WOODY SPECIES COMPOSITION AND DIVERSITY IN VEGETATION OF TULU KORMA, WEST SHAWA, OROMIA, ETHIOPIA

M.Sc. THESIS

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We here by certify that we have read and evaluated this Thesis titled **'Woody Species Composition and Diversity in Vegetation of Tulu Korma, West Shawa, Oromia, Ethiopia'** prepared under our guidance by **Diriba Deresa Gemechu.** We recommend that it be submitted as fulfilling the Thesis requirement.

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DEDICATION

I dedicate this manuscript to my beloved daughter **Lebsi Diriba**, my wife **Bachu Daba,** my mother **Gadiso Dandena,** and my father **Deresa Gemechu,** who sacrified a lot to bring me up to this level**,** nursing me with affection, and for their dedicated partnership in success of my life**.**

STATEMENT OF THE AUTHOR

By my signature below, I declare that this thesis is my own work and all sources of materials consulted for this work have been duly acknowledged. I have followed all ethical principles of the research in data collection, analysis, the preparation and compilation of this thesis. All scholarly matters that are included in the thesis have been given recognition through citation.

This thesis has been submitted in partial fulfillment of the requirement for the degree of master of science in biology from the Postgraduate Program Directorate at Haramaya University. The thesis is deposited in the university library to be made available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma or certificate. Brief quotations from this document are allowable without special permission if an accurate acknowledgment of the source is made. Request for permission for extended quotation from or reproduction of the manuscript in whole or in part may be granted by the head of the School of Biological Sciences and Biotechnology or the director of Postgraduate Program Directorate when the proposed use of the material is in the interest of scholarship. In other instances, however, permission must be obtained from the author.

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ABBREVIATIONS/ ACRONYMS

AAU	Addis Ababa University
CBD	Convention on Biological Diversity
CSA	Central Statistical Agency
DBH	Diameter at Breast Height

EFAP	Ethiopian Forestry Action Plan
FAO	Food and Agricultural Organization
GPS	Geographical Positioning System
HU	Haramaya Universuty
IBC	Institute of Biodiversity Conservation
ICBP	International Council for Bird Preservation
IVI	Importance Value Index
NTFP	Non Timber Forest Products
SFCDD	State Forest Conservation and Development Department
UNEP	United Nations Environmental Programme
USAID	United States of America International Development

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Woody Species Composition and Diversity in Vegetation of Tulu Korma, West Shawa, Oromia, Ethiopia

ABSTRACT

The study on Tulu Korma dry evergreen afromontane forest was conducted with the objectives of assessing its species diversity, dominance and regeneration status. Vegetation data were gathered from 52 quadrats of 20 m x 20 m (400 m^2*) laid systematically along 5 transects. In each quadrat, live woody species were recorded with their number counted and DBH measured for those with DBH>2.5cm. Voucher specimens of species were collected and identified in Haramaya University Herbarium* *using literatures and experts. Quantitative data such as Shannon-Weiner diversity index, eveness, density, basal area and important value index were computed. Species density was also seen against ten DBH classes 1) 2.5-10.0cm, 2) 10.01-20.0cm, 3) 20.01-30.0cm, 4) 30.01-40.0cm, 5) 40.01-50.0cm, 6) 50.01-60.0cm, 7) 60.01-70.0cm, 8) 70.01-80.0 cm, 9) 80.01-90.0cm and 10) 90.01-100.0cm to visualize regeneration status of the vegetation in the study area. Results show that A total of 132 woody vascular plants belonging to 99 genera and 49 families were identified. Fabaceae and Asteraceae are the dominant familes in terms of species richness. Overall average Shannon-Wiener diversity index (H`) was 3.44 and the average evenness values (E') was 0.7 indicating high diversity with more or less even distribution. Furthermore, 9 endemic species many of which are under the Red Data List of IUCN were also identified. Woody species densities for mature individuals were 1608.04 stems ha^{-1}, 1734.9 stems ha^{-1} for saplings and 2217.4 stems ha^{-1} for seedlings. Comparison of Tulu Korma Forest revealed the highest similarity with Menagesha Suba forest (78%). Analysis of the Regeneration status of this forest indicated that saplings and seedlings were densest when compared with matured trees/shrubs, suggesting good regeneration status that should be maintained.*

Key Words: Species Composition, Diversity, Population Structure, Regeneration, Tulu Korma

1. INTRODUCTION

The forests of the world play vital roles in maintaining and balancing natural eco-system. These forest resources fulfill human demands by providing renewable raw materials and energy, maintain biodiversity, protect land and water resources. These resources are extensively under degradation due to increasing population pressure, agricultural and urban expansion, industrialization, infrastructure development and other disturbances (Bhatt, R.P. and Bhatt, S., 2016).

Ethiopia is one of the tropical countries with diverse flora and fauna. The country possesses about 6000-7000 plant species, of which about 12-13% is endemic (Nune *et al*., 2007). Endemism is reportedly to be high on the plateau and in the mountains, in the Ogaden region and southern woodland. This makes the country one of the most diverse floristic regions in the world. This diversity results from its topography and diverse climatic conditions, which led to the emergence of habitats that are suitable for the evolution and survival of various plant and animal species. The highland plateau of Ethiopia with an altitude of above 2500 m covers 40% of the country (EFAP, 1994; Zerihun, 1999).

The vegetation of Ethiopia is complex. The complexity arises from the great variation in altitude employing equally great spatial difference in moisture regime as well as temperature (Zerihun, 1999). Ethiopian forests covered approximately 40% of the land of the country a century ago, but now have shrunken to only 3% (EFAP, 1994; Berry, 2003). The extensive deforestation has also led to the extinction of various biotas resulting in significant biodiversity loss (Zerihun, 1999; Hadgu, 2008). The forest cover of Ethiopia has been diminishing over times due to an ever increasing demand for uncontrolled farmlands, the increasing livestock population, and an increasing demand for fire wood and charcoal with illegal harvesting of the forest and its products (Feyera and Demel, 2003; Teshome *et al.,* 2004). Loss of such forest resources would have great implication for the environment, biological diversity and socio-economic setup of the communities. Now, most of the remaining forests of the country are confined to the south and southwestern parts of the country.

Tulu korma Forest is one of the dry evergreen Afromontane forests and grassland complex with high diversity of flora and fauna. Floristic assessments of this forest would serve as a basis for meaningful planning, sustainable utilization and conservation of this valuable natural resource. However, no ecological investigation has been conducted on this forest. Deforestation and subsequent cultivation of the tropical dry Afromontane forest has also endangered the native forest biodiversity, not only through the direct loss of habitat but also by deteriorating the soil seed banks (Mulugeta and Demel, 2004). For this, scientific information on composition, structure, distribution of species and regeneration status is required. Floristic assessments of Tulu Korma Forest will serve as a basis for meaningful planning, sustainable utilization and conservation of the biodiversity. Thus, this study was designed to carry out investigation of Tulu Korma Forest in Ejere district of West Shawa Zone of Oromia region with the following general and specific objectives.

General objective

The general objective of the study is:

- To carry out floristic study on vegetation of Tulu Korma Forest in Ejere district of West Shawa Zone.

Specific Objectives

The specific objectives of the study are:

- To document woody plant species of Tulu Korma Forest;
- To investigate the diversity, species richness and evenness of woody plant species of Tulu Korma Forest;
- To analyze population structure of Tulu Korma Forest; and
- To determine regeneration status of woody plant species in Tulu Korma Forest.

2. LITERATURE REVIEW

2.1. Vegetation Types and Forest Resources of Ethiopia

Ethiopia is one of the countries in the world endowed with rich biological resources. One of these resources is natural vegetation where floristic and faunistic life form dynamic ecosystems (Girma, 2002). As described by Gardiner (2010), vegetation can be described as collection of plants, which comprises all the structural layers of trees, shrubs, lianas and herbs. Vegetation provides different important services to living things found in our universe.The varied topography, the rift valley and the surrounding lowlands have given Ethiopia a wide spectrum of habitats and a large number of endemic plants and animals (Demel, 1999; Zerihun, 1999).

Many scholars and professionals have attempted to classify and describe the Ethiopian vegetation. Among these EPA (1997), Zerihun Woldu (1999), Friis and Sebsebe Demissew (2001), Sebsebe Demisew *et al.* (2004), Sebsebe Demissew (2009) and others have made a considerable contribution in classification and description of the natural vegetation types mostly based on physiognomic basis as well as in proposing their appropriate conservation measures.

The oldest and overall survey of the vegetation of Ethiopia recognized 24 vegetation types laid the foundation for systematic studies of the vegetation and environmental factors in Ethiopia (Zerihun, 1999). Studies made by Sebsebe (1980), Hailu (1982), Friis *et al.* (1982), Zerihun *et al*., (1989), Zerihun and Mesfin(1990), Tamrat (1993), Tesfaye *et al*., (2001), Kumlachew and Tamrat (2002), Leul (2003), Abate (2006), Kitessa *et al* . (2008), etc., are some of the main vegetation surveys in different parts of Ethiopia aimed at describing community types and their relationship with some natural and anthropogenic features.

The present Ethiopian vegetation is broadly divided into nine major types (Haile *et al.*, 2012; Abyot *et al.*, 2014), some of which are divided into sub-types or form of vegetation mosaics. These are:

1. Desert and semi-desert scrubland,
2. *Acacia – Commiphora* woodland,
3. Moist Evergreen Montane rainforest which can be divided into two natural subtypes (Afro-montane rainforest and Transitional rainforest),
4. Lowland semi-evergreen forest,
5. *Combretum-Terminalia* Woodland and Savannah,
6. Dry evergreen Montane forest and Grassland complex which is divided into four distinct subtypes (Undifferentiated Afro-montane forest, Dry single –dominant

Afromontane forest of the eastern escarpments and transition between single dominant Afromontane forest and East African evergreen and semi-evergreen bushland),

7. Afro-Alpine and sub-afro – alpine vegetation,
8. Riparian and
9. Swamp vegetation.

The Ethiopian highlands cover more than 50% of the country's land area with Afromontane vegetation (Tamrat 1993, 1994), of which dry Afromontane forests form the largest part. The dry Afromontane forests are either *Juniperus-Podocarpus* forests or predominantly *Podocarpus* forests, both with broadleaved species. They occur in both the Northwest and Southeast Highlands, especially on the plateau of Shawa, Wello, Sidamo, Bale and Harerge at altitudes of 1500-2700 m. The average annual temperature varies between 14 and 20°C, and the annual rainfall between 700 and 1100 mm, with most of the rain recorded in July (Friis, 1992).

2.2. Trends and Rate of Deforestations in Ethiopian Vegetation

Ethiopia has the fifth largest floral diversity in tropical Africa (Motuma *et al.*, 2010). Due to its diverse topography, that has given rise to the development of wide diversities of flora and fauna rich with endemic elements. Between; 6,000-7,000 species of higher plants are estimated to exist in the country of which about 780-840 (12-13%) plant species are estimated to be endemic (Demel, 2001; Girma *et al.*, 2004; Nune *et al.*, 2007).

However, these biologically rich resources of Ethiopia are vanishing at an alarming rate due to extensive deforestation. Although several factors drive natural forest destruction in Ethiopia, agricultural land expansion triggered by increasing human population is probably the dominant force (Mulugeta and Demel, 2006; Motuma *et al.*, 2010). Afromontane forests are among the most species-rich ecosystems on earth (Schmitt *et al.*, 2010). They are under severe land-use pressure, because the same environmental conditions that foster high species diversity also render tropical montane forest areas suitable for agricultural uses (Schmitt *et al.*, 2010). Deforestation in Afromontane areas has been generally associated with increased run-off and soil erosion leading to a decline in soil fertility. The Afromontane areas of eastern Africa, including the Ethiopian highlands, constitute vivid examples of tropical forest ecosystems that have exceptional species richness, high concentrations of endemic species, and which are under great human land-use pressure. These are, therefore, internationally recognized as the Eastern montane Biodiversity Hotspot (Schmitt *et al.*, 2010).

In Ethiopia the excessive exploitation of natural pasture and forests without the minimum repair, the extension of cultivation to marginal lands by clearing and burning fragile ecosystems, forest fires, lack of proper forest administration and sound forest management, lack of compatible forest proclamation and other legislations, lack of constant and sustainable institutional organization has resulted in total deforestation and degradation of fertile cultivable land and soil fertility, exposing the country to drought and famine. Thus, the earlier fertile Ethiopia is now on its way changing into a 'stone desert' (UNEP 1995). According to Gebremarkos (1998), the drought and famine that repeatedly visited Ethiopia for the last few decades is the actual result of shortages of rainfall and change of temperature related to deforestation, environmental degradation and desertification. The fast rate of deforestation in this country also seriously exposed the fertile soil to the highest magnitude of erosion. Reversing the trend is possible as long as appropriate measures taken by the concerned governmental sector and the whole society.

2.3. Socio-Ecological Services of Forests

The services provided by forests cover a wide range of ecological, economical, social and cultural considerations and processes. Hence, ecosystem services are the outcome from ecosystem functions that benefit human being (Nasir *et al*., 2002). There are a number of services that forests provide in addition to their values of basic goods. They contribute more than other terrestrial biomass to climate relevant cycles and biodiversity related processes. As stated by Dail (1997), the major services provided by forests includes: Regulation of water regimes, modulating climate, maintenance of soil quality, carbon sequestration, maintenance of biodiversity in themselves and being a habitat for other species, biological control, cultural, aestatic and amenity services.

Forests provide a wide range of products and services catering to a variety of man's socio-economic needs. The economic values of the forest are the basis of a variety of industries including timber, processed wood and paper, rubber, and fruits. They also contain products that are necessary for rural communities including fuel, construction materials and medicines (FAO, 2005). The forest resource of Ethiopia play pivotal role as source of energy and non-timber products. The energy consumption of rural Ethiopia is mainly based on biomass sources for which fuel wood being the highest component. The rural Ethiopian households entirely depend on biomass fuel to meet their energy requirements for cooking, heating and lighting. Biomass based fuel accounts for 85% and 95% of the total energy and household consumptions, respectively. In the share of different biomass based fuels in the total domestic energy, fuel wood and tree residues take 70%, Animal dung 8%, agricultural residues 7% and the rest comes from other sources (EARO, 2000). According to Demel (2002), the most important NTFPs in Ethiopia include Gum Arabic, resin, coffee, spices, incense, edible plant products (fruit, seeds, oil, fodder, etc), fibers, essential oils, tannin and dyes.

2.4. The Threats to the Conservation of Ethiopian Vegetation

The Ethiopian vegetations, particularly the forest resources are under severe pressure because of inhabitants, the need for farmlands and grazing lands. There is a severe and increasing fuel wood gap in the country; which leads to depletion of the standing stock and hence, further degradation of the remaining forest stands (EPA, 1997). The loss of forest resource is severe in the Ethiopian highlands where most of the vast mountain massifs in the heart of the country lie above 1500 m a.s.l (Diriba, 2006). These highlands cover about 44% of Ethiopian land area; accommodate 88% of the total population because of their agricultural potential and low prevalence of diseases, contain about 95% cultivated land and more than 67% of the livestock (EFAP, 1994). The location of Ethiopian high forests on the zone of these densely populated highlands and their unique ecology make them endangered and more susceptible to strong deforestation of forests (Shiferaw and Taye, 2002). Another threat is the conversion of high forest sites to coffee and tea plantations. Currently a number of investors have filed applications for forestland with the regional authorities (Zewdie, 2016).

According to (FAO, 2006) the major threats to the conservation of the Ethiopian vegetation are increasingly intensive use of forestlands for agriculture and livestock, need of fuelwood and construction materials, forest fires and human settlement. These major causes of forest destruction are very much interrelated and most are ultimately initiated by the rapid population growth in the country.

Fire is both a natural and human enhanced factor in ecological system. Forest fires inflict great damages to both the natural and plantation vegetations. In Ethiopia, the forest fires occur during the dry seasons between January and April ranging for three Months (Desta, 2001). The causes of fires vary between highlands and lowlands of the country. As explained by Kinfe (1993) and Dhaba (2001), three types of forest fires are distinguished: ground fire (a forest fire which consumes the organic materials beneath surface litter of forest floor), surface fire (a fire that burns surface litter, other loose debris of the forest floor and small vegetation) and crown fire (a fire that advances from bottom to top of the trees or shrubs more or less independently of the surface fire).

2.5. Plant Diversity

The Convention on Biological Diversity (CBD, 2003) defines biodiversity as: "Biological diversity" means the variability among living organisms from all sources including interalia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems. Biodiversity is the total variety of life on earth. It includes all genes, species and ecosystems and the ecological processes of which they are part (ICBP, 1992). Biodiversity has four components: ecosystems, species, genes and cultural diversity. It includes all levels of natural variation (Huston, 1994). It encompasses the natural variation from the molecular level and genetic level to the species level, where most interactions of the biological diversity take place (Whittaker, 1975).

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

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

2.6. The Value of Plant Diversity

Various plant species have different use values depending on socio-economic conditions of a given community. Natural forests are important sources of non-timber forest products such as fruits, fodder, honey, herbal medicine, as sources of tools and construction materials, timber and food for local communities. Forests also shelter several animal species including those that are endemic to Ethiopia alone. In Ethiopia, the majority of the woody species have economic uses. This has tended to promote unsustainable utilization of tree and shrub species, such unsustainable utilization of few species, especially timber and fuel wood species put them in the endangered category. Hence, there is less awareness of sustainable forest management in the local community.

2.7. The Plant Community

According to Kent and Cooker (1992), plant communities are the collection of plant species, which are growing together in a particular location that shows a definite association with each other. It is the combination of plants that are dependent on their environment, influence one another and modify their own environment. Plant communities are largely based on physiognomy or the growth form of the vegetation. Distinguishing plant communities focuses on the distribution, composition and classification of plant communities. Plant communities are separate from each other based on indicator species in combination with a distinctive floristic composition. There is no fixed size for a community. They can range from very small size to variable expanses of grassland or forest (Chapman and Reiss, 2008).

2.8. Diversity Indices

Floristic description of vegetation community involves the analysis of species diversity, evenness and similarity. Species diversity is one of the most important indices used for evaluating the sustainability of forest communities. Diversity and equitability of species in a given vegetation community is used to interpret the relative variation among and within the community and help to explain the underlying reasons for such a difference (Kent and Coker, 1992). Species diversity is described based on two concepts (factors), the total number of species in the community (species richness) and the relative abundance of species (species evenness) within the sample or community. Species richness is a measure of the number of different species in a given site and can be expressed in a mathematical index to compare diversity between sites (Zerihun, 1985). Species richness index is of great importance in assessing taxonomic and ecological values of a habitat. Evenness is a measure of the relative abundance of the different species making up the richness of an area. Thus, species diversity is a product of species richness and evenness or equitability. Species diversity index provides information about species endemism, rarity and commonness. Measures of species diversity are usually seen to be key indicators for the well-being of ecological systems (Heywood, 1998; Shackelton, 2000). Among many species diversity indices, widely used include Simpson's index and Shannon-Weiner index and Sorenson index of similarity (Mueller-Dombois and Ellenberg, 1974).

2.8.1. Simpson's Diversity Indices

The term Simpson's Diversity Index can refer to any one of 3 closely related indices namely: Simpson's Index (D), Simpson's Index of Diversity (1-D) and Simpson's Reciprocal Index (1/D).

i. Simpson's Index; D =

Where,

n= the number of organisms of a particular species

N= the total number of organisms of all species.

The value of this index ranges between 0 and 1, and the bigger the value of D, the lower the diversity. This index (D) measures the probability that two individuals randomly selected from a sample will belong to the same species.

ii. Simpson's Index of Diversity (1-D) has a value ranging between 0 and 1, but now the greater the value, the greater the sample diversity. In this case, the index represents the probability that individuals randomly selected from a sample will belong to different species.

2.8.2. Shannon - Wiener Index of Diversity

It is the most applicable index of diversity (Greig-Smith, 1983). Like Simpson's Index, Shannon's Index accounts for both abundance and evenness of the species present.

The Shannon Diversity Index (H') is calculated using the following formula:

$$H' = -\sum_{i=1}^{S} p_i \ln p_i$$

Where: H' = Shannon-Wiener Diversity Index; pi = the proportion of individuals or the abundance of i^{th} species expressed as a proportional of total cover in the sample and

ln = log bases (natural logarithms).

Shannon's equitability (EH) or Evenness is calculated as follows:

E = H/Hmax = H/*l*ns

Equitability assumes a value between 0 and 1 with 1 being complete evenness.

Basal area was calculated by using the following formula.

$BA=\pi d^2/4$, where, $\pi = 3.14$; d = DBH (m).

2.9. Regeneration Ecology of Forests

The study of regeneration ecology of forests is essential to gather information on the presence and absence of persistent soil seed banks or seedling banks, quantity and quality of seed rain, longevity of seeds in the soil, losses of seeds to predation and deterioration, source of re-growth after disturbances, etc. Forest plants have been reported to possess various pathways of regeneration. Studies on natural regeneration and seedling ecology can also provide options to forest development through improvement in recruitment, establishment and growth of the desired seedlings. In addition, studies on tree seedling density, their rate of mortality and damage help in the understanding the status of species and natural regeneration (Hubbel *et al.*, 1986).

Seedlings are more vulnerable to environmental hazards and biotic factors especially at the early stages of seedling establishment. Potential causes of seedling mortality include a biotic stresses such as shade and drought and biotic influences such as herbivores, trampling, disease or root competition (Demel, 1996). To reduce the impact of humans on the natural priority species, information on seedling ecology and population structure of these plants has to be obtained.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

Tulu Korma Indigenous Forest is one of the Forest Priority Areas (FPAs) in West Shawa, Oromia to ensure essential protection of the natural Forest and plantation of both exotic and indigenous plants (SFCDD, 1990). It is located in the central part of the country 55 km West of Finfinne (Addis Ababa) on the high way running from Finfinne to Ambo between $09^{o}01.188'$ N and $038^{o}21.570$· E within altitudinal range of 2,163–2,267m in Oromia (Legesse, 2010). Four neighboring kebeles bordering Tulu Korma are Chiri to the north, Kimoye to the west, Hora to the south and Endode to the east.

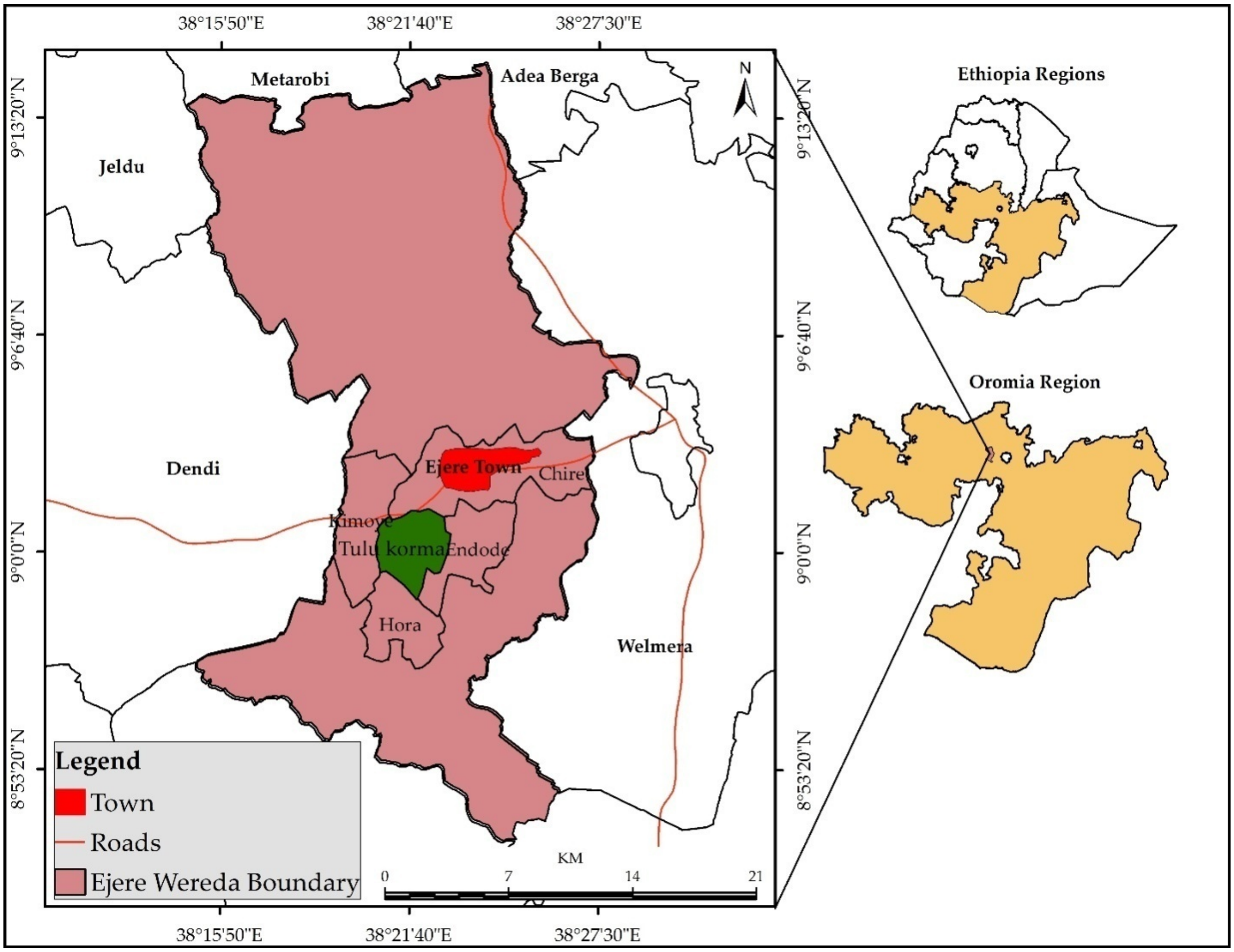

Figure 1.Location map of Tulu Korma Forest and Ejere areas. Source: GPS

3.2. Topography and Soil Characteristics

The area of Tulu korma forest is generally characterized by diverse topographic conditions (Abdi, 2012). There are escarpments, hills, gorges, flat to moderately sloping plateau, which is dissected by deep gullies, bordered by river valleys and other landforms. The diversity of terrain of this area contributes to the slight variation of natural vegetation by determining local variations in climate and soil composition, which enabled the area to have diverse floristic composition (Abdi, 2012).

The physical and chemical compositions of soils are very important in determining the occurrence, growth, diversity and distribution of plant species of the area. Vertisols are the dominant soil class of the study area. According to Misrak (2007), the soil around

Tulu Korma (Ejere) is pellic vertisols, dark in color, which develops from igneous and metamorphic rocks. Cambosols and nitosols are also other soil types of the study area (Misrak, 2007). The volcanic ash, which occured, for example, extensively over western central Ethiopia (Western Shawa) gave rise to well-drained red soils.

3.3. Climate

The five years (2012-20016) data was obtained from NMSA (National Meteorology Service Agency) indicates that the mean minimum temperature of Ejere is 7^{o}C, which was recorded in the month of November, whereas the mean maximum temperature of the area is 26^{o}C, which was recorded in the month of February (NMSA). The mean annual temperature was about 17^{O}C. The main rainy months of the area were June, July and August, which are approximately estimated to contribute 70% of the annual rainfall, whereas the driest months are November, December and January (NMSA). The mean annual rainfall was about 1119 mm (NMSA). During the dry season, the days are pleasantly warm and the nights are cool. During the rainy season both days and nights are cool (Zewdie, 2016) (Fig. 2).

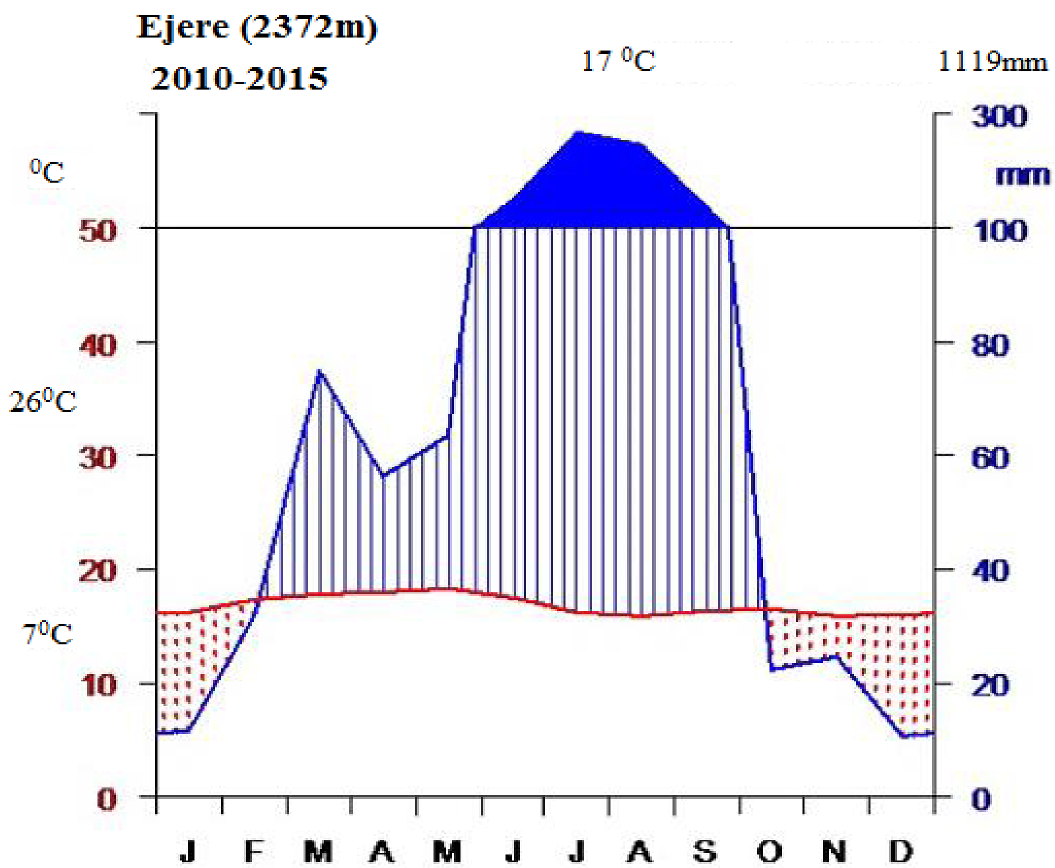

Figure 2. Clima diagram of the study area (National Meteorology Service Agency).

3.4. Vegetation

The study Areas between altitudes of 1800 and 3000 meters have been marked as the Dry evergreen Afromontane forest and grassland complex with the exception of high annual rainfall areas of 1700 millimeters and above (Friis *et al.* 2011). The vegetation of Tulu-korma and its surrounding belongs to such vegetation type and characterized by a canopy dominated by *Podocarpus falcatus* (Podocarpaceae), *Olea europaea* subsp.*cuspidata* (Oleaceae), *Juniperus procera* (Cupressaceae), *Croton macrostachyus* (Euphorbiaceae) and *Ficus spp.* (Moraceae). Shrubs and bush lands, woodlands and plantations are also available (Zewdie, 2016).

Figure 3. Vegetation of Tulu korma Forest (Present Researcher).

3.5. Reconnaissance Survey and Vegetation Sampling

Prior to actual vegetation sampling, reconnaissance survey was made in the study area to have general setting of the environment to determine the position, number and length of transects to be laid across the forest. Sample quadrats 20m x 20 m (Trees), 5m x 5m (Seedlings, Saplings and Shrubs) in a nested form. Thereafter, 52 quadrats 20X20m were systematically laid along 5 transects at every 50m interval across. In each of the quadrats, the following parameters were recorded: identity of all live woody species (WS), number of live individuals with diameter at breast height > 2cm. In the case of seedling and coppices, the number of individuals of each species were counted and recorded in each quadrat. For this, 5 sub-plots of 5X5m one at each corner and one at the center of the big plot were laid. A caliper was used to measure diameter at breast height (DBH=1.3m). For WS that were branched at around the breast height, the DBH were measured separately and averaged. The woody species were preliminarily identified in the field by using the available literature (Flora of Ethiopia and Eritrea). Voucher specimens of each WS were collected, dried and pressed for further identification and confirmation of the authenticity in Haramaya University.

3.6. Data Analysis

3.6.1 Species Richness, Diversity and Evenness

Species richness was determined from the total number of woody species recorded in sample plots. The diversity of woody species was analyzed by using the Shannon-Weiner Diversity Index (Krebs, 1989; Magurran, 2004). The index takes into account the species richness and proportion of each species in all sampled quadrats of the study site. The value of Shannon-Weiner Diversity Index usually found to fall between 1.5-3.5 rarely surpasses 4.5 (Magurran, 1988).

The **Shannon diversity index** is calculated from the following formula:

H' =

Where: H' = Shannon-Wiener Diversity Index; Σ = Summation symbol; pi = the proportion of individuals or the abundance of i^{th} species expressed as a proportion of total cover in the sample and ln = log bases (natural logarithms).

Equitability or evenness, a measure of similarity of the abundances of the different woody species in the study site, was analyzed by using Shannon's Evenness or Equitability Index (Krebs, 1989; Magurran, 2004).

Equitability or evenness index was calculated using the following formula.

$$E = H'/\ln(S) = H'/H_{max}$$

Where: E = Evenness; H' = Shannon-Wiener Diversity Index; Hmax = lnS; S = total number of species in the sample. The value of evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is in their distribution within the given area.

3.6.2 Density, Frequency, Dominance and Important Value Index

Density of the woody species were calculated by converting the total number of individuals of each woody species encountered in all the quadrats and all transects used in the site to equivalent number per hectare.

The **frequency** was calculated as the proportion (%) of the number of quadrats in which each woody species were recorded from the total number of quadrats in the site.

Dominance of the woody species, with diameter at breast height (DBH) of >2cm were determined from the space occupied by a species, usually its basal area. The total basal area of each woody species was converted to equivalent basal area per hectare (Kent and Coker, 1992).

Basal area was calculated by using the following formula.

$$BA = \pi d^2/4$$

Where BA = Basal area in m^2 per hectare

d= diameter at breast height

$\pi = 3.14$

Important Value Index (IVI), which indicates the relative ecological importance of a given woody species at a particular site (Kent and Coker, 1992), was determined from the summation of the relative values of density, frequency and dominance of each woody species.

Consequently, Important value index = Relative Density + Relative Dominance + Relative Frequency where:

Relative density was calculated as the percentage of the density of each species divided by the total stem number of all species ha^{-1}.

Relative density = X 100

Relative frequency of a species was computed as the ratio of the frequency of the species to the sum total of the frequency of all species in the study site.

Relative frequency = X 100

Relative dominance was calculated as the percentage of the total basal area of a species out of the total basal area of all species at the study site.

Relative dominance = X 100

3.6.3. Population Structure and Regeneration Status

The *population structure* of each of the woody species in the study site was assessed through histograms constructed by using the density of individuals of each species (Y-axis) categorized into ten diameter classes (X-axis) (Peters, 1996), i.e. 1=<2cm; 2=2-5cm; 3=5-10cm; 4=10-15cm; 5= 15-20cm; 6= 20-25cm; 7= 25-30cm; 8= 30-35cm; 9= 35-40cm; 10= >40cm. Then, based on the profile depicted in the population structures, the regeneration status of each woody species was determined. Regeneration status of the forest was analyzed by comparing saplings and seedlings with the matured trees according to Dhaulkhandi *et al.* (2008); and Tiwari *et al.* (2010), i.e., Good regeneration, if seedlings >saplings >adults; Fair regeneration, if seedlings> or ≤ saplings ≤ adults; Poor regeneration, if the species survives only in sapling stage, but no seedlings (saplings may be <, > or = adults); and if a species is present only in an adult form it is considered as not regenerating.

3.6.4. Sorensen's (1994) similarity index

Sorensen's similarity index was computed to help comparison between species composition of other vegetations of the region. Sorensen's similarity index was computed using the following formula (Kent and Coker, 1992).

$$S_S=$$

Where: S_S = Sorensen's similarity coefficient (Kent and Coker, 1992).

a= number of woody species common to Tulu korma forest and other forest in comparison

b= number of woody species found only in Tulu korma forest

c= number of woody species found only in the forest in comparison with Tulu korma forest

4. RESULTS AND DISCUSSION

4.1. Plant Diversity and Floristic Composition

A total of 132 woody plant species belonging to 99 genera and 49 families were identified (Table 1). From the identified species, gymnosperms were represented by three species and the remaining 129 species were Angiosperms. *Podocarpus falcatus, Cupressus lusitanica and Juniperus procera* are the three gymnosperms found in the study area. About three major life forms were identified of which 82 (62.1%) of the species were shrubs, 42 (31.8%) were Trees, and the remaining 8 (6.1%) were climbers. The present finding indicated that shrubs were found to be more dominant than trees and climber. Top four plant families with the highest percentages of the total recorded species were Fabaceae 20(15.2%); Asteraceae 9(6.8%); Verbenaceae, Euphorbiaceae and Celastraceae each with 5 (3.8%) and Myrtaceae, Rubiaceae, Solanaceae, Flacourtiaceae, Moraceae, Oleaceae and Rosaceae each with 4(3.0%). About 20.45% of the families were represented by 9 species and 7.6% of the families were represented by five species and the remaining species accounted for 18.15% of the total (Table 1).

The Shannon-Wiener Diversity index (H') and evenness values of Tulu Korma forest were 3.44 and 0.**7,** respectively**.** The value of Shannon-Weiner Diversity Index usually found to fall between 1.5-3.5, and rarely surpasses 4.5 (Magurran, 1988). The Shannon diversity index values observed in Tulu Korma forest fall within the range (0.70 - 3.57) reported for other dry forests of the Sub-Saharan region (Shackleton, 1993; Obiri *et al*., 2002; Venter & Witkowski, 2010). Based on this assumption, the diversity index obtained for this forest shows that Tulu Korma forest has high diversity with the different species having uniform abundance.

The high diversity of woody plants in Tulu Korma forest was probably a result of high species richness and abundance of this study area. Comparison of the diversity value of Tulu Korma forest with other studies conducted on other similar vegetation types of the country e.g. Menagesha Suba Forest with 112 species (H'=2.57) (Dinkissa, 2011), Denkoro Forest with 64 species (Abate, 2006) and Angada forest with 87 species (H'=3.4) (Shambel, 2011) showed that they have lower number of species as compaired to Tulu korma forest.

The relatively high diversity at Tulu Korma may be attributed to low disturbance, habitat conditions and species characteristics (Zegeye *et al.,* 2006, 2011; Tadele *et al.,* 2014).The relatively high diversity and evenness indices the need to conserve the floristic diversity of the study site and protect the woody vegetation from human disturbances(Zegeye*etal.,*2011).

Table 1. Woody plant species of the study site with their mean density (ha^{-1}), frequency (%), Diameter at Breast Height (cm) and basal area (m^2 ha^{-1})

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
1	*Acacia abyssinica* Hocst. ex Benth	Fabaceae	Laaftoo	T	57.69	**128.75**	33.33	2.18
2	*Acacia albida* Del.	Fabaceae	Garbii	T	34.62	9.014	11.34	0.252
3	*Acacia etbaica* Schweinf.	Fabaceae	Dodota	T	7.69	0.46	2.50	0.012
4	*Acacia mearnsii* De. Wild.	Fabaceae	Amoozaa	T	13.46	2.77	9.26	0.168
5	*Acacia melanoxylon* R.Br.	Fabaceae	Omedla	T	23.08	13.41	9.63	0.182
6	*Acacia seyal* De.	Fabaceae	Laaftoo	T	36.54	3.46	9.67	0.184
7	*Acanthus sennii* Chiov.	Acanthaceae	Kosorruu	T	19.23	22.4	5.00	0.049
8	*Adhatoda schimperiana*_	Acanthaceace	Dhumugaa	S	21.15	0.46	4.07	0.033
9	*Aeschynomene abyssinica* (A.Rich.) Vatke	Fabaceae	Diima	S	5.77	7.64	5.67	0.063
10	*Albizia schimperiana* Oliv.	Fabaceae	Muka arbaa	T	25	0.69	23.33	1.068
11	*Allophylus abyssinicus* (Hochst) Radlk	Sapindaceae	Sarara	T	9.62	26.35	5.00	0.049
12	*Aloe macrocarpa* Tod.	Aloaceae	Argiisa	S	5.77	36.75	3.5	0.024
13	*Apodytes dimidiata* E.Mey. ex Arn.	Icacinaceae	Calalaqaa	T	38.46	40	3.72	0.027

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
14	*Arundo donax* L.	Poaceae	Shambaqoo	S	40.39	14.32	5.93	0.069
15	*Asparagus africanus* Lam.	Asparagaceae	Saritii	S	42.31	1.62	3.33	0.022
16	*Asparagus racemosus* Willd.	Asparagaceae	Saritii	S	51.92	2.79	3.67	0.026
17	*Asparagus setaceus (Kunth) Jassop*	Asparagaceae	Saritii	S	5.77	4.81	3.67	0.026
18	*Barleria parviflora* R.Br.ex T.Andres.S.	Acanthaceae	Baalcii	S	13.46	0.69	3.2	0.02
19	*Bersama abyssinica* Fresen.	Melianthaceae	Lolchisa	S	19.23	30.05	17.12	0.575
20	*Bothriochloa insulpta* (A.Rich)	Poaceae	Baallammi	S	9.62	40.87	5.33	0.056
21	*Bougainvillea spectabilis* Willd	Nyctaginaceae	Tiifii	S	21.15	8.78	3.42	0.023
22	*Brucea antidysenterica* J.F. Mill.	Simaroubaceae	Qabanyoo	S	25	17.55	21.33	0.893
23	*Buddleja davidii* Franch.	Loganiaceae	Qaw faranjii	S	13.46	3.01	2.53	0.013
24	*Buddleja polystachya* Fresen.	Loganiaceae	Qawwisa	T	17.31	0.48	3.10	0.019
25	*Caesalpinia decapetala* (Roth) Alston.	Fabaceae	Arang faranji	S	5.77	1.39	6.58	0.085
26	*Callistemon citrinus* (Curtis) Skeels	Myrtaceae	Adaadii	T	5.77	4.62	2.56	0.013

27	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Ceekaa	S	11.54	93.17	18.6	0.679
28	*Capparis tomentosa* Lam.	Capparidaceae	A. guracha	S	13.46	4.63	9.2	0.166
29	*Carissa spinarum* L.	Apocynaceae	Agamsa	S	51.92	**93.17**	25.33	1.26
30	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae	Warallo	T	15.38	0.91	2.52	0.012
31	*Clausena anisata* (Willd.) Benth.	Rutaceae	Ulmaa	S	17.31	1.15	7.2	0.102
32	*Clematis simensis* Fresen.	Ranunculaceae	Hidda fiitii	C	5.77	2.31	3.67	0.026

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
33	*Clerodendrum myricoides* (Hochst.) Vatke	Verbenaceae	Maraasisaa	S	9.62	85.1	18.67	0.684
34	*Coffea Arabica* L.	Rubiaceae	Buna	S	5.77	1.62	7.33	0.105
35	*Cordia africana* Lam.	Boraginaceae	Wadeesa	T	48.08	83.56	22.6	1.002
36	*Crotalaria rosenii* (Pax) Milne-Redh. ex Polhill	Fabaceae	Atara qamale	S	5.77	3.7	9	0.159
37	*Croton macrostachyus* Del.	Euphorbiaceae	Bakkaniisa	T	46.15	**83.56**	26.33	1.361
38	*Cucumis dipsaceus* Ehrenb.ex Spach	Cucurbitaceae	Buqe sexana	C	15.38	8.32	3.1	0.019
39	*Cupressus lusitanica* Mill.	Cupressaceae	Ga.faranjii	T	25	1.38	8.33	0.136

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
40	*Datura margiantum*	Solanaceae	Manjii	S	13.46	20.58	7.4	0.107
41	*Dicrostachys cinerea* (L.) Wight & Arn.	Fabaceae	Adeesaa	S	3.85	7.16	5.33	0.056
42	*Dodonaea angustifolia* L. F.	Sapindaceae	Ittacha	S	9.62	64.42	21.32	0.892
43	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshomii	T	42.31	7.16	18.3	0.657
44	*Dovyalis caffra* (Hook. f. & Harv.) Hook. f.	Flacourtiaceae	Koshomii	S	15.38	25.19	8.8	0.152
45	*Dovyalis vericosa* (Hochst.) Warb.	Flacourtiaceae	Mixmixaa	S	17.30	1.62	3.45	0.023
46	*Echinops kebericho* Mesfin	Asteraceae	Qabarichoo	S	3.85	39.28	3.66	0.026
47	*Echinops spinosus* L.	Asteraceae	Shokolee	S	17.31	49.71	9.65	0.183
48	*Ekebergia capensis* Sparrm.	Meliaceae	Somboo	T	38.46	47.4	17.67	0.613
49	*Embelia schimperi* Vatke	Myrsinaceae	Hanquu	S	36.54	3.93	4.33	0.037
S.No	**Scientific Name**	**Family**	**Local Name**	**Ha**	**Freq**	**Me D**	**DBH**	**MBA**
50	*Entada abyssinica*	Fabaceae	Ambaltaa	T	9.62	2.08	5.67	0.063
51	*Erythrina brucei* Schweinf.	Fabaceae	Waleensuu	T	13.46	4.39	11.71	0.269
52	*Eucalyptus camaldunesis* Dehnh.	Myrtaceae	Bargamoo	T	7.69	13.17	8.00	0.126
53	*Eucalyptus globulus* Labill.	Myrtaceae	Bargamoo	T	11.54	3.22	6.57	0.085

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
54	*Euclea divinorum* Hiern.	Ebenaceae	Mi'essaa	S	3.85	33.51	9	0.159
55	*Euphorbia abyssinica* Gmel.	Euphorbiaceae	Adaamii	T	15.38	29.33	7.33	0.105
56	*Euphorbia pulcherrima* Willd. ex Klotzsch	Euphorbiaceae	Buqqee	S	13.46	9.04	3.45	0.023
57	*Ficus palmata* Forssk.	Moraceae	Luugoo	S	7.69	87.84	12.23	0.294
58	*Ficus sur* Forssk.	Moraceae	Harbuu	T	50	9.25	19.67	0.759
59	*Ficus sycomorus* L.	Moraceae	Odaa	T	5.77	3.7	11.3	0.251
60	*Ficus vasta* Forssk.	Moraceae	Qilxuu	T	3.85	2.79	15.67	0.482
61	*Flacourtia indica* (Burn. f) Merr.	Flacourtiaceae	Wullee	S	3.85	3.46	3.33	0.022
62	*Galiniera saxifraga* (Hochst.) Bridson	Rubiacea	Buniitii	S	5.77	22.4	4.33	0.037
63	*Glycine wightii* (Wigh & Arn.) Verde	Fabaceae	Hid.hantuuta	C	7.69	0.47	3.35	0.022
64	*Grewia ferruginea* Hochst. ex A. Rich.	Tiliaceae	Dhoqonuu	S	3.85	27.74	9.67	0.184
65	*Hypericum quartinianum* A. Rich.	Hypericaceae	Ulee foonii	S	23.08	8.56	3.01	0.018
S.No	**Scientific Name**	**Family**	**Local Name**	**Ha**	**Freq**	**Me D**	**DBH**	**MBA**
66	*Indigofera spicata* Forssk.	Fabaceae	Dhayii	S	19.23	7.6	2.93	0.017

67	*Jasminum abyssinicum* Hochst.ex DC.	Oleaceae	Idda ichilbee	C	11.54	1.15	2.93	0.017
68	*Jasminum florbundum* R.Br.ex.Fres	Oleaceae	Qamaxee	C	9.62	4.85	13.67	0.367
69	*Juniperus procera* Hochst. ex Endle.	Cupressaceae	Gatira habasha	T	42.31	**153.85**	29.33	1.688
70	*Laggera pterodonta* (DC.) Schtz-Bip	Asteraceae	Kaskasee	S	21.15	14.33	2.66	0.014
71	*Lantana trifolia* L.	Verbenaceae	Aqanciraa	S	13.46	4.62	2.67	0.014
72	*Lippia adoensis* Hochst. ex Walp	Verbenaceae	Kusaayee	S	17.31	1.63	5.88	0.068
73	*Lippia adoensis* var. *koseret*	Verbenaceae	Shokonota	S	11.54	10.1	2.54	0.013
74	*Maesa lanceolata* Forssk.	Myrsinaceae	Abbayii	T	5.77	2.89	9.67	0.184
75	*Maytenus arbutifolia* (A. Rich) Wiczek.	Celastraceae	Kombolcha	S	5.77	4.81	5.77	0.065
76	*Maytenus gracilipes* (Welw. ex Olive.) Exell	Celastraceae	Kombolcha	S	5.77	2.07	5.67	0.063
77	*Maytenus obscura* (A.Rich.) Cuf.	Celastraceae	Kombolcha	S	9.62	2.55	5.67	0.063
78	*Maytenus senegalensis*	Celastraceae	Kombolcha	S	9.62	7.84	6.63	0.086
79	*Maytenus undata*	Celastraceae	Kombolcha	S	7.69	30.05	4.98	0.049
80	*Milletia ferruginea* (Hochst.) Bak.	Fabaceae	Birbirraa	T	13.46	40.87	17.67	0.613
8	*Myrica salicifolia* A. Rich.	Myricaceae	Baroodoo	T	15.38	8.8	10.59	0.22

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
182	*Myrsine africana* L.	Myrsinaceae	Qacama	S	19.23	17.55	12.67	0.315
83	*Nuxia congesta* R. Br. ex Fresen.	Loganiaceae	Qawwisa	T	5.76	3.01	2.52	0.012
84	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	Ancabbii	S	3.85	1.83	2.89	0.016
85	*Ocimum urticifolia* Roth	Lamiaceae	Gololee	S	3.85	32.84	2.6	0.013
86	*Olea europaea* subsp.*cuspidata*	Oleaceae	Ejersa	T	63.46	**150**	39.33	3.04
87	*Opuntia ficus-indica* (L.)Miller	Cactaceae	Tiinii	T	5.77	4.62	15.2	0.453
88	*Osyris quadripartita* Decn.	Santalaceae	Waatoo	S	13.46	22.88	9.87	0.191
89	*Oteostegia tomentosa* subsp. *Ambigiensis*	Lamiaceae	Taree	S	11.54	4.63	3.67	0.026
90	*Pavetta abyssinica* Fresen.	Rubiaceae	Qaqallii	S	9.62	6.01	2.33	0.011
91	*Pavonia urens* Cav.	Malvaceae	Gabaabee	S	3.85	0.96	2.53	0.013
92	*Phoenix reclinata* Jacq.	Arecaceae	Meexxii	T	5.77	0.91	3.57	0.025
93	*Phytolacca dodecandra* L`Herit.	Phytolaccaceae	Andoodee	S/C	17.31	1.38	3.90	0.03

94	*Pittosporum viridiflorum* Sims	Pittosporaceae	Soolee	S	21.15	16.63	9.89	0.192
95	*Podocarpus falcatus* (Thunb.) R. B. ex. Mirb	Podocarpaceae	Birbirsa	T	67.31	**154.81**	43.67	3.74
96	*Premna schimperi* Engl.	Verbenaceae	Urgeessaa	S	25	1.85	12.10	0.288
97	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	Arangama dimaa	S	3.85	3.7	4.50	0.04
98	*Rhamnus prinoides* L'Herit.	Rhamnaceae	Geeshoo	S	26.92	19.42	4.50	0.04
99	*Rhamnus staddo* A.Rich	Rhamnaceae	Qadiidaa	S	17.31	26.35	7.33	0.105
S.No	**Scientific Name**	**Family**	**Local Name**	**Ha**	**Freq**	**Me D**	**DBH**	**MBA**
100	*Rhus glutinosa* A. Rich	Anacardiaceae	Daboobesa	T	28.85	48.08	13.33	0.349
101	*Rhus vulgaris* Meikle	Anacardiaceae	Xaaxessaa	T	21.15	8.32	12.54	0.309
102	*Ricinus communis* L.	Euphorbiaceae	Qobbo	S	32.69	52.88	5.90	0.068
103	*Rosa abyssinica* Lindley	Rosaceae	Hangooxoo	S	13.46	1.39	6.57	0.085
104	*Rosmarinus officinalis* L.	Rosaceae	Raashee	S	26.92	20.58	3.67	0.026
105	*Rubus apetalus* Poir.	Rosaceae	Altufa	S	15.38	7.16	2.67	0.014
106	*Rubus steudneri* Schweinf.	Rosaceae	Goraa	S	30.78	31.44	11.09	0.241

S.No	Scientific Name	Family	Local Name	Ha	Freq	Me D	DBH	MBA
107	*Rumex nervosus* Vahl	Polygonaceae	Dhangagoo	S	21.15	4.18	9.53	0.178
108	*Rytigna neglecta* (Hiern) Robyns	Rubiaceae	Mixoo	S	13.46	7.21	13.33	0.349
109	*Salix subserrata* Willd.	Salicaceae	Alaltuu	S	36.54	25.19	5.8	0.066
110	*Sapium ellipticum* (Krauss) Pax	Euphorbiaceae	Bilii	S	5.76	1.44	4.33	0.037
111	*Schefflera abyssinica* (Hochst. Ex A. Rich) Harmon	Araliaceae	Gatamaa	S	34.6	47.6	7.00	0.096
112	*Schinus molle* L.	Anacardiaceae	Leemman	T	36.54	54.33	16.33	0.523
113	*Senna didymobotrya* (Fresen.) Irwin & Barneby	Fabaceae	Ceekaa	T	9.62	3.93	3.72	0.027
114	*Sesbania sesban* (L.) Merr.	Fabaceae	Qajii	S	7.69	2.07	11.89	0.277
115	*Sida schimperiana* Hochst. ex A. Rich.	Malvaceae	Taltallee	T	26.92	7.64	4.5	0.04
116	*Sida tenuicarpa* Vollesen	Malvaceae	Goorii	S	25	12.98	3.55	0.025
S.No	**Scientific Name**	**Family**	**Local Name**	**Ha**	**Freq**	**Me D**	**DBH**	**MBA**
117	*Solanum incanum* L.	Solanaceae	Soolii	S	15.38	4.39	2.66	0.014
118	*Solanum macranthum* A.R.ich	Solanaceae	Dilu arbaa	S	44.23	7.69	5.67	0.063
119	*Solanum marginatum* L. f.	Solanaceae	Fudhii	S	15.38	60.56	3.99	0.031
120	*Stephania abyssinica* (Dillon & A.Rich.) Walp.	Menispermaceae	H/ kalaalaa	S	32.69	9.04	2.57	0.013

121	*Syzygium guineense* (Wild.) DC.	Myrtaceae	Badeessaa	C	23.08	5.77	2.50	0.012
122	*Tacazzea apiculata* Oliver	Asclepiadaceae	H/annannoo	T	9.62	3.22	8.51	0.14
123	*Tagetes minuta* L.	Asteraceae	Bari fidee	C	5.77	1.15	2.78	0.015
124	*Teclea nobilis* Del.	Rutaceae	Hadheesa	S	9.62	13.41	12.50	0.307
125	*Triumfetta rhomboidea* Jaq.	Tiliaceae	Munyii	S	13.46	3.46	11.54	0.261
126	*Vepris dainelli (pichi-serm)* kokwaro	Rutaceae	Addeessaa	S	17.31	22.4	5.33	0.056
127	*Vernonia adoensis* Schtz.Bip	Asteraceae	Reejii	S	38.46	60.58	8.99	0.159
128	*Vernonia amygdalina* Del.	Asteraceae	Ebicha	S	21.15	16.83	3.67	0.026
129	*Vernonia leopoldii* Vatke	Asteraceae	Sokee gogorrii	T	13.46	8.61	13.59	0.362
130	*Vernonia myriantha* Hook. f.	Asteraceae	Reejii	S	5.76	0.69	3.87	0.029
131	*Vernonia urticifolia* A.Rich.	Asteraceae	Monjor	S	28.84	35.1	3.58	0.025
132	*Ximenia americana* L.	Oleaceae	Cayii	S	36.54	26.35	3.50	0.024

Sorenson's coefficient of similarity was computed to compare the similarity in family, genera and species composition of Tulu Korma vegetation with some other similar afromontane forests of the country. Results showed that the highest similarity (78%) in family composition was comparison between Tulu Korma and Menagesh Suba Forest, which is also found in Oromia Special Zone of Surrounding Finfinne followed by that of Angada (68.7%) and Senka Meda (55.4%) forests. The same similarity trend was also seen in terms of species and genera composition (Table 2). Least similarity in species composition was observed with vegetation of Denkoro and Ades (Table 2). The probable reasons for variation in floristic composition between Tulu Korma and Denkoro and Ades vegetations could be variation between the sites in extent of anthropogenic disturbance, excessive exploitation of same species and variation in environmental conditions for regeneration. Anthropogenic disturbances, such as logging or cutting trees, usually, result in an immediate decline in species diversity (Noble and Dirzo, 1997).

Table 2.Sorenson's coefficient of similarity (%) in family, genus and species composition with other studies made in similar afromontane vegetations of the country

Taxa/Study site	Study site					
Species	Tulu korma (2163–2267)	Ades (2517-2743)	Menagesha (2440-3400)	Denkoro (1500-3500)	Angada (2145-2562)	Senka meda (1200-3574)
Tulu korma (Diriba,2017)	-	31.8	56	27.5	44.7	39
Ades Forest (Kidane,2014)		-	67	61	51	63
Menagesha (Dinkissa,2011)			-	58	44	41
Denkoro (Abate,2006)				-	59	53
Angada (Shambel,2011)					-	55
Senka meda (Shambel,2010)						-
Genera						
Tulu korma (Diriba,2017)	-	35.5	60	30	54	45
Ades Forest (Kidane,2014)		-	41.3	23	41.9	30
Menagesha (Dinkissa,2011)			-	32.8	57.8	46.5
Denkoro (Abate,2006)				-	26.5	46.6
Angada (Shambel,2011)					-	54
Senka meda (Shambel,2010)						-

Family						
Tulu korma (Diriba,2017)	-	53	78	53.9	68.7	55.4
Ades Forest (Kidane,2014)		-	51	34	50	47
Menagesha (Dinkissa,2011)			-	63	69.3	52.2
Denkoro (Abate,2006)				-	41.4	71
Angada (Shambel,2011)					-	60.2
Senka meda (Shambel,2010)						-

Out of the plants collected from the study area, 9 were endemic species (Table 3). These endemic species accounted for 6.8% of the total floristic composition of the area, of which shrubs represent 5.3% and trees 1.5%. Endemic plant species of Ethiopia and their level of threat have been given in Ensermu *et al.* (1992) and Vivero *et al.* (2005). According to Vivero *et al.* (2005 and 2006), many of these endemic plant species are listed in Intenational Union for Conservation of Nature and Natural Resources (IUCN) Red Data List (Table 3). Therefore, identifying and knowing these species assist us to give conservation priority and effective management.

Table 3.Endemic plant species in Tulu korma Forest with their conservation status

Scientific Name	Local name	H	Family	Status
Acanthus sennii Chiov.	Kosorruu	S	Acanthaceae	NT
Crotalaria rosenii (Pax) Polh.	Atara qamalee	S	Fabaceae	NT
Echinops kebericho Mesfin	Qabarichoo	S	Asteraceae	LC
Erythrina brucei Schweinf.	Waleensuu	T	Fabaceae	LC
Milletia ferruginea (Hochst.) Bak.	Birbirraa	T	Fabaceae	LC
Pittosporum viridiflorum Sims	Soolee	S	Pittosporacea	LC
Solanum macranthum A.R.ich	Dilu arbaa	S	Solanaceae	LC
Vepris dainelli (pichi-serm.) kokwaro	Hadheessa	S	Rutaceae	LC
Vernonia leopoldii vatke	Soke gogori	S	Asteraceae	LC

Note: EN= Endangered, LC= Least concerned, NT=Near threatened, VU= Vulnerable, CR= Critically endangered

4.2. Density, Frequency and Dominance of Woody Plant Species

Density is expressed as the number of plants per unit area and it is a crucial parameter for sustainable forest management. When put together, the mean density of all the woody species with DBH>2.5cm recorded in Tulu Korma forest was 1608.04 individual ha^{-1}. Of all recorded species, *Podocarpus falcatus* was the most densed (322 individuals h^{-1}) followed by *Olea europaea* subsp. *cuspidata* (320 individuals h^{-1}), *Acacia abyssinica* (267.8 individuals h^{-1}),*Carissa spinarum* (193 individuals h^{-1}) and *Ficus sur* (182 individuals h^{-1}) (Table 1). The mean density of each recorded species was also seen against DBH class and result showed that number of individuals varied with DBH class (Table 1).

Comparison with total densities of woody species from other similar vegetations of the region showed that the proportion of medium-sized individuals (DBH between 10 and 20 cm) is larger than the large sized individuals (DBH > 20 cm) but the ratio is relatively lower than the results obtained for other forests (Chilimo, Menagesha Suba, Senka Meda, Denkoro and Angada) but larger than Menagesha Amba Mariam Forest. The proportion of small-sized individual (DBH<10 cm) was much larger (64.1%) although the above ratio is lower, indicating that Tulu korma Forest is at stages of secondary regeneration.

The frequency of 34.8% of the species was between 20% and 80%, while 65.2% were below 20% frequency. The seven most frequent woody species were *Podocarpus falcatus, Olea europaea* subsp.*cuspidata* and *Acacia abyssinica, Carissa spinarum*, *Cordia africana*, *Croton macrostacchyus* and *Juniperus procera* (Table 4). The species with the least occurrence include *Pavonia urens* Cav., *Echinops kebericho* Mesfin and *Ocimum uritcifolium* Roth (Table 4). Comparison of the most frequent species of Tulu Korma forest with some other similar vegetations of the country showed that the most frequent woody species of Menagesha suba (Dinkissa,2011) were *Juniperus procera* (97%), *Olea europaea* subsp.*cuspidata* (92%) and *Dovyalis abyssinica* (91%) and the frequent species of Angada(Shambel,2011) forest were *Podocarpus falcatus* (100%), *Maytenus addat* (90%), *Carissa spinarum*(81.3%) and *Juniperus procera* (60%) and in Senka Meda(Shambel ,2010) forest the most frequent species was *Podocarpus falcatus*(100%).

Dominance of the woody species, with diameter at breast height (DBH) of > 2.5 cm, was determined from the space occupied by a species, usually its basal area. The total basal area of each woody species was converted to equivalent basal area per hectare. Basal area of all woody species added up to 33.82 m^2/h^{-1}. The most dominant woody species in Tulu Korma forest were *Podocorpus falcatus*, *Olea europaea* subsp. *cuspidata*, *Juniperus procera* and *Acacia abyssinica* (Table 4).

Comparison of the total woody species dominance (basal area) of Tulu Korma forest with some other vegetations of the country showed that it is lower than that of Menagesha (84.17m^2ha), Angada (79.8m^2/ha), Senka Meda (34.7 m^2/ha), Denkoro (45 m^2/ha) Abate, 2006 and greater than Chilimo (30.1 m^2/ha) Tamrat, 1993 . This is due to the lower number of individual tree species in Tulu korma Forest with relatively lower DBH than in the forests mentioned. This indicates that the Tulu korma Forest is found in advanced stage of development than Angada, Denkoro and Senka Meda forests. Similarly, comparison of the most dominant species of Tulu Korma forest with other similar vegetation of the country showed that the most dominant woody species in Menagesha suba, Angada, Senka meda and Denkoro forests were *Juniperus procera* (97%), *Olea europaea* subsp. *cuspidata* (92%) and *Podocarpus falcatus* (91%); *Podocorpus falcatus* (100%) and *Juniperus procera* (60%); *Podocorpus falcatus* (100%) and *Juniperus procera* (10.42%) respectively.

4.3. Important Value Index (IVI)

Important value index (IVI) was calculated from the summation of the relative dominance, relative frequency and relative density values of each woody species and results are shown in (Table 4). It indicates the relative ecological importance of a given woody species at a particular site (Kent & Coker 1992). Results show that *Podocarpus falcatus* was found to have the highest IVI (19.00) followed by *Olea europaea* (16.62), *Acacia abyssinica* (13.33*), Juniperus procera* (12.069), *Croton macrostacchyus* (8.84), and *Carissa spinarum* L. (9.11) (Table 4). Relatively, the higher IVI of these species is due to their high values of density, frequency and dominance. This suggests that these species are dominant species of Tulu Korma forest and play crucial role for the ecological functioning of the area. They are species that are well adapted to the environmental factors of the area and need to be monitored too maintain healthier interaction components of that ecosystem. Many researchers (e.g., Zegeye *et al.,* 2006; Senbeta and Teketay, 2003; Worku *et al.,* 2012) explain that IVI is an important parameter that indicates the ecological significance of species in a given ecosystem. If a species has high IVI value, it will be regarded as more important than those with low IVI values (Zegeye *et al.,* 2011). According to Shibru and Balcha (2004), IVI value helps to set conservation program in such a way that species with low IVI value will be given conservation priority. In the current study, area the least **(**0.22**)** IVI value was recorded for *Pavonia urens* Cav., suggesting that this species needs attention for conservation.

Table 4.Woody Plant Species of the study site with their Relative Density, Relative Frequency, Relative Basal Area and Important Value Index

S.No	**Scientific Name**	**RD**	**RF**	**RBA**	**IVI**
1	*Acacia abyssinica* Hocst. ex Benth	4.37	2.30	6.662	**13.33**
2	*Acacia albida* Del.	0.31	1.38	0.77	2.46
3	*Acacia etbaica* Schweinf.	0.02	0.30	0.037	0.357
4	*Acacia mearnsii* De. Wild.	0.09	0.54	0.513	1.143
5	*Acacia melanoxylon* R.Br.	0.46	0.90	0.556	1.916
6	*Acacia seyal* De.	0.12	1.46	0.562	2.142
7	*Acanthus sennii* Chiov.	0.76	0.77	0.15	1.68
8	*Adhatoda schimperiana*_	0.016	0.84	0.101	0.957
9	*Aeschynomene abyssinica* (A.Rich.) Vatke	0.26	0.23	0.193	0.683
10	*Albizia schimperiana* Oliv.	0.02	1.00	3.264	4.284
11	*Allophylus abyssinicus* (Hochst) Radlk	0.90	0.38	0.15	1.43
12	*Aloe macrocarpa* Tod.	1.25	0.23	0.073	1.553
13	*Apodytes dimidiata* E.Mey. ex Arn.	1.36	1.5	0.083	2.943
14	*Arundo donax* L.	0.49	1.6	0.211	2.301
15	*Asparagus africanus* Lam.	0.06	1.69	0.067	1.817
16	*Asparagus racemosus* Willd.	0.09	2.00	0.08	2.17
17	*Asparagus setaceus* (Kunth) Jassop	0.16	0.23	0.08	0.47
18	*Barleria parviflora* R. Br.ex T.Andres.S.	0.02	0.5	0.061	0.581
19	*Bersama abyssinica* Fresen.	1.02	0.76	1.76	3.54
2	*Bothriochloa insulpta* (A.Rich)	1.39	0.38	0.171	1.941

S.No	Scientific Name	RD	RF	RBA	IVI
0					
21	*Bougainvillea spectabilis* Willd	0.30	0.84	0.07	1.21
22	*Brucea antidysenterica* J.F. Mill.	0.60	1.00	2.73	4.33
23	*Buddleja davidii* Franch.	0.10	0.53	0.04	0.67
24	*Buddleja polystachya* Fresen.	0.02	0.69	0.058	0.768
25	*Caesalpinia decapetala* (Roth) Alston.	0.05	0.23	0.26	0.54
26	*Callistemon citrinus* (Curtis) Skeels	0.16	0.23	0.04	0.43
27	*Calpurnia aurea* (Ait.) Benth.	3.16	0.46	2.075	5.695
28	*Capparis tomentosa* Lam.	0.16	0.54	0.507	1.207
29	*Carissa spinarum* L.	3.16	2.1	3.851	**9.111**
30	*Cassipourea malosana* (Baker) Alston	0.03	0.6	0.037	0.667
31	*Clausena anisata* (Willd.) Benth.	0.04	0.69	0.312	1.042
32	*Clematis simensis* Fresen.	0.08	0.23	0.08	0.39
33	*Clerodendrum myricoides* (Hochst.) Vatke	2.89	0.38	2.09	5.36
34	*Coffea arabica* L.	0.06	0.23	0.321	0.611
35	*Cordia africana* Lam.	2.84	1.92	3.062	7.822
36	*Crotalaria rosenii* (Pax) Milne-Redh. ex Polhill	0.13	0.23	0.486	0.846
37	*Croton macrostachyus* Del.	2.84	1.84	4.16	**8.84**
38	*Cucumis dipsaceus* Ehrenb.ex Spach	0.28	0.6	0.058	0.938

S.No	Scientific Name	RD	RF	RBA	IVI
39	*Cupressus lusitanica* Mill.	0.05	1.00	0.416	1.466
40	*Datura margiantum*	0.70	0.54	0.327	1.567
41	*Dicrostachys cinerea* (L.) Wight & Am.	0.24	0.15	0.171	0.561
42	*Dodonaea angustifolia* L. F.	2.19	0.4	2.726	5.316
43	*Dovyalis abyssinica* (A. Rich.) Warb.	0.24	1.69	2.008	3.938
44	*Dovyalis caffra* (Hook. f. & Harv.) Hook. f.	0.86	0.6	0.465	1.925
45	*Dovyalis vericosa* (Hochst.) Warb.	0.05	0.69	0.07	0.81
46	*Echinops kebericho* Mesfin	1.33	0.15	0.08	1.56
47	*Echinops spinosus* L.	1.69	0.69	0.56	2.94
48	*Ekebergia capensis* Sparrm.	1.61	1.53	1.873	5.013
49	*Embelia schimperi* Vatke	0.13	1.46	0.113	1.703
50	*Entada abyssinica*	0.07	0.38	0.193	0.643
51	*Erythrina brucei* Schweinf.	0.15	0.54	0.822	1.512
52	*Eucalyptus camaldunesis* Dehnh.	0.45	0.3	0.385	1.135
53	*Eucalyptus globulus* Labill.	0.11	0.46	0.26	0.83
54	*Euclea divinorum* Hiern.	1.14	0.15	0.486	1.776
55	*Euphorbia abyssinica* Gmel.	0.99	0.6	0.321	1.911
56	*Euphorbia pulcherrima* Willd. ex Klotzsch	0.31	0.54	0.07	0.92
57	*Ficus palmata* Forssk.	2.98	0.3	0.899	4.179

58	*Ficus sur* Forssk.	0.31	2.00	2.32	4.63
59	*Ficus sycomorus* L.	0.13	0.23	0.767	1.127
60	*Ficus vasta* Forssk.	0.09	0.15	1.473	1.713
61	*Flacourtia indica* (Burn. f) Merr.	0.12	0.15	0.067	0.337
62	*Galiniera saxifraga* (Hochst.) Bridson	0.76	0.23	0.113	1.103
63	*Glycine wightii* (Wigh & Arn.) Verde	0.02	0.3	0.067	0.387
64	*Grewia ferruginea* Hochst. ex A. Rich.	0.94	0.15	0.562	1.652
65	*Hypericum quartinianum* A. Rich.	0.29	0.92	0.055	1.265
66	*Indigofera spicata* Forssk.	0.26	0.77	0.052	1.082
67	*Jasminum abyssinicum* Hochst.ex DC.	0.04	0.46	0.052	0.552
68	*Jasminum florbundum* R.Br.ex.Fres	5.22	0.38	1.122	6.722
69	*Juniperus procera* Hochst. ex Endle.	5.22	1.69	5.159	**12.069**
70	*Laggera pterodonta* (DC.) Schtz-Bip	0.49	0.84	0.043	1.373

S.No	**Scientific Name**	**RD**	**RF**	**RBA**	**IVI**
71	*Lantana trifolia* L.	0.16	0.54	0.043	0.743
72	*Lippia adoensis* Hochst. ex Walp	0.06	0.69	0.208	0.958
73	*Lippia adoensis* var. *koseret*	0.34	0.46	0.04	0.84
74	*Maesa lanceolata* Forssk.	0.10	0.23	0.562	0.892
75	*Maytenus arbutifolia* (A. Rich) Wiczek.	0.16	0.23	0.199	0.589
76	*Maytenus gracilipes* (Welw. ex Olive.) Exell	0.07	0.23	0.193	0.493

S.No	Scientific Name	RD	RF	RBA	IVI
77	*Maytenus obscura* (A.Rich.) Cuf.	0.09	0.38	0.193	0.663
78	*Maytenus senegalensis*	0.27	1.07	0.263	1.603
79	*Maytenus undata*	1.02	0.38	0.15	1.55
80	*Milletia ferruginea* (Hochst.) Bak.	1.39	0.54	1.873	3.803
81	*Myrica salicifolia* A. Rich.	0.30	0.6	0.672	1.572
82	*Myrsine africana* L.	0.60	0.77	0.963	2.333
83	*Nuxia congesta* R. Br. ex Fresen.	0.10	0.23	0.037	0.367
84	*Ocimum lamiifolium* Hochst. ex Benth.	0.06	0.3	0.049	0.409
85	*Ocimum uriticifolia* Roth	1.12	0.15	0.04	1.31
86	*Olea europaea* subsp.*cuspidata*	5.09	2.53	9.00	**16.62**
87	*Opuntia ficus-indica* (L.)Miller	0.16	0.23	1.384	1.774
88	*Osyris quadripartita* Decn.	0.78	0.54	0.584	1.904
89	*Oteostegia tomentosa* subsp. *Ambigiensis*	0.16	0.46	0.079	0.699
90	*Pavetta abyssinica* Fresen.	0.20	0.38	0.034	0.614
91	*Pavonia urens* Cav.	0.03	0.15	0.04	0.22
92	*Phoenix reclinata* Jacq.	0.03	0.23	0.076	0.336
93	*Phytolacca dodecandra* L`Herit.	0.05	0.69	0.092	0.832
94	*Pittosporum viridiflorum* Sims	0.57	0.84	0.587	1.997

95	*Podocarpus falcatus* (Thunb.) R.B.ex.Mirb	5.26	2.68	11.06	19.00
96	*Premna schimperi* Engl.	0.06	1.00	0.88	1.94
97	*Pterolobium stellatum* (Forssk.) Brenan	0.13	0.15	0.122	0.402
98	*Rhamnus prinoides* L'Herit.	0.66	1.07	0.122	1.852
99	*Rhamnus staddo* A.Rich	0.89	0.69	0.321	1.901
100	*Rhus glutinosa* A. Rich	1.63	1.15	1.067	3.847
101	*Rhus vulgaris* Meikle	0.28	0.84	0.944	2.064
102	*Ricinus communis* L.	1.80	1.3	0.208	3.308
103	*Rosa abyssinica* Lindley	0.05	0.54	0.26	0.85
104	*Rosmarinus officinalis* L.	0.70	0.6	0.079	1.379
105	*Rubus apetalus* Poir.	0.24	1.23	0.043	1.513
106	*Rubus steudneri* Schweinf.	1.07	0.84	0.74	2.65
107	*Rumex nervosus* Vahl	0.14	0.54	0.544	1.224
108	*Rytigna neglecta* (Hiern) Robyns	0.24	1.46	1.067	2.767
109	*Salix subserrata* Willd.	0.86	0.23	0.202	1.292
110	*Sapium ellipticum* (Krauss) Pax	0.05	1.38	0.113	1.543
111	*Schefflera abyssinica* (Hochst. Ex A. Rich) Harmon	1.62	1.46	0.293	3.373
112	*Schinus molle* L.	1.85	0.38	1.6	3.82
113	*Senna didymobotrya* (Fresen.) Irwin & Barneby	0.13	0.3	0.083	0.513
114	*Sesbania sesban* (L.) Merr.	0.070	1.07	0.847	1.987

S.No	Scientific Name	RD	RF	RBA	IVI
115	*Sida schimperiana* Hochst. ex A. Rich.	0.26	1.00	0.122	1.382
116	*Sida tenuicarpa* Vollesen	0.44	0.6	0.076	1.116
117	*Solanum incanum* L.	0.15	1.76	0.043	1.953
118	*Solanum macranthum* A.R.ich	0.26	0.6	0.193	1.053
119	*Solanum marginatum* L. f.	2.06	1.3	0.095	3.455
120	*Stephania abyssinica* (Dillon & A.Rich.) Walp.	0.31	0.92	0.04	1.27
121	*Syzygium guineense* (Wild.) DC.	0.20	0.38	0.037	0.617
122	*Tacazzea apiculata* Oliver	0.11	0.23	0.428	0.768
123	*Tagetes minuta* L.	0.04	0.38	0.046	0.466
124	*Teclea nobilis* Del.	0.46	0.54	0.938	1.938
125	*Triumfetta rhomboidea* Jaq.	0.12	0.69	0.798	1.668
1 126	*Vepris dainelli (pichi-serm)* kokwaro	0.76	1.53	0.171	2.461
127	*Vernonia adoensis* Schtz.Bip	2.06	0.84	0.486	3.386
128	*Vernonia amygdalina* Del.	0.57	0.54	0.08	1.19
129	*Vernonia leopoldii* Vatke	0.29	0.23	1.106	1.626
130	*Vernonia myriantha* Hook. f.	0.02	1.15	0.089	1.259
131	*Vernonia urticifolia* A.Rich.	1.19	1.46	0.076	2.726
132	*Ximenia americana* L.	0.89	1.07	0.073	2.033

4.4. Population Structure and Regeneration Status of Tulu Korma Forest

Woody species of Tulu Korma forest were sub-divided into 10 DBH classes (Fig.4). Comparison between the DBH classes in terms of density showed that the majority, about 64% of the total counted individuals of the entire species fall within DBH class of 2.5-10.0cm followed by 22.13% for those with DBH class of 10.01-20.0cm.This result shows that total number of woody species was found to decrease with increasing DBH, suggesting that seedlings and saplings are more in number than the mature/older woody species. This in turn shows that the vegetation of Tulu Korma is generally in a good regeneration status.

Figure 4. Population structure of woody species of Tulu Korma Forest (Present study).

Figure 5. Population structure of woody species of Angada Forest (Shambel, 2011).

Figure 6. Population structure of woody species of Menagesha Suba Forest (Dinkissa, 2011).

Figure 7. Regeneration status of population structure of higher IVI

A description of the regeneration status of a particular area, in this case the protected area of Tulu korma forest, helps to determine and monitor future conservation and management options. Accordingly, the regeneration status of the woody species at Tulu korma forest was determined. From representative woody species, 2217.4 seedlings/ha, 1734.9 saplings/ha and 1608.04 mature individuals/ha were recorded (Appendix 1). The ratio of seedlings and saplings to mature individuals was 1:38 and 1:08 respectively. This result shows the presence of more seedlings than saplings and matures individuals, which shows that the Tulu korma forest is under regeneration. In this study, different species have different densities of seedlings and saplings. The highest density of seedlings and saplings were found in the species *Podocarpus falcatus, Olea europaea* subsp. *cuspidata, Juniperus procera* and *Acacia abyssinica*.

5. Summary, Conclusion and Recommendations

5.1. Summary and Conclusion

Tulu korma Forest is one of the dry evergreen Afromontane forests with high diversity of flora and fauna. Floristic assessments of this forest would serve as a basis for meaningful planning, sustainable utilization and conservation of this valuable natural resource.

Woody Species Composition and Diversity in Vegetation of Tulu Korma Forest have been studied.This study was designed to carry out floristic study on vegetation of Tulu Korma Forest. The result obtained from the study area shows that 132 plant specimens belonging to 99 genera and 49 families were collected. From the collected specimens, shrubs were estimated to cover 62.1%, trees 31.8% and climbers 6.1%. The present finding indicated that shrubs were the most dominant species. Top four plant families with the highest percentages of the total recorded species were Fabaceae 20(15.2%); Asteraceae 9 (6.8%); Verbenaceae, Euphorbiaceae and Celastraceae each with 5 (3.8%) and Myrtaceae, Rubiaceae, Solanaceae, Flacourtiaceae, Moraceae, Oleaceae and Rosaceae each with 4 (3%).

The total basal area of the study area as calculated from DBH data was 33.82 m^2ha^{-1}. The area is found to possess shrub species dominating the area with scattered trees species. The overall density of tree/shrub species which had DBH >2.5cm was 1608.04 individual/ha. The density of trees/shrubs decreased with increasing DBH and height indicating the dominance of small-sized individuals in the area. The importance value index (IVI) of the most common and frequent trees of Tulu korma was calculated and *Podocarpus falcatus* was found to have the highest IVI (19.00) followed by *Olea europaea* subsp.*cuspidata* (16.62), *Acacia abyssinica* (13.33*), Juniperus procera* (12.069), *Croton macrostacchyus* (8.84*)* and *Carissa spinarum* (9.11). The regeneration status of the woody species at Tulu korma forest was determined and representative woody species, 2217.4 seedlings/ha, 1734.9 saplings/ha and 1608.04 mature individuals/ha were recorded. The highest density of seedlings and saplings were found in the species

Podocarpus falcatus, Olea europaea subsp. *cuspidata, Juniperus procera* and *Acacia abyssinica*.

In conclusion, Tulu Korma forest divers forest with individual species uniformly represented and in a good regeneration status. The floristic composition, structure and regeneration of plant species is Tulu Korma Forest has been studied. Fabaceae was found to be the most dominant family followed by Asteraceae. The variation in species composition, and diversity among study area could be attributed to different factors, such as altitude, soil property, slope, anthropogenic activities, of which altitude play a major role. The density of tree species in the forest decreases with increasing DBH and Height classes, which implied the predominance of small sized individuals in the lower classes than in the higher classes indicating well recruitment of the forest and rare occurrence of large individuals. This shows that the forest is in the secondary state of development.

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5.2. Recommendations

Tulu korma Forest provides important economic and social value to the rural communities living in and around the area. To minimize the present human influence on this unique area and for the future management of the study area in a sustainable manner, the following recommendations are made:

- Participatory forest management programme should be introduced and implemented so that local communities are able to develop sense of ownership and responsibility for the management and conservation of the Forest.
- Promoting private and community plantations specifically those with fast growing species (indigenous) to ensure self-reliance with respect to demand for wood in the end and decreasing human pressure on natural forest.
- Assist in the propagation and the distribution of seedlings of plants whose uses are already wide spread in the area e.g. *Juniperus procera, Podocarpus falcatus, Hagenia abyssinica* etc.
- Raising awareness of local communities on the value of forest resources and ecological consequences of deforestation and device mechanisms by which human impacts can be minimized through discussion and consultation with the local communities.
- The present study was limited to Woody Species Composition and Diversity in Vegetation of Tulu Korma Forest thus, further studies on soil seed bank, seed physiology, and land use management system in the area are recommended.

6. REFERENCES

Abate Ayalew, Tamrat Bakele and Sebsebe Demissew.2006. The undifferentiated afromontane forest of Denkoro in the central highland of Ethiopia: a floristic and structural analysis. *SINET: Ethiopian Journal of Science*, 29(1): 45-56.

Abdi Shentema. 2012. *Ecological Study of Shrubland Vegetation along the Escarpments between Addis Alem and Wolenkomi, West Shewa, Oromoia National Regional State* (Doctoral dissertation, Addis Ababa University Addis Ababa, Ethiopia).

Abiyou Tilahun. 2009. *Floristic composition, structure and regeneration status of Menagesha Amba Mariam Forest, central Highland of Shewa* (Doctoral dissertation, M. Sc. Thesis, Addis Ababa University, Addis Ababa).

Abyot Dibaba1, Teshome Soromessa, Ensermu Kelbessa and Abiyou Tilahun.2014.Diversity, Structure and Regeneration Status of the Woodland and Riverine Vegetation of Sire Beggo in Gololcha District, Eastern Ethiopia. Momona Ethiopian Journal of Science (MEJS), 6(1): 70-96

Berry, L. 2003. Land degradation in Ethiopia: Its extent and impact. *Commissioned by the GM with WB support*, 2-7.

Bhatt, R.P. and Bhatt, S. 2016. Floristic Composition and Change in Species Diversity over Long Temporal Scales in Upper Bhotekoshi Hydropower Project Area in Nepal. *American Journal of Plant Sciences*, **7**, 28-47.

Bibby, C. J., Crosby, N. J., Heath, M. J., Imboden, M. F., Johnson, C., Long, T. H., & AJ Thirgood, S. J. 1992. *Putting biodiversity on the map: priority areas for global conservation* No. 333.95 P993. International Council for Bird Preservation, Cambridge (RU).

Breitenbach, F. V. 1963. The indigenous trees of Ethiopia. *The indigenous trees of Ethiopia.*, (2nd ed. (rev.)).

Brenan, J. P. 1978. Some aspects of the phytogeography of tropical Africa. *Annals of the Missouri Botanical Garden*, 437-478.

CBD (Convention on Biological Diversity). 2003. Handbook of the Convention on Biological Diversity Including its Cartagena Protocol on Biosafety, 3rd edition, Secretariat of the Convention on Biological Diversity (Montreal, Canada).1492.

Chapman, J.L. and Reiss, M.J. 2008. *Ecology: Principles and Applications*. 2nd ed. Cambridge University Press, Cambridge. Crawley, M.J. 1998. The structure of plant communities. In: *Plant ecology*. 2nd ed., pp. 475-531 (Crawley, M.J. ed), University Press, Cambridge.

Crawley, M.J. 1998. The structure of plant communities. In: *Plant ecology*. 2nd ed., pp. 475 531 (Crawley, M.J. ed), University Press, Cambridge.

Dail, G. 1997. What are ecosystem services? In: Nature's Services Societal Dependence Daily on Natural Ecossytems (Daily, G. ed.) Island Press, Washington.1 – 10.

Demel Teketay .1999. Past and present activities, achievements and constraints in forest genetic resources conservation in Ethiopia.

Demel Teketay 2002a. Country brief. In: *State of forests and forestry research in Ethiopia*. Indicators and tools of restoration and sustainable management of forests in East Africa. (Demel Teketay and Tesfaye Bekale, eds) I. Too Working paper No. 1. Freiburg, 56 pp.

Demel Teketay. 1996. Seed Ecology and Regeneration of dry afrtomontane Fortest in Ethiopia. Doctoral Thesis, Swedish Unviersity of Agricultural Sciences Umea.

Desta Hamito 2001. Research Methods in Forestry: Principles and practices with particular reference to Ethiopia.

Dhaba Wirtu. 2001. The economic Dimensions of forest fire damages in Oromiya: The case of forest fires of the Year 2000 in Bale and borena zones. *Ethiopian Journal of Natural Resources.*

Dhaulkhandi, M., Dobhal, A., Bhatt, S., & Kumar, M. 2008. Community structure and regeneration potential of natural forest site in Gangotri, India. *Journal of Basic and Applied sciences*, 4(1): 49-52.

Dinkissa Beche. 2011. Floristic Composition, Diversity and Structure of Woody Plant Species in Menagesha Suba State Forest, Central Ethiopia. M.Sc.Thesis Addis Ababa University, Addis Ababa.

Diriba Gelete. 2006. An over view on the distributions, status, uses and research needs of selected indigenous tree and shrub species in the highlands of Ethiopia. **In**: *Policies to increase Forest cover in Ethiopia*. Proceedings of the workshop, Environmental economic policy forum for Ethiopia, (Bana, J., Sisay Nune, Alemu Mekonnen and Bluffstone, R.eds). Forestry Research Center, Addis Ababa.

EARO (Ethiopia Agricultural Research Organization). 2000. *Forestry research strategies for forestery research*. EARO, Addis Ababa. 137.

EFAP (Ethiopia Forestry Action Program). 1994. *The Challenges for Development*. Ministry of Natural Resources, Addis Ababa.

EFAP(Ethiopian Forest Action Programme). 1994. Ethiopian Forest Action Programme, Volume III. The challenge for Development. Ministry of Natural Resource. Addis Ababa, Ethiopia.

Endemic plants of Ethiopia: Preliminary working list to contribute to National plant Conservation target Institute of Biodiversity Conservation, Addis Ababa, Ethiopia.

Ensermu Kelbessa, Sebsebe Demissew, Zerihun Woldu and Edwards, S. 1992. Some threatened endemic plants of Ethiopia. *The status of some plants in parts of tropical Africa*, 35-55.

EPA .2012. National Report of Ethiopia, the United Nations Conference on Sustainable Development (Rio+20). Federal Democratic Republic of Ethiopia, Addis Ababa.

FAO. 2005. Global forest resource assessment 2005. FAO forestry Paper 147. Food and Agriculture Organization of the United Nations, Rome, 348.

Feyera Senbeta and Demel Teketay. 2003. Diversity, community types and population structure of woody plants in Kimphee forest, a unique nature reserve in southern Ethiopia. *Ethiopian Journal of Biological Sciences*, 2(2): 169-187.

Friis I, Sebsebe Demissew & Breugel P. 2011. *Atlas of the Potential Vegetation of Ethiopia*. Addis Ababa University Press, Shama Books, Addis Ababa, Ethiopia.

Friis, I. 1986.The forest vegetation of Ethiopia. *Symbolae Botanicae Upsalienses*, 26(2): 31-47.

Friis, I. 1992. Forests and forest trees of north east tropical Africa: their natural habitats and distribution pattern in Ethiopia, Djibouti and Somalia. *Kew. Bull. Add. Ser*, 15, 396.

Friis, I., F.N. Rasmussen & K. Vollesen. 1982. Studies in the flora and vegetation of SW Ethiopia. *Opera Botanica*, 63, 1-70.

Gardiner, T. 2010. Farming soil carbon calculator (FSCC) – Estimation of soil carbon by improved land management practices in Central West NSW.

Gebre Markos Woldesellassie. 1998. The forest resources of Ethiopia: Past and Present. *Journal of Ethiopian wild life and natural history society: Walia*, (19).

Getachew Tesfaye. 2007. Structure, biomass and net primary production in a dry tropical afromontane forest in Ethiopia. *Institute of plant physiology, University of Bayreuth*.

Girma Balcha. 2002. Proceedings of a national conference on forest resources of Ethiopia. status, challenges and opportunities.

Girma Balcha, Pearce, T & Abebe Demissie.2004. Biological Diversity and Current *ex Situ* Conservation Practices in Ethiopia. In: Smith, R.D., Dike, J.B., Linington, S.H. and Pritenard, H.W. (Eds) Seed conservation Turning Science into Practice Kew; Royal Botanic Garden, Kew, pp 847-856.

Goldsmith, F.B., Harriso, C.M. and Morton A.J. 1986. Deseription and analysis of vegetation. In: *methods in plant Ecology*. 2nd ed. Pp 437.5/5. (Moore, P.D. & Chapman, S.B. eds) Alden Press, Osney.

Greig -Smith, P. 1983. Quantitative Plant Ecology. 3rd ed. Butterworths, London. Grubb, P. J., Lloyd.

Grubb, P. J. 1987. Global trends in species-richness in terrestrial begetation: a view from the northern hemisphere. *The organization of communities, past and present*, 99-118.

Hadgu, K. M. 2008. *Temporal and spatial changes in land use patterns and biodiversity in relation to farm productivity at multiple scales in Tigray, Ethiopia*. Wageningen Universiteit.

Haile Adamu, Tamrat Bekele and Gemedo Dalle.2012. Plant community and ecological analysis of woodland vegetation in Metema Area, Amhara National Regional State, and Northwestern Ethiopia. *Journal of Forestry Research*, 23(4): 599−607.

Heywood, V. H. 1998. The species concept as a socio-cultural phenomenon: a source of the scientific dilemma. *Theory in biosciences*, 117(3): 203-212.

Hubbell, S. P., Foster, R. B., O'Brien, S. T., Harms, K. E., Condit, R., Wechsler, B., & De Lao, S. L. 1999. Light-gap disturbances, recruitment limitation, and tree diversity in a Neotropical forest. *Science*, 283(5401): 554-557.

Huston, M. A., & Huston, M. A. 1994. *Biological diversity: the coexistence of species*. Cambridge University Press.

IUCN (International Universal Conservation of Nature). 2010. *A Good Practice Guide* Sustainable Forest Management, Biodiversity and Livelihoods.

Kent, M. and Coker, P. 1992. Vegetation description and analysis. Ambo practical approach New York, USA, 363.

Kinfe Abebe. 1993. Forest fire: its causes and behaviour related to Ethiopian conditions. In *Proceedings of the National Workshop on Setting Forestry Research Priorities in Ethiopia. Forestry Research Center, Addis Abeba* (pp. 122-142).

Kitessa Hundera. 2008. Floristic Composition and Structure of the Dodola Forest. *Bale Zone, Oromiya Regional State*.

Kumlachew Yeshitela and Tamrat Bekele. 2002. Plant community analysis and ecology of Afromontane and transitional rainforest vegetation of southwestern Ethiopia. *SINET: Ethiopian Journal of Science*, 25(2): 155-175.

Legesse Negash. 2010. *Selection of Ethiopia's indigenous trees*. Addis Ababa University Press.

Magurran, A. E. 2004. *Measuring Biological Diversity.* Malden and Oxford: Blackwell Publishing.

Misrak Tefese. 2007. Growth Performance of three Indigenous and One Endemic Tree Species of Ethiopia on a Degraded Site in Central-West Ethiopia.

Motuma Didita.2010.Floristic and structural analysis of the woodland vegetation around Dello Menna, Southeast Ethiopia. *Journal of Forestry Research*, 21(4): 395-408

Mulugeta Lemenih & Demel Teketay.2006. Changes in soil seed bank composition and density following deforestation and subsequent cultivation of a tropical dry Afromontane forest in Ethiopia. *Tropical Ecology,* 47: 1-12.

Nasi, R., Wunder, S., & Campos, A. 2002. Forest ecosystem services: can they pay our way out of deforestation?.

Noble, I. R., & Dirzo, R. 1997. Forests as human-dominated ecosystems. *Science*, 277(5325): 522-525.

Nune, S., Alemu Mekonnen & Bluffstone, R. 2007. Policies to increase forest cover in Ethiopia. Proceedings of a Policy Workshop organized by Environmental Economics Policy Forum for Ethiopia (EEPFE).

Obiri, J., Lawes, M., & Mukolwe, M. 2002. The dynamics and sustainable use of high-value tree species of the coastal Pondoland forests of the Eastern Cape Province, South Africa. *Forest Ecology and Management*, 166(1): 131-148.

Peoples Democratic Republic of Ethiopia. 1990. Annual report. Addis Ababa, Ethiopia.

Peters, C. M., & Mundial, B. 1996. *The ecology and management of non-timber forest resources*. Washington, DC: World Bank.

Reusing, M. 1998. Monitoring of natural high forests in Ethiopia. Government of the Federal Democratic Republic of Ethiopia, Ministry of Agriculture. *Natural Resources Management and Regulatory Department*.

Sayer, J. A., Harcourt, C. S. and Collins, N. M.(eds.). 1992. The Conservation atlas of tropical forests, Africa. Macmillan Publishers, Great Britain.

Sebsebe Demissew & Friis, I. 2009. Natural Vegetation of the Flora area. IN: Flora of Ethiopia and Eritrea. General Part and Index. *National Herbarium, Biology Department, Science Faculty, Addis Ababa, University, Addis Ababa and Department of Systematic Botany, Uppsala University, Uppsala, Sweden*, 27-32.

Sebsebe Demissew, Cribb, P., & Rasmussen, F. P. N. 2004. *Field guide to Ethiopian orchids*. Royal Botanic Gardens.

Sebsebe Demissew. 1980. A study on the structure of Montane Forest: The Menagesha State Forest. Msc. Thesis. Addis Ababa University.

Sebsebe Demissew. 1998. A Study of the Vegetation and Floristic Composition of Southern Wällo, Ethiopia. *Journal of Ethiopian Studies*, 159-192.

Senbeta, F., & Teketay, D. 2003. Diversity, community types and population structure of woody plants in Kimphee forest, a unique nature reserve in southern Ethiopia. *Ethiopian Journal of Biological Sciences*, 2(2): 169-187.

SFCDD. 1990. Ethiopian Forest Resource Base Identification, Conservation and Rational use in Ethiopia. State Forest Conservation and Development Department, Addis Ababa, Ethiopia.

Shackleton, C. M. 1993. Demography and dynamics of the dominant woody species in a communal and protected area of the eastern Transvaal Lowveld. *South African Journal of Botany*, 59(6): 569-574.

Shackleton, C. M. 2000. Comparison of plant diversity in protected and communal lands in the Bushbuckridge lowveld savanna, South Africa. *Biological Conservation*, 94(3): 273-285.

Shambel Alemu. 2011. *Woody species composition, diversity and structural analysis of Angada Forest in Merti Wereda, Arsi zone of Oromia Region, Ethiopia* (Doctoral dissertation, MSc. Thesis, Addis Ababa University, Addis Ababa, Ethiopia).

Shambel Bantiwalu. 2010. Floristic Composition, Structure and Regenration Status of Plant Species in Sanka Meda Forest, Guna District, Arsi zone of Oromiya Region, Southeast Ethiopia.

Shibru, S., & Balcha, G. 2004. Composition, Structure and regeneration status of woody species in Dindin Natural Forest, Southeast Ethiopia: An implication for conservation. *Ethiop. J. of Biol. Sci*, 1(3): 15-35.

Shiferaw Dessie and Taye Bekele. 2002. Community organizations and their potentials as partners for sustainable utilization and conservation of forest resources. In *A*

National Conference on Forest Resources of Ethiopia, Addis Abeba (Ethiopia), 27-29 Nov 2002. Institute of Biodiversity Conservation/GTZ.

Schmitt, C.B., Denich, M., Sebsebe Demissew, Friis, I.B & Boehmer, H.J.2010. Floristic diversity in fragmented Afromontane rainforests: Altitudinal variation and conservation importance.

Tadele, D., Lulekal, E., Damtie, D., & Assefa, A. 2014. Floristic diversity and regeneration status of woody plants in Zengena Forest, a remnant montane forest patch in northwestern Ethiopia. *Journal of forestry research*, 25(2): 329-336.

Tamrat Bakele. 1993. Vegetation and Ecology of Afromontane forests on the central plateau of shewa, Ethiopia, *Acta phytogeorgr. Suec*. 79.

Tamrat Bekele. 1994. Phytosociology and ecology of a humid Afromontane forest on the central plateau of Ethiopia. *Journal of Vegetation Science*, 5(1): 87-98.

Tesema, Azene Bekele, Biraie Ann,& Bo, T. 1993. Useful Trees and Shrubs for Ethiopia: Identification, Propagation and Management for Agricultural and Pastoral Communities.

Tesfaye Awas, Tamrat Bekele, and Sebsebe Demissew. 2001. An ecological study of the vegetation of Gambella region, southwestern Ethiopia. *SINET: Ethiopian Journal of Science*, 24(2): 213-228.

Teshome Soromessa, Demel Teketay and Sebsebe Demissew. 2004. Ecological study of the vegetation in Gamo Gofa zone, southern Ethiopia. *J. Trop. Ecol.* 45:209-221.

Tiwari, G. P. K., Tadele, K., Aramde, F., & Tiwari, S. C. (2010). Community structure and regeneration potential of Shorea robusta forest in subtropical submontane zone of Garhwal Himalaya, India. *Nature and Science*, 8(1): 70-74.

United Nations Environment Programme (UNEP).1995. Global biodiversity assessment. Cambridge University Press, London. 1140.

Venter, S. M., & Witkowski, E. T. F. 2010. Baobab (Adansonia digitata L.) density, size-class distribution and population trends between four land-use types in northern Venda, South Africa. *Forest Ecology and Management*, 259(3): 294-300.

Vivero, J.L., Ensermu Kelbessa and Sebesebe Demissew. 2005. *The red list of endemic trees & shrubs of Ethiopia and Eritrea*. Fauna & Flora International.

Vivero, J.L., Enserum Kelbessa and Sebsebe Demissew. 2006. Progress on the red list of plants of Ethiopia and Eritrea: Conservation and biogeography of endemic flowering taxa. *Taxonomy and Ecology of African Plants, their Coservation and Sustainable Use*, 761-778.

Whittaker, R. H., & Likens, G. E. 1975. The biosphere and man. *Primary productivity of the biosphere*, 14, 305-328.

Worku, A., Teketay, D., Lemenih, M., & Fetene, M. 2012. Diversity Regeneration Status and Population Structure of Gum and Resin Producing Woody Species in Borana, Southern Ethiopia. *Forests, Trees and Livelihoods,* iFirst Article, 1-12. WCMC (World Conservation Monitoring Center). 1992. *Global Biodiversity: Status of the Earth's Living Resources.* London: Chapman & Hall.

Zegeye, H., Teketay, D., & Kelbessa, E. 2006. Diversity, regeneration status and socio-economic importance of the vegetation in the islands of Lake Ziway, south-central Ethiopia. *Flora-Morphology, Distribution, Functional Ecology of Plants*, 201(6), 483-498.

Zegeye, H., Teketay, D., & Kelbessa, E. 2011. Diversity and regeneration status of woody species in Tara Gedam and Abebaye forests, northwestern Ethiopia. *Journal of Forestry Research*, 22(3): 315.

Zerhun, Woldu, Feoli, E. and Lisanework Nigatu. 1989. Partitioning an elevation gradient of vegetation from southeastern Ethiopia by probabilistic methods. In *Numerical syntaxonomy* (pp. 189-198). Springer Netherlands.

Zerihun Woldu and Mesfin Tadesse. 1990. The status of the vegetation in the Lakes Region of the Rift Valley of Ethiopia and the possibilities of its recovery. *Sinet*, 13(2), 97-120.

Zerihun Woldu, Edward, S., Abebe Demisse, Taye Bekele & Haase, G. 1999. Forests in the vegetation types of Ethiopia and their status in the geographical context.

Zerihun Woldu. 1985. *Variation in grassland vegetation on the central plateau of Shewa, Ethiopia*. J. Cramer.

Zerihun Woldu. 1999. Rehabilitation of fragmentation in Tigray. In: Land Husbandry in the Highlands of Ethiopia, Ewnetu Z, Haile M, Gebrehiwot K (eds).Proceedings of a workshop. Vol. II. Mekelle University College: Mekelle, Ethiopia.

Zerihun Woldu. 2008. The Population, Health and Environment Nexus, The need for integration and networking. *A background paper for the establishment and launching of PHE. Addis Ababa University*, 34.

Zerihun Woldu. 2008. The Population, Health and Environment Nexus. Ethiopia: *Addis Ababa University*, 34.

Zewdie Kassa, Zemede Asfaw and Sebsebe Demissew. 2016. Ethnobotanical study of medicinal plants used by the local peoples of Tulu Korma and its surrounding areas of Ejere District, Western Shewa Zone of Oromia Regional State, Ethiopia. *Journal of Medicinal Plants,* 4(2): 24–47.

7. Appendix

Appendix 1. Shannon-wiener Diversity (H›) index and the average evenness values (H = habit/ Life form, T = tree, S = shrub, H = herb, T/S = tree/shrub, C = climber)

No	Scientific Name	Ha	Seedling	Sapling	Mature	Total	Pi	Lnpi	pilnpi
1	*Acacia abyssinica* Hocst. ex Benth	T	97	87.8	83	267.8	0.048162	-3.033	-0.14607
2	*Acacia albida* Del.	T	3	6.75	9	18.75	0.003372	-5.684	-0.01917
3	*Acacia etbaica* Schweinf.	T	0.1	0.2	0.66	0.96	0.000173	-8.517	-0.00147
4	*Acacia mearnsii* Del. Wild.	T	1	1	3.77	5.77	0.001038	-6.908	-0.00717
5	*Acacia melanoxylon* R.Br.	T	5	9	13.9	27.9	0.005018	-5.298	-0.02658
6	*Acacia seyal* De	T	2.2	3	2	7.2	0.001295	-6.645	-0.0086
7	*Acanthus sennii* Chiov.	T	10	15.6	21	46.6	0.008381	-4.78	-0.04006
8	*Adhatoda schimperiana*	S	0.1	0.66	0.2	0.96	0.000173	-8.517	-0.00147
9	*Aeschynomene abyssinica* (A.Rich.) Vatke	T	1	3.9	11	15.9	0.002859	-5.843	-0.01671
10	*Albizia schimperiana* Oliv.	T	0.22	0.22	1	1.44	0.000259	-8.112	-0.0021
11	*Allophylus abyssinicus* (Hochst) Radlk	T	20.8	19	15	54.8	0.009855	-4.615	-0.04548
12	*Aloemacrocarpa* Tod.	C/S	44	28	4.44	76.44	0.013747	-4.29	-0.05898
13	*Apodytes dimidiata* E.Mey. ex Arn.	S	44	37	2.17	83.17	0.014957	-4.206	-0.06291
14	*Arundo donax* L	S	13	11	5.8	29.8	0.005359	-5.22	-0.02798

15	*Asparagus africanus* Lam.	S	1.37	1	1	3.37	0.000606	-7.419	-0.0045
16	*Asparagus racemosus* Willd.	S	1.8	2	2	5.8	0.001043	-6.908	-0.00721
17	*Asparagus setaceus* (Kunth) Jassop	S	2	3	5	10	0.001798	-6.32	-0.01137
18	*Barleria parviflora* R. Br.ex T.Andres.	S	0.24	0.6	0.6	1.44	0.000259	-8.111	-0.0021
19	*Bersama abyssinica* Fresen.	S	29	49	15.5	93.5	0.016815	-4.492	-0.07553
20	*Bothriochloa insulpta*(A.Rich)	S	35	25	25	85	0.015287	-4.206	-0.0643
21	*Bougainvillea spectabilis* Willd	S	9	5	4.27	18.27	0.003286	-5.714	-0.01877
22	*Brucea antidysenterica* J.F. Mill.	T	6.5	12	18	36.5	0.006564	-5.021	-0.03296
23	*Buddleja davidii* Franch.	S	3.25	2	1	6.25	0.001124	-6.812	-0.00766
24	*Buddleja polystachya* Fresen.	T	0.5	0.3	0.2	1	0.00018	-8.517	-0.00153
25	*Caesalpinia decapetala* (Roth) Alston.	S	1.9	0.5	0.5	2.9	0.000522	-5.259	-0.00274
26	*Callistemon citrinus* (Curtis) Skeels	S	3.6	3	3	9.6	0.001726	-6.377	-0.01101
27	*Calpurnia aurea* (Ait.) Benth.	S	87	63	43.8	193.8	0.034853	-3.355	-0.11693
28	*Capparis tomentosa* Lam.	T	2	4	3.62	9.62	0.00173	-6.377	-0.01103
29	*Carissa spinarum* L.	S	87	63	43.8	193.8	0.034853	-6.119	-0.21327
3	*Cassipourea malosana* (Baker) Alston	C	0.9	0.5	0.5	1.9	0.000342	-8.112	-0.00277

0									
31	*Clausena anisata* (Willd) Benth.	S	1	0.8	0.6	2.4	0.000432	-7.824	-0.00338
32	*Clematis simensis* Fresen.	S	0.8	2	2	4.8	0.000863	-7.013	-0.00605
33	*Clerodendrum myricoides* (Hochst.) Vatke	T	41	59	77	177	0.031832	-3.448	-0.10976
34	*Coffea arabica* L.	S	1.37	1	1	3.37	0.000606	-7.419	-0.0045
35	*Cordia africana* Lam.	T	37	63	73.8	173.8	0.031257	-3.464	-0.10827
36	*Crotalaria rosenii* (Pax) Milne-Redh. ex Polhill	C	3.69	1	3	7.69	0.001383	-6.571	-0.00909
37	*Croton macrostachyus* Del.	T	73.8	63	37	173.8	0.031257	-4.615	-0.14425
38	*Cucumis dipsaceus* Ehrenb.ex Spach	S	8	0.66	9.3	17.96	0.00323	-5.776	-0.01866
39	*Cupressus lusitanica* Mill.	S	0	1.88	1	2.88	0.000518	-7.6	-0.00394
40	*Datura margiantum*	T	7.8	23	12	42.8	0.007697	-4.867	-0.03746
41	*Dicrostachys cinerea* (L.) Wight & Am.	S	44.9	3	33	80.9	0.014549	-5.915	-0.08606
42	*Dodonea angustifolia* L. f.	T	37	40	57	134	0.024099	-3.726	-0.08979
43	*Dovyalis abyssinica* (A. Rich.) Warb.	S	18	3	3.9	24.9	0.004478	-5.915	-0.02649
44	*Dovyalis caffra* (Hook. f. & Harv.) Hook. f.	S	27	23	12.4	62.4	0.011222	-4.667	-0.05237
45	*Dovyalis verucosa* (Hochst.) Warb.	S	1	1	1.36	3.36	0.000604	-7.419	-0.00448

46	*Echinops kebericho* Mesfin	S	9	5	2	16	0.002877	-4.22	-0.01214
47	*Echinops spinosus* L.	T	8	3	1	12	0.002158	-3.985	-0.0086
48	*Ekebergia capensis* Sparrm	S	11	6	3	20	0.003597	-4.034	-0.01451
49	*Embelia schimperi* Vatke	T	2	2.17	4	8.17	0.001469	-6.502	-0.00955
50	*Entada abyssinica*	S	1	1.33	2	4.33	0.000779	-7.13	-0.00555
51	*Erythrina brucei* Schweinf.	T	1	3	5.13	9.13	0.001642	-6.438	-0.01057
52	*Eucalyptus camaldunesis* Dehnh.	T	4	8.4	15	27.4	0.004928	-5.319	-0.02621
53	*Eucalyptus globulus* Labill	S	1	4	1.7	6.7	0.001205	-6.725	-0.0081
54	*Euclea divinorum* Hiern.	T	0	12.7	57	69.7	0.012535	-4.382	-0.05493
55	*Euphorbia abyssinica* Gmel.	S	4	23	34	61	0.01097	-4.51	-0.04948
56	*Euphorbia pulcherrima* Willd. ex Klotzsch	S	9	6.8	3	18.8	0.003381	-5.684	-0.01922
57	*Ficus palmata* Forssk.	T	38	51	93.7	182.7	0.032857	-3.414	-0.11217
58	*Ficus sur* Forssk.	T	2	3.23	14	19.23	0.003458	-5.655	-0.01956
59	*Ficus sycomorus* L.	T	0.7	1	6	7.7	0.001385	-6.571	-0.0091
60	*Ficus vasta* Forssk.	S	0	0.8	5	5.8	0.001043	-6.908	-0.00721
6	*Flacourtia indica* (Burn. f) Merr.	S	0.1	3.1	4	7.2	0.001295	-6.645	-0.0086

1									
62	*Galiniera saxifraga* (Hochst.) Bridson	C	18	15.6	13	46.6	0.008381	-4.78	-0.04006
63	*Glycine wightii* (Wigh & Arn.) Verde	S	0	0.07	0.9	0.97	0.000174	-8.517	-0.00149
64	*Grewia ferruginea* Hochst. ex A. Rich.	S	25	9.69	23	57.69	0.010375	-4.566	-0.04737
65	*Hypericum quartinianum* A. Rich.	S	7	7.8	3	17.8	0.003201	-5.745	-0.01839
66	*Indigofera spicata* Forssk.	C	9	4	2.8	15.8	0.002842	-5.878	-0.0167
67	*Jasminum abyssinicum* Hochst.ex DC.	C	1.4	1	0	2.4	0.000432	-7.824	-0.00338
68	*Jasminum florbundum* R.Br.ex.Fres	T	23	17	14	54	0.009711	-2.854	-0.02772
69	*Juniperus procera* Hochst. ex Endle.	S	140	100	80	320	0.057549	-4.625	-0.26617
70	*Laggera pterodonta* (DC.) Schtz-Bip	S	9	4	1	14	0.002518	-5.22	-0.01314
71	*Lantana trifolia* L.	S	3.6	3	3	9.6	0.001726	-6.377	-0.01101
72	*Lippia adoensis* var. *adoensis* Hochst. ex Walp	S	3.4	0	0	3.4	0.000611	-7.419	-0.00454
73	*Lippia adoensis* var. *koseret*	S	15	6	0	21	0.003777	-5.573	-0.02105
74	*Maesa lanceolata* Forssk.	T	3	1	2	6	0.001079	-6.811	-0.00735
75	*Maytenus arbutifolia* (A. Rich) Wiczek.	S	2	3	5	10	0.001798	-6.32	-0.01137
76	*Maytenus gracilipes* (Welw. ex Olive.) Exell	S	1	1.3	2	4.3	0.000773	-7.13	-0.00551

77	*Maytenus obscura* (A.Rich) Cuf.	S	1	2.3	2	5.3	0.000953	-7.013	-0.00668
78	*Maytenus undata*	T	23	3	1.5	27.5	0.004946	-4.492	-0.02222
79	*Milletia ferruginea* (Hochst.) Bak.	T	40	25	20	85	0.015287	-4.18	-0.0639
80	*Myrica salicifolia* A. Rich.	S	5	3.3	1	9.3	0.001673	-5.714	-0.00956
81	*Myrsine africana* L.	T	32.5	8	17	57.5	0.010341	-5.021	-0.05192
82	*Mytenus senegalensis*	S	13	2.3	1	16.3	0.002931	-5.843	-0.01713
83	*Nuxia congesta* R. BT. ex Fresen.	S	3	2	1.25	6.25	0.001124	-4.492	-0.00505
84	*Ocimum lamiifolium* Hochst. ex Benth.	S	1.8	1	1	3.8	0.000683	-7.264	-0.00496
85	*Ocimum uritcifolium* Roth	S	3	2	1	6	0.001079	-4.398	-0.00475
86	*Olea europaea* subsp.*cuspidata*	T	119	97	96	312	0.056111	-2.88	-0.1616
87	*Opuntia ficus-indica* (L.)Miller	S	0.28	0	9.6	9.88	0.001777	-6.377	-0.01133
88	*Osyris quadripartita* Decn.	S	5	2	1	8	0.001439	-4.756	-0.00684
89	*Oteostegia tomentosa* subsp. *Ambigiensis*	S	4.62	3	2	9.62	0.00173	-6.377	-0.01103
90	*Pavetta abyssinica* Fresen.	S	9	2.5	1	12.5	0.002248	-6.12	-0.01376
91	*Pavonia urens* Cav.	T	1	0	1	2	0.00036	-7.824	-0.00281
9	*Phoenix reclinata* Jacq.		0.9	0.5	0.5	1.9	0.000342	-8.112	-0.00277

2		S/C							
93	*Phytolacca dodecandra* L`Herit.	S	1.88	1	0	2.88	0.000518	-7.6	-0.00394
94	*Pittosporum viridiflorum* Sims	T	11	8.6	15	34.6	0.006223	-5.083	-0.03163
95	*Podocarpus falcatus* (Thunb.) R. B. ex. Mirb	S	149	107	66	322	0.057909	-2.849	-0.16498
96	*Premna schimperi* Engl.	S	0.15	0.7	3	3.85	0.000692	-7.264	-0.00503
97	*Pterolobium stellatum* (Forssk.) Brenan	S	1	3.7	3	7.7	0.001385	-6.57	-0.0091
98	*Rhamnus prinoides* Lyterit.	S	38	2.4	2	42.4	0.007625	-4.92	-0.03752
99	*Rhamnus staddo* A.Rich	T	33	11.8	10	54.8	0.009855	-4.615	-0.04548
100	*Rhus glotinosa* A. Rich	T	55	38	27	120	0.021581	-4.017	-0.08669
101	*Rhus vulgaris* Meikle	S	7.3	6	4	17.3	0.003111	-5.776	-0.01797
102	*Ricinus communis* L.	S	20	11	5	36	0.006474	-3.922	-0.02539
103	*Rosa abyssinica* Lindley	S	0.5	1.9	0.5	2.9	0.000522	-7.6	-0.00396
104	*Rosmerinus officinalis* L.	S	22	9.8	11	42.8	0.007697	-4.867	-0.03746
105	*Rubus apetalus* Poir.	S	9.9	3	2	14.9	0.00268	-5.915	-0.01585
106	*Rubus steudneri* Schweinf	S	12.4	26	27	65.4	0.011762	-4.44	-0.05222
107	*Rumex nervosus* Vahl	S	6.7	1	1	8.7	0.001565	-6.438	-0.01007

108	*Rytigna neglecta* (Hiern) Robyns	S	7	7	1	15	0.002698	-5.915	-0.01596
109	*Salix subserrata* Willd.	S	33	11	8.4	52.4	0.009424	-4.667	-0.04398
110	*Sapium elipticum* (Krauss) Pax	S	1	1	1	3	0.00054	-7.6	-0.0041
111	*Schefflera abyssinica* (Hochst. Ex A. Rich)	T	25	12	37	74	0.013308	-4.029	-0.05362
112	*Schinus molle* L.	T	13	57	43	113	0.020322	-3.897	-0.0792
113	*Senna didymobotrya* (Fresen.) Irwin & Bar	S	3	3	2.17	8.17	0.001469	-6.502	-0.00955
114	*Sesbania sesban* (L.) Merr.	T	2	2	0.3	4.3	0.000773	-7.13	-0.00551
115	*Sida schimperiana* Hochst. ex A. Rich	S	2.9	4	9	15.9	0.002859	-5.843	-0.01671
116	*Sida tenuicarpa* L.	S	17	9	1	27	0.004856	-5.319	-0.02583
117	*Solanum incanum* L.	S	4.13	3	2	9.13	0.001642	-6.438	-0.01057
118	*Solanum macracantum* A.R.ich	S	8	6	2	16	0.002877	-5.843	-0.01681
119	*Solanum marginatum* L. f.	S	87	30	19	136	0.024458	-3.785	-0.09258
120	*Stephania abyssinica* (Dillon & A.Rich)	C	9	9	0.8	18.8	0.003381	-5.684	-0.01922
121	*Syzygium guineense* (Wild.) DC.	T	5	4	3	12	0.002158	-6.215	-0.01341
122	*Tacazzea apiculata* Oliver	C	1.7	1	4	6.7	0.001205	-6.725	-0.0081
1	*Tagetes minuta* L.	S	1	1.4	0	2.4	0.000432	-7.824	-0.00338

23									
124	*Teclea nobilis* Del.	S	17	6.9	4	27.9	0.005018	-5.298	-0.02658
125	*Triumfetta rhomboidea* Jaq.	S	1.2	3	3	7.2	0.001295	-6.645	-0.0086
126	*Vepris dainelli(pichi-serm)* kokwaro	S	13.6	20	13	46.6	0.008381	-4.78	-0.04006
127	*Vernonia adoensis* Schtz.Bip	T	77	43	26	146	0.026257	-3.785	-0.09938
128	*Vernonia amygdalina* Del.	S	6	18	11	35	0.006294	-5.067	-0.03189
129	*Vernonia leopoldii* Vatke	S	7.9	6	4	17.9	0.003219	-5.745	-0.01849
130	*Vernonia myrantha* Hook. f.	S	1	0.44	0	1.44	0.000259	-8.112	-0.0021
131	*Vernonia urticifolia* A.Rich.	S	43	23	13	79	0.014208	-4.343	-0.0617
132	*Ximenia americana* L.	S	35	18	1.8	54.8	0.009855	-4.615	-0.04548
			2217.4	**1734.9**	**1608.04**	**5560.44**	1.000	-759.33	-3.44

T.M = Total Mature; T.S = Total Sapling; T.Se = Total Seedling; pi = proportion of individual, H=3.44, Hmax=4.88, Ev. =0.7


Yunivarsiitii Ambootti Giddugala Mukkeen Biyya Keessaa Tulluu-Kormaa
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Ambo University Tulu-Korma Center For Native Trees