Floristic Composition and Vegetation Structure of Gera Moist Afromontane Forest, Jimma Zoneof Oromia Regional State,Southwest Ethiopia

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Floristic Composition and Vegetation Structure of Gera Moist AfromontaneForest, Jimma Zoneof Oromia Regional State, Southwest Ethiopia

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This is to certify that the thesis prepared by Bruk Bedore Amado, entitled: *Floristic Composition and Vegetation Structure of Gera Moist Montane Forest, JimmaZone of Oromia Regional State, Southwest Ethiopia*and *s*ubmitted in partial fulfillment of the requirements for the Degree of Master of Science (Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

A study was conducted in Gera Moist Afromontane Forest in Jimma Zone of Oromia Regional State, Southwest Ethiopia, with the objective to study the floristic composition and structure of Gera Moist Afromontane Montane Forest. A total of 150 plant species in 112 genera and 60 families were identified and recorded from this Forest, of the total species, 101were collected from sample plots and used for floristic and structural analysis. Therest 49 were collected out side of sample plots but from the forest and used to describe the complete floristiclist. Asteraceae was the most dominant family with thirteen species (8.67%) and seven genera and Fabaceae was the second dominant family with twelve species (8%) and five genera. Nine endemic taxa (6.00%) were recorded from the study area. Systematic sampling method was used to collect vegetation data. Accordingly, 40 quadrats each with 400 m^2 (20 m x20 m) for woody species and subplots of 1 m x1 m within the main plots to sample herbaceous plants were laid along thirteenline transect. All plots were laid at a distance of 200 m along transect lines and transect lines were laid following an interval of 100 m elevation gradient. DBH, basal area, height and frequency were computed and compared to describe the structure of the Forest. The regeneration status of some woody species of the Forest was evaluated based on the number of seedlings and saplings per hactre. For seedlings and saplings, the main quadrats were divided into subplots of 5 m x 5 m (25 m^2). Vegetation classification was performed using R-3.0.2 software packages. Three plant community types were identified and named by after two dominating and/or characteristic species; usually a tree and a shrub.Shannon-Wiener diversity index were used to compute species richness and evenness between the plant communities.

The total seedlings and saplings of 20 selected woody species of Gera Forest were about 2,839 and 1,553individuals per hectare respectively. Future research directions and recommendations are suggested for the sustainable utilization of the vegetation.

Keywords/Phrases: Gera Forest, Floristic composition, plant community, species diversity, vegetation structure.

Table of Contents

Contents **Pages**

LIST OF FIGURES v
LIST OF TABLES vi
LIST OF PLATES vii
LIST OF APPENDICES viii
LIST OF ACRONYMS ixi
CHAPTER ONE 1
1. INTRODUCTION 1
1.1. Statement of the Problem 3
1.2. Objectives of the Study 4
1. 2.1. General Objective 4
1.2.2. Specific objectives 4
CHAPTER TWO 5
2. LITERATURE REVIEW 5
2.1. Floristic diversity of Ethiopia 5
2.2. Vegetation Types of Ethiopia 5
2.3. Moist Montane Forest of Ethiopia 6
2.4. Biodiversity and Threats in Ethiopia 7
2.5. Vegetation Structure and Plant Community 9
2.6. Species Diversity, Richness, evenness and Similarity 9
2.7. Species abundance and frequency 10
2.8. Species importance value index (SIV) and dominance 10
2.9. Vegetation Patterns along Environmental Gradients 11
CHAPTER THREE 12
3. MATERIALAND METHODS 12
3.1. Descriptions of the study area 12
3.1.1. Location 12

3.1.2. Topography 13
3.1.3. Demographics 13
3.1.4. Soil 13
3.1.5. Climate and agro climatic zones 13
3.1.6. Land use, Agriculture, Trade and Tourism 14
3.1.7. Wildlife 16
3.1.8. Drainage 16
3.1.9. Vegetation 16
3.2. Methods 20
3.2. 1. Equipment needed for the research activities 20
3.2.2. Reconnaissance survey 20
3.2.3. Sampling design 20
3.2. 4.Vegetation data collection 21
3.2.5. Data Analysis 22
3.2.6. Diversity and similarity indices 22
3.2.7. Structural data analysis 24
CHAPTER FOUR 25
4. RESULTS 25
4.1. Plant Species Composition of Gera Forest 25
4.2. Endemism 28
4.3. Commercially important tree species 29
4.4. Plant Community types in Gera Forest 29
4.5. Species Diversity 34
4.6. Similarity among plant communities 35
4.7. Vegetation Structure 36
4.7.1. Tree and Shrub density 36
4.7.2. Diameter at breast height (DBH) 37

4.7.3. Height class distributions 39
4.7.4. Importance value index (IVI) 40
4.7.5. Dominant Species 40
4.7.6. Species Population Structure 41
4.7.7. Regeneration Status of Gera Forest 43
CHAPTER FIVE 45
5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS 45
5.1. Discussion 45
5.1.1. Floristic description and Vegetation classification 45
5.1.2. Species Diversity of the Plant Communities 46
5.1.3. Structural Description 46
5.2. Conclusion and Recommendations 50
5.2.1. Conclusion 50
5.2.2. Recommendations 51
REFERENCES 53
APPENDICES 63

LIST OF FIGURES

Figure 1: Map of Ethiopia and Jimma Zone showing the location of the study area…… 12

Figure 2. Climate diagram of the study area showing rainfall distribution and temperature variation from 1995 to 2014……...…….. 14

Figure 3: Habit of plant species collected from Gera Forest…… 25

Figure 4: Dendrogram of the vegetation data obtained from hierarchical cluster analysis…… 33

Figure 5: Density (%)/ha of individuals in DBH classes…….…… 38

Figure 6: Height classes versus individuals/ha in Gera Forest……..... 39

Figure 7: Population structure of some selected tree species…… 42

LIST OF TABLES

Table 1: Land use pattern of Gera District……..... 15

Table 2: Families with their corresponding number of genera and species…….. 27

Table 3: Endemic taxa recorded from Gera Forest and their respective family….. 28

Table 4: Importance value index (IVI) values of Community TypeI…… 30

Table 5: Importance value index (IVI) values of Community TypeII…… 31

Table 6: Importance value index (IVI) values of Community TypeIII……..... 32

Table 7: Synoptic table of the communities…… 34

Table 8: Shannon - Wiener Diversity Index…… 35

Table 9: Sorensen similarity coefficient among community types……...…….35

Table 10: Number of individuals under different DBH classes…….36

Table 11: Comparisons of tree densities with DBH between 10 and 20 cm (a) and tree density with DBH > 20 cm (b) of Gera Forest with 9 other Forests in Ethiopia….37

Table 12: Importance Value Index (IVI) of the dominant tree species of Gera Forest…… 40

Table 13: List of selected woody species with their seedlings and saplings/ha ….. 44

LIST OF PLATES

Plate 1: Part of Gera Forest in Gara Naso locality…….. 17

Plate 2: Part of Gera in Boge Dedo locality…… 17

Plate 3: Impact of agricultural land expansion and over grazing on the forest……..18

Plate 4: Impact of road construction on the Forest……. 19

LIST OF APPENDICES

Appendix 1: Sample Plots together with their corresponding altitude and location.….63

Appendix 2: List of plant species collected from Gera Forest……...…….65

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This paper is deducated to my late, biological father Bedore Amado.I wish for you that your soul rest in peace in heaven.

LIST OF ACRONYMS

AAU	Addis Ababa University
BA	Basal Area
CR	Critically endangered
DBH	Diameter at Breast Height
EFAP	Ethiopian Forestry Action Plan
EN	Endangered
ENMSA	Ethiopian National Meteorological Station Agency
EPA	Environmental Protection Authority
ETH	National Herbarium
EWNHS	Ethiopian Wildlife and Natural History Society
FAO	Food and Agriculture Organization
FEE	Flora of Ethiopia and Eritrea
G.D.A.R.D.O	Gera District Agriculture and Rural Development Office
GPS	Geographical Position System
IBC	Institute of Biodiversity Conservation
IUCN	International Union for Conservation of Nature and Natural Resources
IUFRO	International Union for Forestry Research Organizations
IVI	Importance Value Index
LC	Least concern
MRPP	Multi-Response Permutation Procedure
NBSAP	National Biodiversity Strategy and Action Plan
NFPA	National Forest Priority Area

NMSA	National Meteorological Service Agency
NT	Near threatened
PCC	Population Census Commission
RD	Relative Density
RDO	Relative Dominance
RED	Relative Euclidean Distance
RF	Relative Frequency
TWINSPAN	Two Way Indicator Species Analysis
USAID	United States of America International Development
VU	Vulnerable
WBISPP	Woody Biomass Inventory and Strategic Planning Project
WRI	World Resource Institute

CHAPTER ONE

1. INTRODUCTION

Ethiopia is an important regional center for biological diversity due to its wide ranges of altitude, great geographical diversity with high and rugged mountains, flat-topped plateaus and deep gorges, incised river valleys and rolling plains (Ensermu Kelbessa *et al.*, 1992; Zerihun Woldu, 1999). These lead to wide ranges of habitats that are suitable for the evolution and survival of various plant and animal species. As a result, the country is regarded as one of the most important countries in Africa with respect to endemism of plant and animal species in tropical Africa (EFAP, 1994; EWNHS, 1996). The Flora of Ethiopia contains about 6000 species of vascular plants, of which about 10% are endemic (Ensermu Kelbessa, pers.comm.).

A substantial proportion of the Ethiopian highlands were once believed to have been covered by forests having wide coverage but had gradually been cleared (Friis, 1992).Tamrat Bekele (1993) remarked that the occurrence of isolated mature trees in farmlands and the patches of forests that are seen around church-yards and religious burial grounds indicate the historical presence of vast expanse of forests in the past. Historical documents indicated that Ethiopia had experienced substantial deforestation, soil degradation and an increase in the area of bare land over the years. The need for fuel-wood, arable land and grazing areas have been indicated as the main causes of forest degradation; frequently leading to loss of forest cover and biodiversity, erosion, desertification and reduced water resources (Ensermu Kelbessa and Teshome Soromessa, 2008). Deliberate fire and non-integrated investment activities are also reasons for the reduction of forests in Ethiopia.

The high level of dependency of the local community on agriculture (more than 90%) and high rate of population growth (EFAP, 1994; Tadesse Woldemariam, 2003; Simon Shibru and Girma Balcha, 2004; Feyera Senbeta, 2006) have also accelerated the problems. On the other hand, lack of integration of the local people living around the conservation areas into the conservation efforts, is the major constraint to the overall conservation effort in Ethiopia (Feyera Senbeta and Demel Teketay, 2003). Because of this, it had been realized that unless the local community was involved in the conservation effort, the sustainability of forest resources will always be uncertain (Aklilu Ameha, 2002).

Southwestern Ethiopia was rich in remnants of natural forests, but they disappearing at an alarming rate because of encroachment by agricultural activities and the pressure from investors (Taye Bekele *et al*., 2001). The new investment opportunities being undertaken in southwest Ethiopia are converting the few remaining moist montane forests into other land use systems such as coffee and tea plantations (Taye Bekele *et al*., 2001).

In addition, generation of scientific knowledge through the studies of floristic composition and structural analysis could be one of the intervention mechanisms to contribute towards the conservation of vegetation resources and the associated biodiversity. It is, thus, equally important to study and document the remaining vegetation resources for conservation and sustainable utilization based on scientific knowledge. Hence, this study was conducted with the main objective of investigating floristic composition, and vegetation structure in Gera forest.

1.1. Statement of the Problem

Gera Natural Forest is one of the few forest patches in Ethiopia where one finds high number of plant species diversity and vegetation stands. This forest is highly valued for its high economic and ecological services such as watershed protection, prevent soil erosion and check global warming by using carbon dioxide in photosynthesis. Despite all these economic and ecological services, forest vegetation removal will apparently continue for some time to come for the simple reason that forests are still the principal sources of construction and timber materials for the rural and urban population.

Gera Forest has been continuously exploited through agricultural land expansion and has been used for coffee plantation and there is still a growing interest to invest on the remaining part of this forest. Therefore, detailed biodiversity and ecological studies are desirable to draw the attention of policy makers to understand the ecosystem services of this biodiversity assemblage and undertake appropriate conservation measures. Thus, the present study was initiated to generate basic scientific information on the biodiversity and structure of the Forest.

1.2. Objectives of the Study

1. 2.1. General Objective

- The main objective of this study was to investigate the floristic composition, and vegetation structure of Gera Moist Afromontane Montane forest.

1.2.2. Specific objectives

- To document the floristic composition of the Geraforest,
- To identify and evaluate the plant community types in terms of: Species richness, evenness and species diversity among different plant community types ,
- To investigate the similarity of Gera forest with some other related forests in Ethiopia regarding its floristic composition andvegetation structure,
- To provide baseline information on the forest vegetation that would help for future management.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Floristic diversity of Ethiopia

The variations in latitude have resulted in a wide variation in rainfall, humidity, temperature and exposure to wind. These differences along with edaphic variations form the basis for the wide biodiversity of the country. This geographical and ecological diversity of Ethiopia, with extraordinary range of terrestrial and aquatic ecosystems, contributed to the high rate of endemism and diversity (Demel Teketay *et al.,* 2004). The forest and woody vegetation resources of Ethiopia were estimated to cover greater than 11.7 percent of the land, of this the woodlands cover about 4.5 percent of the total land of Ethiopia (EPA, 1998).

2.2. Vegetation Types of Ethiopia

Vegetation refers to an assemblage of plants growing together in a particular location, or the collective plant cover of an area (Jennings *et al.*, 2003). The vegetation resources of Ethiopia, including forests, woodlands and bush lands have been studied by several scholars (EFAP, 1994).Various authors have been attempted to study and describe the Ethiopian forests and woody vegetation resources employing different systems, among which Hailu Sharew (1982), Lissanework Nigatu (1987), Tamrat Bekele (1994), Sebsebe Demissew *et al*., (1996), Kumilachew Yeshitela (1997), Teshome Soromessa (1997), Sebsebe Demissew (1998) and Zerihun Woldu (1999) were a few. Friis *et al.,* (2010) indicated that there are twelve major vegetation types in Ethiopia. These major vegetation types include Desert, Semi-desert scrubland forest; *Acacia*-

Commiphora woodland and bush land; Wooded grassland of the Western Gambela Region; *Combretum-Terminalia* woodland and wooded grassland; Dry Evergreen Afromontane forest and grassland complex; Moist Evergreen Afromontane forest and bush land; Transitional rain Forest; Ericaceous belt; Afro-alpine belt; Riverine vegetation; Fresh - water lakes; and Salt Lakes vegetation.

2.3. Moist Montane Forest of Ethiopia

This vegetation type is in most cases characterized by one or more closed strata of evergreen trees that may reach a height of 30 to 40 m. Sometimes only the lower stratum remains, due to the removal of the tallest trees. The Moist Afromontane forest, according to Friis (1992) occurs mainly in the south-western part of the Ethiopian highlands between 1500- 2000mm sometimes even higher than 2000 mm, with rain all the year round, but a maximum in April-October.

The Harenna Forest on the southern slopes of the Bale Mountains is the easternmost example of this forest. These forests predominantly contain broad-leaved evergreen species in the multilayered canopy. The most characteristic type of this forest type occurs widely in the upland parts of Welega, Ilubabor and Kefa floristic regions (Sebsebe Demissew and Nordal, 2010).

The characteristic emergent species of this vegetation type that form the 20-30 mhigh canopyis *Pouteriaadolfi-friederici*. Othercharacteristic species include *Albizia gummifera, Sapium ellipticum, Euphorbiaampliphylla, Ekebergia capensis, Ficussur, Hallearubrostipulata, Oleawelwitschii, Polyscias fulva*and *Schefflera abyssinica* (Sebsebe Demissew and Nordal, 2010).

2.4. Biodiversity and Threats in Ethiopia

Owing to the diversity in climatic variations, Ethiopia is one of the richest centers of biologicaldiversity and genetic resources in the world (EWNHS, 1996; EPA, 2003).

A loss in biodiversity due to degradation of environment and other threats to components of ecological systems was the most serious environmental problems Ethiopia is facing (FAO, 1996; NBSAP, 2005). The removal of vegetation cover also reduces the quantity of carbon that can be sequestered from the atmosphere (EFAP, 1994) and contribute to the global warming. The extent of past forest cover on the Ethiopian high lands is evident from the numerous isolated mature forest trees or small patches of forests or woodlands that make conspicuous landmarks on the plateau (Friis, 1992). Large areas with evergreen bush land or farmland mixed with bush land represent formerly forested areas (Friis, 1992). There was a decline in forest cover from the original 35% to 16% by the early 1950's. By the early 1980's, it has been estimated that the land area covered by forest had declined to 3.6% and by 1989 to 2.7% and estimated to be 2.4% in 1992 (Million Bekele and Leykun Berhanu, 2001).

The rich biodiversity of the country was under serious threat from deforestation; land degradation, overexploitation, overgrazing and habitat loss (De Vletter, 1991; EPA, 1998; Demel Teketay, 2001). In addition, Ensermu Kelbessa *et al.*, (1992) mentioned that environmental degradation in Ethiopia, limitations to the opportunities for income generation caused by ecological and socioeconomic constraints exacerbated by a mounting population pressure have, over the years, forced people to cultivate marginal lands and allow over grazing ,environmental degradation and deforestation. In most cases, the major destructive factor of plant diversity was deforestation caused by agricultural expansion and fuel- wood consumption (Ababu Anage, 2009).

In current situations, Ethiopia is in the track of high investment rate, agro-industry expansion and population migration to forests and related resources. However, almost all of these huge activities were done without prior environmental impact assessment. As a result, many virgin and uniqe forests are cleared for different activities like livestock farms, coffee and tea plantations (Kumilachew Yeshitela, 2001; Yonas Yemishaw, 2001; Getachew Tesfaye and Demel Teketay, 2005).

The other threats to the plant biodiversity of the country are unsustainable utilization of natural resources, forest fires, land degradation, habitat loss and fragmentation, extensive replacement of farmer's local varieties or breeds by improved ones, invasive species, wetland destruction and climate change. But all these are related to the root causes of poverty, which are lack of alternative viable livelihoods, increasing population pressure and inadequate awareness of the threats (De Vletter, 1991; EPA, 1998).

These different threats are in rapid progress to decline the trend in the conservation status of Ethiopia's plant diversity. The challenges to conservation and sustainable use of Ethiopia’s biodiversity are very complicated and interlinked (Ababu Anage, 2009). Some reports indicated that there are still high rate of deforestation in Ethiopia (De Vletter, 1991; EPA, 1997; EPA, 1998; Demel Teketay, 2001; Yonas Yemishaw, 2001; FAO, 2007). So, the plant biodiversity of Ethiopia need better attention to conserve and protect from these losses.

2.5. Vegetation Structure and Plant Community

Vegetation structure is the organization in space of the individuals that form a community and by extension a vegetation type or plant association (Muller-Dombois and Ellenberg, 1974). It is the spatial pattern of growth forms in a plant community, especially with regard to their height, abundance or coverage within the individual layer (Jennings *et al.*, 2003).

As stated in Mueller-Dombois and Ellen berg (1974), the floristic composition of vegetation includes all species occurring within a plant community. However, most plant communities consist of many different species which are not particular to discover all species within a community. Hence, it is common to use the dominant species in naming plant communities (Kent and Cooker, 1992).

2.6. Species Diversity, Richness, evenness and Similarity

Species diversity can be viewed from different perspectives: alpha, beta and gamma diversity. Alpha diversity refers to the diversity of species within a particular habitat or community. Beta diversity is a measure of the rate and extent of change in species along a gradient from one habitat to another. It is between habitat diversity that measures turnover rates. Beta diversity is sometimes called habitat diversity (Kent and Coker, 1992). Gamma diversity is the diversity of species in comparable habitats along geographical transect and it depends on the alpha and beta diversity (Kent and Coker, 1992).

Species diversity indices provide information about community composition. Measures of species diversity are usually seen to be key indicators for the wellbeing of ecological systems. Among many of the species diversity indices, diversity and evenness are often calculated using Shannon diversity index (Kent and Coker, 1992). It is the most widely used index that combines species

richness with evenness. Species richness refers to the total number of species in a community while evenness is the relative abundance of species within the sample or community (Kent and Coker, 1992). Diversity is, thus, measured by recording the number of species and their relative abundances.

The two components may be examined separately or combined in some form of index like the Shannon diversity index. Patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes such as soil moisture, disturbance and successionare important for management (Lovett *et al.*, 2000).

Similarity indices measure the degree to which the species composition of quadrats or samples is alike. Sorenson's coefficient which is expressed as Ss = 2a/ (2a+b+c) is the most common binary similarity coefficients because it relies on presence or absence data (Kent and Coker, 1992).

2.7. Species abundance and frequency

Abundance is the number of individual plants of a given species per unit area. It can be used to show spatial distribution and ranges over time. Frequency is the proportion of plots in which a species occurs. It is a measure of the occurrence of a given species in a given area. It indicates how the species are dispersed and is an ecologically meaningful parameter. In other words, it gives an approximate indication of the homogeneity of the stand under consideration (Kent and Coker, 1992).

2.8. Species importance value index (SIV) and dominance

Species importance value index permits a comparison of species in a given location and reflects the dominance, occurrence and abundance of a given species in relation to other associated species

in an area (Kent and Coker, 1992). Therefore, for setting conservation priority, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices.

2.9. Vegetation Patterns along Environmental Gradients

Natural vegetation may respond to environmental gradients in many ways (Desalegn Wana and Zerihun Woldu, 2005). Globally, Patterns of plant species diversity are influenced by latitudinal, altitudinal and soil gradients (Huston, 1994). Altitude is one of the most important environmental factors that determine species diversity and distribution patterns. Species diversity generally tends to decrease with increasing altitude (elevation) (Whittaker, 1975). The interacting influences of climate, topography and soil are primary determinants of plant distribution so that variables such as vegetation structure and productivity also exhibit complex patterns along environmental gradient (Brown, 2001). Altitude affects temperature, moisture, radiation and atmospheric pressure there by influencing the growth and development of plants and the distribution of vegetation (Zerihun Woldu *et al.*, 1989; Getachew Tadesse *et al.*, 2005). ZerihunWoldu *et al*., (1989) indicated that altitude is the main factor that orders the tree-shrub layer into respective vegetation types because it is positively correlated with some environmental factors like organic matter and negatively correlated with pH, clay and calcium.

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

CHAPTER THREE

3. MATERIAL AND METHODS

3.1. Descriptions of the Study Area

3.1.1. Location

The study was conducted in Gera District, Jimma Zone of Oromia Regional State, Southwest Ethiopia (Figure 1). The study Forest is located at about 380 km south west of Addis Ababa and has a total area of 80,830.4 ha. The altitudinal range of the study Forest varies from 1600 to 2400 m a.s.l. Gera District has an area of 1,330.1 Km^2 and one urban center, Chira town. It is bordered on the south by Gojeb River which separates it from the Southern Nations, Nationalities and Peoples Region, on the northwest by Sigmo, on the north by Setema, on the northeast by Gomma, and on the east by Seka ChekorsaDistricts (Figure 1).

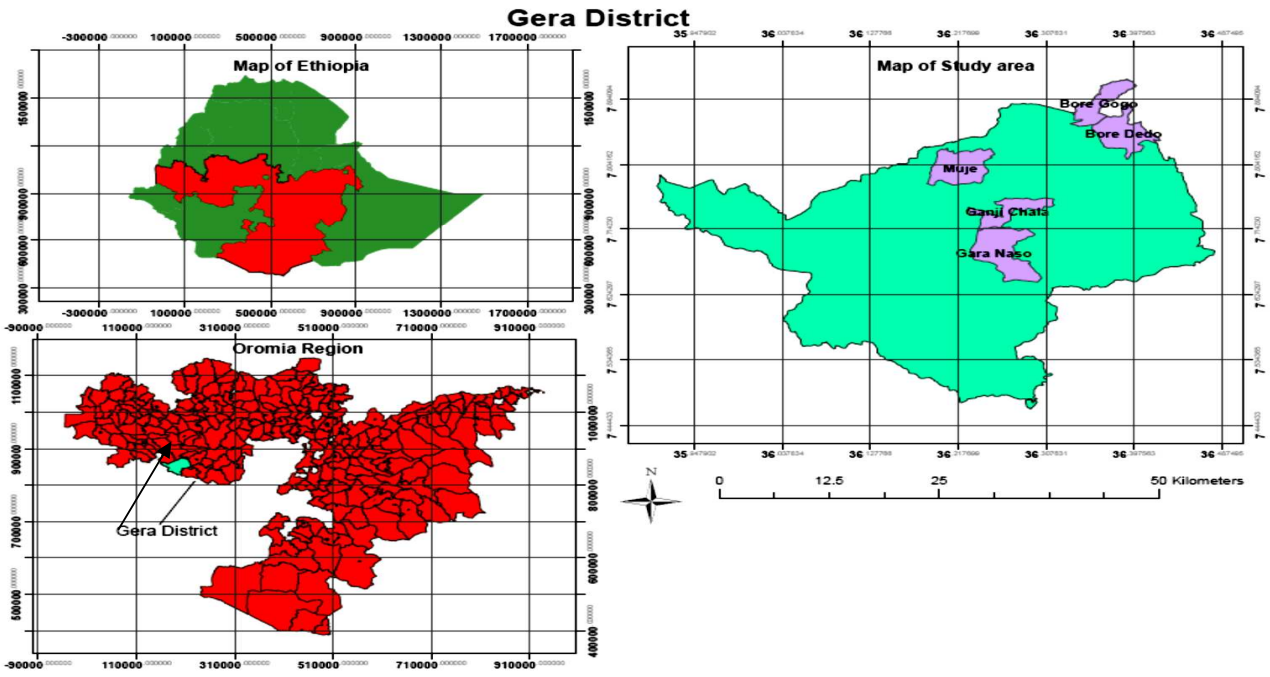


Figure 1: Map of Ethiopia showing Oromia Region and the study Area

3.1.2. Topography

Gera District is characterized by mountains (Waka, Kimbibit and Timba), plateaus (Chewra and Kella), plains (Walla, Kecho, Tuta and Tuam Mayi,) and valleys (Naso and Gojeb). The District extends between 1390 to 2980 meters above sea level (m.a.s.l). Gera Forest, however, is situated in the intermediate altitudinal range between 1819 to 2539 m a.s.l. (GPS reading during field work).

3.1.3. Demographics

The 2007 national census reported a total population for this District of 112,395, of whom 56,488 were men and 55,907 females; 4,746 or 4.22% of the population were urban dwellers. The three largest ethnic groups reported in Gera District were Oromo (86.08%), Amhara (8.27%), and Kafficho (4.16%); all other ethnic groups made up 1.49% of the population.

3.1.4. Soil

The study area has a dystric nitosol soil type, which is deep, clay red soil. The soil is porous and has good potential for agriculture, good physical properties, stable structure, deep rooting volume, and high moisture storage volume. Orthic acrisol and dystric nitosol are the major soil types found in Gera District (G.D.A.R.D.O., 2012).

3.1.5. Climate and agro climatic zones

The rainfall and temperature data for the study area were collected from the nearest Meteorological Station, Agaro, which is about 23 km away from the capital of Gera District. The data were collected from 1995- 2014 by National Meteorological Service Agency (NMSA,

2014).The mean annual temperature is about 20.4 ^{0}C and the mean minimum and maximum temperatures are 10.3 ^{0}C and 31.1 ^{0}C respectively. The mean annual rainfall of the study area is 1638 mm (Figure 2). Gera is classified into dega (5%), woinadega (75%) and kola- (20%) agro climatic zones (G.D.A.R.D.O, 2012).

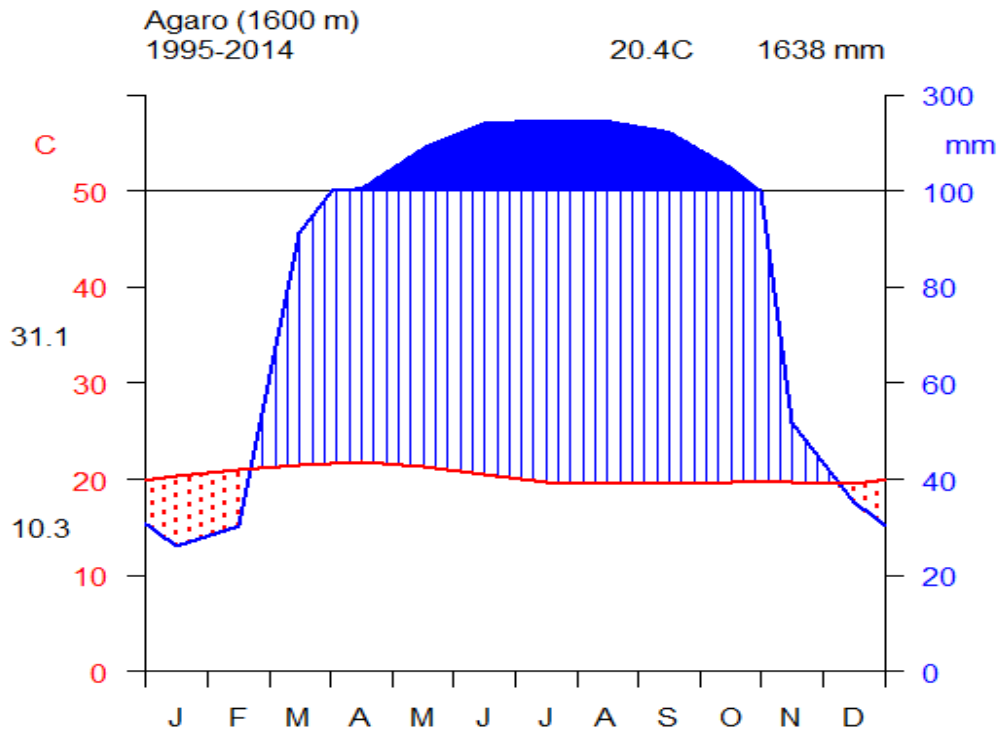


Figure 2: Climadiagramshowing mean monthly rainfall and temperature of Agaro (the nearest metrological station for study area) from 1995-2014

3.1.6. Land use, Agriculture, Trade and Tourism

The proportion ofgrazing, arable and forest lands in Gera District is 5.6%, 15.47% and 56% respectively (G.D.A.R.D.O., 2012). The remaining land area is either degraded, houses built-up or

serves for other purpose (Table 1). High forest, woodland and plantation forests are available in the District. The majority of the natural Forest patches are under the government protection.

Gera District estimated tohave 226,754 cattle, 54,801 sheep, 14,473 goats, 7,041 mules, 30,532 horses, 1934 donkeys and 21, 205 poultry (G.D.A.R.D.O., 2012).

There are some retail traders, small shops, and open markets, in the District. Teff, maize, wheat, sorghum, barely, horse bean, field pea, peppers, fruits, spices, and coffee are important cash crops in the District. Honey production is also practiced in the Forest area. Regarding tourism, water fall on the Naso River, hot springs at Walla and Timba Chele and largely available wild animals are some of the major potentials for the development of tourist industry in the District. Moreover, historically, the District is one of the five Gibe States, created by Guunji, around 1835 (G.D.A.R.D.O., 2012).

Table 1: Land use pattern of Gera District

No.	Land use Type	Area in hectare	**%**
1	Potential arable land	22,323	**15.47**
2	Grazing land	8089.22	**5.6**
3	Forest	80,830.4	**56**
4	Cultivable land	3,148	**2.18**
5	Uncultivable land	5,901.76	**4.09**
6	Construction	9002.62	**6.24**
7	Others	15,045	**10.42**
	Total	144,340	**100**

Source: G.D.A.R.D.O. (2012)

3.1.7. Wildlife

The Forest vegetation of Gera District hosts various species of wild animals including mammals, birds, reptiles and amphibians. Some of the common mammals like buffalo, lion, colobus monkey, gelada baboon, vervet monkey, leopard, warthog, pig, civet cat and antelope are found in the Forest. However, the wildlife populations of these animals are under severe threat due to deforestation and habitat fragmentation mainly because of human encroachment (G.D.A.R.D.O., 2012).

3.1.8. Drainage

Gera District, with an altitudinal range between 1390 to 2980m a.s.l. and wide topographic land forms, is endowed with numerous streams and rivers. Several perennial rivers such as Naso and Gojeb, and intermittent streams (Atta, Naniya, Sassy, Koka, Dacho, etc) are flowing through the District. Locally protected springs, rivers, developed springs and wells are the major sources of drinking water in Gera.

3.1.9. Vegetation

The vegetation type of the study area is broad-leaved and moist montane forest with important species in the Forest including *Olea capensis, Schefflera abyssinica, Prunus africana, Albizia gummifera, Syzygium guineense, Bersama abyssinica, Pouteria adolfi–friedericii, Apodytes dimidiata, Cassipourea malosana, Celtis africana, Croton macrostachyus, Ekebergia capensis* and *Ficus sur* (IBC, 2005).Some areas of Gera Forest have been cleared for coffee plantation, road construction, timber harvesting, and agricultural intensification which resulted in bushland and farmland formation.



Plate 1: Part of Gera forest in GaraNaso locality.



Plate 2: Part of Gera forestin Boge Dedo locality



Plate 3: Impact of agricultural land expansion and over grazing on the forest



Plate 4: Impact of road construction on the forest

3.2. Methods

3.2. 1. Equipment needed for the research activities

The materials that were used during the actual plant data collection in the field were GPS, altimeter, clinometers, tree calliper, roll meter, plant press,ventilator cardboard, blotter and digital camera, secateurs (pruning scissors) - to cut the specimen and plastic bags and other supportive material.

3.2.2. Reconnaissance survey

Reconnaissance survey was made between November 10 and 15/ 2014 in order to obtain an impression of the site conditions and physiognomy of the vegetation, and to identify sampling sites.

3.2.3. Sampling design

Systematic sampling following Kent and Coker (1992) and Muller-Dombois and Ellenberg (1974) was used in this study. Transect lines were laid from south to north direction.A total of thirteen, transects lines were laid by dropping a regular interval of 100 m elevation gradient.

Each of the twelve transects contains three plots and the thirteenth, transect contains four plots respectively with 20 m x 20 m (400 m^2) for woody species. In addition, five sub plots each with 1 m x 1 m, (1m^2) one at each corner and at the center of the main plot were laid to sample herbaceous plants. The distance between two consecutive plots was 100 m apart from their centers. A total of 40 plots were laid for vegetation data collection. Geographical coordinates of the plots were recorded using Magellan NAV5000 Pro GPS navigation system. The number of plots in each transects along with its location and altitude is given in Appendix 1

3.2.4.Vegetation data collection

Data collection was conducted from November 16 – 30, 2014.A complete listoftrees, shrubs, herbs and woody climbers (lianas) were made from the systematically selected plots along each transects. Additional plant species out of the plots but in the forest were recorded for floristic list. Vernacular names of species were recorded during field work.

Plant specimens were collected, pressed, and brought to the National Herbarium (ETH), Addis Ababa University for identification and storage. The nomenclature of the taxa follows Flora of Ethiopia and Eritrea (FEE). In each plot, structural attributes such as diameter and height were recorded for some selected woody plants. Diameter was measured for all individual trees and shrubs having DBH ≥2.5 cm using a diameter tape. Trees and shrubs with DBH less than 2.5 cm were counted. Height was measured for individual trees and shrubs with DBH ≥2.5 cm.

Partition of the major quadrats was made into four, each 25 m^2 (5 m x 5 m) corner and one at the center, so as to make seedling and sapling count easier. In this study, seedling refers to young woody species with height ≤ 1 m and DBH less than 2.5 cm, while sapling refers to woody plants with height between 1 m and 2 m. The cover abundance of each species was first estimated visually, recorded and later converted to the Braun-Banquet 1-9 as modified by van der Maarel (1979) wich means:1= Rare-generally only one individual, 2= Sporadic (few) –less than 5% cover of the total area, 3.= Abundant with less than 5% cover of the total area, 4 = Very abundant and less than 5% cover of the total area, 5= 5-12 % cover of the total area,6= 12= 5-25 % cover of the total area, 7= 25-50 % cover of the total area,8= 50-75 % cover of the total area, 9= 75-100 % covers of the total area.

3.2.5. Data Analysis

Hierarchical cluster analysis is one of the most commonly used multivariate techniques to analyze ecological data. It helps to group a set of observations (vegetation samples) together, based on their attributes or floristic similarities (Kent and Coker, 1992). The equation for Hierarchical cluster analysis is as fallows

$$\text{Euclidean distance equation: } d_{jk} = \sqrt{\sum (Xij - Xik)^2}$$

For this study, agglomerative hierarchical classification using similarity ratio cluster analysis was performed using R for windows version R-3.0.2 to classify the vegetation into plant community types. The plant community types were named after two dominant and/or characteristic species, usually a tree and a shrub. A dominant species is a species having the highest value (mean frequency x mean cover abundance, (Van der Maarel et al., 1987)) and a characteristic species being a species with synoptic cover-abundance value in one of the community types, but absent in most of the other community types.The community types distinguished from the out put were further refined in a synoptic cover-abundance value table.

3.2.6. Diversity and similarity indices

The two main components of measuring diversity are species richness and evenness. Species richness is a measure of the number of different species in a given site.

Species evenness is a measure of abundance of the different species that make up the richness of the area. Shannon-Wiener diversity index is the most popular measure of species diversity because it accounts both for species richness and evenness, and it is not affected by sample size (Kent and Coker, 1992; Krebs, 1999). Thus, Shannon-Wiener diversity index, species richness and

Shannon's evenness were computed to describe species diversity of the plant community types in the vegetation of Gera Forest. Shannon-Wiener diversity index was calculated as follows:-

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

• H'= Shannon Diversity Index,

• S = the number of species,

• Pi = the proportion of individuals or the abundance of the i thspecies expressed as a proportion of total cover and

• ln= logbase$_n$

Evenness (Equitability) J= H'/ H' max, where;

• J= Evenness,

•H' = Shannon-Wiener diversity index and *H'*max= lns where s is the number of species.

Sorensen's similarity index was used to determine the pattern of species turnover among successive communities. It is described using the following formula (Kent and Coker, 1992).

Ss = 2a/ (2a+b+c),

Where;

• Ss = Sorensen's similarity coefficient;

• a = Number of species common to both samples;

• b = Number of species found only in sample 1;

• c = Number of species found only in sample 2.

3.2.7. Structural data analysis

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

IVI = Relative Density (abundance) + Relative Dominance (basal area) + Relative Frequency, Where:

- Relative Density (RD) = the number of all individuals of a species/the total number of all individuals (DBH > 2.5cm) X 100;
- Relative Frequency (RF) = Frequency of a species/total frequency of all species X100.
- Relative Dominance (RDO) = total basal area of all individuals of a species/total basal area of all species X 100 and Basal area (BA) was calculated using DBH as, $BA = \pi d^2/4$, where, $\pi = 3.14$; d is diameter at breast height.

CHAPTER FOUR

4. RESULTS

4.1. Plant Species Composition of Gera Forest

A total of 150 plant species belonging to 112 genera and 60 families were collected, and identified from the study area (Appendix II). Of these only 101 species were used in floristic and structural analysis. The rest were collected outside of the sample plots, but within the Forest and used to make list of the Forest. From all the species collected 58 (38.67%) were herbs, 43 (28.67%) were trees, 36(24.00%) were shrubs, 9(6.00%) were lianas, and 4 (2. 67%) were shrubs / trees (Figure 3).

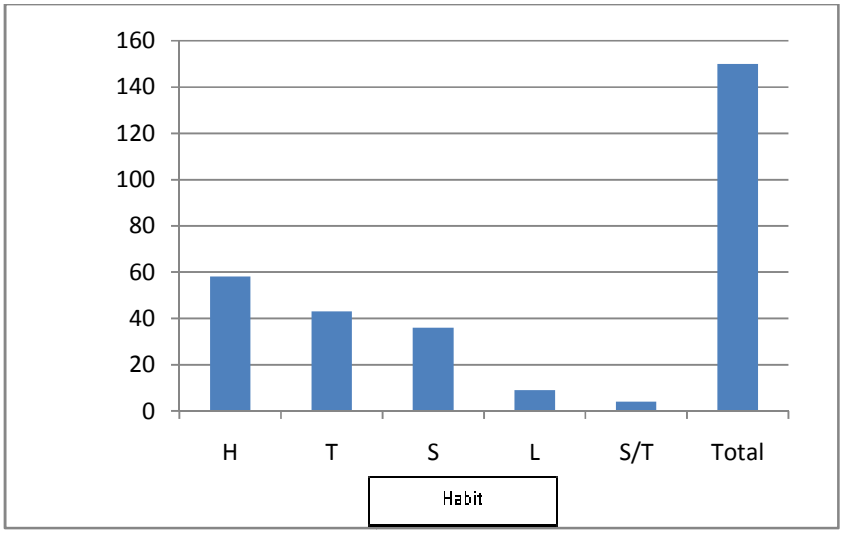


Figure 3: Habit of plant species collected from Gera Forest (H= Herbs, S= Shrubs, T= Trees, L= Lianas and S/T= Shrubs or Trees).

Asteraceae was the most dominant family with thirteen species (8.67%) and seven genera. Fabaceae was the second dominant family with twelve species (8.00%) and five genera (Table 2). The third species- rich family wasRubiaceaewith eight species (5.34%) and six genera.

The fourth species-rich families were Lamiaceae and Euphorbiaceae with seven species (4.67%) and the fifth species-rich families were Acanthaceae and Malvaceae with six species (4.00%) and three genera.Boraginaceae, Celasteraceae and Rutaceae with four species (2.67%) each.

The other species-rich families were Moraceae, Oleaceae, Piperaceae, Polypodiaceae, Rosaceae, Sterculiaceae andUrticaceaewith three species (2.00%) (Table 2).

The families, which contributed two species each, were Apocyanceae, Araceae, Araliaceae, Aspleniaceae, Balsaminaceae, Dracaenaceae, Meliaceae, Menispermaceae, Poaceae, Rhamnaceae, Sapindaceae, Solanaceae, Ulmaceae, Verbenaceae and Zingiberaceae while the rest28 families contained only one species each. Asteraceae, Fabaceae, Rubiaceae, Euphorbiaceae, Lamiaceae, Acanthaceae, Malvaceae, Boraginaceae, Celasteraceae, Rosaceae, Rutaceae, Moraceae, Oleaceae, Piperaceae, Polypodiaceae, Rosaceae, and Urticaceae contributed 61.33% of the total plant species and the remaining 43families contributed 38.67 % of the total plant species.

Table 2: Families with their corresponding number of genera and species.

Family	Number of genera	%	Number of species	%
Asteraceae	7	6.25	13	8.67
Fabaceae	*5*	4.46	12	8.00
Rubiaceae	*6*	5.36	8	5.34
Euphorbiaceae	5	4.47	7	4.67
Lamiaceae	3	2.68	7	4.67
Acanthaceae	3	2.68	6	4.00
Malvaceae	*3*	2.68	6	4.00
Boraginaceae	*5*	4.46	4	2.67
Celastraceae	*4*	3.57	4	2.67
Rutaceae	*3*	2.68	4	2.67
Moraceae	*2*	1.79	3	2.00
Oleaceae	*2*	1.79	3	2.00
Piperaceae	3	2.68	3	2.00
Polypodiaceae	3	2.68	3	2.00
Rosaceae	2	1.78	3	2.00
Sterculiaceae	2	1.78	3	2.00
Urticaceae	2	1.78	3	2.00
Apocyanceae	2	1.78	2	1.33
Araceae	2	1.78	2	1.33
Araliaceae	1	0.89	2	1.33
Aspleniaceae	2	1.79	2	1.33
Balsaminaceae	2	1.79	2	1.33
Dracaenaceae	2	1.79	2	1.33
Meliaceae	1	0.89	2	1.33
Menispremaceae	2	1.79	2	1.33
Poacaeae	1	0.89	2	1.33
Rhamnaceae	1	0.89	2	1.33
Sapindaceae	*2*	1.79	2	1.33
Solanaceae	*2*	1.79	2	1.33
Ulmaceae	1	0.89	2	1.33
Verbenaceae	2	1.79	2	1.33
Zingiberaceae	1	0.89	2	1.33
Others	28	25.00	28	18.67
Total	112	100	150	100

4.2. Endemism

Gera Forest contains a number of flowering plant species that are endemic to Ethiopia. Endemic plant species of Ethiopia and their level of threat have been given in Ensermu Kelbessa *et al.*, *(*1992) and Vivero *et al.,* (2005). Based on the Flora volumes and list of the endemic species and the levels of threat on each taxon are given in Table 3 below. Accordingly, nine endemic taxa (6.00%) in Gera Forest seven of wich are species while two are sub species (Table 3). Among these, *Erythrina brucei, Millettia ferruginea, Solanecio gigas* and *Vepris dainellii,* were species with least concern, while*Impatienstinctoria*subsp.*abyssinica, Justiciadiclipteroides* subsp. *aethiopica*and *Satureja paradoxa*, were in nearly treated category and *Aframomum corrorima* and *Tiliacora troupinii* were in the vulnerable category (Vivero et al., 2005).

Table 3. Endemic taxa recorded from Gera Forest and their respective family, habit and IUCN category: (T = Tree, S = Shrub, H = Herb, L=lianas, NT= Nearly Threatened, LC= Least Concern, VU= Vulnerable, CR= Critically Endangered).

No	Scientific name	Family	Habit	IUCN category	Distribution in Ethiopia
1	*Aframomum corrorima*	Zingiberaceae	H	VU	KF, IL, SD, WG
2	*Erythrina brucei*	Fabaceae	T	LC	WU, WG, GJ, SU, BA, HA, IL, KF, GD, GG, SD
3	*Impatienstinctoria*subsp.*abyssinica*	Balsaminacea	H	NT	KF, IL SU, BA, KF, IL
4	*Justicia diclipteroides* subsp. *aethiopica*	Acanthaceae	H	NT	SU, WG, IL, KF, GG, SD, BA
5	*Millettia ferruginea*	Fabaceae	T	LC	TU, GD, GJ, SU, WG, IL, HA
6	*Satureja paradoxa*	Lamiaceae	H	NT	KF, IL SU, BA, KF, IL
7	*Solanecio gigas*	Asteraceae	S	LC	GD, GJ, WU, SU, BA, KF, IL
8	*Tiliacora troupinii Cufod.*	Menispermaceae	L	VU	SU,IL,KF.SD
9	*Vepris dainellii*	Rutaceae	T	LC	GJ, SU, WG, IL, KF, SD, BA

Note: The distribution of the endemic species follows Flora of Ethiopia and Eretrea

SU = Shewa, IL = Ilubabor, WG = Wellega, AR = Arsi, KF = Keffa, GG = Gamo gofa, SD = Sidamo, GD = Gonder, GJ = Gojam, WU = Welo, BA = Bale, HA = Harar, TU = Tigray.

4.3. Commercially important tree species

Out of 23 major commercial indigenous tree species reported by EFAP (1994), Million Bekele and Leykun Berhanu (2001), nine species (39.13%) were recorded from the study area. Thesetree species are *Albizia gummifera, Apodytes dimidiata, Celtis africana, Cordia africana, Croton macrostachyus, Ekebergia capensis, Olea welwitschii, Syzygium guineense* and *Pouteria adolfi-friederici.*

4.4. Plant Community types in Gera Forest

Cluster analysis of vegetation data revealed three different community types (clusters) for Gera Forest (Figure 4). These clusters were designated as local plant community types and given names after two dominating and/or characteristic species, usually a tree and a shrub.

A dominant species in this case is a species having avalue (mean frequency x mean cover abundance) (van der Maarel *et al*., 1978) of at least three communities and a characteristic species being a species with synoptic values in one of the community types but absent in most of the other community types. Synoptic cover-abundance values for the most important species are shown in Table 7. The description of the plant community types based on the dominant and characteristic species with their altitudinal distribution is as follows.

I. *Bersama abyssinica -Canthium oligocarpum* Community Type

The altitudinal distribution of this community type distributed at altitudes between 2140 and 2445 m a.s.l., this community consists of 37 species. *Bersama abyssinica and Canthium oligocarpum* are the dominant species in the tree layer of this community type. The characteristic species of this type are *Ekebergia capensis* and *Hagenia abyssinica*, *Solaneciogigas*and

Vernonia auriculifera are the dominant species in the shrub layer. Ekebergia capensis, *Schefflera abyssinica, Prunusafricana* and *Oxyanthus speciosus* are the associated tree species. *Oplismenus hirtellus, Monothecium glandulosum, Desmodium repandum* and *impatiens tinctoria* are the dominant species in the herb layer of this community.

Table 4: Importance value index (IVI) values of Community TypeI

(RF =Relative Frequency, RD = Relative Density, and RDO = Relative Dominance)

Species	**RD %**	**RDO %**	**RF %**	**IVI %**
Bersama abyssinica	17.82	18.02	20.2	56.02
Schefflera abyssinica	4.29	4.34	21.13	29.76
Ekebergia capensis	3.3	3.33	9.7	16.34
Syzygium guineense	0.99	1	13.94	15.93
Canthium oligocarpum	6.6	6.67	2.19	15.47
Vernonia auriculifera	6.93	7.01	8.65	22.59
Prunus africana	3.63	3.67	6.26	13.56
Total	43.56	44.04	82.07	169.67

II.*Olea welwitschii - Coffea arabica* Community Type

The altitudinal distribution of this community type distributed at altitudes between 1898 and 2033 m a.s.l., the community consists of 46 species. *Olea welwitschii* species is dominant in the tree layer and *Coffea arabica* is the dominant species in the shrub layer. *Ehretia cymosa* is the characteristic species in the tree layer. Croton macrostachyus, Syzigium guineese, *Diosporyus abysssinica, and Galiniera saxifraga* are the associated tree species in this community Type.

Satureja paradoxa, Tectaria gemmifera, Desmodium repandum and *Bidens biternata* are the dominant species in the herb layer of this community.

Table 5: Importance value index (IVI) values of communityType II

(RF =Relative Frequency, RD = Relative Density, and RDO = Relative Dominance)

Species	**RD %**	**RDO %**	**RF %**	**IVI %**
Olea welwitschii	2.32	2.41	21.03	25.77
Syzigium guineese	1.39	1.44	22.80	25.64
Croton macrostachyus	4.65	4.82	15.74	25.21
Sapim ellipticum	1.86	1.93	13.59	17.38
Coffea arabica	6.97	7.24	7.23	15.46
Prunus africana	1.86	1.93	10.24	14.03
Ficus sur	3.25	3.38	5.04	11.67
Total	22.3	23.15	96.67	142.12

III.*Maesa lanceolata- Albizia gummifera Community* Type

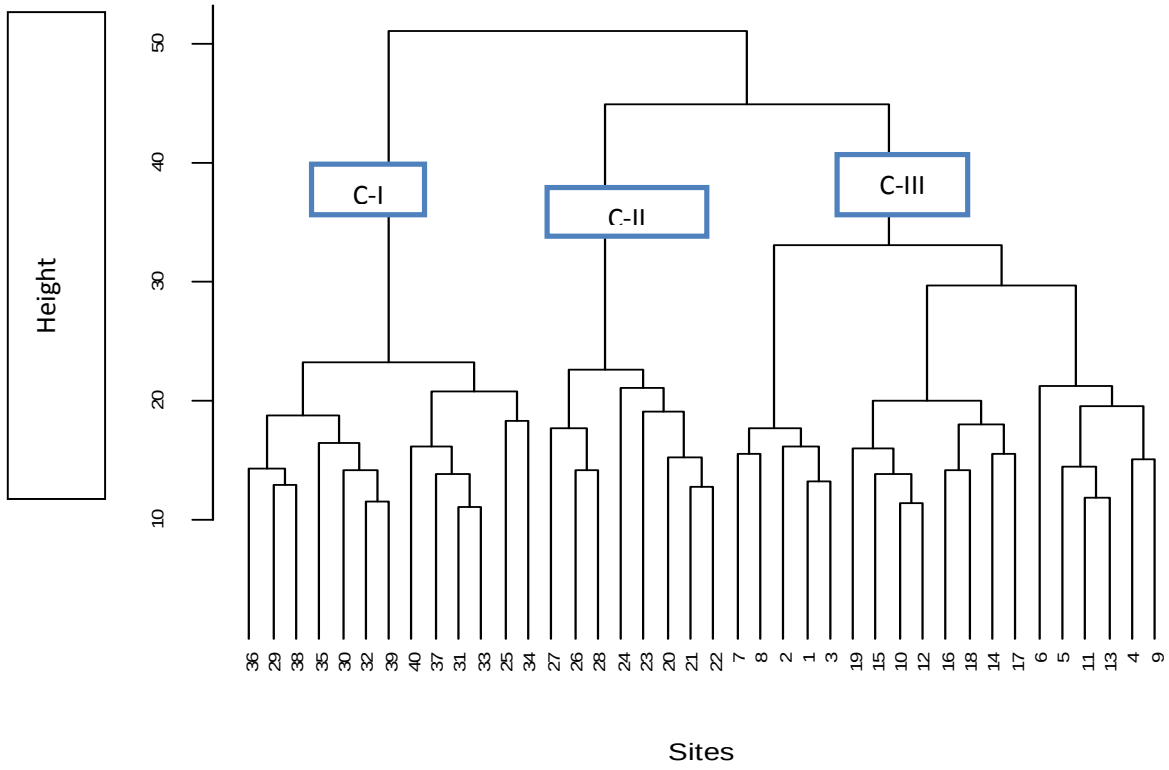
This community type was distributed at altitudes between 2328 and 2262 m a.s.l. and it is represented by 74 species. *Maesa lanceolata* and *Albizia gummifera* are thecharacteristics species of the tree layer, while Syzygium *guineense* is dominant species in the tree layer and *Vernonia auriculifera* is the dominant species in the shrub layer. *Brucea antidysenterica* and *Calpurina aurea* are the characteristic species.

*Bersema abyssinica, Trema orientalis, Schefflera abyssinica, Diosporyus abysssinica, Oxyanthus speciosus*and*Apodytes dimidiata*are associated tree species in this community Type (Table 6).*Croton macrostachyus*and *Prunus africana* are the dominant species in the shrub layer. *Monothecium glandulosum*, *Oplismenus hirtellus*and Euphorbia *schimperiana*are the dominant species in the herb layer.

Table 6: Importance value index (IVI) values of communityTypeIII

(RF =Relative Frequency, RD = Relative Density, and RDO = Relative Dominance)

Species	**RD %**	**RDO %**	**RF %**	**IVI %**
Bersema abyssinica	13.77	1.63	14.14	30.79
Schefflera abyssinica	0.54	27.04	0.96	28.55
Albizia gummifera	7.06	2.28	12.55	21.89
Syzigium guineese	6.73	1.63	6.45	21.25
Allophylus abyssinicus	8.44	1.63	7.02	17.09
Vepris dainellii	2.39	10.5	3.52	16.41
Diosporyusabysssinica	4.89	0.37	8.68	13.95
Oxyanthus speciosus	4.56	1.95	6.56	13.07
Total	48.38	47.03	59.88	155.29



Euclidean distance equation: $d_{jk} = \sqrt{\quad}^{2}$

Figure 4: Dendrogram of the vegetation data obtained from hierarchical cluster analysis of Gera Forest. (CI-CIII = Community types).

Communities (clusters) contain the following plots:-

C I: Plots 25, 29, 30, 31, 32, 33,34,35,36,37,38,39 and 40

C II: Plots 20, 21, 22, 23, 24, 26, 27 and 28

CIII: Plots 1, 2,3,4,5,6,7,8,9,10,11,12,13, 14, 15, 16, 17, 18 and 19

Table 7*:* Synoptic cover-abundance values for species having a value of > 1.0 in at least one community type. (Values in bold refer to occurrences as dominant species).

Species	Community I	Community II	Community III
Bersema abyssinica	**25.93**	0.00	6.25
Canthium oligocarpum	**14.21**	0.00	6.05
Monothecium glandulosum	**9.12**	3.50	9.52
Croton macrostachyus	**10.23**	7.00	8.68
Oplismenus hirtellus	10.25	4.8	0.39
Tectaria gemmifera	**8.48**	7.60	7.76
Olea welwitschii	0.00	**18.55**	0.39
Coffea arabica	0.00	**13.25**	0.37
Maesa lanceolata	0.00	0.00	**18.92**
Albizia gummifera	0.00	0.00	**17.31**
Vernonia auriculifera	5.81	2.70	**18.92**
Syzygium guineense	2.26	3.15	**17.31**
Desmodium repandum	3.69	6.6	0.37
Vernonia amygdalina	1.08	2.24	4.30
Maytenus gracilipes	0.00	3.75	2.21
Millettia ferruginea	0.00	4.87	2.03
Brucea antidysenterica	0.00	0.00	1.77
Vepris dainellii	0.00	2.50	0.87
Oxyanthus speciosus	1.69	0.00	0.84
Calpurina aurea	0.00	0.00	0.82
Erythrina brucei	0.00	0.00	0.73
Ficus sur	0.00	4.40	0.67
Pouteria adolfi–friedericii	3.96	0.00	0.50
Polyscias fulva	1.07	0.00	0.17
Salaneciio angulatus	0.00	0.00	0.08
Diosporyus abysssinica	0.38	1.25	0.00
Teclea noblis	0.46	2.70	0.00
Ehretia Cymosa	0.00	0.50	0.00
Erythrina brucei	0.00	0.00	0.73
Ekebergia capensis	3.25	0.00	0.00
Hagenia abyssinica	1.50	0.00	0.00

4.5. Species Diversity

The highest species richness and diversity was observed in community**III** (Table 8), this community attained a species evenness index of 0.97.

Community TypeIIwas the secondhighest in terms of species richness, diversity and evenness (Table 8). Community I has the least species richness and diversity but the highest in terms of species evenness from all communities (Table 8).

Table 8: Shannon - Wiener Diversity Index

Communities	**Diversity index (H')**	**Species richness (S)**	**H_{max}**	**Equitability (J)**
I	3.57	37	3.61	0.99
II	3.75	46	3.83	0.98
III	4.19	74	4.32	0.97

4.6. Similarity among plant communities

Sorenson's similarity coefficient was used to determine the similarities among plant communities (Table 9). Accordingly, community I and II had the highest similarity ratio which is 0.69. Next to above communities, community II and III had higher similarity ratio which is 0.65. The least similarity ratio was observed among community I and III which is0.64 (Table 9).

Table 9: Sorensen similarity coefficient among community types

	Community I	Community II
CommunityII	0.69	
CommunityIII	0.64	0.65

4.7. Vegetation Structure

4.7.1. Tree and shrub density

The ratio of density of individuals with DBH > 10 cm to density of individuals with DBH > 20 cm is taken as a measure of the size classes distribution (Grubb *et al.*, 1963). Trees and shrubs density of Gera Forest, expressed as the number of individuals with DBH ≥2.5 cm were 1431 individuals /ha. Individuals with DBH between 10 and 20 cm and with DBH greater than 20 cm were 318 /ha (22.22%) and 235 /ha (16.42%) respectively (Table 10). Accordingly, the ratio of individuals between 10 and 20 cm DBH to DBH > 20 cm was 1.35 for Gera Forest, indicating a dominance of small sized individuals. Comparisons of tree densities with DBH between 10 and 20 cm (a), DBH > 20 cm (b) and the ratio (a/b) for Gera Forest with other 10 forests in Ethiopia is given in Table 10.

Table 10: Distribution of individuals in different DBH classes

DBH (cm)	No. of individuals /ha	%
2.5-10.0	878	61.35
10.1-20.0	318	22.22
>20.0	235	16.42
Total	1431	100

Table 11: Comparisons of tree densities with DBH between 10 and 20 cm (a) and tree densities with DBH > 20 cm (b) of Gera Forest with 9 other forests in Ethiopia

Forests	a	b	(a/b)	Sources
Alata-Bolale	365	219	1.67	Woldeyohannes Enkossa, 2008
Belete	613	323	1.90	Kitessa Hundera and Tsegaye Gadissa, 2008
Bibita (Gura Ferda)	500	263	1.90	Derje Denu, 2006
Dodola	521	351	1.48	Kitessa Hundera *et al.* 2007
Donkoro	526	285	1.90	Abate Ayalew *et al*. 2006
Jibat	565	287	1.96	Tamrat Bekele, 1993
Masha - Andaracha	384.7	160.5	2.40	Kumlachew Yeshtela and Taye Bekele, 2003
Menna- Angetu	292	139	2.10	Ermias Lulekal *et al*. 2008
Sese	513.7	412.7	1.24	Shiferaw Belachew, 2010
Gera	318	238	1.35	Present study

4.7.2. Diameter at breast height (DBH)

The diameter at breast height (DBH) class distribution of woody species of Gera Forest is given in (Figure 5). A total of 1,431 individuals/ha with DBH ≥ 2.5 cm were counted within sampled plots. As the DBH class size increases, the number of individuals gradually decreases ranging from 878 stems/ha in the lowest class down to 16stems/ha in the highest DBH classes.

This appears to be a regular distribution that resembles the inverted J-shaped distribution of individuals in the different DBH classes (Figure 5). About 61.35% of individuals have DBH between 2.5 cm and 10 cm. few individuals of *Pouteria adolfi-friederici, Albizia gummifera, Oleawelwitschii, Schefflera**abyssinica*and *Prunus africana* were encountered in the higher DBHclasses.

The middle DBH classes were also dominated by the above species and additionally with few individuals, of *Allophylus abyssinicus, Polyscias fulva, Olea capensis, Syzygium guineense, Millettia ferruginea* and*Ficus sur.* High proportion of DBH density was contributed by*Maytenus gracilipes, Bersama abyssinica, Coffea arabica, Vernonia auriculifera, Croton macrostachyus, Solanecio gigas*and*Canthium oligocarpum.*

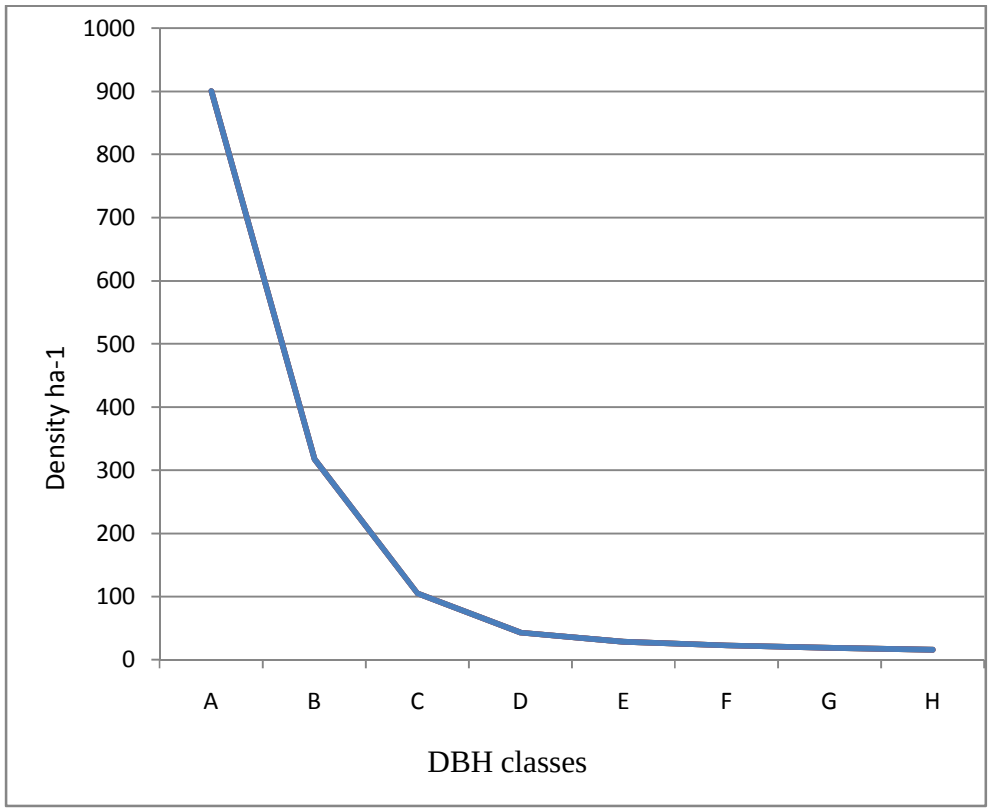


Figure 5: Density (%)/ha of individuals in DBH classes

Legend: DBH class A = 2.5 -10.0 cm, B = 10.1-20.0 cm, C = 20.1- 30.0 cm, D =30.1- 40.0 cm, E= 40.1-50.0 cm, F = 50.1- 60.0 cm, G= 60.1-70.0 cm and H>70.0 cm.

4.7.3. Height class distributions

The height class distribution of trees and shrubs in Gera Forest indicated that more than 62.26 % of the individuals had heights less than nine meters (Figure 6). Species that contributed most to these values in the lower height classes were *Maytenus gracilipes, Coffea arabica, Bersama abyssinica Maesa lanceolata, Millettia ferruginea, Rytigynia neglecta, Dracaena afromontana, Teclea nobilis* and *Vepris dainellii*.

Gera Forest is occupied by species like *Allophylus abyssinicus, Croton macrostachyus, Polyscias fulva, Olea capensis*and*Syzygium guineense*which contributed most to medium heightclasses. Trees representing the highest height classes (2.38%) dominating the upper canopyare*Pouteria adolfi-friederici, Prunusafricana, Oleawelwitschii*and*Albizia gummifera.*

Pouteria adolfi-friederici is the emergent tree and grows above all the canopy trees in Gera forest. Generally, the highest proportion of species is concentrated in the lower height class followed by the middle and upper height classes of the vertical structure of Gera forest.

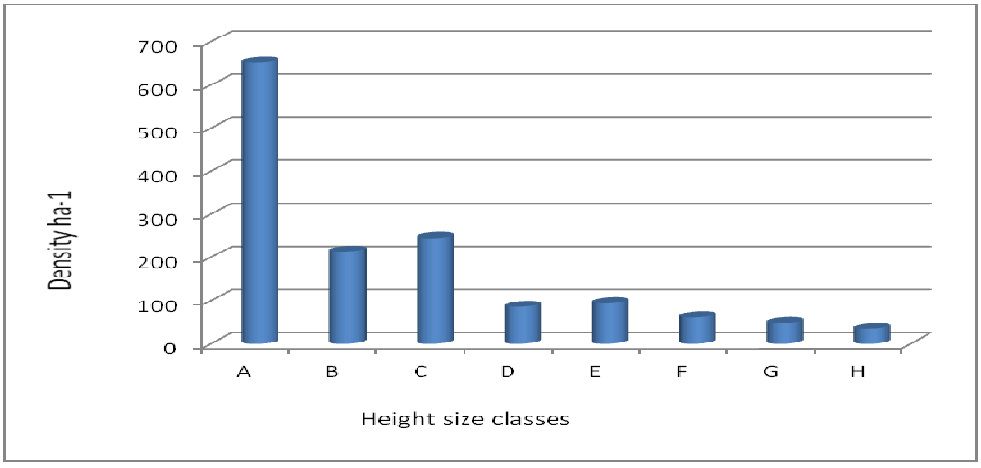


Figure 6: Distribution of individuals/ha among the height classes
Legend: A= 2.5-6.0 m, B= 6.1- 9.0 m, C= 9.1-12.0 m, D= 12.1-15.0 m, E= 15.1-18.0 m, F= 18.1- 21.0 m, G= 21.1-24.0 m and H > 24.0 m.

4.7.4. Importance value index (IVI)

Analysis of importance value index (IVI) is used for setting conservation priority. Those species with lower IVI values need high conservation efforts while those with higher IVI values need monitoring management. The importance value index (IVI) of most dominant species of Gera Forest was calculated and presented in Table 12. The results of the analysis show that *Bersama abyssinica, Maytenus gracilipes, Coffea arabica* and *Vernonia auriculifera*to be the first four most important species with higher IVI values (Table 12). Analysis of the relative *density* indicated that*Bersama abyssinica, Maytenus gracilipes, Coffea arabica,* and *Vernonia auriculifera* were the four most abundant species and constituting about 57.84% of the total density (Table 12).

4.7.5. Dominant Species

Based on their IVIvalues, the most dominant and ecologically use full woody plants in Gera Forest were *Bersama abyssinica, Syzygium guineense, Maytenus gracilipes, Croton macrostachyus, Coffea arabica, Vernonia auriculifera, Oxyanthusspeciosus, Canthium oligocarpum, Solanecio gigas, and Vepris dainellii.*

Table 12: Importance value index (IVI) values of dominant tree species in Gera Forest
(RF =Relative Frequency, RD = Relative Density, and RDO = Relative Dominance)

Species	RD %	RDO %	RF %	IVI %
Bersama abyssinica	16.83	37.51	17.36	71.7
Syzygium guineense	8.52	25.89	8.80	43.21
Maytenus gracilipes	16.54	3.46	17.01	37.01
Croton macrostachyus	8.52	19.00	8.80	36.32
Coffea arabica	12.67	4.08	13.01	29.76
Vernonia auriculifera	11.80	1.20	12.17	25.17
Oxyanthus speciosus	7.12	1.91	7.40	16.43
Canthium oligocarpum	5.22	4.08	5.38	14.68
Solanecio gigas	6.12	0.61	6.40	13.13
Vepris dainellii	4.45	2.25	4.59	11.29
Total	99.79	99.99	99.99	298.7

4.7.6. Species Population Structure

Five generalized patterns of population structure emerged from the analysis of the population structure of 20 selected dominant species in Gera Forest (Figure 7). The first pattern was formed by species with positively skewed distribution (inverted J-curve). These species had the highest density in the lower DBH classes with gradual decrease in density towards the higher DBH classes, which suggested good reproduction and recruitment potential in the Forest (Figure 7*) Bersama abyssinica, Canthium oligocarpum, Maytenus gracilipes, Teclea nobilis* and*V*epris *dainellii* had inverted J-curve structure. The second pattern was bell-shaped distribution formed by species with high number of individuals in the middle DBH classes. Species such as *Croton macrostachyus, Ficus sur,* and*Millettia ferruginea* were characterized by this distribution pattern.

The third pattern was formed by species having irregular distribution over diameter classes. Some diameter classes were poorly represented indicating selective removal of medium- sized individuals while other diameter classes were well represented. Species like *Prunus africana, Olea welwitschii, Albizia gummifera,* and *Macaranga capensis* had this type of population pattern.*Olea capensis*also showed this pattern ofdistribution.

The fourth pattern was exhibited by species with individuals well represented in the lower DBH classes but absent in the higher DBH classes, representing species with good reproduction but bad recruitment. Species like *Coffea arabica, Vernonia auriculifera* and*Oxyanthus speciosus* were characterized by this distribution pattern. The fifth pattern shows poor reproduction and complete absence of individuals in lower and intermediateDBH classes. Species like *Pouteria adolfi-friederici* and *Schefflera abyssinica* were characterized by this distribution pattern.

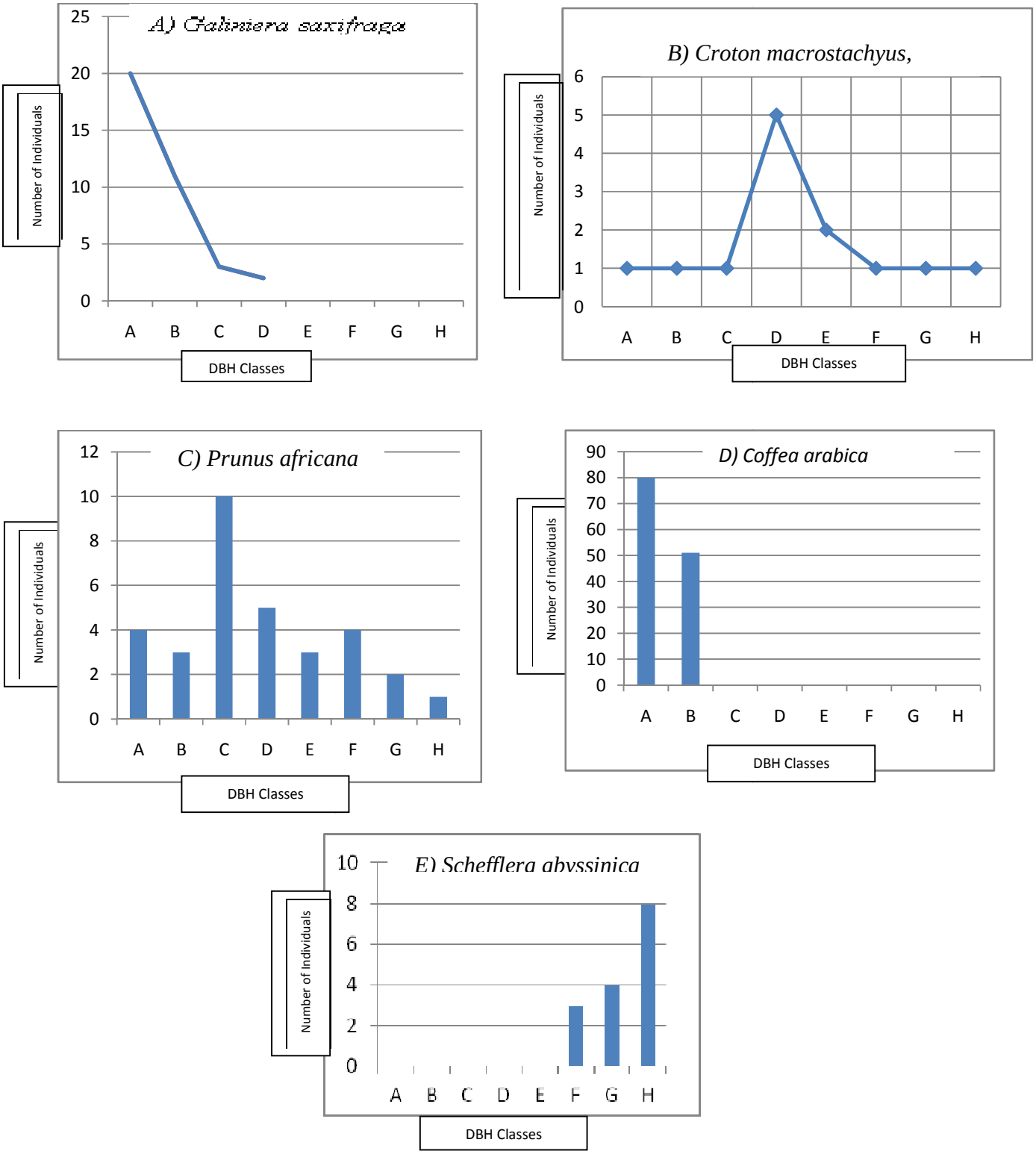


Figure 7(A-E): Population structure of some selected tree species.

Legend: DBH class A = 2.5-10.0 cm, B = 10.1-20.0 cm, C = 20.1- 30.0 cm, D=30.1-40.0 cm, E= 40.1-50.0 cm, F=50.1- 60.0 cm, G = 60.1-70.0 cm and H >70.0 cm.

An inverted J- shaped distribution was exhibited by some tree species representing a healthy regeneration. On the other hand, bell-shaped and irregular distribution patterns were also observed. Most of the species with irregular distributions are tree species that are hunted by the local people selectively for firewood, house construction, and timber or over grazing which affects the seedlings under the mother tree. The complete absence of individuals in some diameter classes indicates that the regeneration of species was in a weak position during one or several phases of their life cycle.

4.7.7. Regeneration Status of Gera Forest

The total seedlings and saplings of dominant woody species in the study area were about 2,839 and 1,553 individuals per hectare respectively.The highest density of seedlings and saplings were recorded for *Maytenus gracilipes, Coffea arabica, Vernonia auriculifera, Bersama abyssinica, Canthiumoligocarpum, Galinierasaxifraga, Oxyanthus speciosus, Solaneciogigas*and*Rytigynianeglecta.*Species like *Maesa lanceolata, Teclea nobilis* and*Syzygium guineense* showed the lowest seedling and sapling densities. On the other hand, some woody species like *Polyscias fulva, Pouteria adolfi-friederici* and*Schefflera abyssinica*lacked both seedlings and saplings in Gera Forest.

Table 13: List of selected woody species with their seedlings and saplings/ha used to determine the regeneration status of Gera Forest.

No.	Name of the species	No. of Seedling	No. of Sapling
1	*Maytenus gracilipes*	609	220
2	*Coffea arabica*	478	242
3	*Vernonia auriculifera*	374	184
4	*Bersama abyssinica*	224	171
5	*Canthium oligocarpum*	213	115
6	*Galiniera saxifraga*	201	108
7	*Oxyanthus speciosus*	177	56
8	*Solanecio gigas*	107	91
9	*Rytigynia neglecta*	104	84
10	*Croton macrostachyus*	59	39
11	*Olea welwichi*	60	35
12	*Prunus africana*	32	44
13	*Vepris dainellii*	32	33
14	*Vernonia amygdalina*	27	25
15	*Millettia ferruginea*	31	20
16	*Teclea nobilis*	25	22
17	*Apodyes dimidata*	19	17
18	*Maesa lanceolata*	14	13
19	*Clausena anisata*	13	12
20	*Syzygium guineense*	40	22
	Total / ha	2839	1553

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATIONS

5.1. Discussion

5.1.1. Floristic description and Vegetation classification

Astreaceae was the most dominant family in Gera forest with 13 species and related forest like Komoto forest with 17 species(Fekadu Gurmessa,2010), Bibita (GuraFerda) forest with 13 species (Derje Denu, 2006).Asteraceae was also reported as dominant family in the Aframontane Flora of Ethiopia (Negusse Tadesse, 2006; Getachew Tena et al. 2008). The high number of species in the family Astreaceae might have to-do well with well developed strategies and adaptive mechanism (topography, geographic isolation and optimal growth condition).

In addition, Astreaceae could produce the large number of seeds than the other plant families.

Dominance of families may vary in different forests of Ethiopia. For example, Kumelachew Yeshitela and Tamrat Bekele (2002) reported the dominance of Euphorbiaceae and Moraceae from Afromontane and transitional rainforest vegetation of southwestern Ethiopia.

Herbs were the highest species composition (38.53%) and the second highest species composition was tree (27.3%) in the floristic composition inGera forest (figure 3).

The reason for the high floristic composition of herbs could be falling old aged big trees and clear cutting of large trees from forest for deferent purposes by human activities. Herbs occupied the highest floristic composition in Bibta (Gura ferda) forest 36 % (Dereje Denu, 2006) and Komoto forest 34.44 % (Fekadu Gurmessa, 2010).

The proportion of endemic plant species (seven endemic species and two endemic sub species in Gera forest was lower than related forests: for example, Komoto forest 18 endemic species (Fekadu Gurmessa, 2010), Bibta (Gura Farda) forest 12 endemic species Derje Denu, 2006, and sese forest has 10 endemic species (Shiferaw Belachew, 2010).

5.1.2. Species Diversity of the Plant Communities

The highest species richnessand diversitywere observed in communities three (Table 8). The possible reason for high species richnessand diversity of community three may be altitudinal factor because intermediate altitude could be associated with optimal conditions of environmental factors that favor vegetation growth. The dominance of *Syzygium guineense in* the community may be due to its low demand for timber and construction purposes by the local people and also its seeds germinating rapidly and easily. Kitessa Hundera and Tsegaye Gadissa (2008) reported similar results from Belete Forest of southwest Ethiopia.

Community two was the second highest interms ofspecies richness anddiversity because its species are evenly distributed (Table 8).Inthis community *high dominance of coffea arabica* indicates, the moist evergreen afromontane forests of South west Ethiopia are the center of origin and diversity of *coffea arabica* and Wild coffee occurs as an under storey shrub in these forests at an altitude between 1,500 and 1,900 meters above sea level (Friis, 1992).

Community I exhibited the least in terms of species richness and diversity, butthe highest in terms of species eveness (Table 8). As the community lies along the margin of the forest (easily accessible), anthropogenic impacts such as selective removal of economically important trees, grazing by live stock etc. could contributed for low species richness and less diversity. For example, Livestock's were observed in the forest margin during field study (Plate 3).

5.1.3. Structural Description

Analysis of population structure revealed that five generalized patterns (Fig. 7).The first pattern was formed by species with positively skewed distribution (inverted J-curve). These species had the highest density in the lower DBH with gradual decrease in density towards the bigger sizes, which suggested good reproduction and healthy regeneration potential in the forest, for example*Galiniera saxifraga*(Figure 7A).The study in Masha Anderacha Forest (Kumelachew Yeshitela and Taye Bekele, 2003) showed a similar pattern.

The second pattern was bell-shaped distribution formed by species with high number of individuals in the middle DBH classes, for example*Crotonmacrostachyus* (Figure 7B). This pattern indicates apoor reproduction and recruitment of species which may be associated with intense competition from the surrounding trees.

The third pattern was formed by species having irregular distribution over diameter classes, for example, *Prunus africana* (Figure 7C). Some diameter classes were poorly represented indicating selective removal of specific sized individuals while other diameter classes are well represented. These plant Species hunted, by local people for different purposes like construction, timber, farm implements and fire wood. For example, *Olea welwitschii* is widely used by the local people for farm implements and debarking of the medium sized individuals for beehive making and the use of bark for smoking houses. Kitessa Hundera and Tsegaye Gadissa (2008) reported similar results from Belete Forest of southwest Ethiopia.

The fourth pattern was exhibited by species with individuals well represented in the lower DBH classes but absent in the higher DBH classes, representing species with good reproduction but bad recruitment,for example *Coffea arabica* (Figure 7D).

The fifth pattern is represented by *Schefflera abyssinica* (Figure 7E). This pattern shows individuals are frequent only in the highest DBH classes and complete absence of individuals in lower and intermediate DBH classes. This indicates poor reproduction, very big trees, and no longer reproducing. This relationship was also observed in Sese Forest by Shiferaw Belachew (2010), Chilimo and Menagesha Forests (Tamrat Bekele, 1993), Masha- Andracha Forest (Kumlachew Yeshtela and Taye Bekele, 2003), and Alata-Bolale Forest (Woldeyohannes Enkossa, 2008) (Table 11).

High proportion of DBH class was contributed by *Maytenus gracilipes, Bersama abyssinica, Vernonia auriculifera, and Solanecio gigas*and*Canthiumoligocarpum.*As the DBH of *Coffea arabica* falls between 2.5 to 10 cm range, it contributes most only for the first DBH class (Figure 7D).

Density distribution at different height classes in the study area showed that more than 77.5% of the individual's less than or equal to 2 meters in height and 16.77 % of individuals fall between 12.1- 21.0 meters range. Individual's ≥ 21.1 meters in height are 5.73% (Figure 6). Density distribution at different height classes also showed similar trend as that of DBH classes. The highest proportion of species is concentrated in the lower height classes followed by the middle and upper height classes of the vertical structure of the Forest.

Thus, this study confirms that the number of individuals decreased as the height of the individuals increased suggesting the dominance of low height individuals in the Forest.

This could be due to long time disturbance of the Forest. This result is in line with the results observed in Bonga Forest by Ensermu Kelbessa and Teshome Soromessa (2008).

Trees representing the highest height classes (5.73%) dominating the upper canopy are *Pouteria adolfi-friederici, Prunus africana, Olea welwitschii* and *Albizia gummifera.*

Two major groups of woody species can be recognized based on the five patterns of species population structure. The first group consists of species that are capable of regenerating in the Forest under-story. These species are *Maytenus gracilipes, Bersama abyssinica, Maesa lanceolata, Syzygium guineense, Vernonia amygdalina* and*Vernonia auriculifera.*

The second group includes those species that are old and large sized but not well represented by their seedlings and saplings showing poor regeneration in the Forest. These species are*Pouteria adolfi-friederici* and*Schefflera abyssinica.*

Nichols (2005) reported that the seeds of *Schefflera abyssinica* do not germinate readily. Young plants of *Schefflera abyssinica* prefers growing on other plants. As a result, the seedlings were not seen on the ground (Ensermu Kelbessa and Teshome Soromessa, 2008).

Most of the species with irregular distributions are tree species that are hunted by the local people selectively for house construction, firewood and timber production or overgrazing which affects the seedlings under the mother trees.

The complete absence of individuals in some diameter classes indicates that the regeneration of species was in a weak position during one or several phases of their life cycle. These mighthave been caused by trampling livestock, selective cutting for construction, timber or firewood purposes (Fekadu Gurmessa, 2010).

High dominance and density of *Bersama abyssinica* and *Syzygium guineense* might be due to their low demand by the local people for timber and other construction purposes andtheier less palatability to brothers.

The highest composition, distribution and density of seedlings and saplings of *Maytenus gracilipes, Coffea arabica, Vernonia auriculifera, Bersema abyssinica, Canthium oligocarpum, Clauseniaanisata, Oxyanthus speciosus* and *Solanecio gigas*are the indicators of the good regeneration status.Finally, the presence of more seedlings and saplings indicate Gera Forest is indicates good regeneration.

5.2. Conclusion and Recommendations

5.2.1. Conclusion

The study has resulted in the documentation of 150 vascular plant species representing 112 genera and 60 families. Asteraceae and Fabaceae were found to be the most dominant families followed by Rubiaceae, Euphorbiaceae, Lamiaceae Acanthaceae, and Malvaceae.Boraginaceae, Celasteraceae, Rosaceae, Rutaceae, Moraceae, Oleaceae, Piperaceae, Polypodiaceae, Rosaceae, Sterculiaceaeand Urticaceae families had also usefull contribution to the overall species composition of Gera Forest. This Forest was also an important reservoir of endemic plants.

About nine endemic plant taxa (species and sub species), some of which are in the IUCN Red Data List were identified. Hence, Gera Forest could serve for the purpose of biodiversity conservation. It also has agronomical significance due to its high wild coffee (*Coffea arabica)* gene pool.

The vegetation of Gera Forest was grouped into three plant CommunityTypes. The highest species richness and diversity was observed in Community three and the second highest species richness and diversity was observed in Community two. Community type 1 exhibited the least species richness and the highest species evenness. The variation in species composition and diversity among communities could be associated with different factors, such as altitude, anthropogenic impacts and soil properties.

The presence of relatively higher percentage of lower diameter size in the Forest indicated that Gera Forest is at stage of good regeneration. In addition, the density of woody species in Gera Forest decreased with increasing DBH and height classes implying good recrutment.

Analysis of population structure of most common species of trees and shrubs revealed different patterns of population structure, indicating a high variation among species population dynamics of Gera Forest. Accordingly, five population patterns have been observed in Gera Forest.

Analysis of regeneration of some selected woody species revealed that some tree species have lower seedling and sapling stages while others are represented by more seedling, sapling and mature stages in the Forest.

5.2.2. Recommendations

Gera Forest is one of the remaining forests harboring a gene reserve of wild coffee and several associated economic plant species. This Forest is ecologically, socially and economically very important for the population residing nearby who are mostly dependent on forest products to make their living. Loss of such a forest and the various threatened species would have great implications for the environment, biodiversity and socio-economic system of the communities.

The concerned bodies have to take due consideration for conservation and sustainable utilization of this Forest resource.

Based on the results of the study, for effective management and monitoring of Gera Forest on a sustainable basis the following recommendations were drawn.

- Creating public awareness, through extension programs, on the multiple uses of forest resources and ecosystems are essential to protect the biodiversity of the Forest because the current destruction of the Forest needs to be arrested through the collaborative effort government and the local community.
- The management strategy should focus on multiple-use conservation approach. For example, undisturbed areas of the Forest can be designated for strict conservation so that they may act as repositories of biodiversity and possibly as a source of forest genetic resources while the peripheral areas could be utilized on a sustainable basis,
- Assist in propagation and distribution of seedlings of *Schefflera abyssinica, Polyscias fulva, Olea capensis, Olea welwitschii* and *Prunus africana* whose uses are already wide spread in the study area.
- Introduce modern beehive so as to reduce the pressure on selectively utilized species for the purposes of hive construction in particular, *Olea welwitshii, Polyscias fulva* and *Croton macrostachyus.*
- Initiate enrichment plantation of those species that have been over utilized for various purposes such as *Prunus africana, Olea welwitschii, Macaranga capensis, Pouteria adolfi-friedrici* and *Polyscias fulva.*
- Natural regeneration of species in the Forest can be facilitated through reduced grazing pressure, and
- The present study is limited to species composition and structure then further studies on environmental parameters, forest management and conservation system, and regeneration of the woody species is recommended.

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APPENDICES

Appendix 1: Sample Plots together with their corresponding altitudeand location

Transect	Plot (Quadrat)	Altitude (m a.s.l)	Latitude	Longitude
1	1	2328	$07^0$77. 433' N	$036^0$23. 609' E
1	2	2338	$07^0$77.33' N	$036^0$23.62' E
1	3	2334	$07^0$77.201' N	$036^0$23.539' E
1	4	2189	$07^0$76.056' N	$036^0$24.051' E
1	5	2180	$07^0$75.943' N	036^0 24.131' E
1	6	2114	$07^0$75.811' N	036^0 24.172' E
2	7	2230	$07^0$45.701' N	$036^0$14.139' E
2	8	2262	07^0 45.767' N	036^0 14.071' E
2	9	2278	$07^0$45.767' N	036^0 14.071' E
1	10	2033	07^0 42.708' N	$036^0$15.734' E
1	11	2043	$07^0$42.726' N	$036^0$15.692' E
1	12	2040	$07^0$42.775' N	036^0 15.604' E
2	13	1819	07^0 38.343' N	036^0 14.358' E
2	14	1828	07^0 38.399' N	036^0 14.358' E
2	15	1846	$07^0$38.459' N	036^0 14.253' E
3	16	1930	07^0 39.088' N	036^0 14.961' E
3	17	1943	$07^0$339.159' N	036^0 14.95' E
3	18	1898	$07^0$39.104' N	036^0 14.815' E

1	19	2460	$07^0$51.684' N	036^0 29.22' E
1	20	2436	$07^0$51.615' N	036^0 20.901' E
1	21	2435	$07^0$51.555' N	036^0 20.911' E
2	22	2431	$07^0$51.414' N	036^0 20.578' E
2	23	2436	$07^0$51.343' N	036^0 20.682' E
2	24	2483	$07^0$1.311' N	036^0 21.032' E
1	25	2539	$07^0$51.436' N	036^0 21.156' E
1	26	2475	$07^0$51.435' N	036^0 21.058' E
1	27	2494	$07^0$51.436' N	036^0 21.059' E
2	28	2439	$07^0$50. 869' N	036^0 20. 869' E
2	29	2526	$07^0$50.955' N	036^0 20.914' E
2	30	2445	$07^0$51.045' N	$036^0$20.97' E
3	31	2140	$07^0$45. 424' N	$036^0$14.367' E
3	32	2105	$07^0$45. 442' N	$036^0$14.583' E
3	33	2139	$07^0$45.510' N	$036^0$14.539' E
2	34	2150	$07^0$45.555' N	$036^0$14. 520' E
2	35	2147	07^0 45.557' N	$036^0$14. 498' E
2	36	2152	07^0 45.685' N	$036^0$14.486' E
2	37	2173	$07^0$45.738' N	$036^0$14.435' E
3	38	2168	$07^0$45.774' N	$036^0$14.614' E
3	39	2181	$07^0$45.788' N	$036^0$14.537' E
3	40	2202	$07^0$45.841' N	$036^0$14.504' E

Appendix 2: List of plant species collected from Gera Forest. Key: T=Tree, S=Shrub, H=Herb, L=liana and S/T = Shrub or Tree.

No	**Scientific Name**	**Family**	**Vernacular Name (afan oromo)**	**Habit**	Coll.No
1	*Acanthus eminens* C.B. Clarke	Acanthaceae	Balawarantii	S	BB0077
2	*Achyranthes aspera* L.	Amaranthaceae	Tebedima	H	BB0076
3	*Achyrospermum schimperi* (Hochst.exBriq.)Perkins	Lamiaceae	Bala dalecha	H	BB102
4	*Adenostemma mauritianumDC.*	Asteraceae	Maxxanee	H	BB0059
5	*Adiantum incissum Forsssk.*	Adiantaceae		H	BB103
*6	*Aframomum corrorima* (Braun) Jansen	Zingiberaceae	Koroorima	H	BB0073
7	*Aframomum zambesiacum* (Baker) K.Schum.	Zingiberaceae ceae	Ogiyo delieessa	H	BB104
8	*Ageratum conyzoides* L.	Asteraceae		H	BB0026
**9	*Albizia gummifera* (J.F.Gumel.) C.A.Sm.	Fabaceae	Hambabbeessa	T	BB0017
10	*Allophylus abyssinicus* (Hochst.) Radlkofer	Sapindaceae	Se'o	T	BB 0032
**11	*Apodytes dimidiata* E.Mey.ex Am.	Icacinaceae	Wandabiyoo	T	BB0025
12	*Arthropteris monocarpa* (Cordem.) C.Chr	Oleandraceae		H	BB105

13	*Asparagus racemosus* Willd.	Asparagaceae	Sariitii	L	BB0083
14	*Asplenium aethopicum* (Burm.f.) Becherer	Aspleniaceae		H	BB106
15	*Asplenium protensum* Schard.	Aspleniaceae	Qawo	T	BB107
16	*Bersema abyssinica* Fresen.	Melianthaceae	Lolchiisaa	T	BB004
17	*Bidens biternata* (Lour.) Merr. &Sherff	Asteraceae	Chegoget	H	BB0034
18	*Brucea antidysenterica* J.F. Mill.	Simaroubiaceae	Boqo	S/T	BB0019
19	*Byttneria catalpitiolata* Jacq.	Sterculiaceae	Haleele	T	BB0093
20	*Calpurina aurea* (Ait.) Benth.	Fabaceae	Ceekaa	S	BB0094
21	*Carduus schimperi* Sch. Bip. Ex A. Rich.	Asteraceae H	Harree	H	BB 149
22	Carissa spinarum L.	Apocyanceae	Hagamsaa	S	BB 148
23	*Canthium oligocarpum*Hiern	Rubiaceae	Mixoo	S	BB003
24	*Clausenia anisata (Willd.)* Benth.	Rutaceae	Ulumaayii	S	BB0028
**25	*Celtis africana* Burm.f.	Ulmaceae	Herngema	S	BB108
26	*Chamaecrista mimosoides* (L.)Greene	Fabaceae		S	BB109
27	*Clerodendron myricoides* (Hochst.) Vatke	Lamiaceae	Marasissaa	S	BB0091

28	*Coffea arabica* L.	Rubiaceae	Buuna	S/T	BB0043
29	*Combretum paniculatum* Vent.	Combretaceae	Baggee	L	BB0080
30	*Commelina benghalensis* L.	Commelinaceae	lalunxyee	H	BB0067
31	*Coniogramme africana* Hieron	Hemionitidaceae	Qmenno	T	BB110
**32	*Cordia africana* Lam.	Boraginaceae	Waddeessa	T	BB0075
33	*Crotolaria incana* L.	Fabaceae	Atokemelle	H	BB0046
34	*Crotolaria mildbraedii* Bak.f.	Fabaceae	Yudo	T	BB111
**35	*Croton macrostachyus* A.Rich	Euphorbiaceae	Bakkanniisa	T	BB092
36	*Culcasia falcifolia* Engl.	Araceae	kello	L	BB0030
37	*Cyathea manniana* Hook.	*Cyatheaceae*	Senso	S/T	BB0066
38	*Cynoglossum amplifolium*.	Boraginaceae	Chaqo	H	BB0084
39	*Cynoglossum coeruleum*Hochst. exA.DC. in DC.	Boraginaceae	Chati	H	BB0065
40	*Deinbollia kilimandscharica* Taub	Sapindaceae	Sookokee	H	BB112
41	*Desmodium repandum* (Vahl) DC.	Fabaceae	Dargu	H	BB0022
42	*Diospyorus abysssinica* (Hiern.) F.White	Ebenaceae	Lookoo	T	BB0033
43	*Domboya longebracteolata Seyani*	Sterculiaceae	Dhoqonuu	S	*BB113*
44	*Dombeya torrida* (J.F. Gamel.) P. Bamps.	Sterculiaceae	Daannisa	*T*	BB0012

45	*Dracaena afromontana* Mildbr.	Dracaenaceae	Emoo	T	BB0018
46	*Dracaena steudneri* Engl.	Dracaenaceae	Haremuko	S	BB114
47	*Drynaria volkensii* (Hieron).	Polypodiaceae	Hadaamii	T	BB115
48	*Ehretia cymosa* Thonn.	Boraginaceae	Ulaagaa	T	BB0068
**49	*Ekebergia capensis* Sparrm.	Meliaceae	Somboo	T	BB0011
50	*Englerina woodforiodes (Schweinf.)*	Lorantaceae	Dambii	T	BB116
51	*Erythrina brucei* Schweinf.	Fabaceae	Waleensuu	T	BB0054
52	*Euphorbia ampliphylla* Pax.	Euphorbiaceae	Akuukkuu	T	BB117
53	*Euphorbia schimperiana* Scheele	Euphorbiaceae		H	BB0090
54	*Euphorbia* Sp.	Euphorbiaceae		H	BB0035
55	*Fagaropsis angolensis* (Engl.) Dale	Rutaceae	Siglu	T	BB0074
56	*Ficus lutea* Vahl	Moraceae	Burui	S	BB118
57	*Ficus thonningii* Blume	Moraceae	Mukafoni	S/T	BB119
58	*Ficus sur* Forssk.	Moraceae	Harbuu	T	BB009
59	*Flacourtia indica (*Burm.f.) Merr.	Flacourtaceae	Hincinnii	S	BB120
60	*Galinieria saxifraga* (Hochst.) Bridson	Rubiaceae	Simararuu	T	BB001
61	*Gardenia ternifolia*chumach. & Thonn.	Rubiaceae	SUddeo	S	BB0029
62	*Geranium arabicum* Forssk.	Geraniaceae	Bucha	H	BB0061

63	*Grewia ferruginea* Hochst. ex A.Rich.	Tiliaceae		H	BB121
64	*Girardinia bullosa* Wedd.	Urticaceae	Doobbii	H	BB0096
65	*Girardina diversifolia* (Link) Friis	Urticaceae	G urgubbee	H	BB0079
66	*Gouania longispicta* Engl.	Rhamnaceae	Homochiisa	L	BB0097
67	*Guizotia scabra* (Vis) Chiov.	Asteraceae	Haadaa	H	BB0037
68	*Guizotia schimperi* Sch.Bip.ex Walp.	Asteraceae	Tuufoo	H	BB0055
69	*Hagenia abyssinica* (Bruce) J.F.Gmel.	Rosaceae	Heexoo	T	BB0088
70	*Halleria lucida* L.	Scrophulariaceae	Kichu	H	BB122
71	*Hibiscus cannabinus* L.	Malvaceae	Kunchegajo	H	BB0082
72	*Hibiscus macranthus* Hochst.ex A.Rich.	Malvaceae		H	BB123
73	*Hibscus micrantus* L.f.	Malvaceae	Nacaa	H	BB0085
74	*Hibiscus vitifolius* L.	Malvaceae			BB124
75	*Hippocrata africana* (Willd.) Loes	Celasteraceae	Hidagalle	L	BB0027
76	*Hypoestes forskaolii* (Vahl) R.Br.	Acanthaceae	geeboo	L	BB125
77	*Ilex mitis* (L) Radlk.	Aqufoliaceae	Hororo	T	BB126
78	*Impatiens hochstetteri* Webb.	Balsaminaceae		*S*	BB127
*****79	*Impatiens tinctoria* A.Rich. *Subsp. abyssinica* (Hook.f.) Grey Wilson	Balsaminaceae	Hansoosilla	H	BB0069

80	*Jasminum abyssinicum* Hochst. ex DC.	Oleaceae	Hidda Ichilbee	L	BB0070
*****81	*Justicia diclipteroides Hedrein* subsp *.aethiopica*	Acanthaceae		*H*	BB128
82	*Justicia schemperiana Hochst.ex Nees.)T.Anders.*	Acantaceae	Dhumugaa	S	BB129
83	*Kalanche quartiniana* A.Rich.	Crassulacea	Bosoqqee	H	BB0049
84	*Kotschya africana* Endl.	Fabaceae	Heennaa	S	
85	*Landolphia buchananii* (Hall.f.) Stapf.	Apocyanceae	Xunanne	T	BB130
86	Lantana trifolia *L.*	Verbenaceae	Munandurba	S	
87	*Lepidotrichilia volkensii* (Gurke.) Leroy.	Meliaceae	Goraa	S	BB131
88	*Lepisorus excavatus (BoryexWilld.)Ching*	Polypodiaceae	Qobo	S	BB132
89	*Leucas martinicensis* (Jacq.) R. Br.	Lamiaceae	Fidoo	H	BB0060
90	*Lippia adoensis* Hochst.ex Walp	Verbenanaceae	kusaayee	S	BB0086
91	Loxogramme abyssinica(Baker)M.G.Price	Polypodiaceae		H	BB133
92	*Macaranga capensis* (Bail.) Sim.	Euphorbiaceae	Wongo	T	BB008
93	*Maesa lanceolata* Forssk.	Myrsinaceae	Abbayyii	S	BB0099

94	*Margaritaria discoidea* (Baill.)Webster	Euphobiaceae		H	BB134
95	*Mariscus sieberianus* Nees	Cypraceae	Qilimxoo	T	BB135
96	*Maytenus arbutifolia* (A .Rich.) Wilczek	Celastraceae		H	BB136
97	*Maytenus gracilipes* (Welw.ex Oliv.) Excell	Celastraceae	kombolchaa	*S*	BB0014
98	*Maytenus undata* (Thunb.) Blakelock	Celastraceae		T	BB137
99	*Medicago polymorpha* L.	Fabaceae	Siddisa	H	BB0036
*100	*Millettia ferruginea* (Hochst.) Bak	Fabaceae	Askira	T	BB0041
101	*Momordica foetida* Schumach.	Cucurbitaceae		H	BB138
102	*Monothecium glandulosum*Hochst.	Acanthaceae	Tobe	H	BB0023
103	*Olea capensis* L.	Oleaceae	Gegema	T	BB0071
***10*4	*Olea welwitschii* (Knobl.) Gilg & Schellenb.	Oleaceae	Baya	T	BB002
105	*Oplismenus hirtellus* (L.) P.Beauv.	Poacaeae	Salmayee	H	BB0021
106	*Oryla latifolia* L.	Poacaeae	Guha	H	BB0020
107	*Oxyanthus speciosus* DC	Rubiaceae	Imbrango	T	BB005
108	*Pavonia schimperiana* Hochst .ex A.Rich.	Malvaceae		H	BB0098

109	*Passiflora edulis* Sims	Passifloraceae		H	BB139
110	*Pentas lanceolata* (Forssk.) Defl.	Rubiaceae	suddee	H	BB0048
111	*Peperomia molleri* C.DC.	Piperaceae	Qetto	S	BB140
112	*Peperomia tetra phyla* (Forster) Hook.	Piperaceae		*H*	BB141
113	Phoenix reclinata Jacq.	Arecaceae	Minan bofa	T	BB142
114	*Physalis peruviana* L.	Solanaceae		L	BB143
115	*Piper capense* L.f.	Piperaceae	Tunjo	H	BB0064
116	*Pittosporum viridiflorum* Sims	Pittosporaceae		*H*	BB144
117	*Plecranthus lanunginosus* (Hochst. ex Benth.) Agnew	Lamiaceae	DamaKesse	H	BB0050
118	*Podocarpus falcatus* (Thunb.) R. B. ex Mirb.	Podocarpaceae	Birbiirsa	T	BB0045
119	*Polyscias fulva* (Hiern) Harms	Araliaceae	Kariyo	T	BB0038
**120	*Pouteria adolfi-friederici* (Eng.) Baehni	Sapotaceae	Qararoo	T	BB0010
121	*Prema schimperi* Engl.	Lamiaceae	Urgessa	S	BB0051
122	*Prunus africana* (Hook.f) Kalkm	Rosaceae	Omoo	T	BB0062
123	*Psychotria orophila* Petit	Rubiaceae		*H*	BB145
124	*Pycnostachys meyeri* Gurke.	Lamiaceae	Xirofetu	S	BB0024
125	*Rhamnus prinoides* L.Herit.	Rhamnaceae	Geeshoo	S	BB0089
126	*Rubus niveusThunb.*	Rosaceae		S	BB0056

127	*Rytigynia neglecta* (Hiern) Robyns	Rubiaceae	Xummane	S	BB0015
128	*Sapium ellipticum* (Krauss) Pax	Euphorbiaceae	Bosoqqaa	T	BB0072
*129	*Satureja paradoxa* (Vatke) Engl.ex Seybold	Lamiaceae	Naddo	H	BB0052
130	*Schefflera abyssinica (*Hochst.ex.A.Rich*)* Harms.	Araliaceae	Boto/ Gatamaa	T	BB0087
131	*Senna septemtrionalis*(Viv) Irwin&Barneby	Fabaceae		S	BB0058
132	*Senna petersiana (Bolle) Lock*	Fabaceae	Raamsoo	S	BB0057
133	*Sida rhombifolia* L.	Malvaceae	Karaba	H	BB0062
*134	*Solanecio gigas* (Vatke) C.Jeffrey	Asteraceae	Xomboroqo	S	BB0040
135	*Solanecio angulatus* (Vahl) C. Jeffrey	Asteraceae	Turugee	H	BB0063
136	Solanum tarderemotumBitter	Solanaceae	Aacoo	H	Bb146
137	*Stephania abyssinica* Dillon & A. Rich Walp.	Menispermaceae	kalaalaa	H	BB0081
**138	*Syzygium guineense* (Wild.) DC.	Myrtaceae	Baddeessaa	T	BB0044
139	*Teclea nobilis* Del.	Rutaceae	Mixiriti	T	BB006
140	*Tectaria gemmifera* (Fee) Alston.	Tectariaceae	Gitto	H	BB0042
141	Thunbergia alata Bojer. ex Sims	Acanthaceae		H	BB147
*142	*Tiliacora troupinii* Cufod.	Menispremaceae	Liqixii	**L**	BB0100
143	*Trema orientalis* (L.) Bl.	Ulmaceae	qa'ee	T	BB0013

144	*Urera hypselodedron* (A. Rich.) Wedd.	Urticaceae	Dhuffiyyee	H	BB0053
*145	*Vepris dainelli* (Pichi-serm.) Kokwaro	Rutaceae	Hadheessa	T	BB007
146	*Vernonia adoensis* Sch. Bip. exWalp.	Asteraceae	Solle	S	BB1001
147	*Vernonia amygdalina* Del.	Asteraceae	Ebbicha	S	BB0039
148	*Vernonia auriculifera* Hiern	Asteraceae	Reejjii	S	BB0031
149	*Vernonia hochstetteriSch. Bip.* ex*Walp.*	Asteraceae	Eilbu	S	BB0089
150	*Vernonia purpurea* Sch. Bip.ex Walp.	Asteraceae	Soyyomaa	S	BB150

* Endemic species recorded from Gera Forest.

**Commercially important tree species in Gera Forest.

Declaration

I, the undersigned declare that this Thesis is my original work and it has not been presented in other universities, colleges or institutes for a degree or other purpose. All sources of the materials used have been duly acknowledged.

Name: Bruk Bedore Amado Signature: _____ Date: _____

This work has been done under my/our supervision.

Name: _____ Signature: _____ Date: _____

Name: _____ Signature: _____ Date: _____