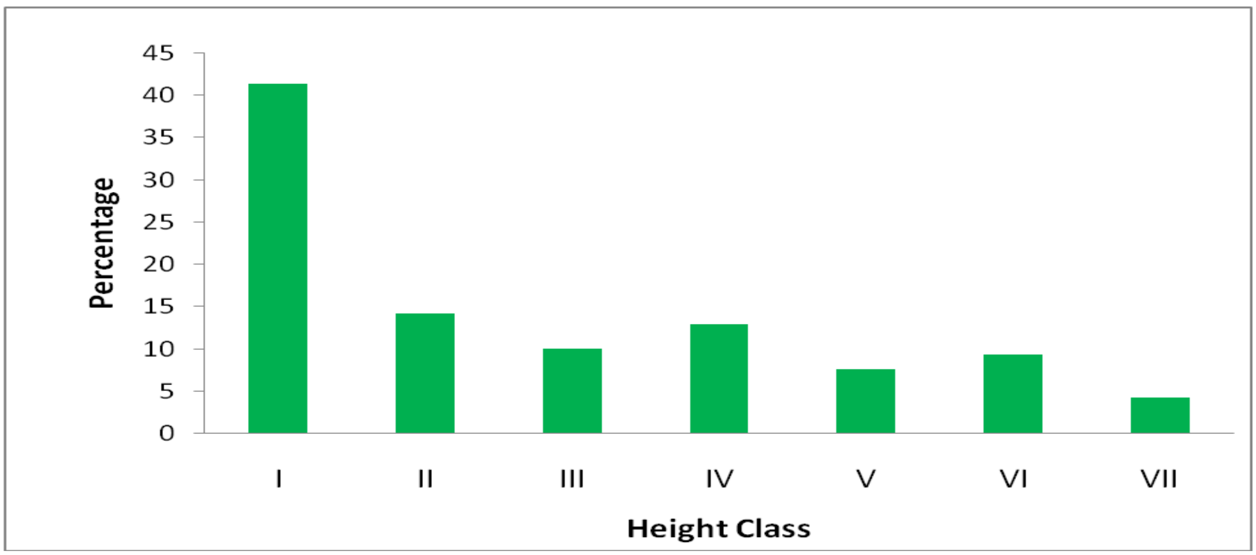


Figure 8: Percentage Distribution of Seven Height Classes of Woody Plant Species in KLNF

As indicated in figure 8, the height of woody plant species in the forest has normal distribution pattern except class IV and VI which are slightly exceeding their Predecessor. This may be due to precence of many woody plant species in these classes wich have similar height classes. According to the study of Tesfaye and Berhanu (2006), presence of high number of plant species of higher height classes in a natural forest indicate presence of adult plant species for reproduction potential of a forest which holds true for this forest also. The general pattern of height class distribution of the forest is reversed J-shaped which inturn indicate the stable population structure.

Different height of trees in a forest is an indicator of role of species and determines vertical structure of a forest (Pascal and Pelissier, 1996). Height variation of of trees plays significant role in ecological phenomenon deciding the distribution of parasitic plants and affecting the microclimate of a forest (Bekele, 1993). More number of individuals per hectare were seen in the first height class (2-5 m) which account for 41.43%. This confirm that woody plants of Kimphe Lafa Natural forest is dominated by plant species of lower height classes. Plant species under lower class are *Vernonia urticifolia Calpurnia aurea, Croton dichogomas, Croton macrostachyus, Currisa spinarum, Maytenus abscura, Maytenus arbutifolia, Olea auropaea and Psydrax schimperiana.* Trees in height class II (6-10 m), III (11-15 m), IV (16-20 m), V (21-25 m), VI (25-30 m) and class VII (>30 m) contribute about 14.27, 10.1, 13.00, 7.63, 9.34 and 4.23% respectively (Figure 8). From the data analysis trees such as *Podocarpus falcatus, Celtis africana, Cordia africana, Croton macrostachyus* and *Ficus sur* in the height class VI and VII were the dominant trees in the upper canopy of the forest. *Podocarpus falcatus, Croton macrostachyus and Celtis africana* were the emergent tree species of the forest.

The general pattern of tree height class distribution was high in the lower height class, decreased in the middle classes except class IV and VI in which slight increment of trees were seen. The data analysis of Kimphe Lafa Natural Forest Agrees with the studies reported in Menagesha Amba Mariam Forest (Tilahun, 2009), Menagesha Forests of central plateau of Ethiopia (Bekele, 1994), Denkero Forest (Ayalew *et al*., 2006) and Argada Forest (Alemu, 2011). The distribution of lower number of large tree species in the medium and higher height classes indicate that the forest is affected by anthropogenic effect from the local people for large trees are needed for different activities like timber production, construction materials, charcoal production and fire wood which is also supported by Fisaha *et al*., (2013).

4.6. Vertical Structure of the Forest

Population structure refers to the distribution patterns of individuals of each species within arbitrarily defined height classes. The description of the vertical structure of Kimphe Lafa Natural Forest was done and three vertical structures were distinguished in forests as per the International Union for Forestry Research Organization (IUFRO) classification system (Lamprecht, 1989). The three vertical structures are lower storey, middle storey and upper storey. For the purpose of the study, the forest was also subdivided into the three different vertical height storeys. The upper storey contains tree height > 2/3 of top height, Middle storey contains tree height between 1/3 and 2/3 of top height and Lower storey contains tree < 1/3 of top height. Based on their height, trees were classified into their corresponding storey. The tallest of all trees in Kimphe Lafa Natural Forest was *Podocarpus falcatus* with 40 m height. Hence, trees contained under lower, middle and upper storey were those having height ranges < 13.3 m, 13.3 – 26.67 m and > 26.67 m respectively.

Table 15: Density, Number of individual plants and Percentage of KLNF Storeys

Story	Density ha^{-1}	No. of Trees	Percentage (%)
Lower	309.33	1658	58.01
Middle	149.81	803	28.10
Upper	74.07	397	13.89

The highest density was found in the lower storey (<13.3 m) which contained 309.33 individuals of trees and shrubs ha^{-1} (about 58.01%) (Table 14). The dominant trees under this storey are *Vernonia urticifolia* (38.73%), *Calpurnia aurea* (22.54%), *Maytenus abscura* (11.37%), *Croton dichogomas* (4.13%), *Croton macrostachyus* (3.24%), *Maytenus arbutifolia* (3.11%), *Bersama abyssinica* (2.92%), *Celtis africana* (2.35%) and *Olea capensis* (2.09%).

The middle storey (13.3-26.67 m) contained 149.81individuals of trees and shrubs ha^{-1} (28.10%) (Table 14). The plant species occupied the storey are *Mimusops kummel* (17.82%), *Podocarpus* *falcatus* (16.91%), *Croton macrostachyus* (16.91%), *Bersama abyssinica* (11.01%), *Ficus sur* (10.35%), *Celtis africana* (8.26%), *Cordia africana* (6.55%) and the rest contributed less than one percent.

The upper storey (>26.67 m) of the forest was composed of 74.07individuals of trees ha^{-1} (13.89%) (Table 14) and tree species dominated this storey are *Podocarpus falcatus* (32.89%), *Croton macrostachyus* (23.72%), *Ficus sur* (22.81%), *Celtis africana* (15.65%) and *Cordia africana* (5.84%). Generally, percentage distributions of plants in Kimphe Lafa Natural Forest were 58, 28 and 14% in lower, middle and upper storeys respectively (Figure 9).

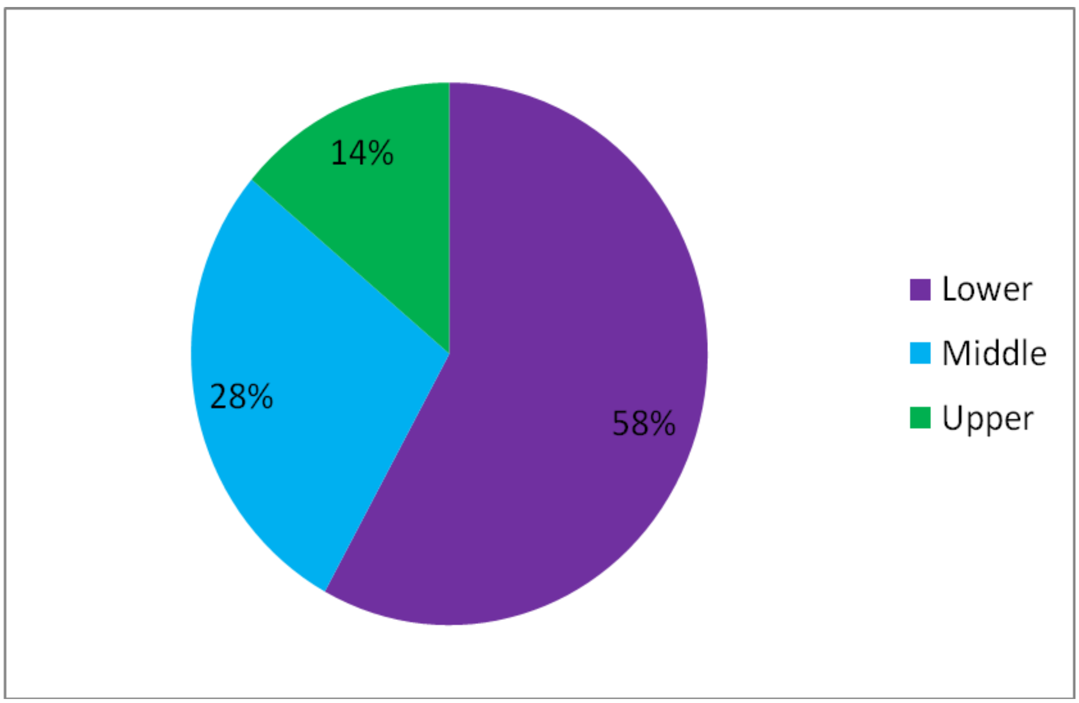


Figure 9: Percentage Distribution of Trees and Shrubs in the three storey in KLNF

4.7. Regeneration status of Kimphe Lafa Natural Forest

Floristic composition, number of seedlings, saplings and analysis of their densities of a forest has an implication regarding regeneration status and management of a natural forest. Density of seedlings and saplings of woody plant species of Kimphe Lafa Natural Forest was analyzed. The density of seedlings and saplings is considered as a key factor for determination of regeneration potential of a given forest (Dhaulkhandi *et al.*, 2008).

Presence of sufficient number of seedlings, saplings and adult plant species shows good regeneration status of a forest and predicts the future floristic composition of that forest. Regeneration status of a forest is poor if number of seedlings and saplings are much less than mature individuals. Analysis of seedlings and saplings of Kimphe Lafa Natural forest indicated that the total density of seedlings and saplings of woody plants species of the forest was 1091.8 and 834.7 ha^{-1} respectively and that of mature individuals was 515.7 ha^{-1} (Figure 10).

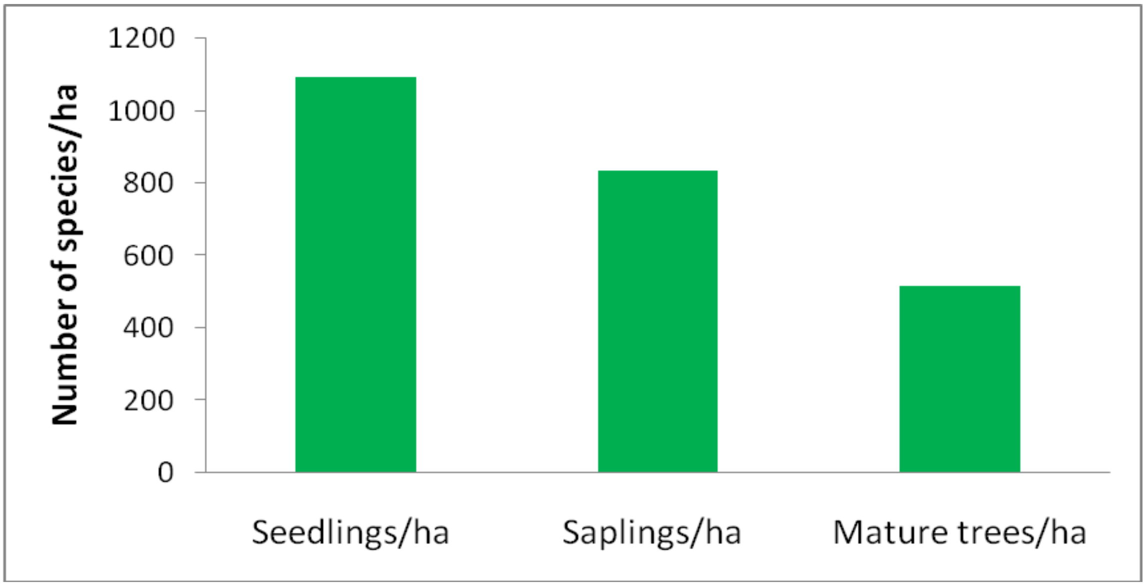


Figure 10: Density ha^{-1} of Seedlings, Saplings and Mature trees of KLNF

Similarly, the density of mature individuals, seedlings and saplings of tree species was 308, 929.8 and 606.2 ha^{-1} respectively. The density of mature individuals, seedlings and saplings of shrub species was 192.2, 288.1 and 209.7 ha^{-1} respectively and the density of mature individuals, seedlings and saplings of lianas was 15.5, 73.8 and 18.8 ha^{-1} respectively (Figure 11).

The number of seedlings and saplings counted from the study area were much less than the seedlings and saplings of Wof-Washa studied by Fisaha *et al*., (2013), Bibita by Denu, (2007) and Belete forest by Hundera, (2010) which reported 8,796.5, 2,555.2 and 3274 to 8564 ha^{-1} respectively. This much variation could be as a result of highly exposure of the forest for grazing.

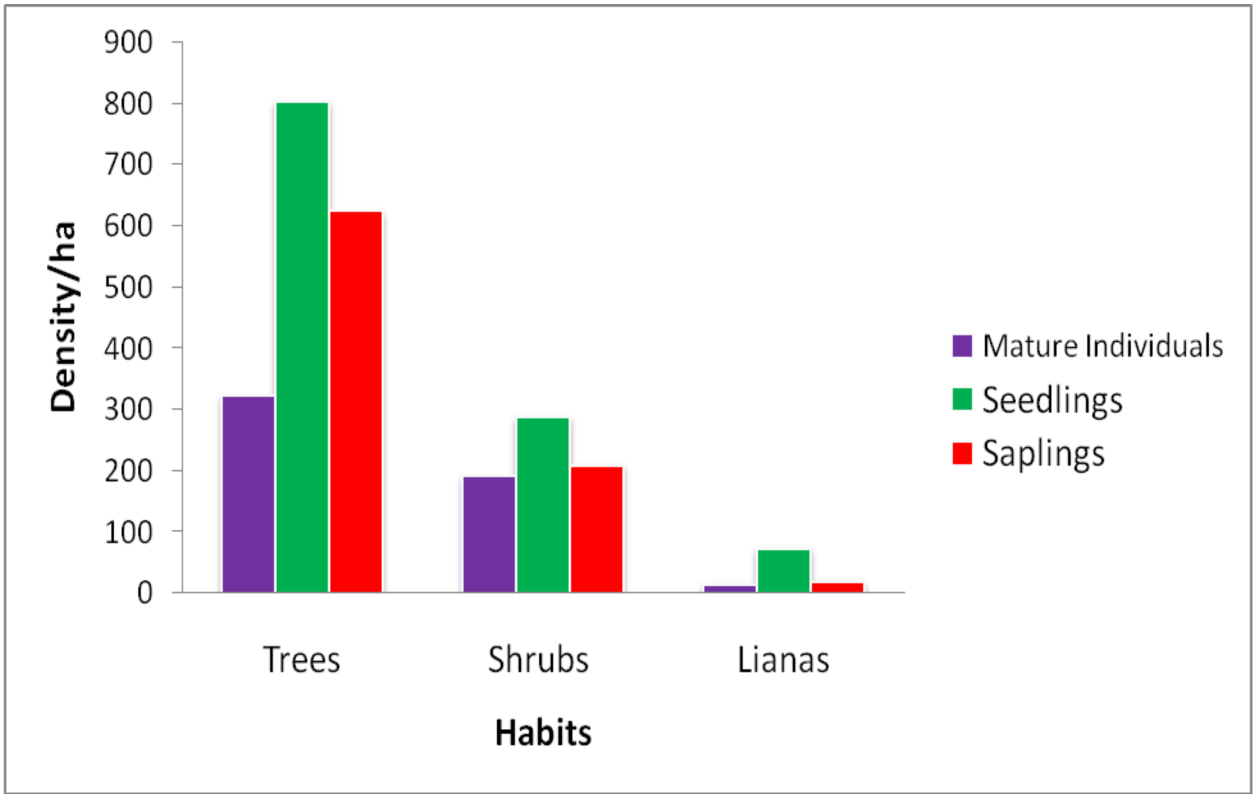


Figure 11: Mature individuals, Seedling and sapling distribution of woody species in KLNF

The density of seedlings and saplings of the study forest is greater than mature trees. This indicates that the regeneration potential of Kimphe Lafa Natural Forest is high due to the high potential of the forest for regeneration. So, if better protection and management is implemented for the forest, the density, composition and structure of the forest will be more than the current status.

The ratio of seedlings to saplings was 1.31, seedlings to mature trees were 2.12 and saplings to mature trees/shrubs were 1.62. These shows that the distribution of seedlings as a whole is greater than that of saplings and mature trees and that of saplings is greater than mature trees. This ratio value indicates that the number of seedlings and saplings being regenerated in the forest is about more than three times of the mature trees of the forest.

Based on the number of seedlings and saplings of woody plant species counted from all 134 sample plots, they were divided in to five classes. This was done for prediction of which plant species could be the dominant in the future, which plant species need special conservation measures and which plant species is in risk of extinction. Class I) includes the number of seedlings and saplings >

300, Class II) includes number of seedlings and saplings 100-299, Class III) includes number of seedlings and saplings 50-99, Class IV) includes number of seedlings and saplings 1-49 and Class V) include number of plant species that do not have any seedling and sapling from the area (Figure 12).

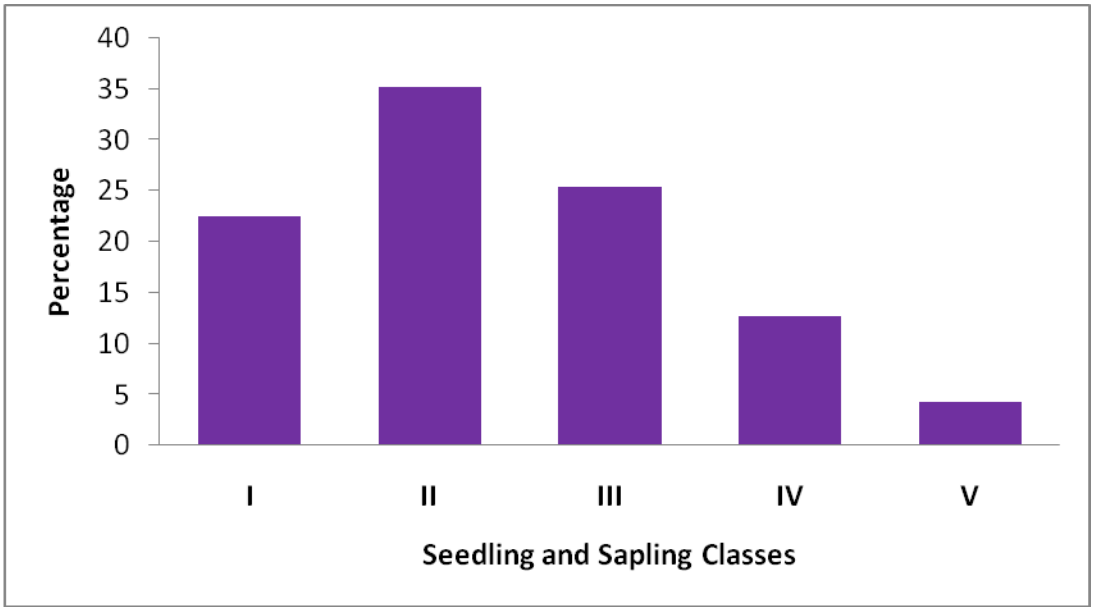


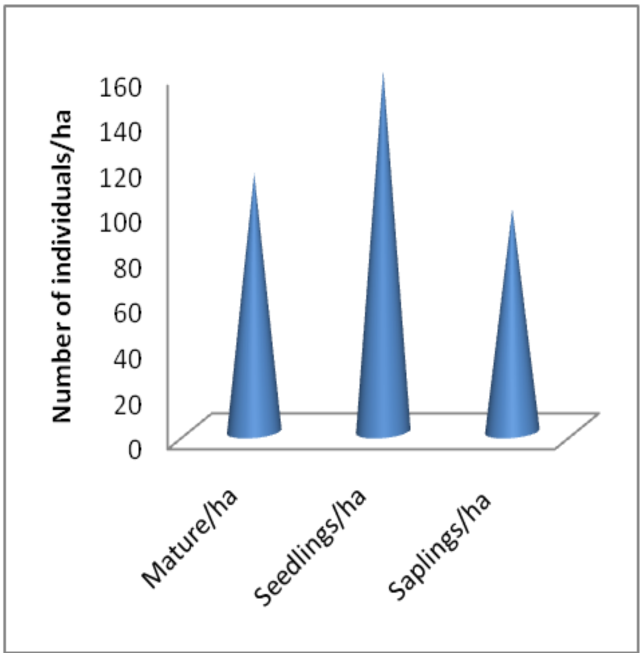
Figure 12: Percentage distribution of Seedlings and Saplings of woody pla species of five Classes in KLNF

Woody plant species under class I cover about 22.54% of all woody plant species of the area and the top plant species under this class include *Podocarpus falcatus, Celtis africana, Vernonia urticifolia, Calpurnia aurea, Mimusops kummel* and *Croton macrostachyus*. Class II covers about 35.21% of woody plant species and these include *Croton dichogomas, Ficus sur, Ficus sycomorus, Olea capensis, Syzygium guineense* and *Ficus thonningii*. Class III covers about 25.35% and includes woody plant species like *Albizia grandibracteata, Diospyros abyssinica, Ficus* sp., *Grewia bicolor* and *Hippocratia africana*. Class IV covers about 12.68% of woody plant species which include *Acacia tortolis, Ilex mitis, Olea auropaea* and *Psydrax schimperiana.* Class V (plant species with no any seedling and sapling) covers about 4.22% of woody plant species. This class has three plant species. These are *Cussonia arborea, Cordia monoica, Ximenia americana* and *Rhus glutinosa*. Based on this classification, conservation priority should be given to plant species classified under class IV and V; specially class V plant species (Figure 12).

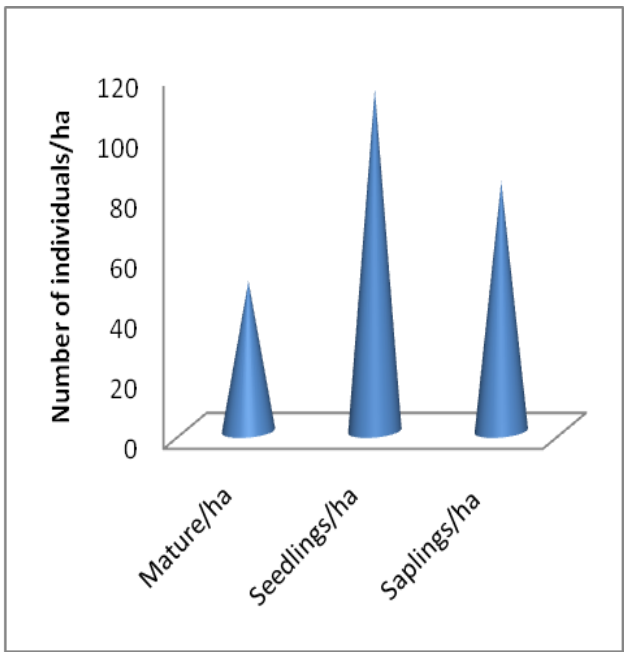
4.7.1. Regeneration patterns of some selected tree/shrub species in KLNF

Some selected plant species with high density of seedlings and saplings were analyzed from the study area. *Vernonia urticifolia* had the highest density of seedlings and saplings which was 272.7 individual/ha^{-1} followed by *podocarpus falcatus, Calpurnia aurea, Croton macrostachus, Celtis africana, Mimusops kummel* and *Bersama abyssinica* with density of 163.06, 159.14, 148.51, 111, 87.49 and 83.39 individuals ha^{-1} respectively (Figure 13a-f). On the other hand, plant species with no seedling and saplings were encountered from the study area, which need high priorities for conservation. These were *Ximenia americana, Cordia monoica, Cussonia arborea* and *Rhus glutinosa.*

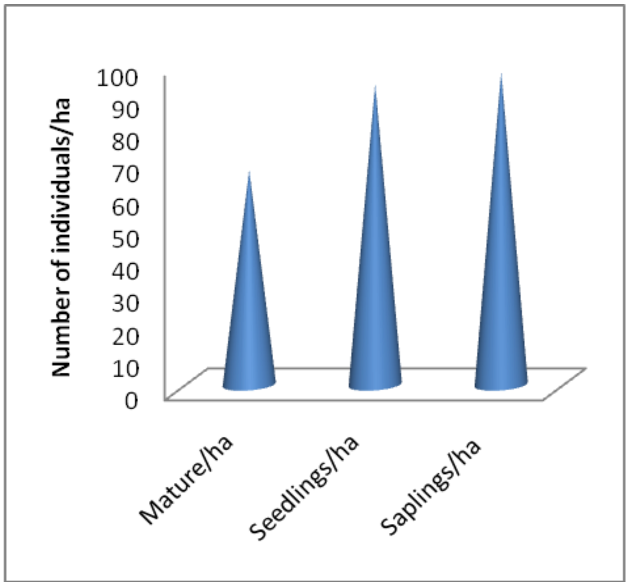
Vernonia urticifolia (a)



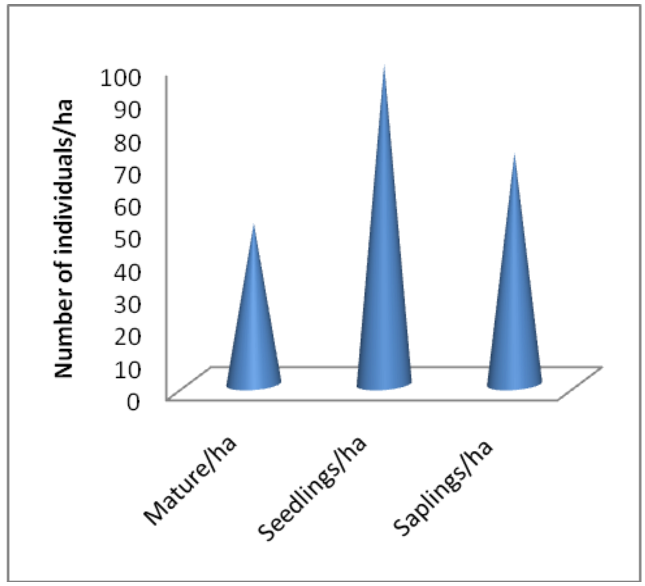
Podocarpus falcatus (b)



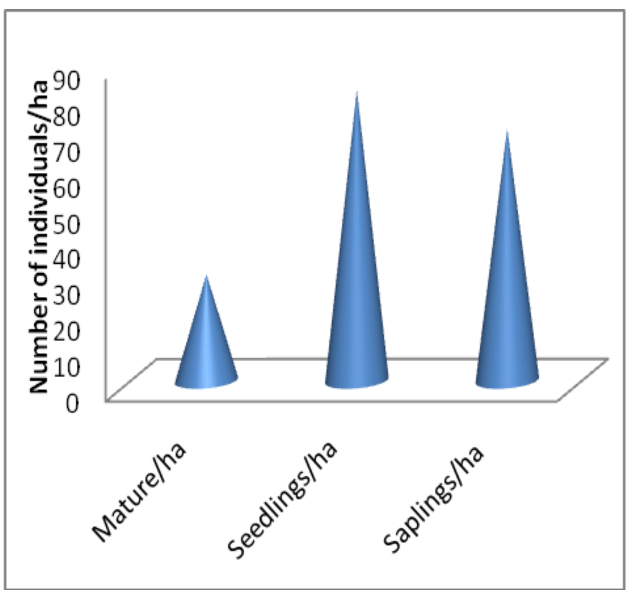
Calpurnia aurea (c)



Croton macrostachyus (d)



Celtis africana (e)



Mimusops kummel (f)

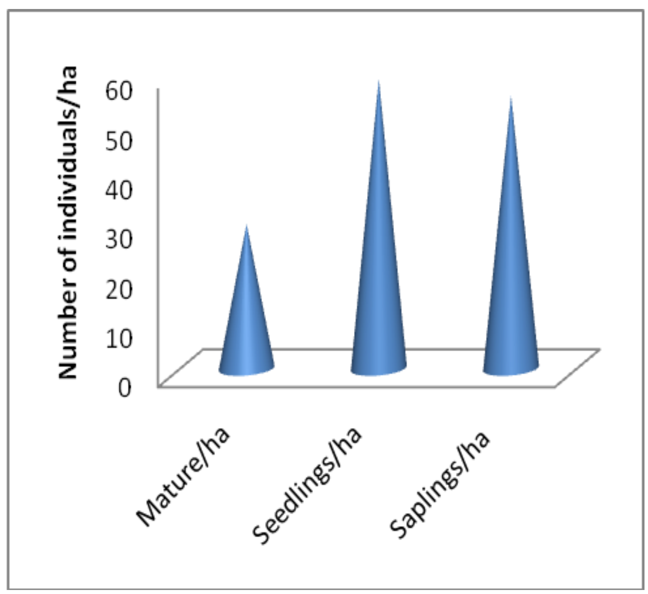


Figure 13: Regeneration patterns of some selected trees/shrubs with high number of seedlings and saplings

4.8. Phytogeographical Comparison

Based on the results obtained from data analysis, Kimphe Lafa Natural Forest is one of the most diversified dry ever green montane forests of Ethiopia. The forest was compared with other eight montane forest of the country. According to Woldemariam (2003) direct comparison of species diversity among forests is impossible due to differences in factors like size of forests, survey methods and objective of the study. However, overall species richness of the forest can give more or less a general impression of diversity and phytogeographical similarity between the forests in comparison. The eight montane forests of Ethiopia compared with Kimphe Lafa Natural Forest were Sanka Meda, Gedo, Menagesha Suba, Chato, Angada, Wof-Washa, Dello menna and Gurra Farda forests.

Sanka Meda Natural forest is located in Oromia Regional State, Arsi Zone, Guna district, southeast of Ethiopia at 260 kms from Addis Ababa and 220 kms east of the zonal capital, Asela town. The site is part of southeast highlands which is the extension of Harerge, Arsi and Bale highland massifs (Teketay, 1996). The forest is located been 8^0 22’ 09’’ - 8^0 24’ 54’’N latitude and 39^0 57’02”- 39^0 58’ 52”E longitude and its altitude ranges from approximately 1200 to 3574 m a.s.l. (Bantiwal, 2010). Gedo Forest is located in Cheliya District, West Shewa Zone of Oromia Regional State with an altitudinal range of 1300-3060 m a.s.l. The District lies approximately between latitudes of 9^0 02` and $9^0$01’ North and longitudes 370 25’ and 37016’ East (Kebede, 2010). Menagesha Suba State forest is located in the central part of the country at 30 km West of Addis Ababa. It is found between 38^0 31’ and 38^0 35’ E and 9^0 89’ and 9^0 00’ N in Oromia Regional State. It is found in central plateau covering an altitudinal range of 2200-3385 m a.s.l. (Bekele, 1994). Chato Natural Forest is located in Horo –Guduru Wollega Zone, Oromia Regional State, Ethiopia. The forest lies approximately between 9^0 40’- $9^0$42’ N latitudes and 36^0 59’-37^0 00’E longitudes. It is found in Horo District at 30 kms north-west of Shambu which is located at about 314 kms west of Addis Ababa and located along altitudinal ranges between 1700 m and 2350 m a.s.l. (Abdena, 2010). Angada forest is located in Arsi Zone, Oromia Regional State at 223 kms southeast of Addis Ababa and 183 kms east of the zonal capital, Asella Town in Merti Wereda. The Forest is located between 593000-588000N latitude and 935000-924000E longitude and altitude ranges from approximately 1050 to 2800 m a.s.l. It is at 18 kms east of Abomsa Town which is the capital of the Wereda and its altitude ranges approximately 1050 to 2800 m a.s.l. (Alemu, 2011). Wof-Washa natural forest is located in Amhara Regional State, Northwestern highlands of Ethiopia, stretching in three districts called Baso, Ankober and Tarma Ber. It is located between 9^{0}34 and 10^{0}20'N and 39^{0}42' and 39^{0}50'E and found in altitudinal ranges between 1700–3600 m a.s.l. it is one of the very few remaining Dry Afromontane forests in Ethiopia (Fisaha *et al*., 2013). Dello Menna forest is located in Dello Menna district, Bale zone of Oromia regional state, southeast Ethiopia. It is located at 555 kms south of Addis Ababa, in the Bale zone of Oromia Regional state and 125 kms from Robe town, the capital of Bale zone. It lies between latitudes 5^{0} 53' N and 6^{0} 27' N, and longitudes 39^{0}15' E and 40^{0} 38' E. The altitude ranges from 800 to 2000 m a.s.l. (Didita *et al*, 2010). Gurra Farda forest is located in Bench Maji zone of the SNNPR in the southwestern part of Ethiopia at a distance of approximately 600 kms away from Addis Ababa. It is located at 6^{0} 81' N and 34^{0} 97'E. The altitudinal range of the Gurra Farda woreda ranges between 800 to 1900 m a.s.l. (Hundera and Deboch, 2008).

The forests were compared with Kimphe Lafa Natural Forest based on similarities in florstic composition. The similarity index used for evaluation was Sorensen's similarity index by the formula Ss=2a/2a+b+c Where: a= species common to Kimphe Lafa and the forest in comparison, b = species found only in Kimphe Lafa Forest, c= species found only in the forest in comparison with Kimphe Lafa and Ss=Sorensen`s similarity coefficient.

The Sorensen's similarity index calculated for all the forests in comparison with Kimphe Lafa Natural forest ranged from 16.53-38.86% from the highest to the lowest. The calculated similarity indices of Sanka Meda, Gedo, Menagesha Suba, Chato, Angada, Wof-Washa, Dello Menna and Gurra Farda forests were 27.23, 38.86, 16.53, 25.43, 22.22, 16.67, 20.20 and 26.39% respectively (Table 15). Gedo forest showed the highest similarity with Kimphe Lafa Natural forest in species composition and the lowest was seen by Menagesha Suba state forest. High similarity of forests in species composition is attributed due to similarities in environmental factors like climate altitude and geographical attributes. On the other hand, low similarity could be attributed due to elevation differences, geographical factors, climatic conditions and anthropogenic disturbances.

Table 16: Sorensen's coefficient of plant species between KLNF and other eight montane forests of Ethiopia.

Forests	Altitude	A	b	C	Ss (%)	References
Sanka Meda	1200–3574 m	26	86	53	27.23	Bantiwal (2010).
Gedo	1300–3060 m	34	93	14	38.86	Kebede (2010).
Menagesha Suba	2200–3385 m	20	110	92	16.53	Beche (2011).
Chato	1700–2350 m	37	93	124	25.43	Abdena (2010).
Angada	1050–2800 m	24	106	62	22.22	Alemu (2010).
Wof-Washa	1700–3600 m	15	115	35	16.67	Fisaha *et al*., (2013).
Dello Menna	800–2000 m	30	100	137	20.20	Didita *et al*., (2010).
Gurra Farda	800–1900 m	26	104	41	26.39	Hundera and Deboch (2008).

4.8. Conservation Status of Kimphe Lafa Natural Forest

Kimphe Lafa Natural Forest is among the few natural forest of Ethiopia. Unless we protect and conserve these forests very well, there may be a risk that results in biodiversity loss and unexpected climatic change which in turn adversely affect the whole ecosystem. Vey very poor protection and management of the forest was seen during the stay in the forest for data collection. Kimphe Lafa Natural forest is exposed for complicated factors highly threatening it. Threats to this forest is also a threats to the wild animals found in this forest like Monkey, Gureza, Ape, Wild fox, Tiger and other large and small animals and various bird species. Local people of the area damage the forest for different purposes. Timber production, expansion of farm land, fire wood, charcoal production and construction materials are among the main factors threatening the forest.

Plate 3: Illegal destruction of *Celtis africana* tree in the center of KLNF (Photo by Kedir Aliyi, 2013).

Plate 4: Destruction of KLNF for fire wood (Photo by Kedir Aliyi, 2013).

For the forest land is suitable for agriculture and endowed with rivers suitable for irrigation, the forest land is being changed into farm land. Timber production is also responsible for clearance of large trees. Local people clear large trees found in the forest directly or indirectly. Indirect clearing of trees is done through peeling off of the bark of a tree so that the tree falls down in a short time (Plate 5). Local residents of the area also use fire for expansion of farm land. Setting fire around forest may result in complete disappearance of living things of the ecosystem.

Plate 5: Bark of *Podocarpus falcatus* tree peeled off so as to dry and fall down easily
(Photo by Kedir Aliyi, 2013).

Plate 6: *Ficus sur* being burnt (left) and *Podocarpus falcatus* already burnt (right) in a farm land around KLNF
(Photo by Kedir Aliyi, 2013).

The other problem threatening the forest is that during dry season, people with their cattle inhabit around border of the forest making temporary huts for them and for their livestock. After a year, the area they inhabited on will be suitable for agriculture and changed to farm land and new area will be inhabited the next summer. This method of farm land expansion is being continued year after year in Kimphe Lafa Natural Forest following the same trend (Plate 7).

Plate 7: Gradual conversion of the forest to the farm lands as a result of livestock migration to the area and inhabited temporarily around border of the forest
(Photo by Kedir Aliyi, 2013).

Plate 8: Farm land expanded about 200 m in side KLNF Forest crossing the demarcation stone

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

The floristic composition, structure and regeneration status of plant species in Kimphe Lafa Natural Forest were studied. A total of 130 plant species were recorded from the forest which belong to 100 genera and 56 families. Of the total plant species, 45 species were trees, 23 species were shrubs, 33 species were herbs, 14 species were climbers, 6 species were lianas, 8 species were epiphytes and 1 species was fern. Family Fabaceae was the most dominant represented by 18 species followed by Asteraceae with10 species, Convolvulaceae and Orchidaceae each with 4 species. Hierarchical cluster analysis was made using PC-ORD windows version 5 and six community types were determined which can be observed in the field based on natural distribution of plants in the forest. Shanno-Weinner diversity index indicated that different species diversity and richness was obtained among the six community types which may be due to environmental factors like altitude and topography.

The Shannon-Weiner diversity index was computed for the six community types and indicated that *Maytanus arbotifolia-Caucanthus auricalatus* community type is the most diverse and has the most even distribution of species which implies that the community has relatively less anthropogenic intervention. *Ficus sur-Podocarpus falcatus* Community type has the least diversity index with the least number of species. Community type I has the highest number of species but with the least species evenness for the community type was dominated by only *Vernonia urticifolia* and *Croton macrostachyus*.

The total density of individuals trees and shrubs of Kimphe Lafa Natural Forest with DBH ≥ 2.5 cm was 533.21 ha^{-1} and those with DBH below 10 cm, between 10 and 20 cm and above 20 cm were 213.99, 183.96 and 135.26 ha^{-1} respectively.

A total of 2858 individuals of woody plant species whose DBH and height is ≥ 2.5 cm and ≥ 2 m respectively were recorded from Kimphe Lafa Natural Forest. The DBH was classified in to nine classes for data analysis of the forest. Generally distribution of all individuals in different DBH size classes showed an inverted J-shaped distribution. This pattern indicates that the majority of the species had the highest number of individuals in lower DBH class which in turn shows that the forest vegetation has good reproduction and recruitment potential. The highest number of individuals of woody plant species of the forest was distributed in the DBH class I with 213.99 individuals ha^{-1}. The distribution of trees in DBH class II was 183.96 individuals ha^{-1}, class III 38.81 individuals ha^{-1}, class IV 21.83, class V 17.54, class VI 20.91 individual ha^{-1}, class VII 11.94 individuals ha^{-1}, class VIII 9.70 individuals ha^{-1} and class IX 14.55 individuals ha^{-1}.

The total basal area of Kimphe Lafa Natural Forest was about 114.4 m^2 $ha^{-1}$for woody plant species that have DBH ≥ 2.5 cm. For the basal area is calculated from the DBH, there is a considerable decrease in number of individuals of trees and shrubs as the DBH of trees and shrubs increase. *Ficus sur* was the most important plant species of the forest with basal area 71.21 m^2 ha^{-1} which is about four times greater than the second most important plant species, *Podocarpus Falcatus*, with basal area 17.38 m^2 ha^{-1}.

All woody plant species of the study area were classified into seven Important Value Index classes for the sake of setting priority. Class I) <0.5, II) 0.5-1, III) 1.01-15, IV) 15.01-25, V) 25.01-35, VI) 35.01-45 and class VII, >45. The top 10 plant species leading with greatest importance value and dominance in Kimphe Lafa Natural Forest were *Ficus sur, Vernonia urticifolia, Podocarpus falcatus, Calpurnia aurea, Croton macrostachyus, Maytenus abscura, Celtis africana, Mimusops kummel, Cordia africana* and *Bersama abyssinica* in relative to other species of the area. Contrarily, top ten plant species that need high priority for conservation in the forest were *Ximenia americana, Acacia tortolis, Acacia abyssinica, Acacia seyal, Dombeya torrida, Grewia ferruginea, Cussonia arborea, Grewia bicolor, Pittosporum viridiflorum* and *Pappea capensis* based on their Important Value Index.

Analysis of seedlings and saplings of Kimphe Lafa Natural forest indicated that the total density of seedlings and saplings of woody plants species of the forest was 1091.8 and 834.7 ha^{-1} respectively and that of mature individuals was 515.7 ha^{-1}. Plant species such as *Ximenia americana*, *Cordia monoica*, *Cussonia arborea* and *Rhus glutinosa* were devoid of both seedling ans sapling.

5.2. Recommendations

Kimphe Lafa Natural Forest is naturally endowed with diversity of plant species. However, the forest is being exploited by local surrounding people for expansion of agricultural land, timber production and construction materials and fire wood. Hence, conservation and management systems should be implemented and as a result, the following recommendations are designed.

1. The present study came up with floristic composition, structure and regeneration of the forest which will be a baseline for conservation and management of the forest. However, as it was limited to species composition, structure and regeneration, further studies like vegetation dynamics, soil seed bank and traditional managing system of the forest are recommended.

2. For evaluating indigenous knowledge of local people toward the forest and various traditional uses of plant species, Ethnobotanical studies should be carried out on the forest.

3. Public discussion with the local people regarding the values of natural forests and problems that can be resulted as a result of deforestation and putting forwarding map to participatory conservation and management of the forest.

4. Kimphe Lafa Natural forest has high regeneration potential. However, overgrazing of the forest by the cattle destroy the regenerating seedlings and saplings. Hence, educating and encouraging the local residents to minimize their cattle, feed their cattle alternative fodder like crop residues to minimize the damage of seedlings and saplings caused by livestock.

5. Buffer zone should be created in the forest so as to strictly protect and conserve species so that the buffer zone is used as repositories of biodiversity and as a source of genetic resources while the peripheral areas of the forest could be utilized in a sustainable manner.

6. Micropropagation should be done for plant species whose seedlings and saplings were absent from the area like *Ximenia americana*, *Cordia monoica*, *Cussonia arborea* and *Rhus glutinosa*.

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7. APPENDICES

Appendix 1: List of plant species collected from Kimphe Lafa Natural Forest Oromia Regional State, West Arsi, Ethiopia T = Tree, S= Shrub, C = Climber, L= Liana, E = Epiphyte, H =Herb, F= Fern

S. no.	Botanical name	Family	Local name	Habit	Code
1	*Abutilon longicuspe* Hochst. ex A. Rich.	Malvaceae		H	KA75
2	*Acacia abyssinica* Hochst.ex Benth.	Fabaceae	Laaftoo	T	KA13
3	*Acacia etbaica* Schweinf.	Fabaceae	Doddota	T	KA72
4	*Acacia mellifera* (Vah.)Benth.	Fabaceae	Goraa	L	KA56
5	*Acacia senegal* (L.) Willd.	Fabaceae	Qarxafaa	T	KA71
6	*Acacia seyal* Del.	Fabaceae	Waaccuu	T	KA34
7	*Acacia tortolis* (Forssk.) Hayne	Fabaceae	Ajoo	T	KA58
8	*Acalypha crenata* A. Rich.	Euphorbiaceae		H	KA40
9	*Achyranthes aspera* L.	Amaranthaceae	Darguu	H	KA74
10	*Acokanthera schimperi* (A.DC) Schweinf.	Apocynaceae	Qaraaruu	S	KA47
11	*Aerangis brachycarpa* (A. Rich.) Th. Dur. And Schinz.	Orchidaceae		E	KA79
12	*Aeschynomene elaphroxylon* (Guill. And Perr.) Taub.	Fabaceae	Boboffee	T	KA41
13	*Albizia grandibracteata* Taub.	Fabaceae	Qarcacee	T	KA29
14	*Amaranthus spinosus* L.	Amaranthaceae	Raafuu harree	H	KA27
15	*Amaranthus caudatus* L.	Amaranthaceae	Urgoo harree	H	KA73
16	*Anagallis arvensis* L.	Premulaceae		H	KA51

Appendix 1: Continued…

17	*Balanites aegyptiaca* (L.) Del.	Balanitaceae	Baddana	T	KA89
18	*Bersama abyssinica* Fresen.	Melianthaceae	Woraqqaa	T	KA33
19	*Buddleja polystachya* Fresen.	Loginaceae		S	KA15
20	*Cadaba farinos* Forssk.	Capparidaceae	Qalqalcha	S	KA82
21	*Calpurnia aurea* (Ait.) Benth	Fabaceae	Ceekataa	S	KA55
22	*Capparis sepiaria* L.	Capparidaceae	Hobbe madaa	L	KA16
23	*Capparis tomentos* Lam.	Capparidaceae	Hunxuxii	L	KA90
24	*Carduus schimperi* Sch. Bip.ex A. Rich	Asteraceae		H	KA26
25	*Carrisa spinarum* L.	Apocynaceae	Agamsa	S	KA42
26	*Caucanthus auricalatus* (Radlk.) Nedenzu	Malpighiaceae	Gaalee	C	KA04
27	*Celtis africana* Burm.f.	Ulmaceae	Amallaqqaa	T	KA14
28	*Cissus petiolata* Hook. f.	Vitaceae	Gaalee abdii	C	KA117
29	*Clematis simensis* Fresen.	Ranunculaceae	Hidda galee	C	KA01
30	*Colocacia esculenta* (L.) Schott	Araceae	Godarree	H	KA69
31	*Commelina africana* L.	Commelinaceae		H	KA91
32	*Convolvulus arvensis* L.	Convolvulaceae		C	KA02
33	*Cordia africana* Lam.	Boraginaceae	Woddeesssa	T	KA92
34	*Cordia monoica* Roxb.	Boraginaceae	Mandheera	T	KA70
35	*Crepis foetida* L.	Asteraceae		H	KA93
36	*Croton dichogomas* Pax	Euphorbiaceae	Ulee foonii	S	KA95

Appendix 1: Continued…

37	*Croton macrostachyus* Del.	Euphorbiaceae	Makkanniisa	T	KA96
38	*Cucumis dipsaceus* Ehrenb ex. Spach	Cucurbitaceae	Abbaa hoolaa	C	KA83
39	*Cussonia arborea* A. Rich.	Araliaceae	Harfattuu	T	KA97
40	*Cynoglossum geometricum* (Bak. & Wright) Edwards	Boraginaceae	Maxxanee	H	KA98
41	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	Maxxannee	H	KA23
42	*Datura stramonium* L.	Solanaceae	Banjii	H	KA78
43	*Delonix elata* (L.) Gamble	Fabaceae	Harangamaa	S	KA57
44	*Desmodium dichotomum* (Klein ex Willd.) DC.	Fabaceae		C	KA63
45	*Dichrostachys cinerea* (L.) Wight and Arm	Fabaceae	Geetoo	T	KA21
46	*Diospyros abyssinica* (Hiern) F. White	Ebenaceae	Xiilloo	T	KA24
47	*Dodonaea angustifolia* L.f.	Sapindaceae	Shuwwaa	S	KA30
48	*Dolichos sericeus* E.Mey.	Fabaceae	Gaalee	C	KA25
49	*Dombeya torrida* (J.F. Gmel.) P. Bamps	Sterculaceae	Daannisa	T	KA99
50	*Drynaria volkensii* Hieron.	Polypodiaceae		E	KA88
51	*Ehretia cymosa* Thonn.	Boraginaceae	Ulaagaa	T	KA100
52	*Englerina woodioides* (Schweinf.) M. Gilbert	Loranthaceae	Harmoo mukaa	E	KA17
53	*Euphorbia depauperata* A.Rich.	Euphorbiaceae	Guurii	H	KA85
54	*Ficus* Sp.	Moraceae	Qilxuu	T	KA67
55	*Ficus sur* Forssk.	Moraceae	Harbuu	T	KA65
56	*Ficus sycomorus* L.	Moraceae	Odaa	T	KA102

Appendix 1: Continued…

57	*Ficus thonningii* Blume	Moraceae	Dambii	T	KA49
58	*Ficus vasta* Forssk.	Moraceae	Qilxuu	T	KA66
59	*Galinsoga parviflora* Cav.	Asteraceae		H	KA103
60	*Grewia bicolor* Juss.	Teliaceae	Harooressa kormaa	T	KA11
61	*Grewia ferruginea* Hochst. Ex A. Rich	Teliaceae	Harooressa dhalaa	T	KA12
62	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae		H	KA104
63	*Helichrysum foetidum* (L.) Moench.	Asteraceae	Adalaa	H	KA105
64	*Helinus mystacinus* (Ait.) E. Mey. ex Steud.	Rhamnaceae	Qacaaculloo	S	KA106
65	*Hibiscus macranthus* Hochst.ex A.Rich.	Malvaceae	Hadaa	H	KA64
66	*Hippocratea africana* (Willd.) Loes.	Celasteraceae	Gaalee hoombaa	L	KA35
67	*Hydrocotyle sibthorpioides* Lam.	Apiaceae	Creeping herb	H	KA31
68	*Hypoestes forskaolii* (Vahl) R. Schult.	Acanthaceae	Darguu	H	KA107
69	*Ilex mitis* (L.) Radlk	Aquifoliaceae	Mi'eessaa	T	KA08
70	*Ipomoea cairica* (L.)	Convolvulaceae	Gaalee	C	KA32
71	*Ipomoea eriocarpa* R. Br.	Convolvulaceae		C	KA84
72	*Ipomoea obscura* (L.) Ker Grawl.	Convolvulaceae		C	KA22
73	*Justicia schimperiana* (Hochst.ex Nees) T. Anders.	Acanthaceae	Dhummuuga	S	KA62
74	*Kalanchoe marmorata* Bak	Crassulaceae	Hancuurraa	H	KA86
75	*Lannea schimperi* (A. Rich.) Engl.	Anacardiaceae	Handarakkuu	T	KA94
76	*Maerua angolensis* DC.	Capparidaceae	Qalqalcha dhalaa	T	KA50

Appendix 1: Continued…

77	*Maerua triphylla* A. Rich.	Capparidaceae	Qalqalcha kormaa	T	KA128
78	*Malva verticillatum* L.	Malvaceae		H	KA60
79	*Maytenus abscura* (A. Rich.) Cuf.	Celasteraceae	Kombolcha	T	KA38
80	*Maytenus arbutifolia* (A. Rich.) Wilczek	Celasteraceae	Kombolcha	T	KA39
81	*Maytenus senegalensis* (Lam.) Exell	Celasteraceae	Wonte fullaasa	T	KA18
82	*Maytenus undata* (Thunb.) Blackelock	Celestraceae	Kokolfaa	T	KA108
83	*Microcoelia globulosa* (Hochst.) L. Jonsson.	Orchidaceae		E	KA87
84	*Mimusops kummel* A.DC.	Sapotaceae	Kolaatii	T	KA37
85	*Momordica foetida* Schumach.	Cucurbitaceae		C	KA109
86	*Neckera remota* Bruch and Schimp.ex Mull. Hal.	Neckeraceae	Arrii mukaa	E	KA80
87	*Nephrolepis exaltata* (L.) Schott	Nephrolepidaceae		F	KA111
88	*Nicandra physaloides* (L.) Gaertn.	Solanaceae	Banjii	H	KA77
89	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	Daaddoo	H	KA101
90	*Ocimum urticifolium* Roth.	Lamiaceae	Cabbicha	H	KA05
91	*Olea auropaea* L.	Oleaceae	Ejersa	T	KA07
92	*Olea capensis* L.	Oleaceae	Siigeda	T	KA52
93	*Opuntia ficus-indica* (L.) Miller.	Cactaceae	Qulqaalii	T	KA68
94	*Oxalis radicosa* A. Rich.	Oxalidaceae		H	KA112
95	*Pappea capensis* Eckl. and nd Zeyh.	Sapindaceae	Wilicaa	T	KA113
96	*Peperomia tetraphylla* (Forster.) Hook. and Arn.	Orchidaceae		E	KA110

Appendix 1: Continued…

97	*Persicaria senegalensis* (Meisin.) Sojak	Polygonaceae		H	KA114
98	*Phoenix reclinata* Jacq.	Arecaceae	Meexxii	T	KA115
99	*Phytolacca dodecandra* L' Herit.	Phylolaccaceae	Handoodee	S	KA03
100	*Pittosporum viridiflorum* Sims	Pittosporaceae	Aaraa	T	KA53
101	*Podocarpus falcatus* (Thumb.) R.B.ex.Mirb.	Podocarpaceae	Birbirsa	T	KA61
102	*Psydrax schimperiana* (A. Rich.) Bridson	Rubiaceae	Gaalloo	T	KA28
103	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	Qonxirii	S	KA116
104	*Ranunculus multifidus* Farssk.	Ranunculaceaea		H	KA118
105	*Rhoicissus tridentata* (L.f.) Willd and Drummond	Vitaceae	Laaluu	C	KA19
106	*Rhus glutinosa* A. Rich.	Anacardiaceae	Xaaxessaa	L	KA43
107	*Ricinus communis* L.	Euphorbiaceae	Qobboo	S	KA06
108	*Rubus apetalus* Poir.	Rosaceae	Garaa waraabessaa	S	KA59
109	*Rytigynia neglecta* (Hiern) Ronyns	Rubiaceae	Bunoo	S	KA120
110	*Senna didymobotrya* (Fresen.) Irwin and Barneby	Fabaceae	Ajaawaa	S	KA81
111	*Senna petersiana* (Bolle) Lock	Fabaceae	Qorsa bofaa	H	KA76
112	*Senna septemtrionalis* (Viv.) Irwin and Barneby	Fabaceae	Ajaawaa	S	KA48
113	*Sesbania sesban* (L.) Merr.	Fabaceae	Saspaniyaa	T	KA36
114	*Solanum dasyphyllum* Schumach.	Solanaceae	Doobbii	H	KA119
115	*Solanum giganteum* Jacq.	Solanaceae	Hiddii woraabessaa	S	KA09
116	*Solanum incanum* L.	Solanaceae	Hiddii	S	KA10

Appendix 1: Continued…

117	*Sonchus asper* (L.) Hill	Asteraceae		H	KA121
118	*Sonchus oleraceus* L.	Asteraceae		H	KA122
119	*Stephania abyssinica* (Dillon & A.Rich.). Walp.	Menspermaceae	Kalaalaa	L	KA123
120	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Baddeessaa	T	KA44
121	*Teclea simplicifolia* (Engl.) Verdoorn.	Rutaceae	Hadheessaa	S	KA124
122	*Tragia brevipes* Pax	Euphorbiaceae	Laalessaa	C	KA45
123	*Tridactyle bicaudata* (Lindl.) Schlrt.	Orchidaceae	Harmoo	E	KA125
124	*Usnea africana*	Usnaceae	Arrii-Mukaa	E	KA126
125	*Vernonia amygdalina* Del.	Asteraceae	Ebicha	S	KA127
126	*Vernonia urticifolia* A. Rich.	Asteraceae	Reejjii	S	KA54
127	*Xanthium strumarium* L.	Asteraceae	Maxxannee(baccarroo)	H	KA20
128	*Ximenia americana* L.	Olacaceae	Hudhaa	T	KA46
129	*Zehneria scabra* (Linn.f.) Sond.	Cucurbitaceae		C	KA129
130	*Ziziphus mucronata* Willd.	Rhamnaceae		S	KA130

Appendix 2: Families and Percentage distribution of Species and Genera in Kimphe Lafa Natural Forest

Family	Species	% Species	Genera	% Genera
Acanthaceae	2	1.54	2	2
Amaranthaceae	3	2.31	2	2
Apiaceae	1	0.77	1	1
Anacardiaceae	2	1.54	2	2
Apocynaceae	2	1.54	2	2
Aquifoliaceae	1	0.77	1	1
Araceae	1	0.77	1	1
Araliaceae	1	0.77	1	1
Arecaceae	1	0.77	1	1
Asteraceae	10	7.69	8	8
Balanitaceae	1	0.77	1	1
Boraginaceae	5	3.85	3	3
Cactaceae	1	0.77	1	1
Capparidaceae	5	3.85	3	3
Celasteraceae	5	3.85	2	2
Commelinaceae	1	0.77	1	1
Convolvulaceae	4	3.08	2	2
Crassulaceae	1	0.77	1	1
Cucurbitaceae	3	2.31	3	3
Ebenaceae	1	0.77	1	1
Euphorbiaceae	6	4.62	5	5

Appendix 2: Continued…

Fabaceae	18	13.85	10	10
Lamiaceae	2	1.54	1	1
Loginaceae	1	0.77	1	1
Lorantaceae	1	0.77	1	1
Malpighiaceae	1	0.77	1	1
Malvaceae	3	2.31	3	3
Melianthaceae	1	0.77	1	1
Menspermaceae	1	0.77	1	1
Moraceae	5	3.85	1	1
Myrtaceae	1	0.77	1	1
Neckeraceae	1	0.77	1	1
Nephrolepidaceae	1	0.77	1	1
Olacaceae	1	0.77	1	1
Oleaceae	2	1.54	1	1
Orchidaceae	4	3.08	4	4
Oxalidaceae	1	0.77	1	1
Phylolaccaceae	1	0.77	1	1
Pittosporaceae	1	0.77	1	1
Podocarpaceae	1	0.77	1	1
Polipodiaceae	1	0.77	1	1
Polygonaceae	1	0.77	1	1
Premulaceae	1	0.77	1	1
Ranunculaceae	2	1.54	2	2

Appendix 2: Continued…

Rhamnaceae	2	1.54	2	2
Rosaceae	1	0.77	1	1
Rubiaceae	2	1.54	2	2
Rutaceae	1	0.77	1	1
Sapindaceae	2	1.54	2	2
Sapotaceae	1	0.77	1	1
Solanaceae	5	3.85	3	3
Sterculaceae	1	0.77	1	1
Teliaceae	2	1.54	1	1
Ulmaceae	1	0.77	1	1
Usnaceae	1	0.77	1	1
Vitaceae	2	1.54	2	2

Appendix 3: The Six Community Types, their Sample plots and Altitude

Community type	**Plots**	**Total plots**	**Altitudinal range(m)**
I	1,2,3,12,49,4,18,72,102,53,7,19, 25,31,16,15,30,36,44,14,129,57, 76,119,22,111,109,51,37,117,67, 17,21,24,46,59,74,67,35,38,45,65, 40,39,99,112	46	1559-1650
II	5,26,52,123,23,8,55,110,50,34, 130,94,105,113	14	1587-1608
III	56,11,98,27,124,35,118,71,125, 29,88,32,42,87,96,116,95,70,84,	23	1597-1619

Appendix 3: Continued…

	93,43,128,79,		
IV	9,75,81,104,13,60,90,134,77,20, 56,66,83,106	14	1588-1600
V	10,133,62,82,91,33,85,127,92,78, 101,28,61,54,48,120,126,64,80, 131,89,132,107,68,103,73,97	28	1590-1616
VI	41,121,122,100,47,63,108,114,115	9	1592-1638