Jimma University

College of Natural Sciences

Department of Biology

# Woody Species Diversity and Structure of Sagi Tagata Natural Forest, Ilu Aba Bor Zone, Oromia National Regional state, Southwest Ethiopia

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# Woody Species Diversity and Structure of Sagi tagata Natural Forest Ilu Aba Bor Zone, of Oromia National Regional state, South West Ethiopia

A Thesis submitted to Department of Biology, College of Natural Sciences, Jimma University in partial fulfillment of the requirement for the degree of Master of Science in Biology

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# Table of content

Content page

## List of figures

## List of Table

## List of Appendices

## List of Acronyms

ADLFDO: Ale District Livestock and Fishery Development Office

ADANRDO: Ale District Agricultural and Natural Resource Development Office

EMA: Ethiopia Mapping Agency

IBC: Institute of Biodiversity Conservation

SNNP: South Nation Nationality and People

EWNHS: Ethiopia Wildlife and Natural History Society

EFAP: Ethiopia Forestry Action Plan

NBSAP: National Biodiversity Strategy and Action Plan

ADANRO: Ale Destrict Agricultural Natural Resource office

EMSA: Ethiopia Meteorological Services Agency

ETH: National Herbarium of Ethiopia

GPS: Geographical Positioning System

NFPA: National Forest Priority Areas

IAB: Ilu Aba Bor

IABZANRDO: Ilu Aba Bor Zone Agriculture and Natural Resource Development Office

OFWE: Oromia Forest and Wild life Enterprise

SMEGAF: Sagi Tagata Moist Ever green Afromontane forest

Abstract

This study was carried out on Sagi Tagata Natural Forest, Ilu Aba Bor Zone, Southwest Ethiopia, with the objectives of assessing the woody species diversity and structure of the vegetation. Sagi Tagata forest is one of the very few remnant moist evergreen afromontane forests in Ethiopia. To identify woody species diversity, community structure and the disturbance level of Sagi Tagata forest, five lines transects having 500m distance between each other were laid down from bottom to top of the mountain. Data were collected from 40 quadrants, each with 20m × 20m (400 $m^2$) laid at the intrvalof 20m in elevation along the transects using GPS. Altitudes and geographic coordinates were recorded for each quadrant, and cover/abundance value was estimated for all woody species. Height and diameter at breast height of all woody species taller than 2m and wider than 2.5cm was measured. Specimens were collected, pressed, dried and taken to Jimma University Herbarium for identification. Community class analysis was done using PC_ORD for Windows version 5.3 and six plant community types were identified. Shannon-Wiener Diversity index for each community type was determined using Past Computer Software version 1.34. Sorensen's similarity index was used to determine the similarity between Sagi Tagata and other forests in Ethiopia in woody species richness. The most dominant tree species relatively with the highest importance value index were Pouteria adolfi–friederici (11.38%), Deinbollia kilimandscharica (9.0%), Albizia gummifera (7.33%), Chionanthus milddbraedii (6.63%), Millettia ferruginea (6.32%) and Croton macrostachyus (4.26%). Analysis of population structure for majority of species revealed normal distribution patterns.The total basal area 0f the Sagi Tagata forest was 31.01$m^2$/ha. Woody species comparisons with other similar forests in the country were showed that Sagi Tagata Natural Forest has more similarity to the moist evergreen Afromontane forests.

Keywords: woody species diversity, plant community, vegetation composition

# 1. Introduction

## 1.1 Background of the study

Diversity of species including plants is characterized by geographical diversification. Africa is characterized by many different species due to its geographical diversity. As it has been indicated in the studies by Anonymous, (1997a, b); Motuma Didita *et al.*, (2010), Dikaso Unbushe and Tesema Tekle, (2016) Ethiopia has the fifth largest floral diversity in tropical Africa. This is due to its diverse topography such as high and rugged mountains, flat-topped plateau and deep gorges, incised river valleys and rolling plains. Although due to altitudinal variation ranges from116m below sea level in Kobar sink to 4620m above sea level at the peak of Ras Dashen (IBC, 2012). Over the ages, erosion, volcanic eruptions, tectonic movements and subsidence have occurred and continued through millennia to accentuate the unevenness of the surface (EMA, 1988). The Great Rift Valley separates the country into two (north-western and south-eastern highlands). The highlands on each side give way to vast semi-arid low land areas in the east and west, especially in the south of the country. The physical conditions and variations in altitudes have resulted in a great diversity of climate, soil, flora and fauna (Brenan, 1978; cited in EWNHS, 1996).

Ethiopia has been regarded as one of the most important countries in Africa with respect to biological resources (EFAP, 1994). The number of species of higher plants found in Ethiopia is about 5757(Excluding Ertria), of which about 9.4% are endemic to the country (Ensermu Kelbessa and Sebsebe Demissew, 2014). This high number of plant species results from the wide variation in climate, geology and terrain working on different time scales (EWNHS, 1996; Sebsebe Demissew *et al*., 2003; Mulgeta Lemenih and Demel Teketay, 2004) and past historical events.

Authors such as Logan, 1946; Breitenbach, 1963; EMA, 1988 and Abate Ayalew *et al*., (2006) indicate that the substantial proportion of highlands of Ethiopia was once believed to have been covered with extensive forests. However, the forest cover of Ethiopia has been declining over times due to an expansion of farmlands in uncontrolled way, the increasing livestock population, and rising demand for fire wood and charcoal with illegal harvesting of the forest and its products (Feyera Senbeta and Demel Teketay, 2003; Million Bekele and Leykun Berhanu, 2001; Teshome Soromessa *et al.*, 2004; Fikadu Gurmessa *et al.*, 2013; Dikaso Unbushe and Tesema Tekle, 2016).

Loss of such forest resources would have great implication for the environment, biological diversity and socio-economic setup of the communities.The forest cover Ethiopia has been estimated variously over years with about 35-40% of the land surface of the country (EFAP, 1994). In the same way this source has shown that the size has exhibited diminishing trend over years that is about 16% was left by early 1950s, 3.1 % by 1982, 2.6 % by 1989 and less than 2.3 % in 1990 (EFAP,1994) establishment. But according to Forest Resources Assessment (FRA), Ethiopia is among countries that have forest cover ranging between 10 to 30 percent of their total land area and its forest cover by now is 12.4 milion hectares ( 11.5%), ( FAO, 2015).

Using landsat imagery, Reusing (1998; 2000) categorized the Ethiopian Natural forests in to closed high forest, slightly disturbed high forest and heavily disturbed high forest. According to this information, closed high forest covers 0.16%, slightly disturbed high forest 0.65% and heavily disturbed high forest 0.92% together covering 1.41% of the land area of Ethiopia. Most of the remaining forests in Ethiopia are confined to the south and south-western parts of the country (Kumilachew Yeshitela and Tamirat Bekele, 2002; Fufa Kenea, 2008; Reusing, 1998; Melese Bekele and Wendawek Abebe, 2016).

However, now a day the remnant natural forests in these areas are also continuously threatened by human activities and the existing ones are in a secondary state of development (Reusing, 1998 and Reusing, 2000; Melese Bekele and Wendawek Abebe, 2016). Deforestation and degradation are the causes of forest cover loss in Ethiopia. This is due to population growth, demand for agricultural lands (Ensermu Kalbessa *et al.*, 1992; Zerihun Tadesse *et al*., 2018). This in turn led to expansion of cultivated fields at the expense of the forest.The annual rate of deforestation in Ethiopia was found to be extremely high (163,600 ha) (Reusing, 1998; Reusing 2000). This unaccustomed deforestation rate is considered a major threat to the Ethiopian biodiversity (Tadese Woldemariam, 2003; Fayera Senbeta and Denich, 2006; IBC, 2009) and the habitats of the 120 threatened endemic plant species of Ethiopia (Vivero *et al.*, 2005). In view of this, generation of sound biodiversity and ecological data on the remaining natural forest of Ethiopia is deemed necessary for their subsequent conservation activities (Fayera Abdena, 2010) So, Sagi Tagata Natural Forest is one of the remnant natural Forests patches in southwest Ethiopia.

## 1.2 Statement of the Problem

Sagi Tagata Natural Forest is one of the few remnant forest patches in southwest Ethiopia. This forest is highly valued for its high economic and other ecological services. The forest is used as common pool for the local community as principal sources of construction and timber. As far as we know, no detailed biodiversity and ecological studies have been done on this forest. As a result, this study was done to fill the knowledge gap and draw the attention of policy makers to understand the plant biodiversity assemblage and undertake appropriate conservation measures. The absence of any previous ecological studies is also equally vital to call for immediate and timely scientific interventions to uphold the conservation of this natural high forest.

## 1.3 Research Question

1. What is woody species diversity of Sagi Tagata natural forest?
2. What is the vegetation structure of Sagi Tagata natural forest?
3. What is the phyto-geographical similarity of Sagi Tagata natural forest with other related forests in Ethiopia?

## 1.4 Objectives of the Study

### 1.4.1 General objective

To assess the woody species diversity and vegetation structure of Sagi Tagata Natural forest.

### 1.4.2 Specific objectives:

1. To assess the woody species richness and diversity of Sagi Tagata forest;
2. To identify the plant community types and vegetation structure of Sagi Tagata Natural forest.
3. To make phyto-geographical comparisons with other related forests in Ethiopia.

## 1.5 Significance of the study

The study was very important in order to assess the woody species diversity and vegetation structure of Sagi tagata Natural forest thoroughly to assess species richness and evenness in their diversifications. Also provide information for future farther ecological studies and about the status of the forest to give direction regarding to the way of conservation. Accordingly used to identify which species are highly threatened and need more attention of conservation.

# 2. Literature Review

## 2.1 Vegetation Types in Ethiopia

Natural forest is one of the richest ecosystems in plant species diversity and used as a home of many and diversified plant species. Natural forest has wide ecological and environmental values and is a source of biodiversity (Bikila Mengistu and Zebene Asfaw, 2016). Several authors have been strived to study the Ethiopian forests and woody vegetation resources employing different systems which have provided substantial contribution to describe vegetation types of Ethiopia. Among these authors, (EFPA, 1994; Kumilachew Yeshitela. and Tamirat Bekele, 2002; Tadese Woldemariam, 2003; IBC, 2005; Fayera Senbeta *et al*., 2007; Teshome soromessa *et al*., 2004; Fekadu Gurmessa *et al*., 2013; Admasu Abdi *et al*., 2016; Melese Worku, 2017; and Nigusie Feyissa *et al.*, 2017; Debissa Lamessa *et al*., 2017; Zerihun Tadese *et al*., 2018) have made considerable contributions toward understanding the vegetation of the country and proposed their conservation strategies.

The general description of the vegetation type and their diversity in different parts of Ethiopia have been illustrated by some recent studies done bythe following investigators, Sebsebe Demissew and Friis, 2009; Motuma Didita, 2007; Alemu Abebe, 2007; Dereje Denu, 2007; Kitessa Hundera *et al*., 2007; Haile Yineger *et al.*, 2008; Ensermu Kelbessa and Teshome Soromessa, 2008; Dikaso Unbushe and Tesema Tekle, 2016; Melese Bekele and Wendawek Abebe, 2016). According to these and other investigators most vegetation types of Ethiopia have been grouped into different categories of flora area. As a result, following similar approach of the previously report, Ethiopia has been divided in to twelve (12) major ecosystems which are represented as follows: (1) Afroalpine belt(AA): is found in areas of highest mountains that peak approximately above an altitude of 3200 m a. s. l., (2) Ericaceous belt (EB): is found adjacent to Afroalpine belt ecosystem in most of the higher mountains in Ethiopia between the altitudinal range of 3000-3200m a. s. l., (3)Transitional rain forest ecosystem (TRF): is found adjacent to Moist evergreen Afromontane forest ecosystem in southwest Ethiopia, (4) Moist evergreen

Afromontane forest (MAF): is characterized by closed strata that may reach to the height of 30 to 40m and where wild coffee is found within the altitudinal range of between 1500-3000m a. s. l. and in areas receiving an annual rainfall between 700-2000mm, (5) Dry evergreen Afromontane forest and grassland complex (DAF): this represents the largest and complex ecosystem in Ethiopia and found in different regions of the country between the altitudes of 1800-3000m, (6) Combretum-Terminalia woodland and wooded grassland (CTW): comprises fairly large sized deciduous trees and grasses and is widely found in lowland areas and western escarpments of Ethiopia, (7) Wooded grassland of the western Gambela region (WGG): is characterized by a tall grass stratum, herbaceous flora, grass species and different acacia species, (8) Acacia-Commiphora woodland bushland (ACB): is found in dry lowland areas of eastern, southern part of Ethiopia and to the east of the highlands in the Rift Valley, (9) Desert and semi-desert scrubland (DSS): here the vegetation cover is scarce and comprises mainly drought tolerant species. Some areas are bare, for example, the salt pans in the Danakil depression lying below 400m a. s. l. altitude in eastern Ethiopia, (10) Riverine vegetation (RV): big rivers and their tributaries form the drainage systems and in areas where altitude is approximately below 1800m a. s. l. these rivers have riverine forests, (11) Freshwater lakes, lake shores, marsh and floodplain (FLV): the major fresh water lakes include Lake Tana, Lake Ashange, Lake Langano, Lake Ziway, Lake Awasa, Lake Abaya and Chamo and Turkana and (12) Salt lakes, salt-lake shores, marsh and pan vegetation (SLV): is represented by salt tolerant species. The salt lakes in Ethiopia are Lake Asale in Danakil depression of Afar region, Lake Abe, Lake Afderera, Lake Abijata and Lake Matahara (Debissa Lemessa and Yayehyirad Teka, 2017). From these vegetation types, the current study area (Sagi Tagata Natural Forest) belongs to the moist evergreen Afromontane forest of the country.

### 2.1.1 Moist Evergreen Montane forest

The moist evergreen montane forest ecosystem is the most diverse ecosystem in composition, structure and habitat types (NBSAP, 2005). However the moist evergreen montane forest mostly characterized by one or more close strata of ever green trees, which may reach a height of 30 m to 40 m. According to Friis, (1992) and Sebsebe Demissew, *et al.,* 2004) the vegetation type of this forest further divided in to two these are: one Afro-montane rainforest which occurs in the southern part of the Ethiopia highland between 1500m and 2600m elevation and the Harenna on the southern slop of Bale mountains. This forest type also includes medium size trees and shrubs. The second one is transitional rain forest which consists of forests of the western Ethiopian highlands occurs in Ilu Aba Bor, Welega and Kafa in between 500 m and 1500m elevation. According to Ermias Lulekal, (2005) this forest consists forests of the country, mainly the southwest forests, wettest and also humid forest in the southeastern plateau known as the Harenna forest. The IBC, (2005) and Several researchers such as (Friis, 1992; Zerhun Woldu *et al*., 1989; Kumlachew Yeshitila and Tamrat Bekele, 2002; Woldeyhanes Enkossa, 2008, Ensermu Kelbessa and Teshome Soromessa, 2008, have studied the composition and structure of this forest vegetation type in southern, southwest and western part of the country and described them on floristic basis.

This forest situated mainly in the south western part of Ethiopia (in Ilu Aba Bor, Wollega and Kafa) with altitudinal ranges of 1500-2500m above sea level, average annual temperature of 18-20$^0$C and annual rainfall between 1500-2000 mm sometimes even higher than 2000 mm, with rain all the year round, but a maximum in April-October (Friis, 1992; Tadese Woldemariam, 2003; NBSAP, 2005; Fayera Senbeta, 2006). According to the study of NBSAP, (2005), this ecosystem is the most diverse ecosystem in composition, structure and habitat types; consequently it is rich in biodiversity with a number of endemic species. The plant species found in this vegetation type are the largest broad-leaved species and commercially the most important frequent emergent species and upper canopy trees such as *Pouteria adolfi-friederici, Podocarpus falcatus, Celtis africana, Schefflera abyssinica, Mimusops kummel, Millettia ferruginea, Croton macrostachyus, Albizia gummifera, Ficus ovata, Ficus thonningii, Syzygium guineense subsp. afromontanum, Ekebergia capensis and Olea welweitschii.*

The lower storey trees and shrubs include: *Maesa lanceolata, Bersama abyssinica, Ehretia cymosa, Clausena anisata, Cordia africana, Matyenus gracilipes, Teclea nobilis, Trema orientalis, Nuxia congesta, Cassipourea malosana, Allophylus abyssinicum, Coffea arabica, Dracaena steudneri, Calpurnia aurea, Phoenix reclinata, Psychotria orophila, Olea capensis subsp. macrocarpa, Carissa spinarum and Rytigynia neglecta*. Lianas are common and include: *Jasmnium abyssinicus, Landolphia buchananii, Combretum paniculatum, Urera hypselodendron, Embelia schimperii, Hippocratea goetzei, Periplo calinearifolia, Tiliacora troupinii and Clematis hirsuta* (Fayera Abdena, 2010). Some studies (Fayera Senbeta, (2006);

Ensermu Kelbessa and Teshome Soromessa, (2008) have described the plant community and their relationships with environmental factors. Due to a long term interaction of factors such as biotic and abiotic, the vegetation cover in a given area has definite structure and composition developed. The way of distribution and vertical stratification change attributed to varied climatic conditions, soil types, latitude and topography of the area which in turn influence the distribution and types of plant and animals in the forest (Dombois and Ellenberg, 1974)

## 2.2 Plant Biodiversity and Threats in Ethiopia

Ethiopia is one of the tropical countries with diverse flora and fauna as well as rich in endemic species. The flora of Ethiopia encompasses about5757 vascular plant species with 9.4% endemic (Ensermu Kelbessa and Sebsebe Demissew, 2014); this distribution puts the country in the fifth largest floral composition in tropical Africa (Motumma Didita *et al*., 2010; DikasoUnbushe, and Tesema Tekle, 2016). However, the forest cover in the country rapidly dwindled due to anthropologenic impact (Teshome Soromessa *et al*., 2004; Million Bekele and Alemu Abebe, 2016). But according to some studies which, (EWNHS, 1996; EPA, 2003; NBSAP, 2005) based on the diversity and climatic variation still Ethiopia is one of the richest centers of biological diversity and genetic resources in the world.

The major threats to the biodiversity of the country are over-harvesting, deforestation, conversion of natural vegetation to farmland, forest fires, land degradation, habitat loss and fragmentation, invasive species, illegal trafficking of domestic and wild animals, poaching, wetland destruction and climate change (IBC, 2009; Haileab Zegeye *et al*., 2014) whereas protected areas frequently serve to insulate biodiversity from the impacts of human development (Rai and Sundriyal, 1997; Shackleton, 2000). As a result, biodiversity resources along with their habitats are rapidly eradicating in the country (Tadese Woldemariam and Demel Teketay, 2001; Tadese Woldemariam *et al*., 2002,Tadese Woldemariam, 2003; Fayera Senbeta, 2006; Fayera Senbeta and Denich, 2006;cited in Fayera, 2010).

This loss in biodiversity due to degradation of environment and other threats to the components of ecological systems is the most serious environmental problems facing Ethiopia at present. Because the loss of this biological diversity due to these factors ultimately results in economic losses of the country and the world as a whole, including reduction in the quantity of carbon that can be sequestrated from the atmosphere (EFAP, 1994). Most highlands have felt the impacts of fundamental changes, as a result of the vegetation deteriorating in its biological potential from the effects of human pressure (Sebesbe Demissew, 1980, Fikadu Gurmessa *et al*., 2013). Although biodiversity has valuable importance and services in terms of economic, ecological and other benefits, humans have a bad record of misuse of these resources. On other hand recent ethno botanical studies have been stated that, during the interaction of biodiversity and human society plants used for different purposes such as food, fodder, medicine, clothing, shelter, agricultural implements, hunting, narcotics, poison, gums, dyes, fuel, fiber, income generation and the fulfilling of cultural and spiritual needs throughout the world Endeshaw, Andargie *et al.*, (2015). Also several factors drive natural forest destruction in Ethiopia, agricultural land expansion triggered by increasing human population is probably the dominant force (Mulugeta Lemenih, and Demle Teketay, 2004; Motuma Didita *et al*., 2010; IBC, 2005).

Generally, there are close connections between poverty, population growth, economic development, and the use of the environment (Woldeyohanes Enkossa, 2008). If now a day population growth will continue, degeneration of natural resources will be even more rapid in the future. This in turn associated with rapid dwindle of the forest every year that resulted in other pressing problems such as land degradation, soil erosion, and water resource degradation (EFAP, 1994; NBSAP, 2005). The recognition of these loss/threats to biodiversity has led to draw conservation strategies at global, regional and national levels.

## 2.3 Plant Community Types

The geographical diversity of Ethiopia has favored different habitats and vegetation types. Plant communities are imagining as types of vegetation recognized by their floristic composition and diversity. The relationships of species compositions in this community express more or less their relationships to one another and environment than any other characteristics (Kent and Cooker, 1992). It can be defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent and Cooker, 1992). Plant community can be understood as combination of plants that are dependent on their environment, influence one another, and modify their environment (Mueller-Dombois and Ellenberg, 1974).

However, most plant communities consist of many different species which are not particular to discover all species within a community. Therefore, it is common to use the dominant species in naming plant communities (Kent and Cooker, 1992). The idea obtained on this analysis of plant population structure helps as a reference reanimation of tree species under utilization. This in turn illustrates the history of forest disturbance level to that species and environment and hence used to forecast the further trend of the population of that particular species (Peters, 1996).Vegetation classification attempts to define discrete, repeatable classes of relatively homogenous vegetation communities /association about which reliable statements can be made. Classification assumes either that natural vegetation groupings do occur, or that it is reasonable to separate a continuum of vegetation composition and/or structure in to a series of arbitrary classes (Kimmins, 1997).

### 2.3.1 Species diversity, species richness, evenness and similarity

Diversity is used to compute for species richness and species evenness of the plant community types in the vegetation. Species richness is the number of species per given area where as species Evenness is the relative abundance of species to all species or an even distribution of individual species (Zerihun woldu, 1985). Hence, diversity and equitability of species in a given plant community are used to clarify the relative variation in each other and within the community and help to explain the basic reason for such a difference. So, the two main factors such as richness and evenness are those factors need attentions during measuring diversity. Species richness index is of great importance in assessing taxonomic and ecological values of habitats.  Each number of indices devised, seeks to express the diversity of a sample or quadrant by a single number. From the various indices, the most frequently used is the simple totality of species numbers to give species richness (Magurran, 1988). Out of many species diversity indices, probably the most widely used to calculate the diversity and evenness includes Shannon-Wiener diversity index, which naturally varies between 1.5 and 3.5 and rarely exceeds 4.5 (Kent and Cooker, 1992). It is widely used index that combines richness and evenness (Krebs, 1999).

According to the study of Rosenzweig, (1995) these Species diversity could be viewed from different approaches in terms of: alpha (α) diversity refers to the diversity of species within a particular habitat or community, beta (β) diversity is a measure of the rate and extent of change in species along a gradient from one habitat to another, which is sometimes called habitat diversity (Kent and Cooker, 1992) and Gamma diversity (γ) that is the diversity of species in comparable habitats along geographical gradients and is independent of the two (Kent and Cooker, 1992; Buley, 2001). Similarity index measures the degree to which the species composition of the quadrants/ samples is alike, whereas dissimilarity coefficient assesses which two samples/ quadrants differ in composition. Jaccard and Sorensen are the most common binary similarity coefficient because they rely on probability data, except that Sorensen gives more weight to the species that are present in both quadrants and therefore less weight to species that are present in only one quadrant (Kent and Cooker, 1992). Patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes that are important for management (Lovett *et al*., 2000).

### 2.3.2 Abundance and frequency

Abundance is the number of plant per unit area. Measurement of plant abundance requires the counting of individual plants by species in a given area. It can be used to show spatial distribution and ranges over time. Frequency is the proportion of plots in which a species occurs. It is a measure of occurrence of a given species in a given area. 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)

### 2.3.3 Species important value index (SIV) and dominance

SIV permits a comparison of species in a given forest and reflects the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Hence, for ambient priority; it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices. Whereas species with lower

SIV require great conservation efforts and those with higher SIV require monitoring management.

## 2.4 Vegetation Patterns along Environmental Gradients

Understanding plant species distribution patterns and plant community composition along environmental gradients gives key information for effective management of forest ecosystems (Lovett *et al*., 2000; Noss, 1999; Naveh and Whittaker, 1980; Siraj Mohammed *et al*., 2016). Thus, it is important to identify plant species diversity and community composition along environmental gradients. All plants in the world like other living organisms have their own way of responding to their environmental gradients. According to the study of (Desalegn Wana and Zerhun Woldu, 2005), Natural vegetation may respond to environmental gradients in many ways. Globally, Patterns of plant species diversity are influenced by environmental factors like latitudinal, altitudinal and soil gradients (Huston, 1994). Altitude is one of the most important environmental factors that determine species diversity and distribution patterns. According to one study Whittaker, (1975) represented that, Species diversity generally tends to decrease with increasing altitude (elevation). The primary determinants of plant distribution are interacting influences of climate; topography and soil. So that variables such as vegetation structure and productivity also exhibit complex patterns along environmental gradient (Brown, 2001). Altitude affects temperature, moisture, radiation and atmospheric pressure thereby influencing the growth and development of plants and the distribution of vegetation (Zerihun Woldu*et al*., 1989; Getachew Tadesse *et al.*, 2005). Additionally Zerihun Woldu *et al*., (1989) stated that, altitude is the main factor that orders the tree-shrub layer into respective vegetation types because it is positively correlated with some environmental factors like organic matter and negatively correlated with pH, clay and calcium.

In general, the distribution, abundance and diversity patterns of species can result from the interaction between biotic and abiotic factors at different spatial and temporal scales (Brown, 2001; Fayera Senbeta, 2006). Variations in climate, temperature and rainfall distribution are generally reflected in the variations of the species composition and structure of communities (Brown, 2001, Grytnes and Vetaas, 2002).

# 3. Materials and methods

## 3.1. Description of the Study Site and Location

The study was conducted on Sagi Tagata Natural Forest, located in Ilu Aba Bora Zone of Oromia National Regional State, Southwest Ethiopia. Specifically the forest is found across boundaries of two districts namely, Ale and Didu. From Ale side the forest was bounded with Jote Koyami, Sagi Tagata, Yobi Mari and Gebre Dema Kebeles. And from Didu side the forest is only bounded with Gordomo kebele only (Fig. 1 and 2). It is bound on north by Gore town on southeast by Didu District, on east direction by Bacho District and on Western direction by Gumaro tea factory. This forest is part of National Forest Priority Areas (NFPAs) and has been known by the name Sagi Tagata forest as part of Gebre Dima forest in the country (EFAP, 1994). The study area is located within the geographic coordinates approximately between $7^{0}$58'30" to $8^{0}$8'30'N latitudes and $35^{0}$28'30" to $35^{0}$33'30"E longitudes (EMA, 1988) (GMSA). And found in Ale District at a distance of 30 kms south-east of Metu town, which is situated at a distance of about 600km south west of Addis Ababa. This forest is located along altitudinal ranges between 1818m and 2041m above sea level.

The natural vegetation of the area is a broad–leaved and evergreen with the most dominant tree species covering an area of about 964 total hectar (Oromia Forest and wildlife conservation enterprise IAB branch personal Communication, 2017).

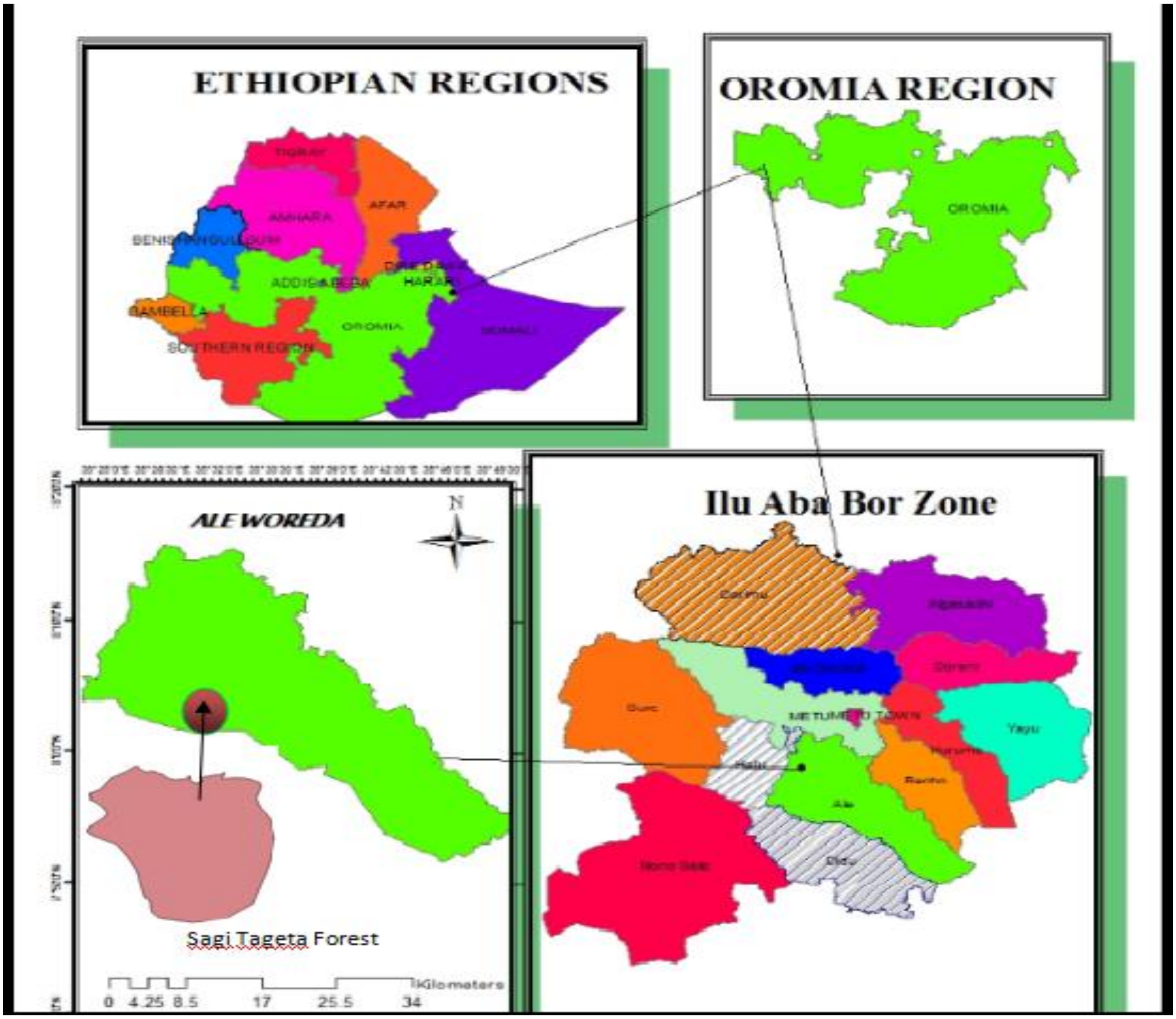


Figure 1: Map of Study area showing Ethiopia, Oroma, Ilubabor Zone and the study forest

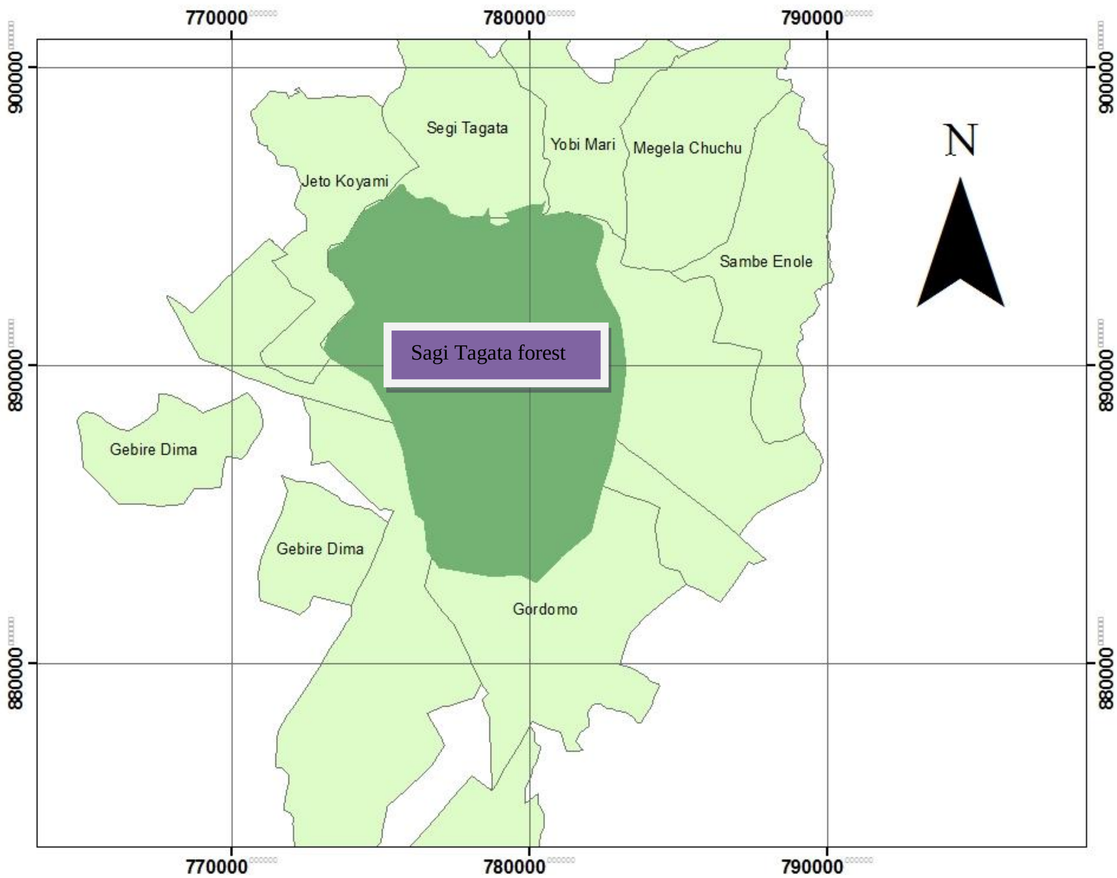


Figure 2: Location map of the study forest (Sagi Tagata natural forest)
Source: Oromia Forest and wild life conservation Enterprise Ilu Aba Bor Zone Branch.

### 3.1.1 Topography

Topographically, the forest is generally characterized by rough topography with undulating plain, hills, slopes, deep valley, gorges, escarpments and dissected plateaus. Several perennial rivers such as Yubi River and Magala River and other streams pass through the forest, all of which emerge from the highlands. Because of topographic nature, the forest area is not easily accessible as it is surrounded by steep, hill, slope and escarpments - it is relatively less disturbed by human actions.

### 3.1.2 Climate

#### 3.1.2.1 Temperature and rainfall

The temperature and rainfall data for this study were obtained from Gore Meteorological Station (EMSA, 2017). The annual average temperature ranges from 17.6$^{o}$c-20.2$^{o}$c, while the annual mean rainfall ranges from 1427.5-1997.2 mm. The distribution of rainfall was also described by using data of 10 years from GMS starting from 2008-2017 as unimodal, or multimodal that characterized by a prolonged wet season and a short dry and long dry period. Therefore, based on the information obtained from GMSA and IABZANRDO the distribution of rain fall is unimodal, characterized by a prolonged wet season from June to September (heavy rain) and a short dry spell showers from mid February to April. And there is dry period from October to the end of February .Based on altitudinal variations, Ale District has three Agro-Climatic Zones: 10% Dega, 70% Wayina Dega and 20% Kola (Ale District Agricultural and Natural resource Office, 2017)

### 3.1.3 Population and Land Use

According to population and housing census report (CSA, 2007) the total population of Ale District was 76,162 (73,983 rural dwellers and 2,179 urban populations). Of the total population, 38,256 were females and 37,906 were males. Like other parts of the highlands of the country, subsistence agriculture is the main economy of the community. Coffee and honey production are also practiced in the forest area. Especially for honey production, the population living around the forest shares the forest equally by traditional means known as "*Kobo".* The owner of "*kobo"* protects the forest in his own kobo from any damage which in turn help to conserve the forest. In addition to this the forest has the committee who follows and control the wise use of the forest. The traditional farming systems enforce the population to exploit the forest, particularly at the marginal areas for agricultural expansions and settlements.

Based on the data obtained from ADANRDO, the total land of the area is 57031ha.The land cover categories of the District include about 45% for potential arable land including land under crops which categorized as the area they cover in hectare and percent. Major crops grown in this district are cereal crops (maize, tef, sorghum, wheat, and barley), pulses (peas, beans, soya bean and Arcot bean) and oil crops (Niger seed and rape seed) and spieces. Also land of the area catagorized as coffee land, rock land, and land reserved goes for pasture land /grazing land, forest land, Swampy and for other purposes (ADANRDO, 2017). During the 2009-2010 E.C.(2017-2018) livestock populations in the district were 70869 cattle, 17143 sheep, 12709 goats, 53647 poultry,6897horses, 620 Mules and 635 donkeys as reported by (ADLFDO, 2017).

### 3.1.4 Vegetation

The District is characterized by the moist everegreen afromontane forests of southwest Ethiopia. The main species of plants found in this forest includes broad-leaved and evergreen with important tree species such as *Pouteria adolfi-friederici, Millettia ferruginea, Chionanthus mildbraedii, Deinbollia kilimandscharica, Tarenna graveolens,, Croton macrostachyus, Dracaena steudneri, Allophylus abyssinicus, Albiza gummifera, Prunus africana,Polyscias fulva, Cordia africana, Diospyros abyssinica, Macranga capensis, Ekebrergia capensis, Ficus spp., Syzygium guineense subsp. afromontaum, Olea capensis, sub sp macrocarpa.*

Although, Sagi Tagata Natural Forest has been designated as a NFPA, it is relatively less disturbed by human actions.Because it was protected by the community in the kebele who were aware of about the importance of the forest and grouped themselves to conserve by Farm African nongovernmental organization.

### 3.1.5 Wild life

Sagi Tagata Natural Forest is home for a variety of wildlife Species, including mammals, various species of birds, amphibians and reptiles. Some of the common wild life includes Calumbus

Monkey, wild pig, Anubis baboon, Varbet monkey, Porcupine, Common warthog, Africana civet cat, Leopard, Common bushbuck and Platypus. Thus, the forest is rich in fauna diversity.

## 3.2 Methods

### 3.2.1 Reconnaissance survey and sampling site selection

Reconnaissance survey of Sagi-Tagata Natural Forest was made from November 21–28, 2017 (one week before the actual data collection) in order to obtain an impression of the site conditions, to collect information on accessibility and to identify sampling design. Therefore, the study area was selected for data collection in Sagi Tagata village kebele.

### 3.2.2 Sampling design

To investigate the woody species diversity and Vegetation structure of Sagi Tagata Moist Evergreen afromontane Forest (SMEAF), a systematic sampling technique was used as a sampling design. Five transects were laid at distance of 500ms along elevation gradients.The reason why the investigater didn't laid down more transects was due to the five transects covers all the plot has been planed to sampled. Sample quadrats of 20m × 20m for all woody species were established at 20m interval along the study transects.  Atotal of 40 quadrats (1.6 hectare) were sampled from 964ha of total hectares.

### 3.2.3 Data collection

The actual data were collected from December 5/2017-March10/2018.In each quarat all woody species in the plot were recorded and their height, cover abundance in each plot were estimated and rated according to modified Braun Blanquet approach (van der Maarel, 1979).The collected plant specimens following standard herbarium technique were numbered, pressed properly and brought to Jimma University for identification referring to Flora of Ethiopia and Eriteria volume 1-8 and consulting expert. Herbarium specimens were deposited at Jimma University Herbarium.

The specimens were collected from 40 plots (each size 400$m^2$) of Sagi Tagata Natural Forest. A complete list of trees and shrubs were made for each plot by Following Fekadu Gurmessa *et al.,(*2013) species occurring within 10m distance from the plots boundaries were also recorded as present for woody species composition. DBH height for all individuals trees and shrubs with a diameter at breast height (DBH) $\geq$ 2.5 cm at 1.3 m above the ground and height $\geq$2 m were measured. Individual species with DBH less than 2.5 cm at 1.3 m above the ground and height less than 2 m were counted as sapling. DBH of all woody plants were measured and recorded using diameter tape and heights were estimated visually.

#### 3.2.3.1 Estimation of percent covers value

Transformations of the Braun-Blanquet cover-abundance scale in to a new numerical scale has been introduced by Van der- Maarel (1979). This new cover-abundance scale is an effective, easy to use directly in the field and the raw data can be easily entered in to the data-processing system for vegetation community classification. Therefore, the percent cover-abundance value were estimated visually for each species within the sample plot and recorded. These were later used for the estimation of cover/abundance values and converted to the Braun-Blanquet 1-9 scale as modified by van der Maarel (1979) as follows:

1 = rare generally one individual,

2 = occasional < 5% cover,

3 = abundant < 5% cover,

4 = very abundant <5% cover,

5 = cover values between 5-12%,

6 = cover values between 12-25%,

7 = 25-50% cover;

8 = 50-75% cover and

9 = 75- 100% cover of the total plots area.

### 3.2.4 Data Analysis

#### 3.2.4.1 Plant community determination

Plant community type was determined from agglomerative multivariate cluster analysis computing the estimated cover abundance using PC-ORD for Windows version 5.3 (McCune and Mefford, 1999; McCune and Grace, 2000). Bray-Curtis Distance measurer was used for clustering the study plots based on the cover abundance values of wood species.

#### 3.2.4.2 Diversity Index

Diversity indices are simple mathematical expressions that summarize a lot of data recorded in one or sets of figures. Of the various indices, Shannon-Wiener diversity index (H') is the most applicable index of diversity (Grieg-Smith, 1983). It was used to compute for both species richness, species evenness and species diversity of the plant community types in the vegetation (Magurran, 1988).

Shannon Diversity index was calculated using the following formula:

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

Where, H'= Shannon diversity index,

S = the number of species;

Pi = the proportion of individuals or the abundance of the species expressed as a

Proportion of the total cover

ln = log base n (natural logarithm)

**Equitability** (E),

Evenness was calculated from the ratio of observed diversity to maximum diversity using the equations;

$E = H'/ H'\ max$, or $E = H'/ \ln S$, with $H'_{max} = \ln S$

Equitability assumes a value between 0 and 1 with 1 being complete evenness (Kent and Cooker, 1992). The higher the value of evenness index, the more even the species is in their distribution within the given area.

### 3.2.4.3 Similarity Index ($S_s$)

Sorensen's similarity coefficient is applied to qualitative data to assess diversity as described by Grieg-Smith (1983) and is widely used because it gives more weight to the species that are common to the samples rather than to those that only occur in either sample which was calculated by using the following formula:

Ss = 2 a /2a+b+c

Where: Ss =Sorensen's similarity coefficient

a = is number of species shared by the two forests/ samples;

b = is the number of species in forest/ sample 1(community1);

c = is the number of species in forest/ sample2 (community2) Kent and Coker (1992).

### 3.2.4.4 Analysis of the vegetation structure

In this study, in order to describe the vegetation structure of the forest the following components were used: frequency, DBH and height class distribution, Important Value Index (IVI), basal area, and the stem density. Tree or shrubs density and basal area values were analyzed on hectare basis. Therefore, based on study of Kflay Gebrehiwot and Kitessa Hundera, (2014) eleven DBH constructed that is: 1= 2.5-9.5, 2=9.6-20, 3=20.1-30, 4=30.1-40,5=40.1-50,6=50.1-60,7=60.1-70,8=70.1-80.9=81-90, 10=90.1-100 and 11=>100. In addition; the percentage distribution of individuals in each class was calculated. Also to meassure the storey of the forest was taking the highest (tallest) individual of the woody species. Divide its height in to three classes one third of it for (lower storey, ≤13.3), two third of it for (middle storey, 13.3-26.6) and greater than two third for (upper storey, >26.6).The percentage distribution of individuals in each class was computed for each species.

#### 3.2.4.5 Importance Value Index (IVI)

IVI is one way of studying vegetation which considered by ecologists as the most realistic aspect in vegetation study as it combines data of three parameters (Curtis and McIntosh, 1951). IVI can be calculated by using the following formula. Importance Value Index (IVI) is useful to compare the ecological significance of a species (Dereje Denu, 2007). High value of IVI indicates that the species sociological structure in the community is high.

IVI = Relative Density (RD) + Relative Dominance (RDO) + Relative Frequency

$$RD = \frac{\textit{number of all individual of species}}{\textit{total number of all individual of the sumple}} \times 100$$

$$RD = \frac{\textit{basal area a species}}{\textit{total basal area of the sampl}} \times 100$$

$$RF = \frac{\text{the nuber of plot where species occur}}{\text{total occurrence of all species}} \times 100$$

Family Importance Value Index (FIVI) was calculated based on the formulae given below (Mori *et al*., 1983; cited in Nebel *et al*., 2001).

$$\textit{Relative diversity (RDV)} = \frac{\textit{number of species of a family}}{\textit{total number ofindividuals of a sample}} \times 100$$

$$\textit{Relative density (RD)} = \frac{\textit{number of individual family}}{\textit{total number of individuals of the sample}} \times 100$$

$$\textit{Relative dominance (RDO)} = \frac{\textit{basal area of a family}}{\textit{total basal area of the sample}} \times 100$$

FIVI = relative diversity (RDV) + relative density (RD) + relative dominance (RDO).

The frequency distribution of tree species was calculated as follow:

$$\% \text{ of Frequency of species} = \frac{\text{Number of quadrats in which a species occurs}}{\text{total number of a quadrats assessed}} \times 100$$

Basal area is the cross-sectional area of woody stems at breast height. It measures the relative dominance (the degree of coverage of a species as an expression of the space it occupies) of a species in the forest. Computed for all woody species both trees and shrubs DBH $\geq$2.5. Also the population structure of the tree species in the sample plot was analyzed using DBH $\geq$ 2.5cm and the pattern that emerged were interpreted as indication of variation in population dynamics in the forest (Kumelichew Yeshitila and Taye Bekele, 2003; Bikila Mengistu and Zerhun Asfaw, 2016)

Generally, it is a measure of dominance where the term "dominance" refers to the degree of coverage of a species as an expression of the space it occupies and was calculated by using DBH; using the following the formulae:

$BA = \pi d^2/4$, where BA= Basal Area in $m^2$ per hectare

d = diameter at breast height (m)

In turn, DBH value was calculated from circumference measurements by using the formula as follows: $d = C/\pi$

Following the study of Fayera Abdena, (2010) phyto-geographical comparison was accomplished in order to identify the relationships between Sagi tagata natural forests with other Dry/moist montane forest of Ethiopia. The woody species composition and species distribution was evaluated by using Sorensen similarity coefficient.

# 4. Result and discussion

## 4.1 Woody Species composition

A total of 69 woody species belonging to 66 genera and 34 families were identified from 40 plots assessed from Sagi Tagata natural forest. These plant species are comprised of trees (44.93%), shrubs 29 (42.03%) and woody climbers (13%). With regards to species number, the most dominant family was Rubiaceae (6 species), followed by Araliaceae (5 species), Celastraceae, Euphorbiaceae, Fabaceae, and, Malvaceae (each with 4 species), Asterraceae and Meliaceae were (each with 3species), Moraceae, Oleaceae, Acanthaceae, Boragin*ace*ae, Dracenaceae, Rocaceae and Sapindaceae (each with 2 species). The remaining families were composed of one species each.

This forest contains 13 (54%) of the 24 national priority tree species (EFAP, 1994). These are *Pouteria adolfi-friederici*, *Schefflera africana*, *Ekebergia capensis*, *Albizia gummifera*, *Syzygium guineense*, *Cordia africana*, *Croton macrostachyus*, *Prunus africana*, *Olea capensis*, *Milletia ferruginea*, *Apodyates dimidiata*, *Chionanthus mildbraedii* and *Deinbollia kilimandscharica*.

## 4.2 Plant community classification

In the current study a total of six plant community types were clearly classified using hierarchical cluster analysis (Fig.3). Each community type was named after two woody species with higher cover abundance values within the group. The dominant species were those with the highest mean cover–abundance value for a given community.

Table 1: The most dominant species with the highest mean cover–abundance value for a given community

| | C1 | C2 | C3 | C4 | C5 | C6 |
|---|---|---|---|---|---|---|
| Species Name | mean c/v | mean c/v | mean c/v | mean c/v | mean c/v | meanc/v |
| *Pouteria adolfi-friedericii* | 8 | 9 | 0 | 5 | 1 | 5 |
| *Millettia ferruginea,* | 7 | 6 | 7 | 3 | 7 | 3 |
| *Hippocratea goetzei* | 7 | 3 | 5 | 4 | 4 | 4 |
| *Deinbollia kilimandscherica* | 7 | 6 | 8 | 6 | 8 | 8 |
| *Syzygium guineense* | 7 | 0 | 0 | 0 | 1 | 0 |
| *Albizia gummifera* | 6 | 3 | 5 | 5 | 8 | 1 |
| *Tarenna graveolens* | 6 | 2 | 4 | 5 | 7 | 3 |
| *Chionanthus mildbraedii* | 6 | 7 | 5 | 7 | 5 | 8 |
| *Schefflera abyssinica* | 5 | 0 | 0 | 0 | 0 | 0 |
| *Lepidotrichilia volkensii* | 5 | 3 | 0 | 0 | 4 | 7 |
| *Dracaena afromontana* | 2 | 8 | 1 | 1 | 0 | 2 |
| *Rothmannia urcelliformis* | 0 | 4 | 2 | 4 | 3 | 5 |
| *Justicia schimperiana* | 2 | 3 | 3 | 2 | 2 | 3 |
| *Maytenus arbutifolia* | 4 | 3 | 2 | 1 | 3 | 0 |
| *Olea capensis* | 4 | 6 | 1 | 5 | 3 | 1 |
| *Croton macrostchyus* | 1 | 1 | 7 | 6 | 4 | 0 |
| *Ehretia cymosa* | 2 | 1 | 5 | 5 | 4 | 3 |
| *Ficus sur* | 5 | 0 | 3 | 3 | 2 | 0 |
| *Kirkia burgeri* | 0 | 2 | 3 | 2 | 1 | 1 |
| *Sericostachys scandens* | 3 | 2 | 3 | 6 | 1 | 1 |
| *Galiniera saxifraga* | 0 | 2 | 3 | 3 | 3 | 2 |
| *Combretum paniculatum* | 3 | 2 | 3 | 3 | 3 | 5 |
| *Hippocratea africana,* | 3 | 2 | 3 | 3 | 3 | 7 |

**1. *Pouteria adolfi-friederici-Millettia ferruginea* community type**

The altitudinal range of this community was 1,838m-1,841m a.s.l. The total number of species in this community was 49. Among these, the first ten most abundant woody species were *Pouteria adolfi-friedericii, Millettia ferruginea, Deinbollia kilimandscherica, Hippocratea goetzei, Syzygium guineense, Albizia gummifera, Tarenna graveolens, Schefflera abyssinica, Chionanthus mildbraedii and Maytenus arbutifolia.*

**2. *Chionanthus mildbraedi-Pouteria adolfi-friedericii* community type**

*Chionanthus mildbraedi* and *Pouteria adolfi-friederici* community type is distributed in the elevation range of 1,818m to 1,858m a.s.l. This community type consists of six sample plots and 43 species which are free of anthropogenic disturbance. Some of the woody species associated with this community type were *Pouteria adolfi-friederici, Chionanthus mildbraedi, Millettia ferruginea, Dracaena afromontana, Olea capensis, Rothmannia urcelliformis, Justicia schimperiana, Maytenus arbutifolia, Albizia gummifera* respectively based on their cover abundance value.

**3. *Deinbollia kilimandscharica- Croton macrostchyus* community type**

This community resulted from 10 plots which consist of 51 species of trees and shrubs. The community situated at altitudinal rage between 1,861m to 2,041m a.s.l. This community is to some extent under intense human impact such as logging, hive making, and construction purposes. The first ten top dominant tree and shrubs in this community were *Deinbollia kilimandscherica, Croton macrostchyus, Millettia ferruginea, Hippocratea goetzei, Olea capensis, Albizia gummifera, Ehretia cymosa, Tarenna graveolens, Justicia schimperiana and Ficus sur.*

**4. *Chionanthus mildbraedii- Croton macrostachyus* community type**

This community type is located between 1,961-2001m a.s.l. and comprised of 9 plots and 50 species. This community is found mostly at the inner most area of the forest. Altitudinal gradients and topographic factors have their own impact on distribution of plant species. Some woody species belonging to this community are: *Olea capensis, Deinbollia kilimandscharica, Croton macrostachyus, Millettia ferruginea, Dracenna steudneri, Rothmannia urcelliformis, Sericostachys scandens, Pouteria adolfi-friederici, Albizia gummifera, Ehretia cymosa, Tarenna graveolens and Cordia africana*.

**5. *Albizia gummifera- Deinbollia kilimandscharica* community type**

The community was named by two species with the highest cover abundance values (*Albizia gummifera, Deinbollia kilimandscharica*). The altitudinal range of this community was from 1,818m to 2,041m a.s.l. Woody species associated with this community type are *Albizia gummifera, Deinbollia kilimandscharica, Tarenna graveolens, Millettia ferruginea, Chionanthus mildbraedii, Hippocratea goetzei, Croton macrostachyus, Galiniera saxifraga, Lepidotrichilia volkensii and Ehretia cymosa.*

**6. *Chionanthus mildbraedii - Deinbollia kilimandscharica* Community type**

The altitudinal range of this community ranges from 1,961-1,998m a.s.l. This community type was composed of 42 species distributed within three plots. The woody species in this community include: *Chionanthus mildbraedii, Deinbollia kilimandscharica, Hippocratea africana, Lepidotrichilia volkensii, Rothmannia urcelliformis, Combretum paniculatum, Allophylus abyssinicus, Bersama abyssinica, Ehretia cymosa and Justicia schimperiana.*

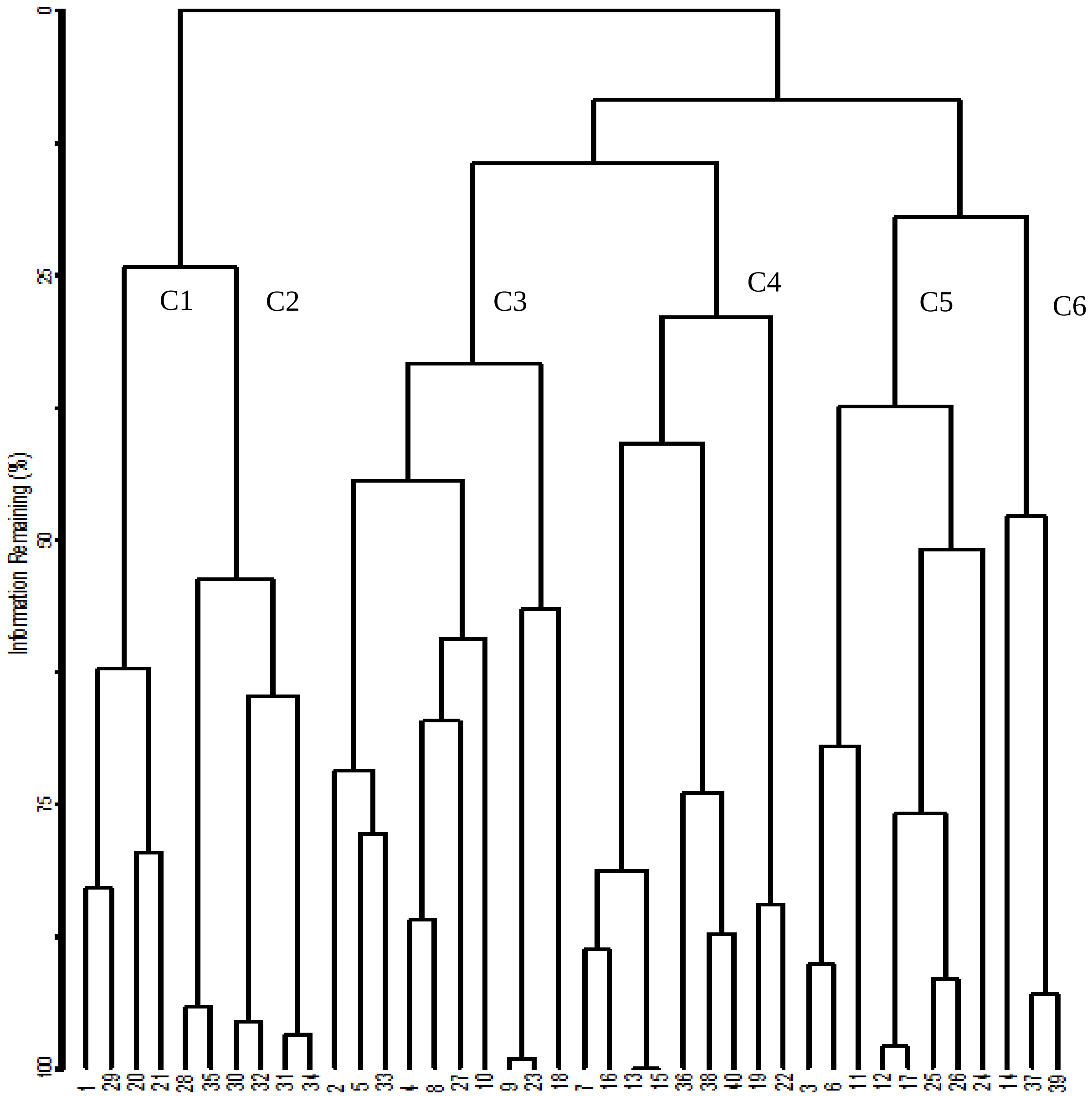


Fig.3: Denderogram output of the vegetation data obtained from agglomerative hierarchical cluster analysis of the forest

Table 2: The number of plots in each community type

| Community Type | Plots |
|---|---|
| Community 1 | 1, 20, 21, 29 |
| Community 2 | 28, 30, 31, 32, 34, 35 |
| Community 3 | 2, 4, 5, 8, 9, 10, 22, 36, 38, 40 |
| Community 4 | 7, 13, 15, 16, 19, 22, 36, 38, 40 |
| Community 5 | 3, 6, 11, 12, 17, 24, 25, 26 |
| Community 6 | 14, 37, 39 |

## 4.3 Species richness, evenness and diversity of plant Community types

The species richness, species evenness and diversity recorded in all six communities were listed below in (table 3).

Table 3: Shannon wiener Diversity index among the six communities

| Community Type | Species Richness | Species evennes | Diversity (H') | Elevation (m) |
|---|---|---|---|---|
| C1 | 38 | 0.81 | 3.43 | 1838-1841 |
| C2 | 33 | 0.77 | 3.24 | 1818-1858 |
| C3 | 40 | 0.80 | 3.47 | 1861-2041 |
| C4 | 44 | 0.81 | 3.57 | 1961-2001 |
| C5 | 36 | 0.79 | 3.35 | 1818-2041 |
| C6 | 30 | 0.78 | 3.16 | 1961-1998 |

Among the six community types, community type 4 has the highest species richness and evenness with the relatively high species diversity, while community 6 was the least in species richness and diversity.

## 4.4 Similarities among the six community types

The similarity among the six plant community types was given in (table 4). In this similarity analysis, community 3 and 4 have the highest similarity in species composition (86.9%) followed by community 2 and 4 (85.7%). This is probably due to similarity in altitudinal range. The least similarity was recorded between community 2 and 6 (69.3%) (See table 4). The least similarity ratio was exhibited by community type 1. This may have few more common species because of variation in slope and other environmental factors such as soil type.

Table 4: Sorreson's coefficients of similarity index among communities

| Community | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| 1 | - | 0.765 | 0.764 | 0.771 | 0.730 | 0.756 |
| 2 | - | - | 0.775 | 0.857 | 0.725 | 0.693 |
| 3 | | | - | 0.869 | 0.800 | 0.820 |
| 4 | | | | - | 0.839 | 0.847 |
| 5 | | | | | - | 0.750 |
| 6 | | | | | | |

## 4.5 Analysis of vegetation structure

### 4.5.1 Stem density

The density of woody species with DBH >2.5cm in this study was 784.375/ha. The species with the highest density were *Pouteria adolfi-friederici, Chionanthus mildbraedii, Deinbollia kilimandscharica, Tarenna graveolens, Millettia ferruginea, Croton macrostachyus, Albizia gummifera, Ehretia cymosa, Lepidotrilichilia volkensii, Dracaena afromontana and Maytenus arbutifolia (*table 5*)*. Most of the remaining species were scarcely populated in the study forest (Appendexi 2). The highest density (232/ha) of woody species was observed for DBH >10cm and 104/ha for the individuals with DBH >20cm. The ratio described as a/b is taken as a measure of size classes distribution (Grubb *et al.*, 1963). Accordingly, the ratio of individuals with DBH between 10 and 20 cm (a) to DBH > 20 cm (b) was 2.23 for Sagi Tagata moist evergreen afromontane forest.

Table 5: The most densly populated species in Sagi Tagata natural forest

| Species name | Density/sampled area | Density/hectare | %Density/ha |
|---|---|---|---|
| *Deinbollia kilimandscharica* | 145.63 | 91.02 | 11.60 |
| *Chionanthus mildbraedii* | 86.25 | 53.90 | 6.87 |
| *Millettia ferruginea* | 81.88 | 51.17 | 6.52 |
| *Albizia gummifera* | 61.88 | 38.67 | 4.93 |
| *Tarenna graveolens sub sp* | 36.25 | 22.65 | 2.89 |
| *Dracena afromontana* | 35.63 | 22.27 | 2.84 |
| *Pouteria adolfi-friederici* | 34.38 | 21.48 | 2.74 |
| *Lepidotrilichilia volkensii* | 25.63 | 16.02 | 2.04 |
| *Croton macrostachyus* | 24.37 | 15.23 | 1.94 |
| *Ehretia cymosa* | 23.12 | 14.45 | 1.84 |
| *Maytenus arbutifolia* | 16.88 | 10.55 | 1.34 |

Sagi Tagata forest has relatively higher density/ha compared with Wof washa (1.53), Alata Bolale (1.67), Chato (1.71), Magada (1.83) Gura Farda (1.9), but exhibited a strong variability with Chilmo (2.55), Masha-Andercha (2.4) and Menagesha suba (2.33) forest.

Table 6: The comparison of Sagi Tagata natural forest with other related forest in the country

| Forest | Alatitude(m) | DBH 10-20cm | DBH >20 | Ratio (a/b) | Sources |
|---|---|---|---|---|---|
| Chato | 1714-2144 | 33 | 194 | 1.71 | Fayer Abdena (2010) |
| Chilimo | 500-929 | 638 | 280 | 2.55 | Tamirat Bekele (1993 and 1994) |
| Masha-Andercha | 1250-2700 | 385 | 160 | 2.4 | Kumilachew Yeshitela and Taye Bekele(2003) |
| Magada | 1850 - 2006 | 608 | 332 | 1.83 | Garuma Gerbaba and Wendawek Abebe(2016) |
| Alata Bolale | 2061-2360 | 365 | 219 | 1.67 | Woldeyohannes Enkossa (2008) |

Table 6 continued

| | | | | | |
|---|---|---|---|---|---|
| Menagesha suba | 2300-3000 | 484 | 208 | 2.33 | Tamirat Bekele (1993 and 1994) |
| Wof-Washa | 1700 - 3060 | 329 | 215 | 1.53 | Tamrat Bekele (1993 ) |
| Gura Farda | 1730-2055 | 500 | 263 | 1.9 | Dereje Denu (2007) |
| Sagi Tagata | 1818-2041 | 232 | 104 | 2.23 | Present study |

### 4.5.2 Frequency

Frequency denotes the number of plots in which a given species occurred in the study area. The most frequently occurring species in Sagi Tagata forest were *Deinbollia kilimandscharica and Hippocratea goetzei* occurring in 97.5% of the study plots followed by *Chionanthus mildbraedii* (Table 7).

Table 7: The first nine most frequent species in the study area

| Species | occurrence | % occurrence |
|---|---|---|
| *Deinbollia kilimandscharica* | 39 | 97.5% |
| *Hippocratea goetzei* | 39 | 97.5% |
| *Chionanthus mildbraedii* | 33 | 82.5% |
| *Maytenus arbutifolia* | 32 | 80% |
| *Albizia gummifera* | 32 | 80% |
| *Millettia ferruginea* | 31 | 77.5% |
| *Combretum paniculatum* | 30 | 75% |
| *Tiliacora funifera* | 29 | 72.5% |
| *Ehretia cymosa* | 27 | 67.5% |

### 4.5.3 Diameter at Breast Height (DBH)

The DBH of woody species of Sagi Tagata Natural forest was classified in to eleven classes (fig.4). According to this DBH class distribution, about 87% of the individuals were found in the first two classes. All the remaining classes account for about 13%. The number of stems per hectare in DBH >10cm is 448.75$h^{-1}$ that is 35.76% and for DBH class of 10cm - 20 cm is 29.56%, while it is about 13.23% for DBH >20cm.

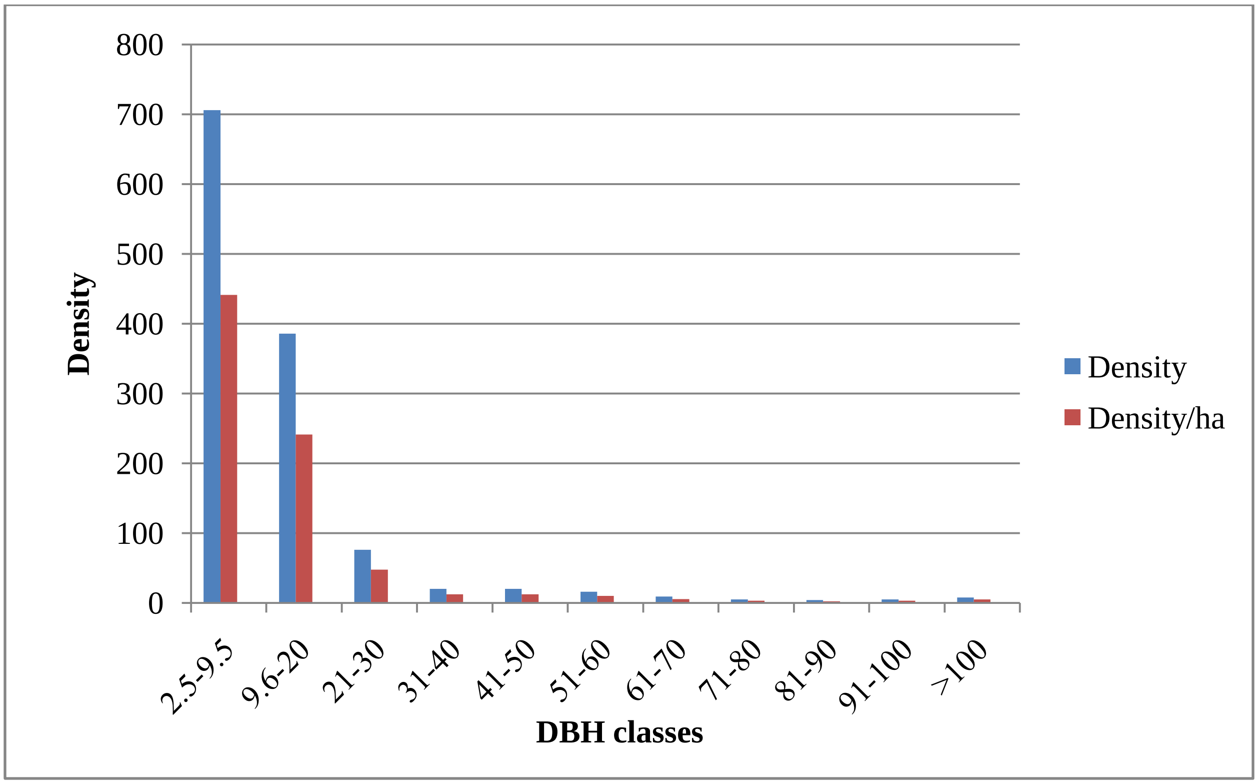


Figure 4: DBH class distribution of Sagi Tagata Moist Evergreen Montane Forest

### 4.5.4 Vertical stratification

The trees in the study area were divided into three storeys (lower, medium and upper). The lower storey contains all tree species with height (≤13.3m), Medium storey contains tree species with height is between (13.3-26.6 m), and the upper storey contains those with height ≥26.6m. The percentage of tree decreases from the lower to the upper storey. The large number of trees remains in the lower storey (80%), while the number of trees reaching the upper storey was less (9.64%). The general height class distribution pattern indicates a normal distribution of species and maximum values occurred in the first class and reduced gradually in the medium height class and rise up again in the third class. This pattern represents there is no good reproduction status and regeneration potential.

Table 8: The vertical layer class distribution of Moist ever green montane forest of Sagi Tagata

| Height class distribution | Height class | No of individual species | % |
|---|---|---|---|
| Lower class | ≤13.3 | 1005 | 80 |
| Medium class | 13.3-26.6 | 121 | 9.64 |
| Upper class | >26.6 | 129 | 10.36 |

### 4.5.5 Basal Area

The basal area of all tree species in Sagi Tagata natural forest was found to be 31.01m$^2$/ha. The highest basal area of the forest was contributed by *Pouteria adolfi-friederici* (ca.43.08%), *Schefflera abyssinica* (ca. 21%), *Albizia gummifera* (ca. 20%), *Olea capensis* (ca.14.5%), *Croton macrostachyus* (ca. 10.6%), *Ficus Sur* (ca.9.3), *Millettia ferruginea* (ca.7.4%), *Chionanthus mildbraedii* (ca.7.3%), *Deinbollia kilimandscharica* (ca.5.4%).

Generally the Basal area of the present study was showed relatively low when compared with some of the different studied forest in the country and relatively similar with Chilimo Forest (Table 9)

Table 9: Comparison of Sagi Tagata forest with other 10 afromontane forests in Ethiopia with respect to basal area

| Forests | Basal area(in $m^2$/ha) | Sources |
|---|---|---|
| Magada | 68.52 | Genene Bekele,2005 |
| Masha Anderacha | 81.90 | Kumilachew Yeshitela And TayeBekele(2003) |
| Menagesha suba | 36.10 | Tamirat Bekele (1993 and 1994) |
| Chilimo | 30.10 | Tamirat Bekele (1993 and 1994) |
| Chato | 65.8 | Fayera Abdena,2010 |
| Wof Washa | 101.80 | Tamrat Bekele (1993 ) |
| Dodolla | 129.00 | Kitessa Hundera (2003) |
| Belete | 103.5 | Kflay Gebrehiwot and Kitessa Hundera(2014) |
| Watagisho | 45.14 | Dikaso Unbushe andTesma Tekle,2016 |
| Bibita(Gurafarada) | 69.9 | Dereje Denu ,2007 |
| Sagi Tagata | 31.01 | Present study |

Table 10: Basal area and density distribution of top ten tree species in the Sagi Tagata Natural Forest

| Species | BA | BA% | Density |
|---|---|---|---|
| *Pouteria adolfi-friederici* | 13.4 | 43.1 | 34.4 |
| *Schefflera abyssinica* | 6.5 | 20.9 | 1.9 |
| *Albizia gummifera* | 6.2 | 19.9 | 61.9 |
| *Olea capensis* | 4.5 | 14.5 | 17.5 |
| *Croton macrostachyus* | 3.3 | 10.6 | 24.3 |
| *Ficus Sur* | 2.9 | 9.3 | 14.4 |
| *Millettia ferruginea* | 2.23 | 7.4 | 81.9 |
| *Chionanthus mildbraedii* | 2.3 | 7.3 | 86.2 |
| *Deinbollia kilimandscharica* | 1.7 | 5.4 | 145 |
| *Polyscias fulva* | 0.77 | 2.5 | 3.8 |

This forest has a more similarity proportion (13.23%) of tree with DBH greater than 20cm as compered with the study on Chato (19.79%) by Fayera Abdena (2010). According to this information Sagi Tagata natural forest is less dense than the other studied forest in the country listed above such as Chilmo (2.55), Masha-Andercha (2.4) and Menagesha (2.33) forest. But it is comparable with all the rest such as Wof–washa (1.53), Alata Bolale (1.67), and Chato (1.71), Magada (1.83) Gura Ferda (1.9) forest.

### 4.5.6 Species Important value Index (SIVI)

The vegetation structure was studied by using an index which we call important value index(IVI) following the methodology of Curtis and McIntosh's (1951).This is calculated by summing up the total RD, RF and RDO of all species sampled in the area. According to this result the highest SIV was contributed by six dominant species such as *Pouteria adolfi –friederici* (11.38%), *Deinbollia kilimandscharica (9.0%)*, *Albizia gummifera* (7.33%), *Chionanthus mildbraedii* (6.63%), *Millettia ferruginea* (6.32%) and *Croton macrostachyus* (4.26%) species in the forest.

The lowest SIV that is less than one (<1) contributed by seven species such as *Kirkia burgeri* (0.29%), *Dombeya torrida* (0.28%), *Schefflera volkensii* (0.27%) , *Macaranga capensis* (0.23%), *Vernonia auriculifera* (0.20%), *Rytigynia neglecta* (0.12%) , *Acacia brevispica* (0.12%) species respectively. This SIV value is used for comparison of ecological significance of species in which high SIV values indicate that the species is ecologically more important in the community.

#### 4.5.6.1 Family Important value Index (FIVI)

For the current study the FIV is calculated following Mori *et al.*(1993; cited in Nebel *et al.*,2001) from relative density, relative frequency and relative dominance (appendexi 4). Sagi Tagata forest is dominated by Fabaceae with 10.01m$^2$/ha which accounts only for 16.99% of the total basal area of the forest. This family contains three species with the total individual stem 201 (125.625/ha). Fabaceae is followed by Sapindaceae (9.71m$^2$/ha), Oleaceae 7.47m$^2$/ha, Robiaceae 4.33m$^2$/ha of the total basal area of the forest. This agrees with Curtis and McIntosh (1951).

Table 11: The four most important families with their FIV index

| Families name | % FIV |
|---|---|
| Fabaceae | 38.8 |
| Sapindaceae | 32.7 |
| Oleaceae | 23.96 |
| Araliaceae | 23.41 |

## 4.6 Phyto-geographic comparisons with other Forests of Ethiopia

Sagi Tagata moist evergreen afromontane forest was compared with other montane forests in Ethiopia based on similarities in species distribution.

From this study, a similarity analysis between Sagi Tagata forest and three dry and six moist Afromontane forests in Ethiopia was carried out to evaluate the relationship between them based on the presence of woody species. Tree and shrub species were used in this similarity analysis. The result shows that Sagi Tagata forest is more similar to the moist forests than to the dry forests (Table 12).

Table 12: Phyto-geographical comparisons of SMEAF with other forests in Ethiopia; N= Number of species included in comparison, a = common to both forests, b = found only in SMEAF, c = found only in the forest in comparison with SMEAF, and S = Sorensen`s similarity coefficient.

| Forest | Altitudinal Range(masl) | N | a | b | c | S | Refrence |
|---|---|---|---|---|---|---|---|
| Belete | 16864-2210 | 157 | 36 | 25 | 96 | 0.36 | Kflay Gebrehihot and Kitessa Hundera, 2014 |
| Yayu | 1200-2000 | 102 | 48 | 21 | 104 | 0.43 | Tadese Woldemariam *et al*., 2008 |
| Sheko | 900-1810 | 155 | 60 | 75 | 95 | 0.37 | Fayera Senbeta *et al*., 2007 |
| Gura Ferda | 800-1900 | 66 | 46 | 59 | 20 | 0.53 | Kitessa Hundera and Bishaw Deboch, 2008 |
| Wotagisho | 2002-2137 | 51 | 31 | 38 | 20 | 0.52 | Dikaso Unbushe and Tesema Tekle, 2016 |
| Chato | 1700-2350 | 154 | 38 | 25 | 116 | 0.35 | Fayera Abdena( 2010) |
| Menagesha | 2300 -3000 | 77 | 31 | 17 | 59 | 0.45 | Tamrat Bekele (1993) |
| Jibat | 2000 – 3000 | 87 | 25 | 62 | 23 | 0.37 | Tamrat Bekele (1994). |
| Jemjem | 1570-1940 | 66 | 27 | 60 | 39 | 0.35 | Hailu Shiferaw (1982) |

In this aspect, the similarity indices used is Sorensen's similarity Coefficient; Sagi Tagata showed high similarity with moist montane forests. Sagi Tagata Natural Forest has relatively higher similarity (53%) with Gura Ferda followed by Wotagisho (52%) due to their geographical proximity, similar climatic and altitudinal factors and probably due to species migration (Table12). The study forest has the least similarity (35%) in species composition with Chato and Jemjem Forest.

## 4.7 Discussion

Different land uses in different ecological ranges encompass various types of biological diversity. Among them, woody species are one of the dominant types which are basically grown naturally and mannualy (Bikila Berhanu and Zerhun Asfaw, 2016). Therefore, to the study woody species diversity and structure, components such as Community type, rechiness, evenness and diversity, species stem density, frequency, DBH, Height, Basal area, SIV, FIV Index were used. The plant communities of the study area were classified in to six plant community type based on hierarchical cluster analysis in PC-ORD for windows version 5.3 (McCune and Mefford, 1999; McCune and Grace, 2000). The most species recorded within community 3 and community 4 which contain few endemic plants.

According to the information obtained from this community classification community four has the most species richness while community six has the least species richness. The differences in species divesities among the different communities are often explained as due to micro-site factors. As IBC (2005) pointed out that tree growth in woodland ecosystems is generally determined by edaphic factors, principally nutrient and moisture availability, landscape position, the effects of fire, and anthropogenic disturbances. The woody species diversity, richness, evenness and similarity sampled from the studied area was illustrated some dominant trees such as *Pouteria adolfi-friederici, Deinbollia kilimandscherica, Chionanthus mildbraedii, Millettia ferruginea, Tarenna graveolens, Albizia gummifera* and shrubs *Justicia schimperiana* while the dominant woody climbers were *combertum paniculatum,Tiliacora funifera* and *Hippocratea africana*. When these trees compared with other related forest in the country, the higher dominancy trees were shown in Sagi Tagata forest than Watagisho forest. However, more related with Belete, Gura Ferada, and Chato forests.This relation is may be due to similar climatic conditions they share.

On other hand the woody species richness of Sagi Tagata natural forest is high with 69 species recorded and compares well with similar studies carried out elsewhere in the south west

Ethiopia. For example in Kitessa Hundera and Bishaw Deboch, (2008) 66 species recorded in Gura Ferda forest. In Dikaso Unbushe and Tesema Tekle, (2016) 51 species recoreded in Watagisho forest.The species evenness in between each community in the current studied forest more or less different when compared with Chato forest and Watagisho forest in which their species evenness are more related. However more species eveness was seen in this Sagi Tagata forest.This indicated that there is homogeneous distribution of tree species than the others. Also the species diversity of forest in the current study is higher than some of the southwest and western forest of Ethiopia such as Watgisho, Maze national park and more similar with Chato,Yayu and Gura Ferda forest. However, Sagi Tagata Moist Evergreen Afromontane Forest shared significant number of species with Yayu, Belete, Gura Ferda, and Chato forest in decreasing order. The high similarity observed among these forests could be due to similar climatic conditions. But the proportion of the endemic species in the forest was rare as compared with the proportion of endemic plant species of Ethiopia which is ranging between11-15% of the total number of species (Friis and Sebsebe Demissew, 2001). So, in this case the forest needs more attention in endemic species conservation.

In the comparison of stem density/ha in different DBH classes, the density in the lower DBH class was much higher than the density in the medium and higher DBH classes. The proportion of stem densities in the medium size is also higher than the densities in the higher class. The highest density (232/ha) of woody species has been observed for DBH >10cm and 104/ha for the individuals with DBH >20cm. The ratio described as a/b is taken as a measure of size classes distribution. Accordingly, the ratio of individuals with DBH between 10 and 20 cm (a) to DBH > 20 cm (b) was 2.23 for Sagi Tagata moist evergreen montane forest. This (a/b) ratio for Sagi Tagata forest is relatively high compared with Wof -washa (Tamrat Bekele, 1993 ), Alata Bolale (Woldeyohannes Enkossa, 2008 ), Chato (Fayera Abdena,2010), Magada (Genene Bekele,2005), Gura Ferda (Dereje Denu, 2007).This is may be due to the difference in suitable climatic condition and the way of forest area conservation management. But exhibited a strong variability with Chilmo (Tamirat Bekele, 1993 and 1994), Masha-Andercha (Kumilachew Yeshitela and Taye Bekele, 2003) and Menagesha suba (Tamirat Bekele (1993 and 1994) forest.This strong varability also, may be due to the difference in wisel use of the forest by local community and the attention given for forest conservation.

The most frequently occurring species in Sagi Tagata forest were *Deinbollia kilimandscharica and Hippocratea goetzei* followed by *Chionanthus mildbraedii*. The frequency of these species is very high when compared with the species frequency has been recorded in other studied forest in the country. This is may be due to habitat restricted preferences and seed predators (Mwavu and Witkowski, 2009). Also the DBH of all the species sampled were classified into classes and based on the ratio of the result obtained, similarity comparison was done between the other forests in the country as in (Table 5). The overall DBH class distribution of the population structure showed a reversed J-shape for the most selected dominant treess pecies (fig.4). This might be associated with selective cutting of trees by local communities in the area for construction and other house use. This showed similarities with some of the forests studied in the country such as Belete (Kflay Gebrehiwot and Kitessa Hundera, 2014), Chato (Fayer Abdena (2010), Watagisho (Dikaso Unbushe and Tesema Tekle, 2016), Gura Farda forests (Dereje Denu, 2007). According to this DBH class distribution, more individual/ha were rcorded in DBH <9.5cm. These accounts for about 56.25% while the least number of stems/ha were recorded in DBH > 50cm and very few number of stems/ha recorded in DBH > 60cm. This shows that appropriate attention has not been given to the higher classes for the past decades.

More species were recorded in the lower storey (80%) and least species occurred in medium storey (9.64%). This indicated that there is unhealthy regeneration of species in the forest, so, it requres monitoring management. The total basal area of the species in studied area was 31.01$m^2$/ha and the highest basal area of the forest was contributed by *Pouteria adolfi-friederici*, *Schefflera abyssinica*, *Albizia gummifera*, *Olea capensis*, *Croton macrostachyus*, *Ficus Sur*, *Millettia ferruginea*, *Chionanthus mildbraedii*, *Deinbollia kilimandscharica.* The basal area of Sagi Tagata natural forest was relatively low compared to the findings of Midgleya and Niklas (2004). Also the Basal area of this forest was less than the basal area of other related forest in the country such as Magada (68.52$m^2$/ha),Masha Anderacha (81.90 $m^2$/ha), Menagesha suba (36.10$m^2$/ha), Wof Washa(101.80$m^2$/ha), Dodolla (129.00 $m^2$/ha), Belete (103.5$m^2$/ha),chato forest(65.8 $m^2$/ha), watagisho forest(45.14 $m^2$/ha, Bibita (Gurafarada) (69.9$m^2$/ha) (Table 8). But relatively similar with chilimo forest, that is (30.10$m^2$/ha).This indicates that less conservation measures was given for the forest in the past decades.

Also distribution of species among different IVI classes indicated that most of the species were in the lower IVI classes which require monitoring management. According to this result the highest IVI was contributed by six dominant species such as *Pouteria adolfi–friederici*, *Deinbollia kilimandscharica*, *Albizia gummifera*, *Chionanthus mildbraedii*, *Millettia ferruginea* and *Croton macrostachyus* and they contributed about 45.22% of the total IVI of species in the forest. The lowest IVI that is less than one (<1) contributed by seven species such as *Kirkia burgeri*, *Dombeya torrida*, *Schefflera volkensii*, *Macaranga capensis*, *Vernonia auriculifera*, *Rytigynia neglecta*, *Acacia brevispicata* those accounts for about 1.51% only from the total IVI of species. The high IVI value of the species is mainly due to their high dominance and density which may be due to their low demand by local community for timber production and other purpose such as construction material and their high value for honey production. This can be understood from the activity of elected forest conservation committee in the study area.

Also the FIVI of the species in this forest was showed some characteristics of the individual families. Accordingly Sagi Tagata forest is dominated by Fabaceae with 10.01$m^2$/ha which accounts only for 16.99% of the total basal area of the forest and contains four species with the total individual stem 201 (125.625/ha). This family followed by Sapindaceae (9.71$m^2$/ha), Oleaceae 7.47$m^2$/ha, Rubiaceae 4.33$m^2$/ha of the total basal area of the forest. This is similar with some of the studied forests in the country like, Belete forest (Kflay Gebrehiwot and Kitessa Hundera,2014), Watagisho forest (Dikaso Unbushe and Tesema Tekle, 2016) and Maze National park(Siraj Mohamed *et al*.,2016) vegetation of southwest Ethiopia.This is because they might be in the same climatic condition. According to the Phyto-geographical comparison of this forest with other Moist Evergreen afromontane Forest in Ethiopia it is more related with Gura farda and Watagisho forest.This is may be due to their similar in climatic condition, altitudinal factors and probably due to species migration.

In general, the current study was indicated that the importance of exploring the species diversites in relation to environmental gradients to identify the appropriate conservation approach and correspondingly set conservation priority that fits to woody land ecosystem.

# 5 Conculution and Recomondation

## 5.1 Conculusion

During Data collection 69 species were sampled and assigned to34 families and 66 genera. From identified families the most dominated one is Fabaceae which is followed by Sapindaceae, Oleaceae and Robiaceae in ascending order of their dominancy. As the assessment disturbance level implies that even if the forest is under protected area still the marginal edge of the forest is highly disturbed by local population due to coffee land expansion. Also from the core area of the forest a slight disturbance was seen especially on plot nine and ten. During this study six community types were produced from the cluster analysis of vegetation data. These communities have their own indicator and dominant species. Among these communities in community 3 and community 4 more species were recorded.As a result of different environmental stresses a slight variation was seen in between each community in terms of species diversity, evenness and composition.

Also when the population structure of the most common species was analyzed the majority of them show reversed J-shape. On other hand when the phytogeographical comparison was done the Sagi tagata Foret was more similar with moist evergreen montane forest in the country due to it encompasses most common species characterized this type of forest. But low similarity with other forests in the country.The reason for this low similarity could be attributed to elevation difference, geographical factors, climatic conditions and human related disturbances.

## 5.2 Recommendation

The Sagi Tagata moist evergreen natural forest is one of the National Forest Priority Area (NFPA) of Ethiopia that enclosed economically and ecologically important plants. The current study conducted on this forest addressed the basic information of data on plant woody species diversity and structure to inform the appropriate reference in order to direct the future ecological study. AS structural analysis of vegetation in the forest showed that there was similar trend in both size and height.That means the density of woody species shows declination in increasing of DBH and height.This is due to anthropogenic activities of the local population, as they cut trees for house consruction and making house furniture, charcoal making, hive making for honey production especially according to investigator observation during data collection the tree species under this pressure is Poutria adolfi-fredrici which is also used for timber making, coffee land expansion especially at the marginal region of the forest, over grazing were some of these activities. Therefore as plant species are the potential stocks for future genetic resource and would have great implications for the environment, biological diversity, and socio-economic importance a great attention should be given to conserve the forest. Also this apparent forest resources degradation is alarming and the establishment and reinforcement of stringent forest resources conservation measures should be put in place. The inclusion of local communities in conservation activities is also equally useful for forest resource conservation. As a result of this all stakeholders especially the Ilu Aba Bor zone and Ale District natural resource conservation and environmental protection bureau, the Oromia forest and wild life conservation Bureau Ilu ababor branch and Gebredema District have to give attention for this Natural forest.They have to work properly on:

- Raising awarness of local population on the value of the forest resource and ecological consequence deforestation.
- Creating participatory fire management by which human impacts can be minimized through discussion and consultation with local population.
- Continuous forest enventory should be conducted.
- Especially species with low IVI should be given more attention and should be conserved *in-situ* through the collaboration local communities and other stock holders.
- Sustainable protection and management of the forests will be needed through the collaborative effort of the government, Non Governmental Organization and also the local community on the way of reduction of tree cutting and production of charcoal.
- Intervention is crucial to enance the natural regeneration of poorly represented species through planting seedlings.

Generally, detail ecological study is very important concering the possible plant communities, in relation to other environmental factors such as edaphic factors, which is not the part of this study.

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## 7. Appendices

Appendix 1: The list of plant species identified from the current study of Sagi Tagata forest

| No | Genus and species name | Local name (Afaan Oromoo | Family | Growth habit |
|---|---|---|---|---|
| 1 | *Acacia brevispica Harms* | Arangamaa Booyyee | Fabaceae | Sh |
| 2 | *Acanthus eminens* C.B.Clarke | Qosombee Booyyee | Acanthaceae | Sh |
| 3 | *Albizia gummifera* | Ambabeessa | Fabaceae | T |
| 4 | *Allophylus abyssinicus* (Hochst.) Radlkofer | Se'oo | Sapindaceae | T |
| 5 | *Apodytes dimidiata* E.Mey.ex Am. | Wandabi'oo | Icacinaceae | T |
| 6 | *Asparagus Africanus* Lam. | Sarariitii | Asparagaceae | Sh |
| 7 | *Bersema abysinica Fresen* | Lolchiisaa | Melianthaceae | T |
| 8 | *Brucea antidysenterica J.F. Mill.* | Qomonyoo | Simaroubaceae | Sh |
| 9 | *Chionanthus mildbraedii (*Gilg&schelleb) Steam | Gagamaa*(Gme.l)C.A. Sm.* | Oleaceae | T |
| 10 | *Clausenia anisata (*Wild.) Benth | Ulmayyaa | Rutaceae | Sh |
| 11 | *Clematis longicauda* steud.ex A.Rich | Hidda Fiitii | Ranuncluaceae | Wc |
| 12 | *Coffea Arabica* L. | Buna | Rubiaceae | Sh |
| 13 | *Combretum paniculatum* Vent. | Baggee | Combretaceae | WC |
| 14 | *Cordia africana* Lam | Waddeessa | Boraginaceae | T |
| 15 | *Craterispermum schweinfurthii* Hiern | Mola'ee | Rubiaceae | Sh |
| 16 | *Croton macrostachyus* Del. | Bakkanniisa | Euphorbiceae | T |
| 17 | *Cyathea manniana* Hook. | Gixoo muka manaa | Cyatheaceae | T |
| 18 | *Dalbergia lacteal* Vatke | Sarxee Quncee | Fabaceae | Sh |
| 19 | *Deinbollia kilimandscharica* Taub | Hadheessa/Abrangoo | Sapindaceae | T/sh |
| 20 | *Diospyros abyssinica* (Heim) F.White | Lookoo | Ebenaceae | T |
| 21 | *Dombeya torrida (*J.F.Gumel.) P.Bamps | Sendoo | Sterculiaceae | T |
| 22 | *Dracaena afromontana* Mildbr | Eemoo | Dracaenaceae | Sh |
| 23 | *Dracaena steudneri* Engl. | Sarxee | Dracaenaceae | T/Sh |
| 24 | *Ehretia cymosa* Thonn. | Ulaagaa | Boraginaceae | T/Sh |
| 25 | *Ekebegia capensis* Sparm. | Somboo | Meliaceae | T |
| 26 | *Erythrococca trichogyne* (Muell.Ar.) Prain | Caakkoo | Euphorbiaceae | Sh |
| 27 | *Ficus sur* Forssk | Harbuu | Moraceae | T |
| 28 | *Fioria dictyocarpa Mattei* | Quncee Iftee | Malvaceae | Sh |
| 29 | *Flacourtia indica* (Burm.f.)Merr | Akuukkuu | Filacortiaceae | T |
| 30 | *Galineria saxifraga* (Hochst.) Bridson | Simararuu | Rubiaceae | T |
| 31 | *Gouania longispicata* Engl | Omachoo | Rhamnaceae | WC |
| 32 | *Hippocrata africana* (Willd) Loes | Geebboo | Celastraceae | WC |
| 33 | *Hippocrata africana* (Willd) Loes | Xi'oo | Celastraceae | WC |

| | | | | |
|---|---|---|---|---|
| 34 | *Hippocratea goetezi* Loes | Qa'oo | Celastraceae | WC |
| 35 | *Justicia schimperiana* (Hochst. Ex Nees) T. Anders | Dhumuugaa | Acanthaceae | Sh |
| 36 | *Kirkia burgeri* Stannard | Qassoo | Simaroubaceae | T |
| 37 | *Kosteletzkya begoniifolia* (Ulbr.)U1br. | Incinnii | Malvaceae | Sh |
| 38 | *Lepidotrilichilia volkensii* (Gurke) Leroy | Alalee | Meliaceae | T |
| 39 | *Macaranga capensis* (Baill.)S | Ungoo | Euphorbiceae | T |
| 40 | *Maesa lanceolata* Forssk. | Abbayyii | Myrsinaceae | T |
| 41 | *Maytenus arbutiolia* (A.Rich.) Wilczek | Kombolcha | Celastraceae | Sh |
| 42 | *Milicia excels* (Welw.) C.C. Berg | Tunjoo | Moraceae | Sh |
| 43 | *Millettia ferruginea*(Hochst) Baechni | Sotalloo | Fabaceae | T |
| 44 | *Olea capensis* L. | Bahaa | Oleaceae | T |
| 45 | *Phylanthus ovalifolius* | Tumanee/Qacama | Euphorbiaceae | Sh |
| 46 | *Polyscias fulva* (Hiern) Harms | Karasoo | Araliaceae | T |
| 47 | *Pouteria adolfi –friederici* (Engl.)Baehni | Qararoo | Sapotaceae | T |
| 48 | *Prunus africana* (Hook.f) Kalkm | Omii | Rosaceae | T |
| 49 | *Ritchiea albersii* Gilg | Daqoo Qamalee | Capparidaceae | Sh |
| 50 | *Rothmania urcelliformis* (Hiern) Robyns | Diiboo | Rubiaceae | T |
| 51 | *Rubus steudneri* Schweinf. | Goraa | Rosaceae | Sh |
| 52 | *Rytigynia neglecta*(Hiern) Bobyns | Hexoo Saree | Rubiaceae | Sh |
| 53 | *Sapium ellipticum* (Krauss)Pax | Bosoqa | Euphorbiaceae | T |
| 54 | *Schefflera abyssinica* (Hochst.ex.A.Ric) Harms | Gatamaa | Araliaceae | T |
| 55 | *Schefflera myriantha* (Bak.) Drake | Solee | Araliaceae | T |
| 56 | *Schefflera volkensii* (Engel) | Ceekaa | Araliaceae | Sh |
| 57 | *Sericostachys scandens* Gilg& Lopr. | Hidda suddii | Amaranthaceae | WC |
| 58 | *Sida rhombifolia* L. | Karabii | Malvaceae | Sh |
| 59 | *Solanecio gigas* (Vatke) C. Jeffrey | Tamboo Arbaa | Asteraceae | Sh |
| 60 | *Solanum sp.* L. | Hiddii | Solanaceae | Sh |
| 61 | *Senra incana Cay* | Quncee guracha | Malvaceae | Sh |
| 62 | *Syzygium guineense* (Wild.)DC | Baddeessaa | Myrtaceae | T |
| 63 | *Tarenna graveolens* (S.Moore) Bremek | Abrangoo Jaldeessaa | Rubiaceae | Sh |
| 64 | *Tiliacora funifera* Oliv | Liqixii | Menispermaceae | WC |
| 65 | *Trichilia dregeana* Sond. | Luuyyaa | Meliaceae | T |
| 66 | *Urera hypselodendron* (A.Rich.) Weed. | Chaphoo | Urticaceae | WC |
| 67 | *Vangueria apiculata* k. schum. | Bururiiadii/Nexoo | Rubiaceae | Sh |
| 68 | *Vernonia auriculifera* Hiern | *Reejii* | Asteraceae | Sh |
| 69 | *Vernonia biafrae* Olivo & Hiern | Sooyama Diimtuu | Asteraceae | Sh |

T= tree, Sh = shrub, WC= woody climbers

Appendexi 2: Desity of species their DBH≥2.5cm sampled from the study area

| Genus and species name | No individual sp | Density/ha |
|---|---|---|
| *Acacia brevispica* Harms | 1 | 0.63 |
| *Albizia gumifera* (Gme.l)C.A.Sm. | 99 | 61.87 |
| *Allophylus abyssinicus* (Hochst.) Radlkofer | 14 | 8.75 |
| *Apodytes dimidiate* E.Mey.ex Am. | 19 | 11.87 |
| *Bersema abysinica* Fresen | 11 | 6.87 |
| *Chionanthus mildbraedii* (Gilg&schelleb) Steam | 138 | 86.25 |
| *Clausenia anisata* (Wild.) Hook. F.ex. Benth | 23 | 14.37 |
| *Clematis longicauda* Steud.ex A.Rich | 1 | 0.63 |
| *Combretum paniculatum* A.Rich. | 6 | 3.75 |
| *Cordia Africana* Lam. | 22 | 13.75 |
| *Croton macrostachyus* A.Rich | 39 | 24.37 |
| *Deinbollia kilimandscharica* Taub | 233 | 145.63 |
| *Diospyros abyssinica* (Heim) F.White | 5 | 3.13 |
| *Dombeya torrida* (J.F.Gumel.) P.Bamps | 1 | 0.63 |
| *Dracaena afromontana* Mildbr | 57 | 35.63 |
| *Dracaena steudneri* Engl. | 6 | 3.75 |
| *Ehretia symosa* Thonn. | 37 | 23.13 |
| *Ficus sur* Forssk | 23 | 14.37 |
| *Flacourtia indica* (Burm.f.)Merr | 9 | 5.63 |
| *Galineria saxifraga* (Hochst.) Bridson | 14 | 8.75 |
| *Gouania longispicta* Engl | 3 | 1.87 |
| *Hippocrata africana* (Willd) Loes | 13 | 8.13 |
| *Hippocratea Africana* (Willd) Loes | 4 | 2.50 |
| *Hippocratea goetezi* Loes | 9 | 5.63 |
| *Justicia schimperiana* (Hochst. Ex Nees) T. Anders | 2 | 1.25 |
| *Kirkia burgeri* Stannard | 7 | 4.37 |
| *Lepidotrilichilia volkensii* (Gurke) Leroy | 41 | 25.63 |
| *Macaranga capensis* (Baill.)S | 2 | 1.25 |

Appendex 2 continued

| | | |
|---|---|---|
| *Maesa lanceolata* Forssk. | 6 | 3.75 |
| *Maytenus arbutifolia* (A.Rich.) Wilczek | 27 | 16.87 |
| *Milicia excels* Welw.) C.C. Berg | 8 | 5.00 |
| *Millettia ferruginea* (Hochst)Baechni | 131 | 81.87 |
| *Olea capensis* L. | 28 | 17.50 |
| *Phylanthus ovalifolius* | 1 | 0.63 |
| *Polyscias fulva* (Hiern) Harms | 6 | 3.75 |
| *Pouteria adolfi –friederici* (Engl.)Baehni | 55 | 34.37 |
| *Prunus africana* (Hook.f) Kalkm | 4 | 2.50 |
| *Rothmania urcelliformis* (Hiern) Robyns | 34 | 21.25 |
| *Rytigynia neglecta (*Hiern) Bobyns | 2 | 1.25 |
| *Sapium ellipticum (*Krauss)Pax | 1 | 0.63 |
| *Schefflera abyssinica (*Hochst.ex.A.Ric) Harms | 3 | 1.87 |
| *Schefflera myriantha* (Bak.) Drake | 5 | 3.13 |
| *Schefflera volkensii* (Engel) | 1 | 0.63 |
| *Sericostachys scandens* Gilg& Lopr | 22 | 13.75 |
| *Solanecio gigas* (Vatke) C. Jeffrey | 7 | 4.37 |
| *Syzygium guineense* (Wild)DC | 8 | 5.00 |
| *Tarenna graveolens* (S.Moore) Bremek | 58 | 36.25 |
| *Tiliacora funifera* Oliv | 2 | 1.25 |
| *Trichilia dregeana* Sond. | *1* | 0.63 |
| *Vangueria apiculata* k. schum. | 2 | 1.25 |
| *Vernonia auriculifera* Hiern | 4 | 2.50 |

Appendex 3: The SIV for 48 tree species and woody climbers identified in the sampled area of the forest with corresponding values for each species

| Species name | RD | RF | RDO | SIV |
|---|---|---|---|---|
| *Schefflera abyssinica* | 0.16 | 0.39 | 13.13 | 13.68 |
| *Chionanthus mildbraedii(*Gilg&schelleb) Steam | 11 | 4.32 | 4.57 | 19.89 |
| *Deinbollia kilimandscherica* Taub | 18.48 | 5.09 | 3.39 | 26.96 |
| *Justicia schimperiana (*Hochst. Ex Nees) T. Anders | 0.16 | 3.01 | 0.15 | 3.32 |
| *Hippocratea africana* (Willd) Loes | 1.04 | 3.39 | 0.07 | 4.50 |
| *Tarenna graveolens* (S.Moore) Bremek | 4.62 | 4.18 | 0.65 | 9.45 |
| *Pouteria adolfi –friederici* (Engl.)Baehni | 4.38 | 2.76 | 27 | 34.14 |
| *Maytenus arbutifolia(*A.R.joh) | 2.15 | 2.61 | 0.70 | 5.46 |
| *Millettia ferruginea*(Hochst)Baechni | 10.43 | 4.05 | 4.50 | 18.98 |
| *Hippocratea goetezi* Loes | 0.72 | 5.09 | 0.08 | 5.89 |
| *Tiliacora funifera* Oliv | 0.08 | 3.78 | 0.001 | 3.861 |
| *Flacourtia indica*(Burm.t.Merr) | 0.72 | 1.83 | 0.04 | 2.59 |
| *Ficus sur* Forssk | 1.83 | 2.83 | 5.83 | 10.49 |
| *Apodytes dimidiata* E.Mey.ex Am | 1.91 | 2.74 | 0.73 | 5.38 |
| *Clausena anisata(*Wild) Benth | 1.83 | 2.87 | 0.23 | 4.93 |
| *Macaranga capensis* (Baill.)S | 0.16 | 0.52 | 0.03 | 0.71 |
| *Syzygium guineensis* (Wild)DC | 0.64 | 0.91 | 1.65 | 3.20 |
| *Croton macrostchyus*-Del | 3.11 | 3.01 | 6.65 | 12.77 |
| *Combretum paniculatum* A.Rich | 0.48 | 3.91 | 0.026 | 4.416 |
| *Draceana steudneri* Engl. | 1.43 | 1.56 | 1.01 | 4.00 |
| *Rothamanic ulchifamic* (Hiern) Robyns | 2.71 | 2.87 | 0.4 | 5.98 |
| *Vernonia auriculifera* Hiern | 0.4 | 0.91 | 0.06 | 1.37 |
| *Gouania longispicta* Engl | 0.32 | 1.83 | 0.23 | 2.38 |
| *Cordia Africana* Lam. | 1.75 | 1.70 | 1.87 | 5.32 |
| *Diospyros abyssinica* (Heim) F.White | 0.4 | 3.05 | 0.06 | 3.51 |
| *Albizia gummifera (*Gme.l) C.A.Sm. | 7.88 | 5.97 | 8.46 | 22.31 |

Appendex 3 continued

| | | | | |
|---|---|---|---|---|
| *Bersema abysinica* freseon | 0.79 | 1.76 | 0.24 | 2.79 |
| *Solanecio gigas* (Vatke) C. Jeffrey | 0.56 | 0.39 | 0.11 | 1.06 |
| *Galiniera saxifraga* (Hochst.) Bridson | 1.13 | 1.95 | 0.18 | 3.26 |
| *Clematis longicauda* Steud.ex A.Rich | 0.08 | 1.79 | 0.01 | 1.88 |
| *Olea capensis* L. | 2.23 | 2.88 | 9.09 | 14.20 |
| *Allophylus abyssinicus* (Hochst.) Radlkofe | 1.13 | 1.24 | 1.10 | 3.47 |
| *Lepidotrilichilia volkensii (*Gurke) Leroy | 3.26 | 2.58 | 0.58 | 6.42 |
| *Polyscias fulva* (Hiern) Harms | 0.48 | 1.04 | 1.54 | 3.06 |
| *Hippocratea Africana* (Willd) Loes | 1.035 | 0.91 | 0.03 | 1.975 |
| *Craterispermum schweinfurthii* Hiern | 0.32 | 0.78 | 0.05 | 1.15 |
| *Maesa lanceolata* Forssk. | 0.16 | 0.89 | 0.07 | 1.12 |
| *Vangueria apiculata* k. schum. | 0.16 | 0.43 | 0.025 | 0.615 |
| *Prunus Africana* (Hook.f) Kalkm | 0.16 | 0.26 | 2.58 | 3.00 |
| *Ehretia symosa* Thonn | 2.94 | 3.76 | 1.51 | 8.21 |
| *Dombeya torrida* (J.F.Gumel.) P.Bamps | 0.16 | 0.77 | 0.09 | 1.02 |
| *Sapium ellipticum* (Krauss)Pax | 0.075 | 0.45 | 0.8 | 1.413 |
| *Dracaena afromontana* Mildbr | 3.9 | 1.3 | 0.03 | 5.44 |
| *Rytigynia neglecta*(Hiern) Bobyns | 0.16 | 0.14 | 0.06 | 0.36 |
| *Schefflera volkensii*(Engel) | 0.41 | 0.36 | 0.05 | 0.82 |
| *Sericostachys scandens* Gilg& Lopr. | 1.43 | 0.46 | 0.29 | 2.18 |
| *Acacia brevispica* Harms | 0.08 | 0.26 | 0.02 | 0.36 |
| *Kirkia burgeri* Stannard | 0.56 | 0.3 | 0.02 | 0.88 |
| Total | 100 | 100 | 100 | 300 |

Appendexi 4: The FIV of 34 Families adentified from the study area.

| Name of the Families | RDV | RD | RDO |
|---|---|---|---|
| Araliaceae | 7.3 | 1.4 | 14.7 |
| Oleaceae | 3 | 12 | 9.1 |
| Sapindaceae | 2.8 | 15.7 | 4.5 |
| Moraceae | 3 | 3.6 | 5.8 |
| Acanthaceae | 1.6 | 0.6 | 0.01 |
| Celastraceae | 5.8 | 4.3 | 0.8 |
| Rubiaceae | 11.5 | 8.3 | 1.4 |
| Sapotaceae | 1.4 | 4.3 | 26.9 |
| Fabaceae | 5.9 | 16 | 17 |
| Menispermaceae | 1.4 | 0.1 | 0.003 |
| Simaroubaceae | 2.8 | 1.3 | 0.02 |
| Flacourtiaceae | 1.4 | 0.7 | 0.1 |
| Boraginaceae | 3 | 4.6 | 3.4 |
| Urticaceae | 3 | 0.4 | 0.03 |
| Icacinaceae | 1.4 | 1.5 | 0.7 |
| Rutaceae | 1.4 | 1.6 | 0.2 |
| Euphorbiaceae | 6.0 | 3.2 | 7.6 |
| Myrtaceae | 1.4 | 0.7 | 1.4 |
| Combretaceae | 1.4 | 0.5 | 0.03 |
| Dracaenaceae | 3 | 5.4 | 2.1 |
| Asteraceae | 4.4 | 0.4 | 0.2 |
| Milianthaceae | 1.4 | 0.7 | 0.24 |
| Ranuncluaceae | 1.4 | 0.1 | 0.004 |
| Rosaceae | 2.8 | 3.4 | 2.6 |
| Malvaceae | 7.3 | | |
| Appendex 4Continued | | 0.8 | 0.6 |

| | | | |
|---|---|---|---|
| Myrsinacea | 1.4 | 0.2 | 0.1 |
| Capparidaceae | 1.4 | 2.1 | 0 |
| Solanaceae | 1.4 | 0.2 | 0 |
| Sterculiaceae | 1.4 | 3.2 | 0.2 |
| Cyatheaceae | 1.4 | 0.2 | 0 |
| Asparagaceae | 1.4 | 0.2 | 0 |
| Amarnthaceae | 1.4 | 2.1 | 0.3 |
| Meliaceae | 3 | 0.1 | 0 |
| Ebenacee | 1.4 | 0.1 | 0.1 |
| | 100 | 100 | 100 |

## Declaration

Oncerning to this thesis,confidentially I the undersigned declar this study is my original work as no body have been done any work up to I have searching for as areference. And all the source of the materials used in this work of thesis has been only duly acknowledged decleration.

Tamiru Merga signature ________________Date____________

His thesis has been done under the supervisor of

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