ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

OFFICE OF GRADUATE STUDIES

Woody Plant Species Diversity Assessment at Berche Natural Forest in Gololcha Woreda, Bale Zone, Oromia Regional State, Ethiopia

A Thesis

Submitted to the Department of Applied Biology

School of Applied Natural Science

In Partial Fulfillment of the Requirement for the Degree of Master's in Biology

By

Belay Mengesha Faris

Adama, Ethiopia

September, 2017

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Advisor: Dr. Mesele Admasu

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APPROVAL OF BOARD OF EXAMINERS

We, the undersigned, members of the Board of Examiners of the final open defense by **Belay Mengesha Faris** have read and evaluated his thesis entitled **"Woody Plant Species Diversity Assessment at Berche Natural Forest in Gololcha Woreda, Bale Zone, Oromia Regional State, Ethiopia**" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master of Science in Biology.

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Advisor	Signature	Date
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Internal Examiner	Signature	Date
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External Examiner	Signature	Date

DECLARATION

I hereby declare that this MSc Thesis is my original work and has not been presented for a degree in any other university, and all sources of material used for this thesis have been duly acknowledged.

Name: Belay Mengesha Faris

Signature: _____________

This M.Sc. Thesis has been submitted for examination with my approval as thesis advisor.

Name: Dr. Mesele Admasu

Signature: ______________

Date of submission: ______________________

ADVISOR’S APPROVAL SHEET

To: Applied Biology department

Subject: Thesis Submission

This is to certify that the thesis entitled **“Woody Plant Species Diversity Assessment at Berche Natural Forest in Gololcha Woreda, Bale Zone, Oromia Regional State, Ethiopia**” submitted in fulfillment of the requirements for the degree of Master’s of Science in Biology, the Graduate program of program of Applied Biology, and has been carried out by Belay Mengesha Faris, **Id.No** GSU/0399/06, under my supervision. Therefore, I recommend that the student has fulfilled the requirements and hence hereby he can submit the thesis to the department.

Name of major Advisor: Dr. Mesele Admasu

Signature: ___________________

Date: ___________________

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Table of Contents

Content Page

LIST OF TABLES **Page**

LIST OF FIGURES **page**

LIST OF APPENDICES **page**

ACRONYMS

DBH	Diameter at Breast Height
FAO	Food and Agriculture Organization
GPS	Geographical Positioning System
H'	Shannon-Wiener Diversity index
ha	Hectare
IISD	International Institute for sustainable Development
IVI	Important Value Index
NEPAD	New partnership for Africa's Development
OFWE	Oromia Forest and Wild life Enterprise
WBISPP	Woody Biomass Inventory and Strategic Planning Project

ABSTRACT

A study on woody plant species diversity assessment at Berche natural forest in Gololcha woreda was conducted from October 2016 to July, 2017. The study site was selected purposefully based on the presence of highly dense forest in Berche Natural forest. Systematic Sampling method was employed. To investigate the woody species structure, composition and diversity of Berche forest, six transects were laid. Sample quadrats measuring 20m x20 m, and 5m x 5m were laid for trees; shrubs and saplings respectively in a nested form. The sample quadrats were laid down along transects at a distance of 200m from each other using GPS. A total of 30 quadrats were sampled. Vegetation classification was performed using R 3.3.1 package by using species cover-abundance. The other structural analysis were performed using Microsoft excel. Shannon - Wiener diversity index, species richness and Shannon's evenness were computed to describe species diversity of the plant community structure. Results showed that a total of 58 woody species representing 34 families and 48 genera were recorded. The major families were Fabaceae and Anacardiaceae each represented by 7 species (12%) and 6 (10%) respectively. The majority of the families were represented by one species only. Based on the results of vegetation classification, three plant communities were recognized and described. Species richness, diversity and evenness varied among the plant communities. Community three has the highest species diversity and evenness with 3.8 and 97% respectively. The forest is dominated by understory and shrub layer. Participatory forest management is recommended for better management of the forest.

Key Words: Berche Natural forest, Diversity, Population structure, Species richness, Woody species composition

1. INTRODUCTION

1.1. Background of the Study

The global forest cover is 3952 million hectare, which is about 30 percent (%) of the world's land area (FAO, 2006a). However, Forests and woodlands occupy an estimated 650 million ha or 21.8 % of the land area in Africa. These accounts for 16.8 % of the global forest cover (FAO, 2005).The forest sector in Africa plays an important role in the livelihoods of many communities and in the economic development of many countries. This is particularly so in Western, Central and Eastern Africa where there is considerable forest cover. Africa has a high per capita forest cover at 0.8 ha per person compared to 0.6 ha globally (FAO, 2002).On average, forests account for 6 % of Gross Domestic Product (GDP) in Africa, which is the highest in the world (NEPAD , 2003).

Ethiopia has the fifth largest floral diversity in tropical Africa (Didita *et al.,* 2010). Due to its diverse topography that has given rise to the development of wide diversities of flora and fauna rich with endemic species. About 6,000-7,000 species of higher plants are estimated to exist in the country of which about 780-840 (12-13%) plant species are estimated to be endemic (Nune *et al*., 2007).

Plant communities are the foundation for terrestrial trophic webs and animal habitat, and their structure and species composition are an integrated result of biological and physical drivers (Gates, 1993). Additionally, they have a major role in geologic, geomorphologic and soil development processes (Stevens and Walker, 1970). The multipurpose role of trees and shrubs as a source of feed for both domestic and game animals, firewood, construction materials, source of medicine, mulch and soil conservation in semi-arid regions has long been recognized by scholars in the past (Smit, 2002).

Land use and land cover dynamics are widespread, accelerating, and significant processes driven by human actions but also producing changes that impact humans (Agarwal *et al*., 2002). These dynamics alter the availability of different biophysical resources including soil, vegetation, water, animal feed and others. Consequently, land use and cover changes could lead to a decreased availability of different products and services for human, livestock, agricultural production and damage to the environment.

Although, several factors drive natural forest destruction in Ethiopia, agricultural land expansion triggered by increasing human population is probably the dominant force (Didita *et al*., 2010). Forest degradation and deforestation in Ethiopia entails several socioeconomic and environmental challenges that have strongly affected the capacity of forests to provide ecosystem services (Badege, 2001). Gradually, in 1989 the coverage was shrunk down to 2.7 % (Dessie and Christians, 2007). Though, there is in consistency about rate of deforestation in literature, a large parts of the forest land in the country has been destroyed due to agricultural expansion, illegal settlement and timber extraction. 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 threats affecting the life of millions of people (Pimm *et al*., 1995).

Oromia Regional State which contained over 50% of the high forest in the country is estimated to have lost 31% of its forest as a result of agricultural expansion .The total forest cover loss from1990 to 2015 is estimated to be in the range of 803, 000 ha (WBISPP, 2004). Extraction of fuel wood and charcoal for major towns in the country has increased the rate of deforestation and natural resource depletion. The ever increasing of woodland clearance for rain-fed agriculture and irrigation under takings further enhanced the vulnerability of the ecosystem. Over forty taxa in this ecosystem are threatened (Kelbessa *et al.,* 1992).

1.2. Statement of the Problem

Forest degradation in Sub-Saharan Africa, takes place widely because people gain immediate economic benefits from forest and forest -related economic activities (Mogaka *et al*. 2001). Besides, lack of technical knowledge, awareness and political instability have exacerbated the problem in many developing countries (Ayyad, 2003).

The importance of forest resources to the livelihoods of people living in and around forests has increasingly been recognized during the last three decades (Carter and Gronow 2005; Yemiru *et al.*, 2010). International Institution for Sustainable Development (IISD) also explained that over the past two decades, a rapid population growth has led to a significant expansion of human settlements, an increase in the demand for crop and grazing land and wood for fuel and construction in Bale ecosystem which threatened the conservation value of the forest and sustainability of natural resources based livelihoods (IISD, 2015). In addition to this, the Kubayo Forest is affected by recurrent fires, which often significantly threaten local biodiversity and habitats. Fire that occurred between January and April was the most severe from 2008-2015 and destroyed approximately 500 hectare of dry land forest (OFWE, 2015).

In areas where indigenous trees were grown, the need for construction purpose is high and especially trees were used illegally. In addition, the forest is severely damaged by local communities for the purpose of fuel wood (fire wood), illegal settlement in the forest. Due to the intervention of communities into the forest the wild animals were migrated to the other areas (OFWE, 2015). This type of deforestation practice is also very common in Gololcha Woreda in Berche Natural Forest when the habitat loss results, species will extinct. Nevertheless, in this study area little research has been done that indicates woody biodiversity assessment. Therefore, this study was designed to assess the woody plant species, mainly shrubs and trees species diversity of Berche forest in Gololcha wereda.

1.3. Objectives of the study

1.3.1. General Objective

The general objective of this thesis was to assess woody plant species diversity with emphasis to shrubs and trees growing in Berche natural forest.

1.3.2. Specific Objectives

- To assess woody plant species richness and abundance of shrubs and trees in Berche natural forest.
- To identify the dominant tree and shrub species growing in Berche natural forest.
- To identify the density, frequency and important value index of trees and shrubs species existing in Berche natural forest.
- To determine population structure of selected tree species.

1.4. Research questions

To address the objectives stated above, the following basic research questions were raised to investigate study problems:

- What is the composition and structural pattern of the woody plant species of the study area?
- What is the dominant woody species of the study area?

- What are the densely populated trees and shrubs plant species growing in Berche natural forest?
- What is the distribution of trees and shrub species existing in Berche natural forest?

1.5. Significance of the Study

Various attempts have been made to study the forests in different parts of Ethiopia. However, the assessment of woody species composition diversity and structural analysis and other attributes has not been studied so Berche Natural Forest renders significant ecological and socio-economic services to the local communities. Hence, there is a need of sound conservation and sustainable use of this forest. This necessitates perceiving the nature of its plant community, species diversity and its linkage to the local communities. Lack of such basic information is one of the serious problems that hampered the conservation and rational utilization of the forest resources of the area. Thus, species documentation, community identification and description of this forest are important and this study is initiated to provide primary information about woody plant composition, species diversity and population structure of Berche Natural Forest. Besides, to provide information on woody species richness and diversity of the forests useful for forest management purpose and help in understanding forest ecology and ecosystem functions. The result of the study benefits the people who need knowledge of floristic composition and structure of forest. It also helps them in identifying ecologically and economically important plant.

1.6. The Scope of the Study

Taking into consideration the financial and time constraint, this study was mainly focused on assessment of woody species of trees and shrubs in Gololcha woreda Berche natural forest.

2. LITERATURE REVIEW

2.1. Importance of Forest

The forest sector in Africa plays an important role in the livelihoods of many communities and in the economic development of many countries. Africa has a high per capita forest cover at 0.8 ha per person compared to 0.6 ha globally (FAO, 2002).

Forests and woodlands are now recognized as an important component of the nation's stock of economic assets and they contribute in excess of $546.6 million to the economy through forestry, tourism, agriculture and energy (Emerton and Muramira ,1999). Forests and woodlands also contribute to the long-term social and economic development goals of New Partnership for Africa's Development (NEPAD) and can play an important role in addressing the Millennium Development Goals (MDGs) and meeting its targets. They provide energy, food, timber and non-timber forest products (NTFPs) and are important contributors to wealth and health at the household, community, national, sub-regional, regional or even global level .Forest and woodlands are also key components of the environment and provide essential services that are critical to combating land degradation and climate change, as well as to conserving wetlands, coastal areas and freshwater systems. In this regard, the NEPAD programmed on forests and woodlands is critical to the success of the other NEPAD programmers, including those on combating land degradation and climate change, and on conserving wetlands, coastal and freshwater resources. In Central and Western Africa, the forest sector contributes more than 60 % of GDP through export of timber products (FAO 2003b). Africa's wood production (including round wood and fuel wood), this increased from 340 million in 1980 to 699 million in 2000 (FAO, 2003b).

Wood fuel supports lucrative local trade. Trade in charcoal is a major source of income for many households. For example, in Zambia, the charcoal industry generated about $30 million in 1998 alone, and in the same year about 60 000 Zambians directly depended on charcoal production for the bulk of their income (Kalumiana, 2000).

Medicinal plants contribute to a foreign exchange in Egypt, Morocco and Cameroon, with annual earnings of $12.4, 12.8 and 2.9 million, respectively (FAO, 2002). Northern Africa has one of the richest, oldest and most diverse uses of medicinal plants in the region. Medicinal plants are also an important commodity in local markets as many people still rely on traditional medicine for their primary health care. In Ethiopia 600 plant species are documented as being used in traditional medicine (FAO, 2002).

Forests play great (major) roles in the regulation of hydrological cycles, climate and the reduction of the atmospheric pollution, and they also play an essential role in the global carbon cycle (REMA, 2009). As stated by Dail (1997), the major services provided by forests include: Regulation of water regimes, modulating climate, maintenance of soil quality, carbon sequestration, and maintenance of biodiversity in themselves and being a habitat for other species, biological control, cultural, aesthetic and amenity services. The economic values of the forest are the basis of a variety of industries including timber, processed wood and paper, rubber, and fruits. They also contain products that are necessary for rural communities including fuel, construction materials and medicines (FAO, 2005).

2.2. Environmental Protection

Plants make up a vital part of the natural environment. In a healthy ecosystem, plants provide food and shelter for animals, secure the soil to prevent erosion, cast shade to create microclimates, conserve water to keep it in the ecosystem instead of allowing it to be lost, and participate in the breakdown and recycling of organic material to keep the ecosystem thriving. Plants produce oxygen and have been heavily implicated in the creation of the Earth's currently oxygen-rich atmosphere. The flora of Ethiopia is very heterogeneous and has a rich endemic element owing to the diversity in climate, vegetation and terrain. It is estimated to contain between 6,500–7000 species of higher plants. Among these about 12% are endemic (Soromessa *et al.*, 2004).

The plant populations on our planet must be sustained all forms of life to exist on this planet being provided with the energy harvested from the sun by green plants through photosynthetic processes. The plant populations need to be maintained for the lives continue to exist on this planet as we know it through effective management measures. Various scholars also agreed on the urgency and importance of studying and documenting the vegetation resources of Ethiopia (Soromessa *et al.,* 2004; Kelbessa and Soromessa, 2008; Soromessa *et al.,* 2011; Gurmessa *et al*., 2012; Feyissa *et. al.*, 2013; Soromessa, 2013; Soromessa and Kelbessa, 2013a,b; Soromessa and Kelbessa, 2014; Gedefaw *et al.,* 2014) are the once to mention.

2.3. Impact of Deforestation

Deforestation has been a major problem for quite a long time with serious consequences to Ethiopia. These consequences include decline or loss of biodiversity, degradation of land and water bodies, possible negative effects on the local, regional and global climatic conditions as well as negative impacts on the welfare of human beings. At the close of the twentieth century, the country found itself undergoing rapid and complete de-vegetation in some places. Forest clearances for crop cultivation, unsustainable exploitation of wood for timber, construction and fuel, overgrazing and civil unrest are among the main causes of deforestation in Ethiopia. Thus, at present, small remnant forests, woodlands or shrub land shave become restricted to inaccessible areas such as hillsides, mountaintops, and around churches, monasteries, mosques or graveyards, particularly in the northern parts of the country. Larger forest relics are only found in the southern parts of the country (Emiru *et al*., 2006).

Deforestation has been practiced by humans for tens of thousands of years before the beginnings of civilization (Jeremy, 2008**)**. Fire was the first tool that allowed humans to modify the landscape (Uncovsky, 1998). It is used to convert closed forests into more open ecosystems favorable to grazing land and crop cultivation. With the diversification of agriculture, fire became the prime tool to clear land for crops (Angelsen and Kaimowitz, 1999).

Deforestation is the logging and/or burning of trees in a forested area (Maddox, 2006). There are several reasons for deforestation to occur: trees or derived charcoal can be sold as a commodity and used by humans, while cleared land is used as pasture, plantations of commodities and human settlement (Tsegaye, 2007). The removal of trees without sufficient reforestation has resulted in damage to habitat, biodiversity loss and aridity and deforested regions often degrade into wasteland (Gessesse and Carl, 2007).

In Ethiopia, deforestation is an ongoing issue that is causing extinction, changes to climatic conditions, desertification, and displacement of indigenous people. However, among countries with a per capita GDP of at least $4,600, net deforestation rates have ceased to increase (Rojahn ,2006).There are many root causes of deforestation in Ethiopia such as inequitable distribution of wealth and power, overpopulation, and urbanization (Sucoff , 2003). Globalization is often viewed as another root cause of deforestation, though; there are cases in which the impacts of globalization (new flows of labor, capital, commodities, and ideas) have promoted localized forest recovery (Marcous, 2000). Claims that population growth drives deforestation have been disputed; one study found that population increases due to high fertility rates were a primary driver of tropical deforestation in only 8% of cases (Ehrhardt , 2003).

2.3.1. Atmospheric Impact on Forest Ecosystem

Deforestation is ongoing and is shaping climate and geography of Ethiopia. Because of huge amount of CO_2 is released to the atmosphere due to deforestation. Deforestation is a contributor to global climate change, and is often cited as one of the major causes of the enhanced greenhouse effect (David, 2008). Tropical deforestation is responsible for approximately 20% of world greenhouse gas emissions.

Deforestation mainly in tropical area account for up to one-third of total anthropogenic carbon dioxide emissions (Tsegaye, 2007). Trees and other plants remove carbon in the form of carbon dioxide from the atmosphere during the process of photosynthesis and release oxygen back into the atmosphere during normal respiration (Maddox, 2006). Only when actively growing can a tree or forests remove carbon over an annual or longer time frame. Both the decay and burning of wood releases much of these stored carbon back to the atmosphere. In order for forests to take up carbon, the wood must be harvested and turned into long-lived products and trees must be re-planted. Forests are stores of carbon and can be either sinks or sources depending upon environmental circumstances. Mature forests alternate between being net sinks and net sources of carbon dioxide (Brown and Leipold, 2007).

2.3.2. Hydrological Impact on Forest Ecosystem

According to Gore (2006), the water cycle is also affected due to deforestation. Trees extract groundwater through their roots and release it into the atmosphere. When part of a forest is removed, the trees no longer evaporate away , resulting in a much drier climate which clearly visible in Ethiopia evidenced by the current frequent drought and climate change such as El-Nino.

Deforestation reduces the content of water in the soil and groundwater as well as atmospheric moisture. Deforestation reduces soil cohesion, so that erosion, flooding and landslides ensue. Forests enhance the recharge of aquifers in some locales; however, forests are a major source of aquifer depletion on most locales (Brown et al., 2006).

Deforestation also contributes to decreased evapotranspiration, which lessens atmospheric moisture which in some cases affects precipitation levels downwind from the deforested area, as water is not recycled to downwind forests, but is lost in runoff and returns directly to the oceans (Jonathan *et al*., 2005).As a result, the presence or absence of trees can change the quantity of water on the surface, in the soil or groundwater, or in the atmosphere. This in turn changes erosion rates and the availability of water for either ecosystem functions or human services. The forest may have little impact on flooding in the case of large rainfall events, which overwhelm the storage capacity of forest soil if the soils are at or close to saturation which in turn dries out the rivers, streams and springs (Susanna *et al*., 2006).

2.3.3. Soil impact on vegetation distribution

Deforestation generally increases rates of soil erosion, by increasing the amount of runoff and reducing the protection of the soil from tree litter. This can be an advantage in excessively leached tropical rain forest soils in which Ethiopia is part of the tropics (Hobbs and Harris, 2001). Tree roots bind soil together, and if the soil is sufficiently shallow they act to keep the soil in place by also binding with underlying bedrock. Tree removal on steep slopes with shallow soil thus increases the risk of landslides, which can threaten people living nearby. However most deforestation only affects the trunks of trees, allowing for the roots to stay rooted, negating the landslide (Mishra *et al*., 2004).

2.3.4. Ecological Services of forest ecosystem

According to Angelsen and Kaimowitz (1999), deforestation results in declines in biodiversity. The removal or destruction of areas of forest cover has resulted in a degraded environment with reduced biodiversity. Forests support biodiversity, providing habitat for wildlife; moreover, forests foster medicinal conservation. With forest biotopes being irreplaceable source of new drugs, deforestation can destroy genetic variations (such as crop resistance) irretrievably (Jeremy, 2008).Since the tropical rain forests are the most diverse ecosystems on Earth and about 80% of the world's known biodiversity could be found in tropical rain forests, removal or destruction of significant areas of forest cover has resulted in a degraded environment with reduced biodiversity (Marcoux, 2000).

2.4. Vegetation of Ethiopia

A key source of information on forests and other land uses in Ethiopia is WBISPP.WPISPP (2005) classified the land cover types in Ethiopia into 9 major types (Table 1).In the recent forest proclamation (No. 542/2007), high forests, woodlands, bamboo forests are recognized as forests. Based on WBISPP, the land use/land cover statistics in Ethiopia indicates that woody vegetation including high forests cover over 50% of the land (WBISPP, 2005). The definition of forest is ambiguous in the IPCC Good practices Guideline. Following the definition of FAO (2001) the vegetation of Ethiopia that may qualify as ‘forests’ are natural high forests, woodlands, plantations and bamboo forests, with an estimated area of 35.13 million ha. If the shrub lands are added to this (considering the definition of IPCC for forest), the estimated cover is over 50% (61.62 million ha). The next largest land use type is cultivated land with 18.6% cover.

Table 1. The lands cover types of Ethiopia and their magnitude (WBISPP, 2005)

Land cover type	Area in hectare	Percentage (%)
Cultivated land	21,298,529	18.6
High forests	4,073,213	3.56
Plantations	501, 522	0.4
Woodlands	29,549,016	25.8
Shrub lands	26,403,048	23.1
Grasslands	14,620,707	12.8
Afroalpine	245,326	0.21
Highland bamboo	31,003	0.027
Lowland bamboo	1,070,1981	0.97

Source: WBISPP (2005)

The topography and diverse climatic conditions of Ethiopia have led to the occurrence of habitats that harbor some unique plant species and animals and their assemblages. As a result, Ethiopia is one of the countries in the world with high level of biodiversity. The overall results of the environmental degradation in Ethiopia, whether at a local level or ecosystem level, leads to desertification and its manifestations which eventually become the overriding cause for loss of biodiversity. These disruptions have meant that much endemic biodiversity has been lost and more is threatened (Woldu, 2008).

Biodiversity is influenced by different mechanisms, to the extent that particular species may exist where others perish in response to the same environmental conditions (Crawley, 1998). Globally, patterns of plant species diversity are influenced by latitudinal, altitudinal and soil gradient (Huston, 1994). The diversity of higher plant species increases as one moves from the poles to the tropics, reaching its peak in the tropical rainforests. Generally, species diversity tends to decrease with an increase in elevation (Whittaker, 1975).

The growth of forest and other woody vegetation in Ethiopia is primarily determined by the amount of rainfall, modified by local topography and drainage properties. Chaffey (1982), EFAP (1994) and WBISPP (2005) presented estimates of forest growth stocks for Ethiopia.

The present Ethiopian vegetation is very complex. Several authors classified Ethiopian vegetation differently since 1957. To mention some Demissew and Friis (2009) divided Ethiopian vegetation broadly into nine major types. These are

1. Desert and semi-desert scrubland
2. *Acacia – Commiphora*woodland
3. Moist Evergreen Montane rainforest which can be divided into two natural subtypes (Afro-montane rainforest and Transitional rainforest)
4. Lowland semi-evergreen forest
5. *Combretum-Terminalia*Woodland and Savannah
6. Dry evergreen Montane forest and Grassland complex which is divided into four distinct subtypes (Undifferentiated Afro montane forest, Dry single –dominant Afromontane forest of the eastern escarpments and transition between single dominant Afromontane forest and East African evergreen and semi-evergreen bush land)
7. Afro-Alpine and sub-afro – alpine vegetation
8. Riparian
9. Swamp vegetation. These major vegetation types are considered natural ecosystems of the country.

The vegetation of the present study area falls in the dry evergreen afromontane forest vegetation type in the country (Friis 1992; Bekele, 1994; EFAP 1994).

Recent classification by Friis *et al*., (2011) described twelve major vegetation types in the present Atlas of the potential vegetation of Ethiopia. These vegetation types are:

1. desert and semi-desert scrubland
2. *Acacia-Commiphora* woodland and wooded grassland of the Rift valley
3. Wooded grassland of the western Gambella Region
4. *Combretum–Terminalia* woodland and wooded grassland
5. Dry evergreen Afromontane forest and grassland complex
6. Moist evergreen Afromontane forest
7. Transitional rainforest
8. Ericaceous belt

9. Afroalpine vegetation
10. riverine vegetation
11. Fresh water lakes (including lake shores, marshes, swamps and floodplain vegetation).
12. Salt water lakes (including lake shores, salt marshes and pan vegetation).

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study area shares boundaries with in South Ginir Woreda and in the North Western Arsi and Western Hararge; in the East Sawena Woreda and in the West Gasera woreda. Jara, which is the center of the woreda, is located South Eastern of Robe Town. It is about 550km far from Addis Ababa. It is located 13^{0} 15’00”- 13^{0}38’30” N latitude and 49^{0}17’30”-39^{0}47’30” E longitudes (Figure 3). The altitude ranges from 1200 m up to 2260 m above sea level. According to the annual report of OFWE (2015), Forest and woodland shrubs covers about 77,603.67 hectare. However, the study area covers 2147.08 hectare.

The highest forest covers the South - Eastern part of the woreda. Its bimodal types of rainfall characterize the woreda. The first season of rainfall, which is the longest rainy season, extends from March to June while the second season starts in the middle of August and ends at the end of November (Figure 1).

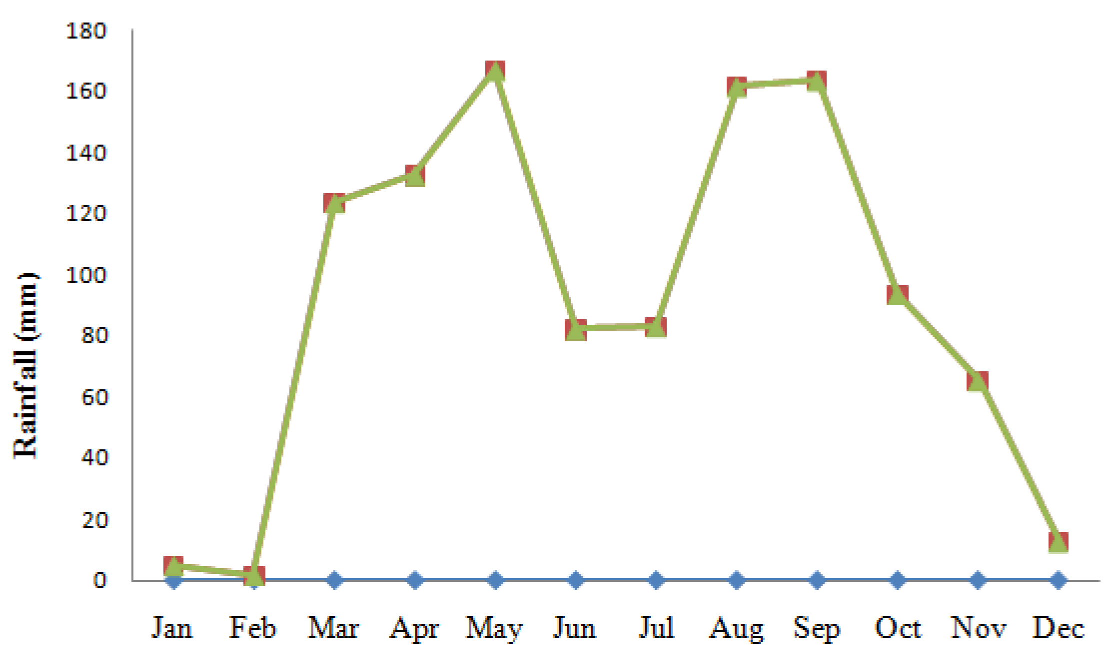

Figure 1: Annual rainfall of the study area 2011-2015 (ENMA, 2017)

The mean annual temperature of the woreda is 19.27 ^{o}c with a range of 12.5^{o}c to 26.3^{o}c (figure 2).

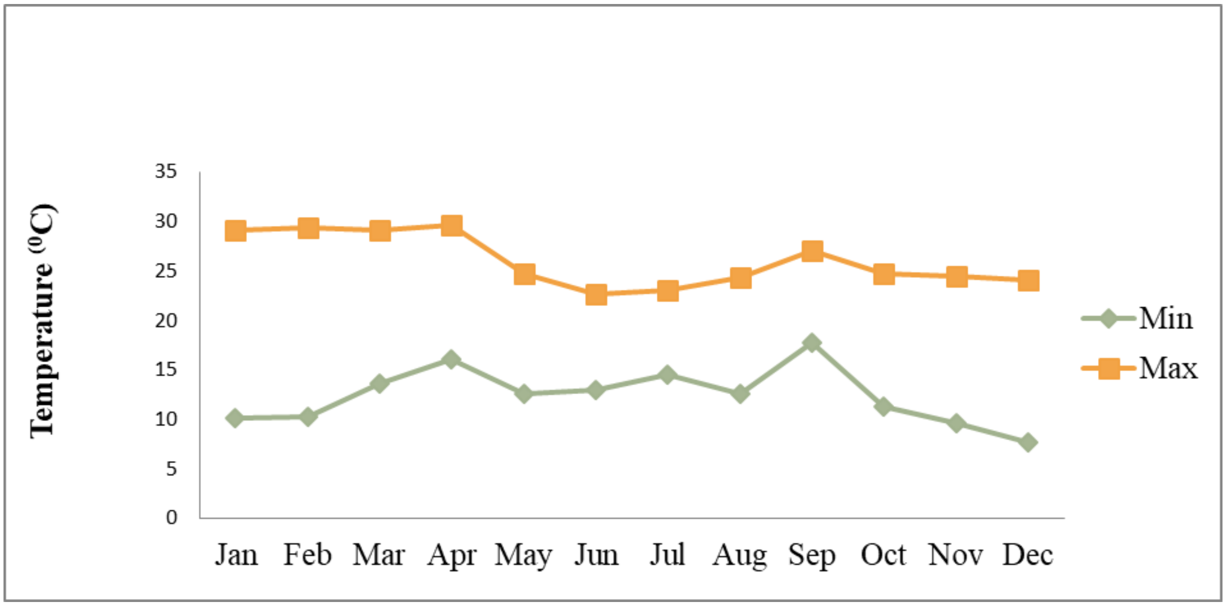

Figure 2: Annual rainfall of the study area 2011-2015 (EMA, 2017))

About 70% of the soil type in the study area is Sandy soil, where as 30% of the soil type is Clay. Kubayo Natural Forest, in particular, has five Blocks. These are Dinsa Block (7801.71 ha); Kurawada Block (11177.27 ha); Kenjila Block (8503.62 ha); Kejewa Block (9744.32 ha) and Buriya Block (3043.32). Totally the forest covers 40270.24 ha of the woreda land according to OFWE (2015). Dinsa block consists of four compartments. These are Berche, Borama, Sharota and Welenso compartment.

This study was conducted at Berche Compartment which is part of the Dinsa block. The Berche Compartment is boarded by Kura forest in East, Dinsa Town in West, Sherota forest in North and Kenjila forest in South. Its altitude is from 1500m to 2150m above the sea level .The study site area covers 2147.08 ha of the total area of the Dinsa Block.

Agriculture is the main economic activity for local communities of the study area. Expansion of agricultural land is very high in the area. Livestock is another very common economic activity and major natural resource management issue in Bale in general and in the study area in particular (OFWL, 2015).

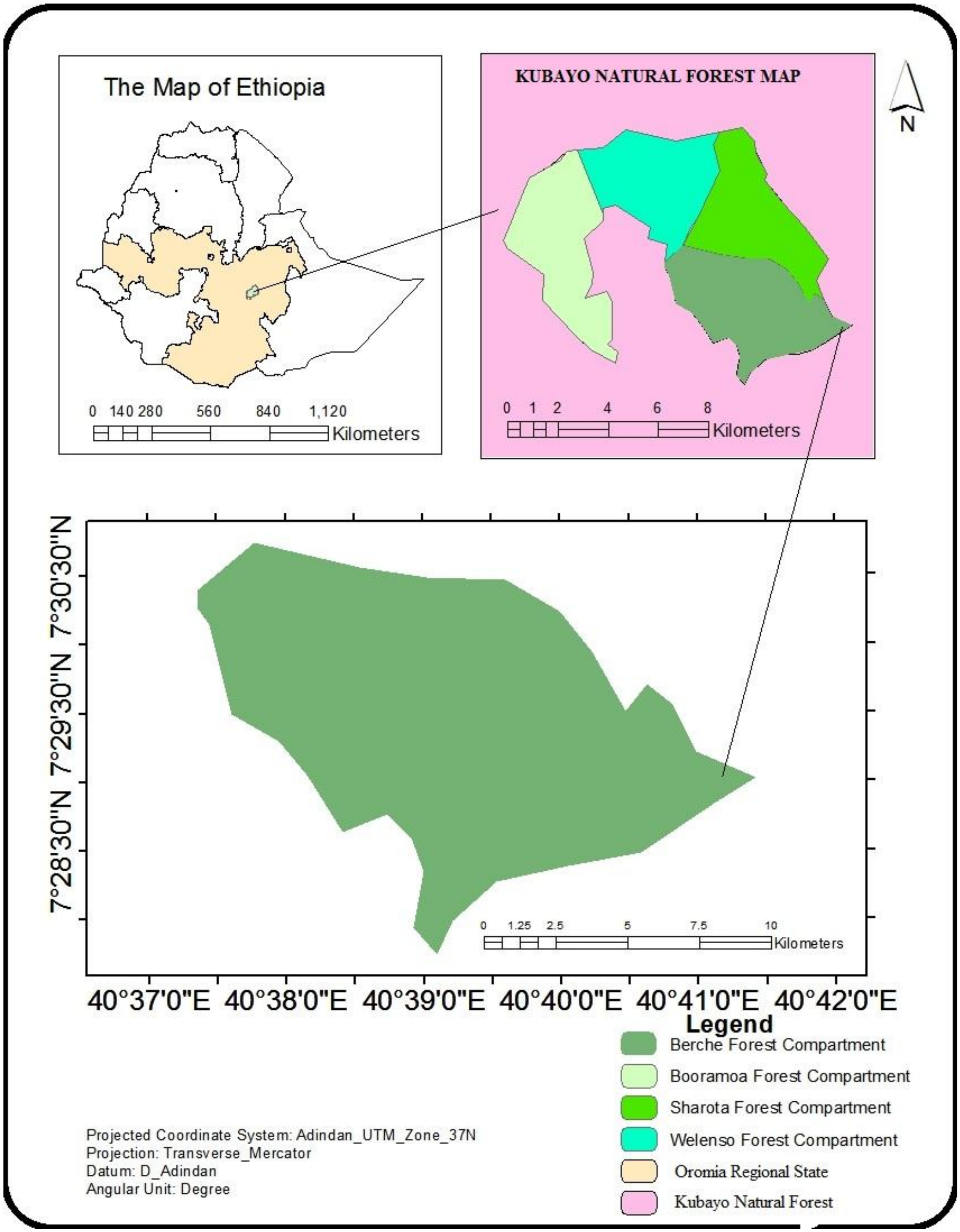

Figure 3: Map of the study area

Source: Gololcha Woreda kubayo Natural Forest District 2015

3.2. Sampling Design

A systematic sampling was used to collect data on woody species diversity. The method was considered to be employed by aligning six transect lines from North to south. Each transect line contains five plots (quadrats). The plots were established at every 200 m intervals along transect. A distance between two successive transect lines were determined to be 400 m. Sample quadrats of 20m x 20 m (for trees), 5m x 5m (for saplings and shrubs) were laid down (smaller quadrats within the larger quadrats). The plots for shrubs and saplings were laid four at the corners and one at the center (Figure 4). Lianas were recorded when encountered in the whole plot.

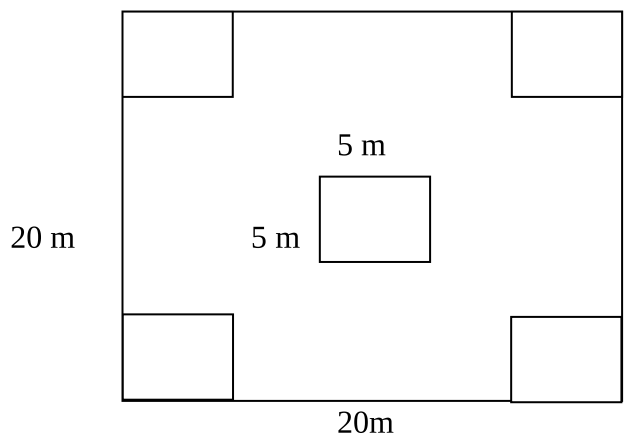

Figure 4: Sampling design for woody plant data collection.

The most commonly operational terms that were used include:

- Basal area is defined as a cross-sectional area of a tree at breast height.
- Diameter at Breast Height (DBH) is a parameter of a tree that can be measured at height of 1.3 meter above the ground. This height is also known as breast height and use to calculate the basal area.
- Sapling: woody plant sapling in which its height is between 1 and 3 m.
- Liana: woody climber.
- Tree is a woody plant having one erect perennial stem (trunk) that has diameter greater than or equal to 10 cm with a height greater than or equal to 1.3 m.
- Shrub is woody plant with several perennial stems that may be erect or may be close to the ground.

3.3. Data Collection

Data collection on the woody plant species was carried out from March, 2017 to April, 2017 after the reconnaissance survey made on January, 2017. The first sample plot was selected randomly. The plots were located 50 m from main road and river. Along each transect line; two nested square quadrants that have dimensions of 20 m x 20 m and 5 m x 5 m were by using GPS laid at every 200 m interval (Mueller-Dombois and Ellenberg, 1974). Geographic location and elevation of each quadrat were taken by using GPS. DBH were recorded by using Caliper. Heights of the woody species were measured by Hypsometer for trees and Bamboo wood stick for the shrubs. However, once few measurements were measured by hypsometer, visual estimation was also used to estimate the larger and difficult tree species height. All woody species encountered during this study were recorded using vernacular name (Afan Oromo). To identify the local name of plant species, two local farmers who have good understanding about the forest in general and woody species in particular were involved. Plant species collected during the study were properly pressed, dried and transported to the National Herbarium of AAU (ETH) for further identification, so that, a scientific name (botanical names) were given to each plant species. Voucher specimens were deposited in the Herbarium of AAU (ETH).

3.4. Structural data collection

All woody species with diameter at breast height (DBH) greater than 2.5 cm at 1.3 m above ground were counted as tree, shrub or sapling following Senbeta and Teketay (2003). Those having a value less than 2.5 cm were considered as seedling. Species cover-abundance were estimated by observation and later converted to Braun-Blanquet 1-9 scale as modified by Van der Maarel (1979).Within the same plots (25 m^2), seedling number were counted and recorded after laying out at each plot and, data collection was conducted. Tree height was measured using hypsometer and visually estimated.

The Diameter at Breast Height (DBH), basal area, tree density, frequency and important value index were used for description of vegetation structure in the study area.

A. **Diameter at breast height (DBH):** measurements were taken at about 1.3 m above the ground by using caliper (Figure5), for those woody plants having circumferences greater than 7.8 cm (> 2.5cm diameter) and later the diameter is calculated from circumference (C) = π D where D is diameter at breast height.

B. **Basal area (BA):** Basal area is the outline of a plant near the surface of the ground. It can be expressed in square meter/hectare (Mueller-Dombois and Ellenberg, 1974). Basal area is also used to calculate the dominance of species. BA = π (D/ 2)2 = (DBH/2)2 X 3.14, where D or DBH is diameter at breast height.

Figure 5: DBH measurement in the field during data collection

Source: Photo by Habtamu Dirro,2017

C. **Density**: Density is a count of the numbers of individuals of a species within a quadrat (Kent and Coker, 1992). It is closely related to abundance but more useful in estimating the importance of a species. Counting is usually done in each quadrat in the area under study. Afterwards, the sum of individuals per species in all quadrat is calculated in terms of species density per convenient area unit such as a hectare (Mueller-Dombois and Ellenberg, 1974).

3.5. Data Analysis

3.5.1 Vegetation Data Analysis

Woody species diversity was analyzed by using Shannon- Wiener diversity Index (H') and other important parametric like woody species dominance, frequency, and relative density, relative dominance, relative frequency and importance Value Index were analyzed. Subsequently, the analysis of quantitative data was conducted by using descriptive statistic expression like Percentage and frequency.

A hierarchical cluster analysis was performed using R 3.3.1 statistical software to classify the vegetation into plant community types based on species cover-abundance data of the species in each quadrat. The data matrix contained 30 quadrats and 58 woody species. The indicator species in each community type were determined by the species with higher IVI. The clusters were designated as plant community types and given names after two or three dominant or characteristic species.

3.5.2. Shannon - Wiener diversity Index

The Index based Biodiversity Analysis is a mathematical measurement of species diversity in community. It provides quantitative information about species diversity (Christoph *et al*, 2010). Among, many indexes, Shannon Wiener diversity Index are used widely, because it gives equal weight to the presence of each species than to the abundance. For this reason Shannon Index is chosen, Shannon index is designated by:

$$H' = -\sum_{i=1}^{S} \mathrm{Pi} \ln \mathrm{pi}$$

Where, H' = the Shannon- Wiener diversity Index

i═ number of individual species

ln = natural logarithm

p_i = the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total cover

S = species richness

Finally, to determine, Shannon Wiener diversity index, the resulting products is summed across species, and multiplied by negative one. Mostly, the Shannon's index ranges from 1.5 to 3.5 and rarely reaches 4.5 (Gaines *et al.*, 1999).

Evenness or Equitability index: Evenness (E') was calculated from the ratio of observed diversity to maximum diversity using the equation and hence, it is possible to calculate a separate additional measure of evenness as:

$$E = \frac{H'}{lnS} = \frac{H'}{H'max}$$

Where Hmax is the maximum level of diversity possible within a given population, which equal ln (number of species). E' is normal between 0 and 1, and with 1 representing a situation in which all species are equally abundant.

3.5.3. Structural data analysis

The structure of the vegetation was described by using frequency distributions of DBH and Importance value index (IVI). Tree or shrub density and basal area values were computed on hectare basis. Importance value indices (IVI) were computed for dominant woody species based on their relative density (RD), relative dominance (RDO) and relative frequency (RF) to determine their dominance (Kent and Coker, 1992). The following structural parameters were calculated following Mueller-Dombois and Ellenberg (1974).

- Relative Density (RD) $= \frac{\text{The number of all individuals of a species}}{\text{The total number of all individuals}} \times 100$
- Relative Frequency (RF) $= \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$
- Relative Dominance (RDO) $= \frac{\text{Total basal area of all individuals of a species}}{\text{Total basal area of all species}} \times 100$
- IVI = Relative Density + Relative Dominance (basal area) + Relative Frequency

4. RESULTS AND DISCUSSIONS

4.1 Results

4.1.1 Floristic Composition

Totally 58 woody species belonging to 48 genera and 34 families were identified from Berche Natural Forest (Appendix1). The collected species were composed of 30 (51.7%) trees, 25 (43.1%) shrubs and 3 (5.17%) lianas (Figure 6). Fabaceae and Anacardiaceae are the highest species represented by 7(12%) and 6(10%), respectively. The majority of the families were represented by only one species (Table 2).

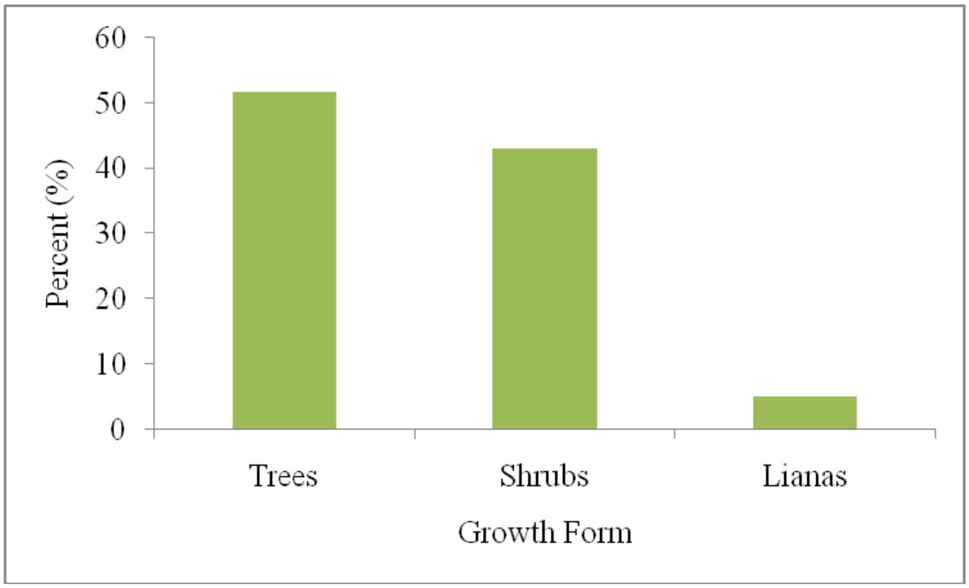

Figure 6 Growth forms of woody plant species from the study area

Table 2 Family distribution

Family	Species represented	Percent (%)	Family	Species represented	Percent (%)
Anacardiaceae	6	**10.34**	Moraceae	2	3.45
Apocynaceae	2	3.45	Myrsinaceae	1	1.72
Araliaceae	1	1.72	Oleaceae	2	3.45
Barbeyaceae	1	1.72	Pittosporaceae	1	1.72
Boraginaceae	2	3.45	Podocarpaceae	1	1.72
Burseraceae	2	3.45	Rhamnaceae	1	1.72
Capparidaceae	1	1.72	Rubiaceae	3	5.17

Table 2: Continued

Celastraceae	3	5.17	Rutaceae	1	1.72
Combretaceae	2	3.45	Santalaceae	1	1.72
Cupressaceae	1	1.72	Sapindaceae	1	1.72
Ebenaceae	1	1.72	Sapotaceae	2	3.45
Ericaceae	1	1.72	Sterculiaceae	1	1.72
Euphorbiaceae	1	1.72	Tiliaceae	1	1.72
Fabaceae	7	**12.07**	Ulmaceae	1	1.72
Flacourtiaceae	2	3.45	Vitaceae	1	1.72
Lamiaceae	2	3.45	Malpighiaceae	1	1.72
Loganiaceae	1	1.72	Meliaceae	1	1.72

4.1.2 Plant community classification

All 58 identified woody plant species were used in vegetation classification into community together. Three community types were recognized or identified based on Cluster analysis of vegetation data (Figure 7). The name for each community types were given after two dominant woody species (trees and /or shrubs) occurring in each group using the relative magnitude of the highest mean cover abundance within the cluster.

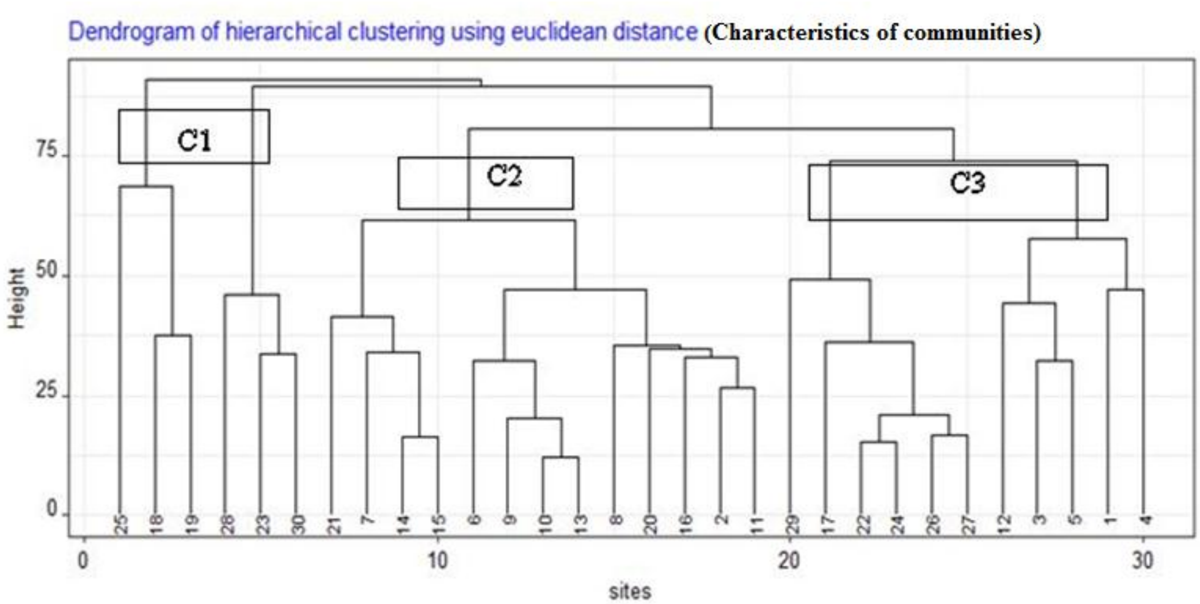

Figure 7: Dendrogram of plant community

Note: C= community

→ Communities (clusters) contain the following plots:

Community 1:- Plots 18, 19, 23, 25, 28, 30

Community 2:- Plots 2, 6, 7, 8, 9, 10, 11, 13, 14, 15, 16, 21, 20

Community 3:- Plots 1, 3, 4, 5, 12, 17, 22, 24, 26, 27, 29

4.1.2.1: Community I: *Juniperus procera -Canthium lactescens* Community

This community contains the lowest number of quadrats, 6 which is located in the altitudinal range between 1847 and 1869 m. above sea level and it is represented by 9 species. The community is dominated by *Juniperus procera* and *Canthium lactescens.* Both are trees. *Dombeya torrida* and *Dodonea angustifolia* are the dominant species in the shrub layer. While *Clerodendrum myricoides, Carissa edulis* and *Vangueria madagascariensis* are associated shrubs in the community.

4.1.2.2: Community II: *Olea europaea subsp. Cuspidata- Pistacia aethiopica* Community

This community is located in the altitudinal range between 1721 and 1860 m above sea level and it is represented by 13 quadrats. The dominant plant species in this community is the woody climber *Caucanthus auricalatus* and Various trees and shrubs including *Terminalia brownie*, *Ozoroa insignis*, *Rhamnus staddo*, *Olea europaea s*ubsp. Cuspidata, *Pistacia aethiopica, Schefflera abyssinica*, *Maytenus gracilipes* and *Croton macrostachyus* make up this community.

4.1.2.3: Community III: *Pouteria adolfi-friedrici-Combretum molle* Community

This community is represented by 11 quadrats. The altitudinal range of this community is 1779 to 1852 m.a.s.l. *Pouteria adolfi-friedrici* is the most dominant species of this community followed by *Combretum molle*. The common woody climber of this community is *Hyppocratea africana*, *Euclea racemosa, Maytenus sengalensis* and *Erica arborea* were also found in this community.

Community type 1- (*Juniperus procera-Canthium lactescens*) were the third community in species richness, evenness and diversity (Table 3). Few woody plant species like *Juniperus procera,* *Canthium lactescens*, *Dombeya torridda* and *Dodonea angustifolia* were highly dominant in this community.

Community type 2- (*Olea europaea* subsp.*Cuspidata-Pistacia aethiopica*) located between altitudinal ranges of 1721 and 1860 m.a.s.l this community is characterized by large sized trees with good canopy and & a woody climber *Caucanthus auriculatus*. The second highest species richness and evenness were obtained in this community. The characteristic woody plants in this community include *Terminalia brownie*, *Ozoroa insignis*, *Rhamnus staddo*, *Oleaeuropia s*ubsp. cuspidata, *Pistacia aethiopica*, *Schefflera abyssinica*, *Maytenus gracilipes*, and *Croton macrostachyus*. This community however, is highly susceptible to agricultural activities (Expansion of farm land) logging for construction purpose, for firewood and intensive grazing. Due to the reduction of the natural dominant plant species in the area and some of the residents in the area have become dependent on it for their livelihood.

Community 3 (*Pouteria adolfi friedrici- Combretum molle*) this community is least in every aspect like species richness, evenness, diversity and it is also located in lower altitude. Moreover, this community is found at the lower path of the study area (Berche Natural Forest). May be due to this favored the reduction in species richness, evenness and diversity in this community.

4.1.3 Species diversity, richness and evenness of the plant community types

Species diversity is a combination of the number of species and their relative abundance. From the computation of vegetation data obtained from study area, the results of Shannon Wiener diversity index showed that, community 3 have highest species richness, evenness and diversity (Table 3). This community attained a Diversity Index (H') of 3.8 and 97% species evenness. Whereas, lowest Diversity Index (H') is found to be in Community type 1.

Table 3 Shannon–Wiener Diversity Index

Community	Richness	Diversity Index(H')	Shannon evenness
1	9	1.92	0.87
2	18	2.83	0.86
3	31	3.8	0.97

4.1.4 Analysis of Vegetation Structure

4.1.4 .1 Density of woody species

Results revealed that *Juniperus procera, Pistacia aethiopica, Canthium lactescens* and *Pouteria adolfi-friederici* were found to be with the highest relative density consisting 15.85%, 13.24%, 7.19% and 7.03% respectively (Table 4). The average number of tree and shrub individuals as calculated from the data taken from all plots is 1035.5 per ha. High density in community three were seen with abundance of 4941 individuals per ha., followed by community two with 1713 individuals per ha. However, community one has least density value with1169 individuals per ha.

Table 4: Relative density of tree species

No.	Species name	Relative Density	No.	Species name	Relative Density
1	*Acacia abyssinica*	1.31	16	*Ficus sycomorus*	1.14
2	*Acacia persiciflora*	1.47	17	*Ficus thonningii*	1.96
3	*Acokanthera schimperi*	2.12	18	*Juniperus procera*	**15.85**
4	*Barbeya oleoides*	2.61	19	*Lannea schimperi*	0.33
5	*Canthium lactescens*	**7.19**	20	*Maytenus sengalensis*	4.08
6	*Celtis africana*	1.96	21	*Olea europaea*	6.54
7	*Clerodrum myricoides*	2.12	22	*Ozoroa insignis*	1.80
8	*Combretum molle*	4.90	23	*Pistacia aethiopica*	**13.24**
9	*Combretum molle*	1.80	24	*Pittosporum abyssinicum*	3.59
10	*Commiphora africana*	0.98	25	*Podocarpus falcatus*	2.45
11	*Cordia africana*	1.31	26	*Pouteria adolfi-friederici*	**7.03**
12	*Croton macrostachyus*	1.47	27	*Psydrax schimperiana*	1.31
13	*Ehretia cymosa*	1.14	28	*Schefflera abyssinica*	1.31
14	*Ekebergia capensis*	1.63	29	*Schrebera alata*	4.08
15	*Erythrina abyssinica*	0.82	30	*Terminalia brownie*	2.45

4.1.4 .2 Frequency

Frequency is the number of quadrats in which a given species occurred in the study area. The frequency of all the woody plant species in the study area is given in (Figure 13). One woody plant species which occurred most frequently (in 30 quadrats out of 30) was *Pistacia aethiopica.*The second most frequent species were *Juniperus procera* (28 quadrants out of 30*), Olea europaea*(25quadrats out of 30*)*, and *Pouteria adolfi-friederici*(20 in quadrats out of 30*)* The least frequent species in the study area that occurred in a single quadrat were 7 in number followed by 45 species which were occurred in 2-6 quadrats only (Table 5).

Table 5 Frequency of tree species

No.	Species Name	Relative Frequency	No	Species Name	Relative Frequency
1	*Acacia abyssinica*	3.33	16	Ficus thonningii	3.33
2	*Acacia persiciflora*	3.33	17	Juniperus procera	93.33
3	*Acokanthera schimperi*	13.33	18	Lannea schimperi	3.33
4	*Barbeya oleoides*	16.67	19	Maytenus sengalensis	20.00
5	*Canthium lactescens*	**43.33**	20	Olea europaea subsp.cuspidata	**83.33**
6	*Celtis africana*	13.33	21	Ozoroa insignis	20.00
7	*Clerodrum myricoides*	3.33	22	Pistacia aethiopica	**100.00**
8	*Combretum molle*	**40.00**	23	Pittosporum abyssinicum	26.67
9	*Commiphora africana*	3.33	24	Podocarpus falcatus	20.00
10	*Cordia africana*	3.33	25	Pouteria adolfi-friederici	**66.67**
11	*Croton macrostachyus*	13.33	26	Psydrax schimperiana	3.33
12	*Ehretia cymosa*	3.33	27	Rhoicissus tridentata	13.33
13	*Ekebergia capensis*	6.67	28	Schefflera abyssinica	23.33
14	*Erythrina abyssinica*	6.67	29	Schrebera alata	20.00
15	*Ficus sycomorus*	10.00	30	Terminalia brownie	6.67

4.1.4 .3 Important Value index

The results of important value index (Table 6) showed that *Schefflera abyssinica*, *Pistacia aethiopica. Olea europaea*, *Junirus procera*, and *Acacia etbaica* were the species with highest IVI respectively. Even though the density was lower in the species *Schefflera abyssinica*, it was compensated by its large DBH or relative dominance which was measured maximum of 50cm.

Considering their IVI value, the majority of the woody species scored lower score. This could be due to the major anthropogenic disturbances such as overgrazing and selective cutting which were observed in the research period. It is, therefore, a good implication for conservation. It is a good index for summarizing vegetation characteristics, ranking species and conservation practices (Kent and Coker 1992). In other words, it reflects the degree of dominance and abundance of a given species in relation to the other species in the area.

Table 6: Important value indices of most dominant Species

NO	Species Name	Relative frequency	Relative Density	RelativeDominance	IVI
1	*Combretum molle*	1.78	1.23	7.85	10.86
2	*Juniperus procera*	2.89	14.56	4.53	21.98
3	*Pistacia aethiopica*	4.56	12.5	7.86	24.92
4	*Pouteria adolfi-friederici*	2.43	4.5	3.56	10.49
5	*Olea europaea*	3.06	13.5	6.40	22.96
6	*Schefflera abyssinica*	23	1.52	10	34.52
7	*Canthium euryoides*	2.3	1.56	6.53	10.39
8	*Acacia etbaica*	1.56	8.56	5.32	15.44
9	*Maytenus sengalensis*	0.75	2.56	3.25	6.56
10	*Croton macrostachyus*	0.52	3.4	5.62	9.54

4.1.4 .4 Diameter at Breast Height (DBH)

Diameter at Breast Height distribution of Berche forest was classified into five classes conventionally (Figure 8). As presented in (Figure 5) about 63% of the individuals are found in the first two classes (<15 cm). The remaining three classes together account for about 37%. The number of stems in DBH class less than 15cm is about 320 ha^{-1}.

The present study revealed that the forest is dominated by lower DBH classes. However, the density of higher DBH classes is very low. This might indicate the cutting of medium sized individuals for timber, firewood, construction and etc.

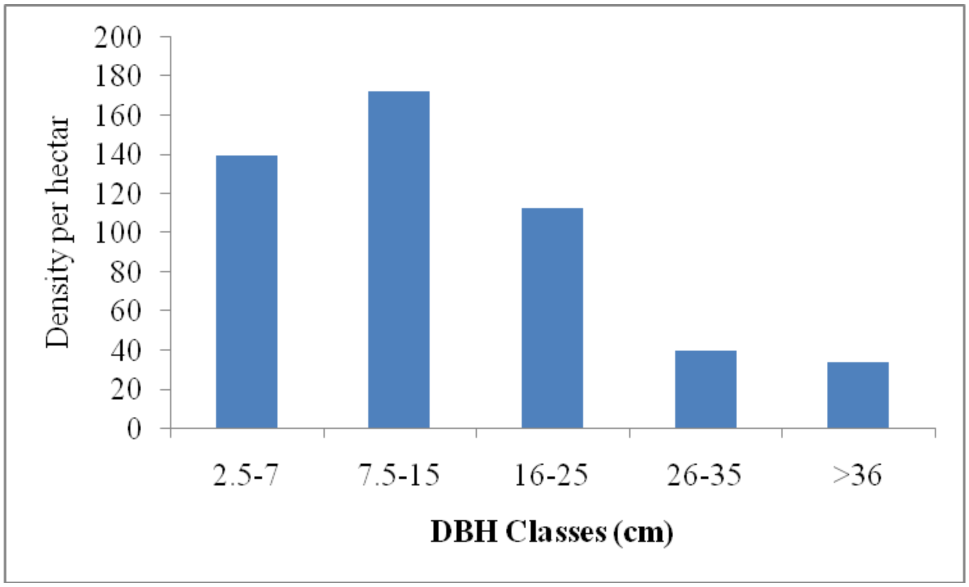

Figure 8: DBH classes

4.1.4 .5 Vertical stratification

The vertical structure of a forest refers to its structural complexity, which is influenced by the presence of different plant life forms (such as vines and epiphytes), the arrangement of leaves on branches, and the amount and distribution of leaves, branches, and twigs, at different heights. Vertical canopy profile may have distinct peaks in both the understory and overstory. As time passes and canopy material accumulates, the peaks become less distinct. In the last stage, overstory trees die, leaving a large opening in the canopy, which stimulates regeneration. Obviously, this could have provision for wildlife habitat. The vertical stratification of the study area was explained following (Butler and Rhett, 2006) classification scheme. According to Butler and Rhett (2006) classification scheme, these structures are distinguished as Overstory (> 39.6m), Canopy (30.48-39.6m), Understory (6-30.5m), Shrub layer (1.5-6m) and Ground level or forest floor (grasses, ferns, ground cover). Hence, the present study as stated in (Figure 9) is categorized under understory and shrub layer. Canopies were hardly observed in the present study. This could be attributed to the selective removal of medium sized individuals.

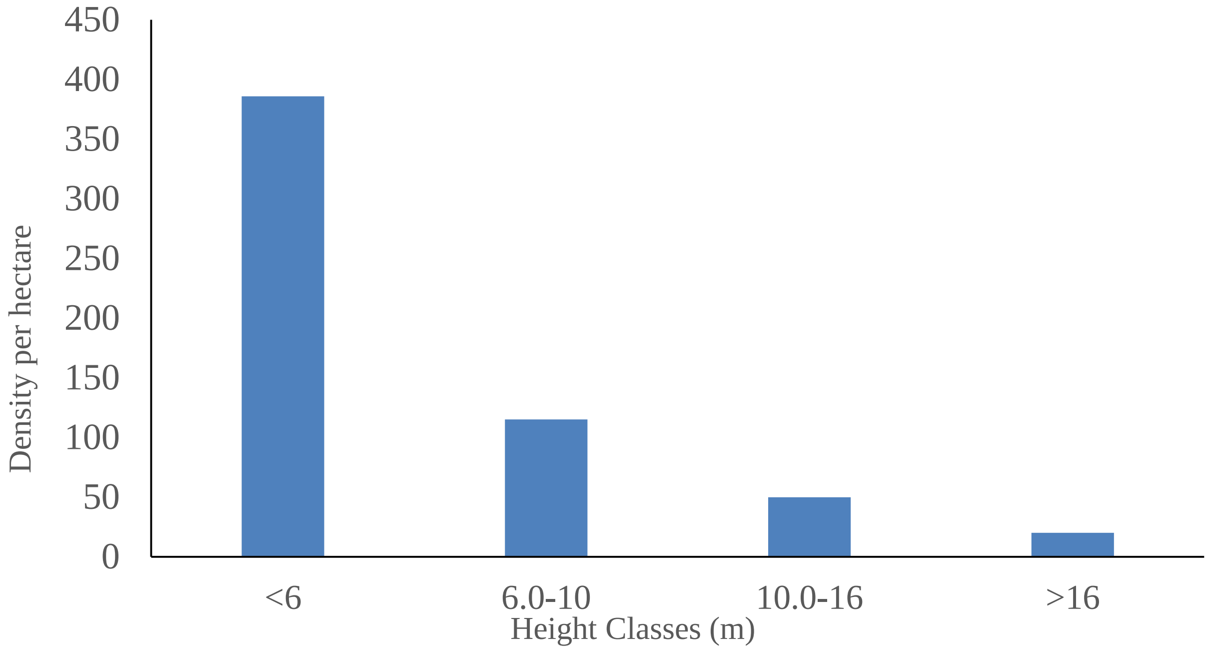

Figure 9***: Height classes of the study area***

4.1.4 .6 Population structure of selected plants

Examination of patterns of population structures could provide valuable information about their regeneration and recruitment status that could be further employed for devising conservation and management strategies. The patterns of diameter class distribution in Berche indicated different trends of population dynamics and recruitment processes of a given species (Figure 10-13). The evaluation of selected tree species reveals six main patterns of population structure. These include;

a) J-shape: which shows a type of frequency distribution in which there is a low number of individuals in the lower diameter classes but increases towards the higher classes (*Schefflera abyssinica*)

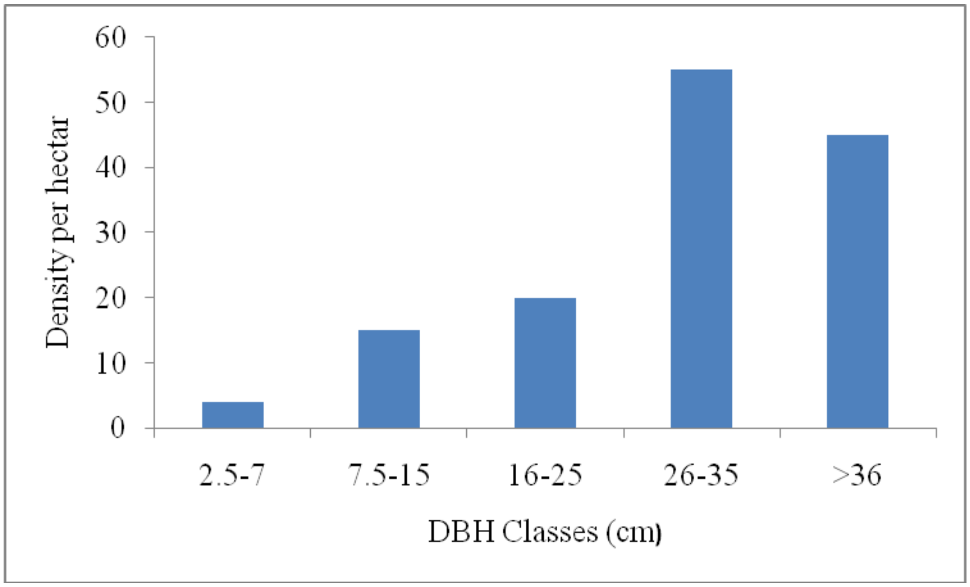

Figure 10

Figure 10: Population structure of *Schefflera abyssinica*

b) Inverted J-shape: shows a pattern where species frequency distribution has the highest frequency in the lower diameter classes and a gradual decrease towards the higher classes (*Pistacia aethiopica*) which shows good reproduction and recruitment.

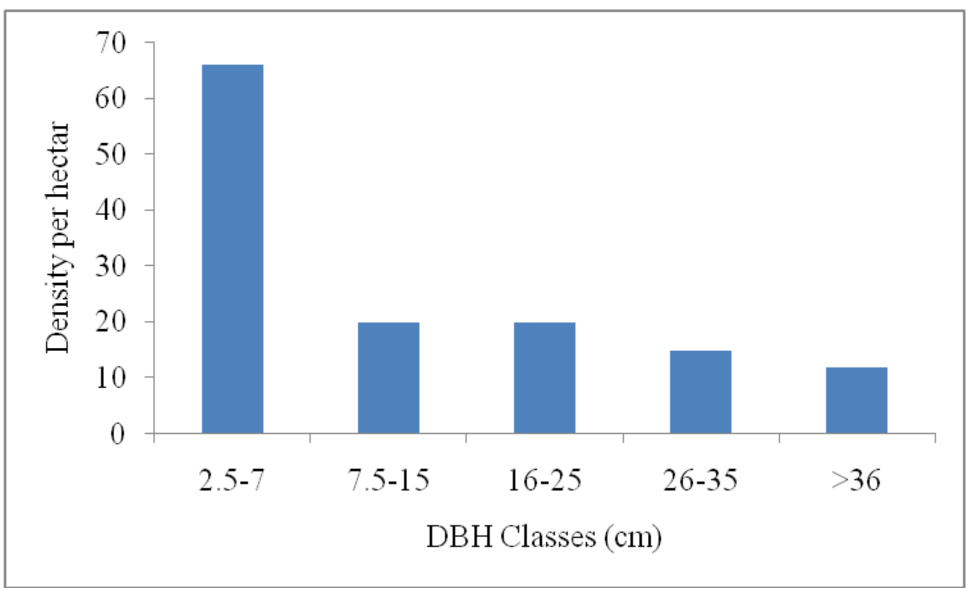

Figure 11: Population structure of *Pistacia aethiopica*

c) Irregular: in which they are distributed differently in almost all classes (*Olea europaea*) and the first pattern was formed by the species having high number of individuals in the second class and relatively lower in first and third class then decrease with increasing DBH towards the higher classes

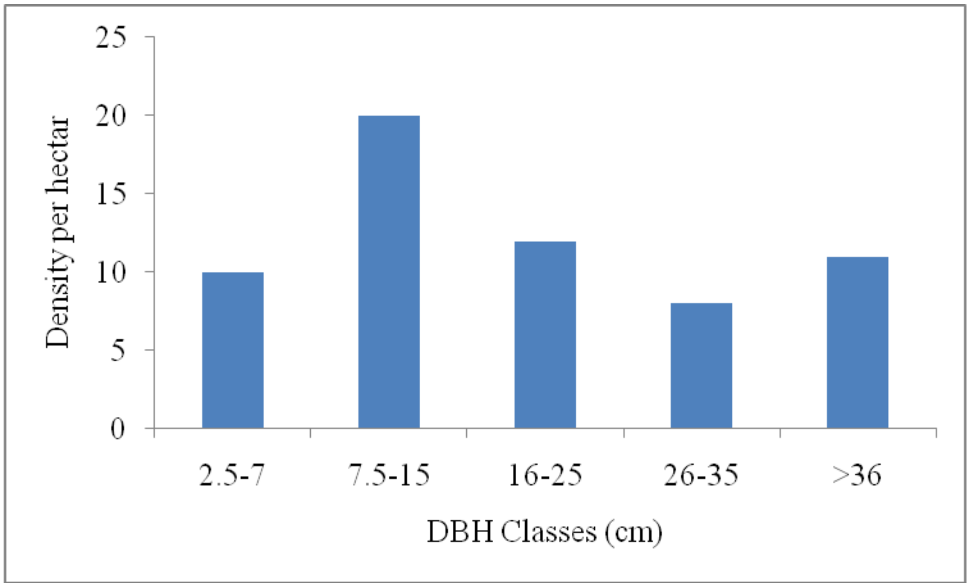

Figure 12: Population structure of *Olea europaea*

d) U-shape: which shows a type of frequency distribution in which there is a high number of lowest and highest diameter classes but a very low number in the intermediate classes (*Juniperus procera*) in which the intermediate diameter classes are poorly represented may be due to selective removal of medium sized individuals.

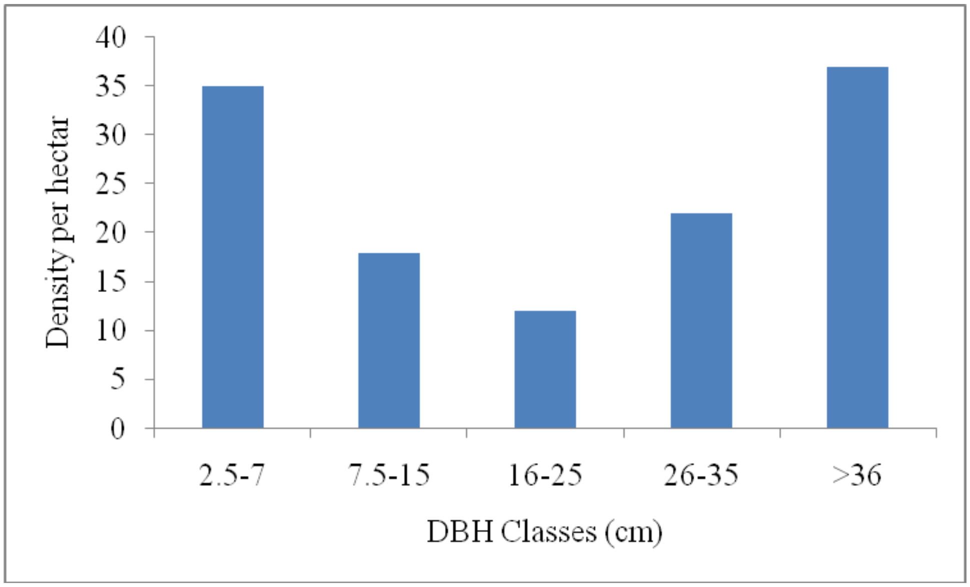

Figure 13: Population structure of *Juniperus procera*

4.2. Discussions

The dominance of Fabaceae and Asteraceae could be attributed to their efficient and successful dispersal mechanisms and adaptation to a wide range of ecological conditions (Ensermu Kelbessa andTeshom Soromessa, 2008). Different studies reported dominance of Fabaceae and Asteraceae in Afromontane vegetation type (Tena Getachew 2008; Didita *et al.*, 2010; Yohannes *et al.*, 2013).

Generally, vegetation of the area consists of short-stemmed and multi branched shrubs of 3 – 4m tall with occasional tackiest and scattered umbrella shaped trees reaching medium height. Shrubs mostly dominated high and low altitudes and trees mostly dominated medium altitudes but both of them are not restricted to the indicated areas only. This could be resulted from either excessive cutting or the presence of high regeneration but lower recruitment and absence of matured individuals. It might be also due to the presence of competition among the species and the area was disturbed by anthropogenic factors. The study by Senbeta and Teketay (2003) revealed that the dominance of small trees and shrubs in the forest suggests that the bigger tree species are selectively removed or exploited. However, selective removal and cutting is absent in this study site.

Plant communities show spatial and temporal heterogeneity across landscapes (Didita *et al.*, 2010). Community three and two were found in almost similar altitudes. Whereas, community one was found in areas with higher altitudes areas compared to the rest of the communities. According to Korner (1998), the major decline in species richness in mountainous areas in higher elevations is due to eco-physiological constrains, such as reduced growing season, low temperature and low ecosystem productivity. In addition, the boundary effect may also have an influence on the species richness at high elevations (Gerytnes and Vetaas, 2002).

According to Colwell and Lees (2000), boundary effect or edge effect is defined in relation to the degree of species resistance to dispersals and survival. Mountains can be represented as islands through their reduced connectivity for colonization by plants. As elevation increases, the isolation of slopes from pathways of migration increases linearly. With reduction of channel available for immigration, reduction in the number of species that occupy high elevation site is great. This may be one of the cases for the reduction of diversity in Berche Natural Forest.

The values of species diversity depend upon levels of species richness and evenness (Manuel and Molles, 2007). Lower evenness indicates the dominance of few species in the area (Senbeta Feyera, 2006). On the contrary, higher species evenness shows even distribution of plant species. Since, Shannon-Wiener diversity index usually ranges between 1.5 and 3.5 in which rarely exceeds 4 (Gaines *et al.*, 1999), the diversity of the woody species diversity is medium.

The structural analysis of the present study revealed that woody species of lower and medium DBH classes is higher than the individuals with higher DBH classes. Even though structural analysis is not the primary means to determine the regeneration status, the results revealed Berche forest is in good regeneration. This result is similar with others Menna angetu (Lulekal *et al*., 2008) and Belete moist evergreen forest (Gebrehiwot Kifly and Hundera Kitessa, 2014). If a particular tree species or a forest displays such a size distribution, then continuous recruitment can generally be inferred, suggesting that the population is viable as sufficient regeneration it taking place for the population to be maintained (Newton, 2007). The height class also showed the same pattern as the DBH classes. The decreasing in density of each height class towards the highest height classes reveals the dominance of small sized individuals in the forest which was the attribute of high rate of regeneration. This may be due to selective cutting of large sized individuals. The density of each height class decreases with the increase in height showing an inverted J-shape, this reveal a trend which is similar to that of DBH class distribution. Similar patterns were reported in Komto (Gurmessa Fikadu, 2011) and Gura-lopho (Kumesa Lemessa 2010) forests.

The pattern of population structure plays significant role in management of the forest in general and individual species in particular. *Schefflera abyssinica* showed a J-shaped pattern. Furthermore, the patterns in the population structure of some species are suggestive of the past occurrence of disturbance. This shows that the species is not at a good regeneration status (Gebrehiwot Kifly and Hundera Kitessa, 2014) because the lower DBH classes or the saplings were lower than the matured trees. However, *Pistacia aethiopica* showed a good regeneration with an inverted pattern of population structure (Takele Tesfaye 2006). Irregular pattern were also observed in *Olea europaea.* All DBH classes were represented almost similarly. This might show there is no selective removal of the individuals. The U-shape pattern was observed in *Juniperus procera*. The individuals of this species in the medium DBH classes were lower than both the lower and upper DBH classes. Because of individuals with the medium classes were removed selectively for both construction and firewood. Similar reports by GebrehiwotKifly and Hundera Kitessa (2014).

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

The woody composition, structure and diversity of plant species in Berche natural forest have been studied. Results revealed that the forest has 58 woody plant species belonging to 48 genera and 34 families were recognized. Fabaceae was found to be the most dominant family followed by Anacardiaceae. Hierarchical cluster analysis recognized three community types. The highest species richness and maximum diversity was observed in community three i.e., *Pouteria adolfi-friedrici-Combretum molle* community.

Out of 58 woody plant species, only 7 species have IVI value greater than 10. The species with the highest IVI were found to be; *Schefflera abyssinica, Pistacia aethiopica. Olea europaea, Juniperus procera* and *Acacia etbaica*. DBH classes and vertical strata analysis showed that Berche Natural forest is dominated by medium sized, understory and shrub layer. These were also reflected in the population structure of selected tree species. This is could be resulted from the anthropogenic disturbances in the forest.

5.2 Recommendations

Forests in general Berche forest in particular have a crucial economic and ecological importance. Thus, the following recommendations are pinpointed to enhance the forest woody species diversity and forest ecosystem services.

- Farmers are using the forest and forest products for agriculture and logging for construction purpose which caused the forest to be dominated by small sized individuals. This is a worrying trend. Thus, it is here recommended to restrict the expansion of farm lands by creating a buffer zone.
- Raising awareness of local communities on the value of forest resources and ecological consequences of deforestation.
- Moreover, participatory forest management practices should be introduced to the forest community
- The present study was limited to woody species composition, diversity and structure thus, further studies on soil seed bank, seed physiology, herbaceous plants and land use management system in the area are recommended.

- Plantation of indigenous seedlings based on the woody species population structure should be performed to compromise the poor regeneration of the species with J-shaped population structure.

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7. APPENDICES

Appendix 1: List of plant species collected in Berche natural forest, Southeast of Ethiopia.

Voucher No	vernacular Name	Botanical Name	Family Name	Habit
001	Adado	*Buddleja polystachya* Fresen.	Loganiaceae	SH
002	Allola	*Ekebergia capensis* Sparrm.	Meliaceae	T
003	Ara	*Pittosporum abyssinicum* Del.	Pittosporaceae	T
004	Aroresa	*Grewia tembensis* Fresen.	Tiliaceae	SH
005	Bate	*Acacia persiciflora* Pax	Fabaceae	T
006	Biqa	*Combretum molle* R. Br. ex G. Don	Combretaceae	T
007	Birbirsa	*Podocarpus falcatus* (Thunb.) R. B. ex. Mirb.	Podocarpaceae	T
008	Biresa	*Terminalia brownie* Fresen.	Anacardiaceae	T
009	Bururi	*Vangueria madagascariensis* Gmel.	Rubiaceae	SH
010	Chekata	*Calpounia aurea* (Ait.) Benth.	Fabaceae	SH
011	Dabobessa	*Rhus natalensis* Krauss	Anacardiaceae	SH
012	Dambi	*Ficus thonningii* Blume	Moraceae	T
013	Danisa	*Dombeya torrida* (J.F.Gmel.) P.Bamps	Sterculiaceae	SH
014	Demee	*Schrebera alata* (Hochst.) Welw.	Oleaceae	T
015	Dodoti	*Acacia etbaica* Schweinf	Fabaceae	SH
016	Dogro	*Clerodrum myricoides* (Hochst.) vatke	Lamiaceae	T
017	Ejersa	*Olea europaea subsp.cuspidata* (Wall.ex G.Don) C.f.	Oleaceae	T
018	Faranqasa	*Sideroxylon oxyacanthum* Baill.	Sapotaceae	SH
019	Fullessa	*Acacia sieberiana* DC. Var. woodii (Brutt-Davy) Keay& Brenan	Fabaceae	SH

Appendix 1: Continued

020	Gaaleedikii	*Hyppocratea africana* (will) Loes.	Celastraceae	L
021	Gadila	*Caucanthus auriculatus* (Radlk.) Niedenzu	Malpighiaceae	L
022	Galessa	*Maytenus sengalensis* (Lam.) Exell	Celastraceae	T
023	Gallo	*Canthium lactescens* Hiern	Rubiaceae	T
024	Gallo buno	*Psydrax schimperiana* (A. Rich.) Bridson	Rubiaceae	T
025	Gari	*Barbeya oleoides* Schweinf.	Barbeyaceae	T
026	Garigolfa	*Ozoroa insignis* Del. Subsp. Insignis	Anacardiaceae	T
027	Gerersa	*Pistacia aethiopica* Kokwaro	Anacardiaceae	T
028	Gomgoma	*Acokanthera schimperi* (A.DC.) Schwein	Apocynaceae	T
029	Hadessa	*Teclea nobilis* Del.	Rutaceae	SH
030	Hagamsa	*Carissa edulis* Wahl.	Apocynaceae	SH
031	Hamesa	*Commiphora africana* (A. Rich.) Engl.	Burseraceae	T
032	Handaraku	*Lannea schimperi* (A. Rich) Engl.	Anacardiaceae	T
033	Harfatu	*Schefflera abyssinica* (Hochst. ex A. Rich.) Harms	Araliaceae	T
034	Hindessa	*Juniperus procera* Hochst. ex Endl.	Cupressaceae	T
035	Itacha	*Dodonea angustifolia* L.f.	Sapindaceae	SH
036	Jirime	*Dichrostachys cinerea* (L.) Wight & Am.	Fabaceae	SH
037	Kachema	*Myrsine africana* L.	Myrsinaceae	SH
038	Kadida	*Rhamnus staddo* A. Rich.	Rhamnaceae	SH
039	Kalkalcha	*Maerua triphylla* A.Rich.	Capparidaceae	SH
040	Karo	*Osyris quadripartita* Decn.	Santalaceae	SH
041	Keraru	*Pouteria adolfi-friederici* (Engl.) Baehni	Sapotaceae	T

Appendix 1: Continued

042	Kokolfa	*Oncoba spinosa* Forssk.	Flacourtiaceae	SH
043	Kombolcha	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	Celastraceae	SH
044	Laaluu	*Rhoicissus tridentata* (L. f) Wild & Drummond	Vitaceae	L
045	Lafto	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	T
046	Marasisa	*Clerodendrum myricoides* (Hochst.) Vatke	Lamiaceae	SH
047	Mataqoma	*Celtis africana* Burm. f	Ulmaceae	T
048	Mekenissa	*Croton macrostachyus* Del.	Euphorbiaceae	T
049	Miessa	*Euclea racemosa* Murr. Subsp. Schimperi (A. DC.)	Ebenaceae	SH
050	Oda	*Ficus sycomorus* L.	Moraceae	T
051	Ruku	*Combretum molle* R. Br. ex G. Don	Combretaceae	T
052	Sato	*Erica arborea* L.	Ericaceae	SH
053	Simbirqolli	*Flacourtia indica* (Burm.f) Merr.	Flacourtiaceae	SH
054	Tetesa	*Rhus ruspolii* Engl.	Anacardiaceae	SH
055	Tirro	*Commiphora boranensis* Engl.	Burseraceae	SH
056	Ulaga	*Ehretia cymosa* Thonn. var.	Boraginaceae	T
057	Wadesa	*Cordia africana* Lam.	Boraginaceae	T
058	Walena	*Erythrina abyssinica* Lam. ex DC	Fabaceae	T

Key: T=tree Sh=shrub L=Liana

Appendix 2**: Record sheet for measurements of trees and Lianas with in plot size 20x20m**

Plot No. _____ Altitude _______ Date ____

Vernacular Name	Botanic Name	DBH in Centimeter	Height in Meter

Appendix 3: **Record sheet for measurements of seedlings, saplings and shrubs within plot size 5mx5m**

Plot No.____________ Altitude ___________Date_________

Vernacular Name	Botanic Name	DBH in centimeter	Height in meter