ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUTE STUDIES

DEPARTMENT OF BIOLOGY

Floristic Composition and Structural Analysis of Gedo Dry Evergreen Montane Forest, West Shewa Zone of Oromia National Regional State , Central Ethiopia

By Birhanu Kebede Kuris

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A Thesis Submitted to School of Graduate Studies of Addis Ababa University in Partial Fulfillment of the Requirements for the Degree of Master of Science in Biology (Botanical Science)

Approved by Examining Board

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ACRYNOMS

AAU	Addis Ababa University
BA	Basal Area
CR	Critically Endagered
DBH	Diameter at Breast Height
EFAP	Ethiopian Forestry Action Plan
EWNHS	Ethiopian Wildlife and Naural History Society
FEE	Flora of Ethiopia and Eritrea
GPS	Geographical Positioning System
IUFRO	International Union for Forestry Research Organization
IVI	Important Value Index
IUCN	International Union for the Conservation of Nature and Natural Resources
LC	Least Concern
MRPP	Multi- Response Permutation Procedure
NT	Near Threatened
RD	Relative Density
RDO	Relative Dominance
RF	Relative Frequency
USAID	United States of America International Development
VU	Vulnerable

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ABSTRACT**:** *This study was conducted on Gedo Dry Evergreen Montane Forest in West Shewa Zone of Oromia National Regional State, 182-196 km west of Addis Ababa (Finfinne). The objective of the study was to determine floristic composition and structural analysis of Gedo Forest. Systematic sampling method was used to collect vegetation data from 72 (20 m x 20 m) and subplots of 1 m x 1 m at the four corners and the center of the large quadrat for herbaceous plants. Vegetation classification was performed using PC-ORD software package. Sorensen's similarity coefficient was used to detect similarities and dissimilarities among communities. Shannon - Wiener diversity index was applied to quantify species diversity and richness. All trees and shrubs with Diameter at Breast Height (DBH) ≥ 2 cm were measured for height and diameter. A total of two hundred thirty five specimens of plants (herbs, shrubs, lianas and trees) were recorded. One hundred and fourty of the species collected from sample plots were used for floristic and structural analysis. The rest, 95, were collected out of sample plots but from the forest and used to describe the complete floristic list. Asteraceae is the most dominant family with 36 species in 24 genera followed by Fabaceae with 16 species in 14 genera and Lamiaceae with 16 species and 13 genera. Out of the plants identified in this study, 25 were endemic species which have been included in the preliminary list assessed for IUCN Red Data List, of which 1 species is Critically Endangered, 18 species in Least Concern, 4 species Nearly Threatened, and 2 species vulnerable. The density of tree species in Gedo Forest decreases with increasing height and DBH classes. The forest is characterized by high density of trees in the lower class than in the higher. Three layers (lower, middle and upper) of tree were identified from the study of vertical stratification of Gedo Forest following the International Union for Forestry Research Organization (IUFRO) classification scheme. The regeneration status of selected woody species was assessed as well as the forest was compared with five dry evergreen forests of Ethiopia. Based on the result of the study, research on the soil seed bank, population dynamics, biology and ecology of endemic species and Ethnobotanical studies to explore the indigenous knowledge on the diverse uses of plants and its conservation, and Participatory management of the forest were recommended.*

Key words/Phrases: *Dry evergreen montane forest, Endemic species, Gedo Forest, IUCN Red Data List, Phytogeographical comparison, vegetation structure*

1. INTRODUCTION

Ethiopia is an important regional center for biological diversity due to its wide ranges of altitude, its 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 helped the emergence of 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 country possesses about 6000 species of higher 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 than at present, but have 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 presence of vast expanse of forests earlier. At the moment, most of the remaining forests of the country are confined to south and south-western parts of the country; however, nowadays the remnant forests in these areas are threatened by human activities (Tamirat Bekele, 1994).

Historical document indicated that Ethiopia had experienced substantial deforestation, soil degradation and an increase in the area of bare land over the years. The need for fuelwood, arable land and grazing areas have been indicated as the 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.

Apparently, biodiversity resources along with their habitats are rapidly disappearing in many parts of the country (Demel Teketay, 1992; Tadesse Woldemariam and Demel Teketay, 2001; Tadesse Woldemariam *et al*., 2002; Tadesse Woldemariam, 2003; Feyera Senbeta, 2006; Feyera Senbeta and Denich, 2006). The destruction of vegetation and environmental degradation have become issues of national and global concern in recent years. This is because of the fact that declining vegetation cover and depletion of natural resources are closely associated with drought and food shortages that have become major threat affecting the life of millions of people.

Gedo Forest is a dry evergreen montane forest that is found in the high lands of Shewa. It is one of National Forest Priority Areas with an area of about 10, 000 hectares (EFAP, 1994).

1.1 Statement of the Problem

Although Gedo State Forest is one of the 58 Regional Forest priority areas for conservation, it received little attention up to now. Information on vegetation may be required to help to solve an ecological problem: for biological conservation and management purposes; as an input to environmental impact statements; to monitor management practices or to provide the basis for prediction of possible future changes.

Forests can be seen as an earth`s lungs. They play a crucial role in tempering the effects of climate and help protect vital water catchments. Trees provide a wide range of products, including food and fruit, timber, fodder for livestock, habitat for wildlife and medicines for both people and livestock. Forests supply goods of commercial, cultural, and sacred value, and used as several raw materials, which are primarily used in wood-based industries and they comprise a vital safety net in times of need.

Gedo Forest is one of the forests that have been providing the above uses. However, because of its accessibility, the vegetation has been severely and unwisely exploited. Consequently, the existing conditions call for a critical mitigating means. The vegetation of this area was intact previously (information from community elders) but highly depleted at present. It has also not been studied before and hence, the need to gather information on the ecology and

composition of the forest is very important. Without a full assessment of the properties of the various sites in a forest and their relation to vegetation growth, the management of the forest will be severely handicapped.

1.2 Objectives

1.2.1 General Objective

To study floristic compositions and structural analysis of Gedo Forest.

1.2.2 Specific Objectives

- To assess floristic composition and structure of Gedo Forest;
- To identify plant community types and analyze species richness, evenness and diversity among different plant community types;
- To make phytogeographical comparisons with other related forests in Ethiopia;
- To determine regeneration status of some selected woody species; and
- To recommend solutions for better management of the forest

2. LITERATURE REVIEW

2.1 Dry Forest

Dry Forest is a type of forest characterized by relatively sparse distributions of pine, juniper, oak, olive, acacia, mesquite, and other drought-resistant species growing in scrub woodland, savanna, or chaparral settings, occurs in the southwestern United States, Mediterranean region, sub-Saharan Africa, and semiarid regions of Mexico, India, and Central and South America (http://www.answers.com/topic/dry-forest).

2.1.1 Geographical variation

Dry forests tend to exist north and south of the equatorial rainforest belt, south or north of the subtropical deserts, generally in two bands, one between 10° and 20°N latitude and the other between 10° and 20°S latitude. The most diverse dry forests in the world occur in southern Mexico and in the Bolivian lowlands. The dry forests of the Pacific Coast of northwestern South America support a wealth of unique species due to their dry climate. The subtropical forests of Maputoland-Pondoland in southeastern Africa are diverse and support many endemic species. The dry forests of central India and Indochina are notable for their diverse large vertebrate faunas; Madagascar dry deciduous forests and New Caledonia dry forests are also highly distinctive (pronounced endemism and a large number of relictual taxa) for a wide range of taxa and at higher taxonomic levels (http://en.wikipedia.org/wiki/Tropical and subtropical dry broadleaf forests).

2.1.2 Biodiversity patterns and requirements

Species inhabiting dry forests tend to have wider ranges than moist forest species, although in some regions many species do display highly restricted ranges; most dry forest species are restricted to tropical dry forests, particularly in plants; beta diversity and alpha diversity are high but typically lower than adjacent moist forests. Effective conservation of dry broadleaf forests requires the preservation of large and continuous areas of forest. Large natural areas are required to maintain larger predators and other vertebrates, and to buffer sensitive species from hunting pressure. The persistence of riparian forests and water sources is critical for many dry forest species. Large swathes of intact forest are required to allow species to recover from occasional large events, like forest fires (http://en.wikipedia.org/wiki/Tropical and subtropical dry broadleaf forests).

2.1.3 Distribution of tropical dry evergreen forest

According to Parthasarathy (2008), dry evergreen forests have also been reported elsewhere in the tropics as summarized in Table 1, along with aspects researched therein. The information provided in Table 1 is a result of a systematic review that has been made possible through extensive survey of literature sources that report the occurrence of dry evergreen forests, either as a vegetation formation or as a forest type. There are no unified features for this rare and unique forest type and it has been chosen based on local climatic, biotic and edaphic factors, which influence the forest's physiognomy, stand structure, species composition, and dynamics.

Table 1 Distribution of tropical dry evergreen forests in the tropics and aspects studied therein. (* Cl- Climate; Sl-Soil; Veg-Vegetation structure; FC-Floristic Composition; Dyn-Dynamics; Phy-physiology; N.Cy-Nutrient Cycling; Repr-Rproductive ecology; FU-Forest utilization; T&D-Threats and Disturbance; Con-Conservation) (Parthasarathy *et al.,* 2008).

Location	**Aspects studied***										
	Cl	**Sl**	**Veg**	**FC**	**Dyn**	**Phy**	**N. Cy**	**Repr**	**FU**	**T &D**	**Con**
Tropical America											
Antigua	✓	✓	✓	✓							
Bahamas	✓	✓	✓	✓						✓	
British Guiana	✓	✓	✓	✓							
Jamaica	✓	✓	✓	✓							
Trinidad	✓	✓	✓	✓							
Tobago	✓	✓	✓	✓							
Africa											
Ethiopian highlands	✓	✓	✓	✓					✓	✓	✓
Tanzania	✓	✓	✓	✓			✓				✓
Zambia	✓	✓	✓	✓						✓	
Asia											
Thailand	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
Sir Lanka	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓
India	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓

2.1.4 Dry Forests in Africa

Dry forests are found in a band across Africa from Senegal in the west, making a loop around the Congo basin, to Ethiopia in the east and South Africa in the south (Fig. 1). Dry forests partly or fully cover Angola, Botswana, Burkina Faso, Cameroon, Central African Republic, Chad, Congo, DRC, Ethiopia, Gabon, Guinea, Kenya, Lesotho, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Senegal, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe.

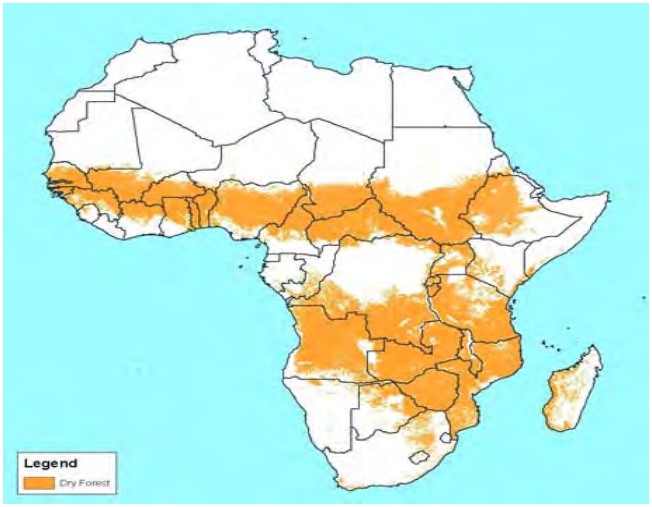

Fig. 1 Map of Africa showing Dry Forest in it.

Source: (http://www.cifor.cgiar.org/dryforest/_ref/home/map.htm the web site of Centre for International Forest Research

Dry forests are highly sensitive to excessive burning and deforestation; overgrazing and exotic species can also quickly alter natural communities; restoration is possible but challenging, particularly if degradation has been intense and persistent. Degrading dry broadleaf forests often leaves thorny shrublands, thickets, or dry grasslands in their place (http://www.cifor.cgiar.org/dryforest/_ref/home/map.htm). Because most of the dry forests are classified as “open access”, their sustainable management is greatly influenced by complex issues surrounding tenure governance, decentralization and benefit sharing. Exacerbating their unsustainable management is their inherent low biological endowment and erraticrainfall(http://www.cifor.cgiar.org/Publications/Corporate/NewsOnline/NewsOnline39 /dry forests.htm).

2.2 Vegetation in Ethiopia

Vegetation formation is influenced by a combination of many factors, such as climate, geology, edaphic factors and biotic factors, including interference by humans in ecological succession. Vegetation is dynamic, that is, constantly changing. Reasons for the changes can be ecological or evolutionary processes, climatic change, human land use, and interaction between factors (Skarpe, 1991).

Among scholars who attempted to classify the vegetation of Ethiopia are Ensermu Kelbessa *et al*. (1992), Sebsebe Demisew *et al.* (1996), Zerihun Woldu (1999), Friis and Sebsebe Demisew (2001), Sebsebe Demisew *et al*. (2004), Friis and Sebsebe Demisew (2009). According to Sebsebe Demisew *et al*. (2004), the vegetation of Ethiopia is divided into eight major types. This vegetation classification is as follows: Desert and Semi-desert Scrubland, Small-leaved Decidous Woodland, Moist Evergreen Montane Rainforest which can be further divided into two sub divisions (The Afromontane-rainforest and the Transitional rain forest), Lowland Semi-evergreen Forest, Broad-leaved Decidous Woodland and Savannah, Dry Evergreen Montane Forest and Grassland Complex, which is also divided into four subtypes (Undifferentiated Afromontane Forest, Dry Single - Dominant Afromontane Forest of the Ethiopian Highlands, Afromontane Woodland, Wooded Grassland and Grassland, Dry Single-Dominant Afromontane Forest of the Eastern Escarpments and Transition between Single Dominant Afromontane Forest and East African Evergreen and Semi-evergreen Bushland), Afro-alpine and Sub-Afroalpine Vegetation, and Riparian and Swamp Vegetation**.** Out of these major vegetation types, the present study area is one of the dry evergreen montane forests in the country. The forest is dominated by *Olinia rochetiana, Olea europaea* subsp*. cuspidata, Prunus africana, Ekebergia capensis, Allophylus abyssinicus, Syzygium guineese* subsp*. afromontanum*. However, *Juniperus procera* that is common in most dry forests of Ethiopia is almost none in Gedo Forest except few plantations on the east edge of the forest may be due to heavy degradation in the past.

2.2.1 Dry Evergreen Montane Forest of Ethiopia

The Ethiopian highlands are the largest mountain complex in Africa and comprise over 50% of the African land area covered by Afromontane vegetation, of which dry afromontane

forests form the largest part (Tamrat Bekele, 1993; Demel Teketay, 1996). Dry Evergreen Montane Forest is a very complex vegetation type occurring roughly above 1500 m and below 3200 m in altitude, with average annual temperature and rainfall of 14-25°C and 700-1100 mm, respectively (Friis, 1992; Zerihun Woldu, 1999). It is inhabited by the majority of the Ethiopian population and represents a zone of sedentary cereal-based mixed agriculture for centuries. This type of forest develops in areas of relatively high humidity, but not much rain, and where there is a prolonged dry season. The forests have diminished due to human interference and replaced by grasslands in flatter areas with deep soil and by bushlands on steeper slopes with thin soil. Soils have become shallow as a result of soil erosion that has been taking place for centuries (Ensermu Kelbessa *et al*., 1992; Zerihun Woldu, 1999). In such type of forests, the canopy is usually dominated by *Podocarpus falcatus, Juniperus procera, Croton macrostachyus, and Olea europaea* subsp. *cuspidata*, true lianas, epiphytes including *Peperomia*, ferns and orchids are common. The ground cover is rich in ferns, grasses, sedges and small herbeouceous cotyledons. At the upper limits *Erica arborea, Hagenia abyssinica, Hypericum revolutum, Myrsine africana, Myrsine melanophloeos, Rosa abyssinica,* and *Nuxia congesta* and clumps of *Arundenaria alpina* are also common (Friis, 1992).

The prominent features of tropical dry forests are their seasonality with respect to rainfall compared with the rain forests where the environment is stable throughout the year. Dry evergreen montane forests experience long dry seasons (4-8 months) and the rainy period is somewhat unreliable. During the dry season, not only moisture stress but also temperature increases and daytime humidity drops and watercourses either dry up or greatly diminish inflow (Demel Teketay, 1996). Degradation in this zone is very high and even severe in the northeastern Ethiopia where, forests have virtually disappeared, as a result most of the mountains sides are bare, valleys have been gullied, and springs and streams, which used to have water the whole year round are now mainly dry in the dry season (Abate Ayalew *et al*., 2006).

The characteristic plant species in this vegetation type include *Olea europaea* subsp. *cuspidata, Juniperus procera, Podocarpus falcatus, Ilex mitis* and *Erica arborea.* The shrubs occurring in this vegetation type include *Carissa spinarum* and *Dodonaea angustifolia* (Zerihun Woldu, 1999). Some of threatened endemic plant species in dry forest are *Acalypha*

marissima, Maytenus addat, Pentas concinna, Rubus aethiopicus, and *Sedum epidendron* (Ensermu Kelbessa *et al*., 1992).

Friis (1992) classified this forest type as follows:

a. Dry single dominant Afromontane forest which occurs in the NW and NE Ethiopian highlands between altitudes of (1600)/ 2200 ca. 3200 (-3300) m, with annual temperatures from 12-18 ^{0}C and annual rainfall between 500 and 1500 mm.
b. Undifferentiated Afromontane forest, which are either *Juniperus-Podocarpus* forest, or predominantly Podocarpus forest, both with an element of broad-leaved species. They occur in both the NW and SE highlands, especially on the plateau of Shewa, Wello, Sidamo. Bale and Harerge between altitudes of 1500 to 2700 m, with average annual temperature between 14 and 20 ^{0}C and annual rainfall between 700 and 1100 m.
c. Dry single dominant Afromontane forest of the escarpments and transition between single dominant Afromontane forest and East African evergreen and semi-evergreen bush land occurring on the eastern escarpment of the NW highlands and on the eastern escarpment of the SE highlands on rocky ground with unimpeded drainage, between altitudes of about 1500 m to 2400 m, annual rainfall between 400-700 mm and average annual temperature between 15-20 ^{0}C.

2.3 Forests and Threats on Forest Resources of Ethiopia

Forest resources are the fruits of evolution that are developed through the combined influence of physical environment and people, and play important economic, social and cultural roles, particularly in the lives of many local communities (Regassa Feyissa, 2001). The natural forests of Ethiopia are organized under 58 national forest priority areas. Following the regionalization of the country and the consequent devolution of power, the national regional states and their executive organs are administering most of these forest priority areas. All of these forest priority areas, invariably, are under extreme pressure from settlement, land use conversion to farming and grazing, excessive extraction, and neglect in terms of forest management and protection (Yonas Yemshaw, 2002).

The majority of Ethiopians are farmers for thousands of years. Highland vegetations were cleared to give way to cultivation and grazing without due consideration to soil conservation practices. People were attracted only to temporary yields obtained at the initial stage without realizing the outcome they would be facing in the long term (Alemu Abebe, 2007). The growth of human and livestock population had caused the country to face the following problems: Environmental degradation, severe soil erosion, drought and famine and the loss of economically important indigenous tree species. Any change in the status of these factors disturbs the vegetation composion, persistent disturbance caused by biotic exploitation regress change in vegetation that finally results in the decline of quality of vegetation and reduction in the diversity and abundance of indigenous plant species and the majority of the fauna (Tamirat Andarge, 2001).

The trees and forests of Ethiopia are under tremendous pressure because of the drastic decline in mature forest cover and the continual pressures of population increase, rudimentary farming techniques, land use competition, land tenure, and forest degradation and conversion. The status of the forest resources should be considered at risk. However, the attention given to conservation and sustainable use of these biological resources is inadequate due to low level awareness about the role of the forests (Dereje Denu, 2007). Although deforestation is known to occur in the remaining forested areas of the country, rates of deforestation have been more difficult to estimate. The most important reason behind the rapid deforestation rate in the country is the ever-increasing human population growth. This rapid increase in human population is associated with a very high demand for agricultural and grazing lands, forest resources for firewood, charcoal, timber, construction, and many other purposes. Fire, inappropriate investment activities, and lack of viable land use policy have also been key factors for the rapid decline of forests in the country. At present, few remaining high forests are threatened by pressure from investors who are converting moist evergreen montane forests into other land use systems such as coffee and tea plantations (Friis, 1992; Million Bekele and Leykun Berhanu, 2001; Haile Yineger *et al*., 2008).

Forest resources in the country have under gone substantial changes over the years due to competing land uses and unbalanced forest utilization. As a result it is often quoted that the closed natural high forests, which were once covered more than 40% of the Ethiopian highland have now decreased to less than 3%. Ethiopian Forestry Action Program (1994)

indicates that the forest cover was reduced to 2.7% in 1989 and less than 2.3% in 1990. One reason for the decline of the forest is attributed to energy requirement. About 94% of the energy requirement of the country relies on biomass alone (Haileleul Tebicke, 2002) of which, trees and shrubs contribute the largest proportion.

According to USAID (2008), threats to Ethiopia's biodiversity, tropical forests, and resource base can be broadly linked to the following categories: limited governmental, institutional, and legal capacity; population growth; land degradation; weak management of protected areas; and deforestation. These threats are largely interrelated and self-reinforcing, and it is therefore important not only to understand the individual threats but also to examine them in a holistic fashion that recognizes their interrelation and can help to propose solutions to decrease the threats and mitigate their effects.

Environmental problems such as soil degradation, erosion and decrease in biodiversity as well as the loss of potential natural resources are negative effects resulting from the destruction of these habitats. Indigenous knowledge on medicinal and other useful plants is eroded with destruction of these forests (Kitessa Hundera and Tsegaye Gadissa, 2008*).* To address these threats, it is critical to raise government decision makers' awareness of the importance of natural resource policies to Ethiopia; facilitate dialogue among the government, civil society, and national and international organizations; and to closely examine and revise those policies requiring clarification or harmonization. Family planning can also help to reduce family size and slow population growth, and efforts toward generating alternative livelihoods activities can give people options other than farming or herding that are less dependent on limited natural resources. Other key actions include increased enforcement of rules and boundaries; environmental education; and efforts to strengthen the relationships among protected areas and communities, with emphasis on returning the benefits of the protected areas to those communities. Taking the lost opportunities into account, foresters and conservationists have to develop new initiatives to respond to the convergence of local communities and forests (Regassa Feyissa, 2001).

3. MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Geographical location

Gedo Forest is located in Cheliya District, West Shewa Zone of Oromia National Regional State. (Fig. 2). The District is now divided into Ilu Galan and Cheliya districts. However, the forest is found in more than two districts and the map shown here is that of Cheliya District which was before 2008 with total area of about 67,472.5 hectares; and with an altitudinal range of 1300-3060 m a.s.l. The northwestern part of the District is covered with hilly slopes and mountainous escarpments rising to an elevation of about 3060 m a.s.l. at Tullu Jarso Mountain (Endalew Amenu, 2007). The study area District lies approximately between latitudes 9^0 02` and $9^0$01` North and longitudes 37^0 25` and $37^0$16` East

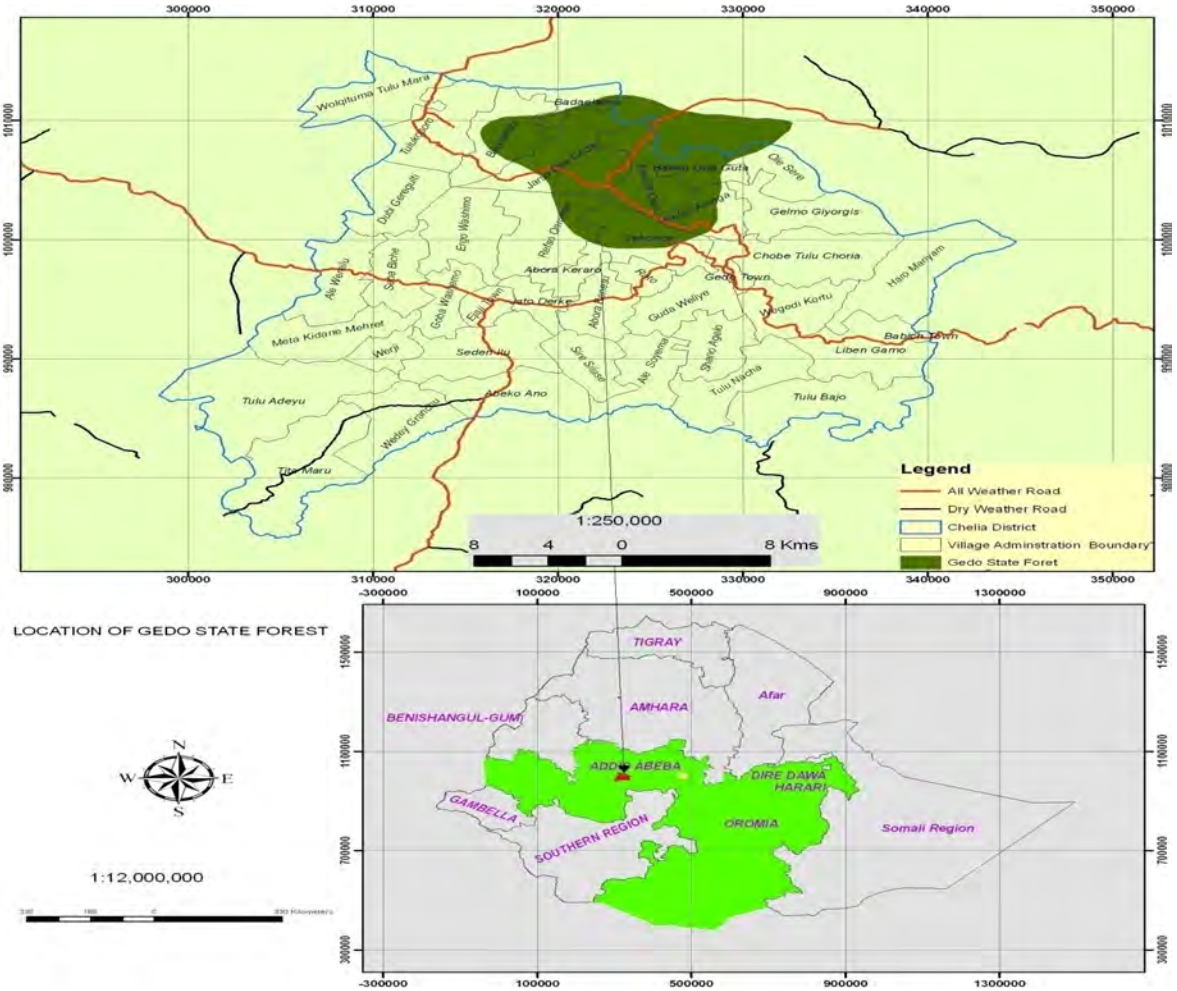

Fig. 2: Map of Ethiopia and the study area

3.1.2 Climate

Meteorological data obtained from National Meteorology Service Agency (Addis Ababa) indicates that Gedo area obtains high rainfall between May to September and low rainfall from December to February (Figure 3). The highest mean annual rainfall of the study area within ten years (2000-2009) was 186.4 mm recorded in July followed by 183.2 mm in August whereas the lowest mean annual rainfall was 15.1 mm recorded in December. The rainfall distribution increases from mid February to mid March then decrease slightly in mid April. From mid April to mid September the amount of rainfall is high. The lowest mean temperature over ten years was 8.7ºC recorded in December, whereas the highest was 24.6ºC recorded in February.

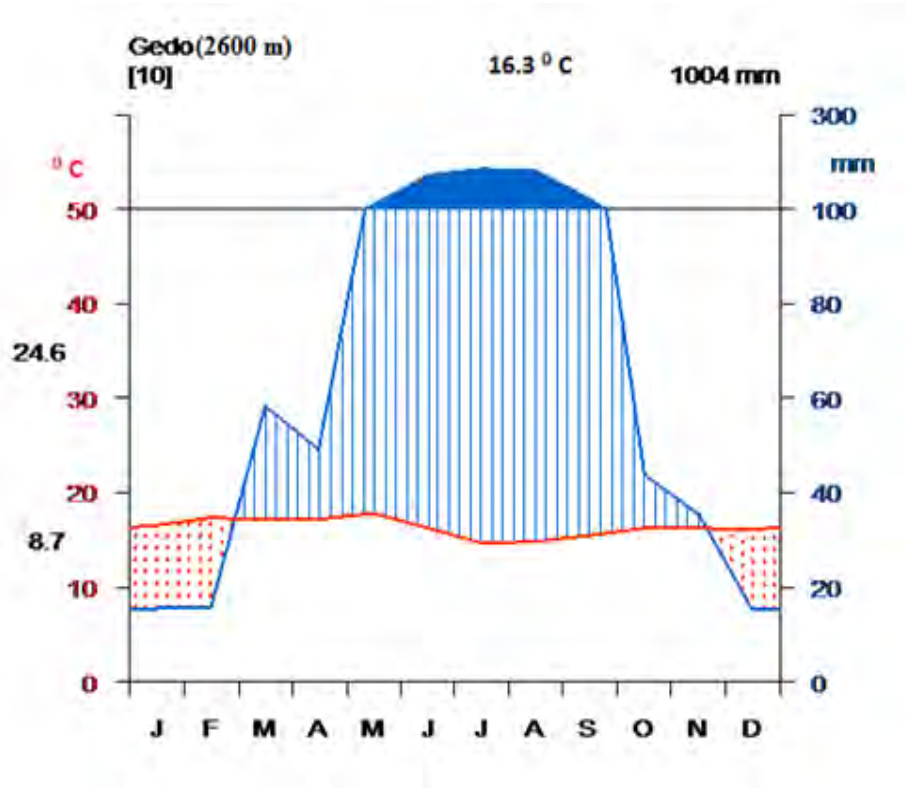

Fig. 3 Climadiagram showing rainfall distribution and temperature variation from 2000-2009 at Gedo Station.

Source: Data obtained from National Meteorological Service Agency (2010)

3.1.3 Population status and Land use

The total population of the District is estimated to be 180,600 of which 89,032 are males and 90,300 are females (Socio economic profile of Cheliya District). Crop production and livestock rearing are the main activities of the people of the District. Due to high rainfall intensity during rainy season there is high land degradation and soil erosion, which leads to loss of soil fertility and damage to agricultural land.

Land inheritance and transfer of ownership from generation to generation is culturally based and only males inherit family's land. This enables males to have power to inherit, conserve and preserve resources on family land. The people of the study area use and classify their land through functional categorization i.e. grazing land, browsing land, agricultural land and forestland. Cheliya District Agricultural Office (2004) annual report showed 45,849.5 hectares of land as used for farming purpose. Different crop types are cultivated in the District. Agricultural production is based on rain fed cultivation and few irrigation activities are found around Ejaji. Major food crops grown by farmers are largely field crops (Endalew Amenu, 2007).

3.1.4 Livestock population

Livestock population of the area is significant. According to Cheliya District Agricultural Office (2004) the District possesses 226,155 livestock population consisting of 124,713 cattle; 22,220 goats; 11,578 mule; 8,294 horses; 1,331 donkeys; 4,993 sheep and poultry 53,026. There are problems like shortage of grazing and browsing land and adequate health services and facilities. These all problems directly or indirectly affect the biodiversity in the District mainly forests. The District has one hospital, one central veterinary clinic and three health posts. As the District, size and health facilities do not match and unable to support this vast population of livestock, people try to treat their livestock by ethnoveterinary medicine (Endalew Amenu, 2007).

3.2 METHODS

3.2.1 Data collection

3.2.1.1 Reconnaissance survey

Reconnaissance survey of the vegetation area was conducted in the first week of October 2009 to get an overview observation in the study area. The survey focused on identifying the vegetation types and familiarize with the study area and Oromia Forest and Wildlife Enterprise, Finfinne Forest Agency employees, Forest guards and local communities. Data collection was made from October 17 to November 17, 2009.

3.2.1.2 Sampling Design

Vegetation data were collected from sample plots placed in transect lines, which are systematically laid. A total of 72 plots were laid along transect lines following the Braun-Blanquet approach of phytosociology as modified by van der Maarel (1979). Quaqrats of 20 m x 20 m (400 m^2) were laid at every 200 meters along 12 transect lines, which are laid 300 meters apart. Transects are used because they are considerable importance in the description of vegetative change along an environmental gradient, or in relation to some marked feature of topography. For the collection of herbaceous species, subplots of 1 m x 1 m at the four corners and the center of the large quadrat were laid.

3.2.1.3 Floristic data collection

All plant species including herbs, shrubs, lianas, epiphytes, ferns and trees in each quadrat were recorded. Additional plant species occurring out side quadrats, but inside the forest were also recorded only as 'present', but they were not used in the subsequent data analysis. The vernacular (local) names were used when available. In the study area, physiographic variables such as altitude, longitude, latitude and aspect were measured for each quadrat using altimeter, GPS, and compass respectively. The plant specimens collected were brought to the National Herbarium (ETH) of Addis Ababa University for identification. The specimens were dried in the dryer, kept in a deep freezer for 72 hours and identified referring to the volumes of Flora of Ethiopia and Eritrea, consulting experts and lastly using authenticated specimens at the Herbarium and finally deposited there with their labels.

3.2.1.4 Structural data collection

Each individual of the woody species was counted, circumference at breast height, i.e. 1.3 m, of all trees and shrubs having circumference greater than 6 cm (DBH greater than 2 cm) were measured and later it was changed in to diameter and the heights of tree and shrub species above 2 m were visually estimated and recorded and later grouped into height classes. For the purpose of the study "seedlings", "saplings" and "mature trees/ shrubs" were defined as plants with heights less than 1 m, 1-3 m and greater than 3 m respectively. Percentage cover abundance was estimated and later converted into modified Braun Blanquet scale. The 1-9 modified Braun-Blanquet scale was used following van der Maarel (1979). Accordingly, the scale represents:

1 = rare, generally one individual,
2 = occasional or sporadic with less than 5% cover of the total area,
3 = abundant, with less than 5% cover of total area,
4 = very abundant, with less than 5% cover of the total area,
5 = 5-12% cover of the total area,
6 = 12.5 -25% cover of total area,
7 = 25-50% cover of the total area,
8 = 50-75% cover of the total area, and
9 = 75-100% cover of the total area

3.2.2 Structural data analysis

All individuals of species recorded in all the 72 quadrats were used in the analysis of vegetation structure. The Diameter at Breast Height (DBH), basal area, tree density, height, frequency and important value index were used for description of vegetation structure.

Diameter at Breast Height (DBH): DBH measurement was taken at about 1.3 m from the ground using a measuring tape for those woody plants having circumferences greater than 6 cm and later the diameter is calculated from circumference (C) = πd where d is diameter at breast height. This technique is easy, quick, inexpensive and relatively accurate. There is direct relationship between DBH and basal area (Kent and Coker, 1992).

Basal area is the area outline of a plant near ground surface. It is expressed in square m/hectare (Mueller-Dombois and Ellenberg, 1974). Basal area is also used to calculate the dominance of species.

$BA = \pi (d / 2)^2 = (DBH/2)^2$ X 3.14, where d is diameter at breast height.

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

$$D = \frac{\text{The number of above ground stems of a species counted}}{\text{Sampled area in hectare}} \times 100$$

$$\text{Relative density} = \frac{\text{Number of ground stems of a species}}{\text{Total number of above ground stems in the sample area}} \times 100$$

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

$$F = \frac{\text{Number of plots in which a species occur}}{\text{Total number of plots}} \times 100$$

The frequencies of the tree species in all the 72 quadrats were computed. The higher the frequency, the more important the plant is in the community. Although a high frequency value means that the plant is widely distributed through the study area, the same is not necessarily true for a high abundance value. This abundance is not always an indicator of the importance of a plant in a community. A better idea of the importance of a species with the

frequency can be obtained by comparing the frequency of occurrences of all of the tree species present. The result is called the relative frequency and is given by the formula:

$$F = \frac{\text{Frequency of a species}}{\text{Total frequency of all species}} \times 100$$

$$\text{Relative Dominance (RDO)} = \frac{\text{Total BA of a species}}{\text{Sum of BA of all tree species}} \times 100$$

Importance Value Index (IVI): is useful to compare the ecological significance of species. It combines data for three parameters (relative frequency, relative density and relative abundance) or it often reflects the extent of the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992).

Importance value index (IVI) = RD + RF + RDO

Where, RD is Relative Density, RF is Relative Frequency, and RDO is Relative Dominance.

Height: is a straight forward parameter used for direct measurement purposes. The Tree height was also classified into ten classes (3-6 m, 6-9 m, 9-12 m, 12-15 m, 15-18 m, 18-21 m, 21-24 m, 24-27 m, >27m).

3.2.2.1 Plant community analysis

Hierarchical cluster analysis (classification) was made using PC-ORD windows version 5 (McCune and Mefford, 1999; McCune and Grace, 2002). The analysis was based on the abundance of the species (number of individuals). The Relative Euclidean Distance (RED) measures using Ward`s method was used. The Euclidean Distance was used because it eliminates the differences in total abundance among sample units; and the Ward`s method was used because it minimizes the total within group mean of squares or residual sum of squares (van Tongeren, 1995; McCune and Grace, 2002). The identified groups were tested for the hypothesis of no difference between the groups using the multi-purpose permutation procedure (MRPP). Dufrene and Legendre`s (1997) method of calculating species indicator values was used to detect the value of different species for indicating environmental conditions.

3.2.2.2 Plant diversity analysis

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

Shannon-Wiener diversity index is calculated as follows.

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

Where,

H' = Shannon diversity index

S = the number of species

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

Ln = $\log base_n$

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

3.2.3 Phytogeographical Comparison

The association of Gedo Forest with other five dry evergreen forests in Ethiopia was made. The Sorensen's similarity coefficient (Sc) was used for this comparison was It is used to measure similarities between two habitats. Sorensen's coefficient is calculated using the following formula.

Sc =2a / 2a + b + c

Where a = number of species common to both habitats.

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

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

4. RESULTS AND DISCUSSION

4.1 Floristic composition

Two hundred thirty five specimens of plants (herbs, shrubs, trees, shrubs/trees, climbers, lianas and tree/lianas) were collected from Gedo Forest. The specimens identified belong to 190 genera and 78 families (Appendix 1). Asteraceae is the most dominant family with 36 species and 24 genera followed by Fabaceae with 16 species and 14 genera showing that the area is highly disturbed since the Asteraceae are mosly herbs and weeds, they are common in such areas. The third species richest family was Lamiaceae with 16 species and 13 genera followed by Acanthaceae (10 species and 6 genera), Rubiaceae (10 species and 10 genera) and Poaceae (7 species and 7 genera). The proportion of families represented only by one species each were 51.28%, 2-5 species 32.05%, 5-10 species 10.26% and with grater 10 species were 6.41% (Appendix 2).

One hundred and fourty of the species collected in the 72 quadrats were used in floristic and structural analysis. Quadrats and their characteristics were given in Appendix 3. The rest were collected outside the sample quadrats but within the forest and used to make the complete floristic list of the forest. From all the species collected 38% (90) were herbs, 28% (64) shrubs, 24% (56) trees, 3% (8) shrubs/trees, 5% (11) climbers, 2%(4) lianas and 1% (2) tree/lianas. Gedo Forest also contained some national priority tree species which are commercially important (Million Bekele and Berhanu Leykun, 2001). These include *Cordia africana, Albizia schimperiana, Celtis africana, Ekebergia capensis, Croton macrostachyus, Prunus africana, Podocarpus falcatus, Syzygium guineense, Apodytes dimidiata, Hagenia abyssinica* and *Juniperus procera.*

Out of the plants identified in this study, 25 were endemic species which are included in the preliminarily assessed list for IUCN Red Data List, of these 1 species is Critically Endangered (*Kniphofia hildebranditii*), 18 species in Least Concern, 4 species Nearly Threatened and 2 species Vulnerable (Ensermu Kelbessa Unpublished data). High conservation priority should be given due to its richness in endemism and natural resoureces. From the endemic species that recorded in IUCN Red List in the study area herbs, shrubs, trees and climbers constitute 48%, 32%, 12%, and 8% respectively.

Fourty eight percent of the endemic species in the study area were from family Asteraceae (Table 2). Two species are found at subspecies level *Millettia ferruginea* subsp. *ferruginea* and *Justicia diclipteroides* subsp. *aethiopica.*

Table 2 Endemic species of the study area, their IUCN categories and distributions (Ha= Habit, T = tree, S = shrub, H = herb, C = climber, NT= Nearly Threatened, LC= Least Concern, VU= Vulnerable, CR= Critically Endangered). .

Scientific name	**Family**	**Ha**	**IUCN Category**	**Distribution in Ethiopia**
Acanthus sennii Chiov.	Acanthaceae	S	NT	GD, GJ, WG, SU, HA, AR, BA, KF, GG, SD
Bidens ghedoensis Mesfin	Asteraceae	H	LC	SU, WG. IL, KF, GG, SD
Cirsium dender Friis	Asteraceae	H	VU	SU, KF, GG, AR
Clematis longicauda Steud ex A. Rich.	Rununculaceae	C	LC	GD, GJ, SU, WG, KF, IL, SD
Conyza abyssinica Sch. Bip. ex A. Rich.	Asteraceae	S	LC	TU, GD, GJ, SU, SD, BA, HA, KF
Echinops kebericho Mesfin	Asteraceae	H	VU	TU, SU, GJ
Echinops longisetus A. Rich.	Asteraceae	S	LC	GD, GJ, SU, WG, KF, WU, AR, HA, BA,GG, SD
Emilia serpentinus Mesfin & Beentje	Asteraceae	H	LC	SU, KF, IL, SD, GG, HA
Erythrina brucei Schweinf.	Fabaceae	T	LC	WU, WG, GJ, SU, BA,HA, IL, KF, GD, GG, SD
Justicia diclipteroides Lindau subsp. *aethiopica* Hedren	Acanthaceae	H	NT	SU, WG, IL, KF, GG, SD, BA
Kalanchoe petitiana A.Rich.	Crassulaceae	H	LC	GD, GJ, WU, SU, GG, SD, AR, BA, HA
Kniphofia hildebranditii Cufod.	Asphodelaceae	H	CR	SU,
Lippia adoensis Hochst. ex Walp.	Verbenaceae	S	LC	TU, GJ, SU, AR, HA, KF, GG
Maytenus addat (Loes.) Sebsebe	Celastraceae	T	NT	SU, AR, SD, GG
Mikaniopsis clematoides (Sch.Bip. ex A.Rich.) Milne-Redh.	Asteraceae	C	LC	TU, GD, SU, HA, BA, AR, KF
Millettia ferruginea (Hochst.) Bak. subsp. *ferruginea*	Fabaceae	T	LC	TU, GD, GJ, SU, WG, IL, HA
Phagnalon abyssinicum Sch. Bip. ex A. Rich.	Asteraceae	H	LC	TU, GD, GJ, WU, SU, AR, HA
Pycnostachys abyssinica Fresen.	Lamiaceae	H	NT	IL, KF, GG, SD, WU, SU, AR, HA
Senecio myriocephalus Sch. Bip. ex A. Rich.	Asteraceae	S	LC	TU, GD, WU, SU, KF, HA, BA, SD, AR
Senecio schimperi Sch. Bip. ex A. Rich.	Asteraceae	H	LC	TU, GD, GJ, SU, AR, BA, HA, SD
*Solanecio gigas(*Vatke) C. Jeffrey	Asteraceae	S	LC	GD, GJ, WU, SU, BA, KF, IL

Scientific name	Family	Ha	IUCN Category	Distribution in Ethiopia
Solanum marginatum L.f.	Solanaceae	S	LC	TU, GD, SU, GJ, GG, AR, SD, BA, HA
Thymus schimperi Ronniger	Lamiaceae	H	LC	TU, GD, WU, SU, AR, SD, BA, HA
Urtica simensis Steudel	Urticaceae	H	LC	TU, GD, GJ, SU, AR, BA, SD
*Vernonia leopoldi (*Sch. Bip. ex Walp.) Vatke	Asteraceae	S	LC	TU, GD, GJ, SU, WG, KF, HA

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

4.2 Plant community types

Vegetation classification is a powerful tool employed for several purposes, including: efficient communication, data reduction and synthesis, interpretation, and land management and planning. It also provides one way of summarizing our knowledge of vegetation patterns (Jennings, *et al*., 2003). Hence four plant community types (clusters) were identified from the hierarchal cluster analysis using PC-ORD version 5 computer programme (Fig. 4). The data matrix contains 72 quadrats and 140 species. The clusters were significantly different ($P < 0.001$) using the Multiple Response Permutation Procedure (MRPP) test which is used to test whether the community types are true or not true by comparing the clusters repeatedly. The decision on the number of plant communities was based on the MRPP technique. The test statistic T value for the four communities was -19.57 ($P < 0.001$) which shows the difference of the communities are highly significant, and the agreement statistic A was 0.05. The test statistic T describes the separation among the groups with more negative T value indicating the stronger the separation. The agreement A describes within group homogeneity, and falls between 0 and 1. When all items within groups are identical, A=1 and 0 when the groups are heterogeneous. In community ecology, values of A (agreement) are commonly below 0.1 (McCune and Mefford, 1999).

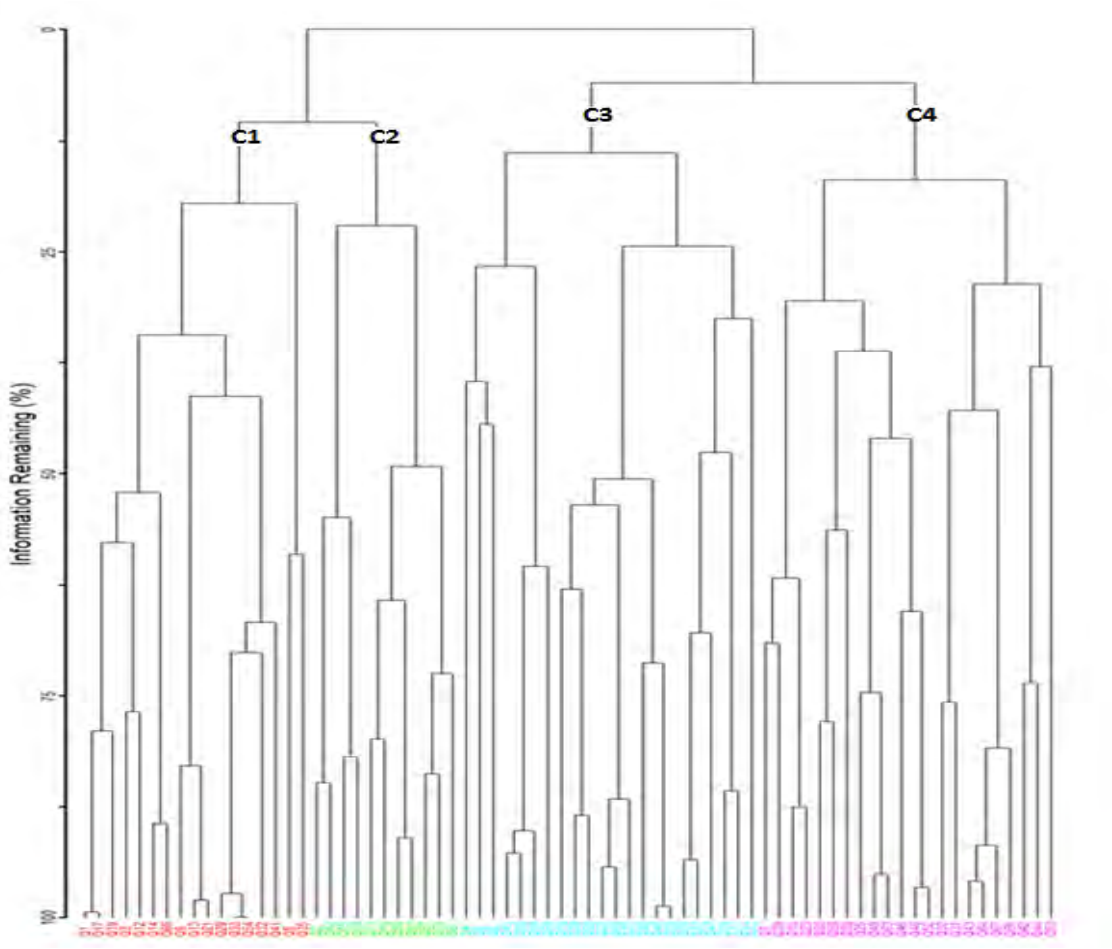

Fig. 4 Dendrogram showing plant community types of the study area

Description of the plant community types with their altitudinal distribution is given below. The four community types obtained in this way were named after two or three characteristic and/ or dominant tree and/or shrub/ or herb species. The highest mean cover estimate that appears in their particular cluster was used as a criterion for giving name to these local vegetation communities. Accordingly, the following is a description of the community types identified.

1. Chionanthus mildbraedii-Olea capensis subsp. *macrocarpa*- Community type

This community type is distributed between the altitudinal range of 2279-2538 m a.s.l. It is represented by 17 quadrats and 97 associated species (Appendix 4). *Chionanthus mildbraedii* and *Olea capensis* subsp. *macrocarpa* are the dominant species and main indicator species of

the community. Other species including trees, shrubs and herbs were associated to the community. *Podocarpus falcatus* is also an indicator tree species and other tree layer includes *Scolopia theifolia, Olea europaea* subsp. *cuspidata, Olinia rochetiana* and *Prunus africana. Galiniera saxifraga, Carissa spinarum, Solanecio gigas* and *Psychotria orophila* are indicator shrub layer in the community. *Smilax aspera* is an indicator climber while *Thymus schimperi* covers some parts of the ground layer.

2. ***Brucea antidysenterica-Allophylus abyssinicus*- Community type**

This community type is distributed between the altitudinal range of 2350-2565 m a.s.l and contains 11 quadrats and 71 species (Appendix 4). It is dominated by *Allophylus abyssinicus, Brucea antidysenterica, Prunus africana* tree species and *Olinia rochetiana, Calpurnia aurea, Teclea nobilis* and *Bersama abyssinica* are some associated tree species in the community. The community is dominated by small trees and shrubs which show there is disturbance in the community. The shrub layer is dominated by *Myrsine africana, Solanecio gigas* and *Chionanthus mildbraedii* while *Asparagus africanus, Vernonia bipontini* and *Rubus apetalus* are associated shrub species in the community. The ground layer is dominated by *Hypoestes forskaolii* which is common in the open canopy of the forest while *Ricinus communis, Mentha aquatica and Dregea schimperi* are some of the associated species in the lower layer. A climber *Periploca linearifolia* is also one of the dominant species in the community.

3. ***Maesa lanceolata-Vernonia auriculifera-Olea europaea* subsp. *cuspidata*- Community type**

The quadrats in this community are distributed in the altitude range of 2319-2767 m a.s.l and represented by 22 quadrats and 104 associated species (Appendix 4). *Olea europaea* subsp. *cuspidata, Albizia schimperiana* and *Ficus sur* are dominant tree species in the community (Fig. 5) while *Rosa abyssinica, Vernonia auriculifera* and *Mikaniopsis clematoides* are dominant shrubs and climber respectively. The herb layer is mainly covered by *Hypoestes forskaolii.* Other species include *Croton macrostachyus, Maytenus arbutifolia, Vernonia amygdalina, Bersama abyssinica, Rhus glutinosa, Podocarpus falcatus, Prunus africana,*

Millettia ferruginea subsp. *ferruginea, Rhus vulgaris* from the tree layer, *Hypericum quartinianum, Echinops macrochaetus, Maytenus gracilipes, Clausena anisata* from the shrub layer. *Periploca linearifolicia, Dregea schimperi* and *Clematis simensis* are the species which have more density among the climbers in the community.

Fig. 5 Gedo Dry Evergreen Forest dominated by *Olea europaea* subsp. *cuspidata* and *Olinia rochetian* (Photo by Birhanu Kebede).

4. Gnidia glauca- Echinops macrochaetus- Olinia rochetiana Community type

This community type is distributed between the altitudinal range of 2330-2600 m a.s.l and contains 22 quadrats and 114 species (Appendix 4). In addition to *Gnidia glauca, Olinia rochetiana* and *Echinops macrochaetus, Rhamnus staddo* and *Hagenia abyssinica are* also indicator species in the community. Other tree species include *Maytenus arbutifolia, Nuxia congesta, Buddleja polystachya. Osyris quadripartita* and *Hypericum quartinianum* are both dominant and indicator shrub species in the community where as other species like *Carissa spinarum* and *Rosa abyssinica* covered most of the shrub layer. *Hypoestes triflora, Hypoestes*

forskaolii and *Satureja punctata* are some of the herbs which covered the ground layer. Climbers like *Clematis simensis* and *Cissampelos pareira* are also common in the community. *Hagenia abyssinica, Erythrina brucei, Syzygium guineense* subsp. *guineense, Euclea divinorum, Ocimum urticifolium, Phytolacca dodecandra* are among the species which are found only in this community.

Table 3 Indicator values of indicator species for each community and Mounte Carlo test of significance observed for each species (P< 0.05).

	Indicator values in Communities				
Species name	**C1**	**C2**	**C3**	**C4**	**P* Value**
Chionanthus mildbraedii	**45**	20	4	0	0.0002
Olea capensis Subsp. Macrocarpa	**38**	1	3	0	0.0016
Gainiera saxifraga	**28**	0	1	1	0.0064
Carissa spinarum	**34**	5	15	19	0.008
Podocarpus falcatus	**31**	2	18	1	0.0152
Smilax aspera	**19**	0	0	1	0.034
Psychotria orophila	**18**	0	0	2	0.042
Brucea antidysenterica	20	**45**	7	0	0.0002
Solanecio gigas	19	**41**	1	3	0.0016
Prunus africana	14	**30**	20	1	0.0348
Periploca linearifolia	9	**30**	14	10	0.0446
Allophylus abssinicus	4	**61**	4	3	0.0002
Hypoestes forskaolii	2	**27**	5	9	0.0266
Olea europaea subsp. *cuspidata*	22	2	**33**	14	0.0164
Vernonia auriculifera	2	0	**28**	8	0.0094
Mikaniopsis clematoides	1	1	**20**	3	0.0452
Rosa abyssinica	0	8	**29**	19	0.031
Maesa lanceolata	0	4	**33**	3	0.005
Albizia schimperiana	0	2	**21**	0	0.0298
Olinia rochetiana	21	24	6	**32**	0.0262
Myrsine africana	11	18	4	**29**	0.0486
Osyris quadripartita	2	7	14	**29**	0.026
Echinops macrochaetus	1	0	25	**32**	0.0088
Gnidia glauca	0	0	0	**45**	0.0002
Rhamnus staddo	0	0	5	**31**	0.0042

4.3 Community similarity analysis

The Sorensen's similarity coefficient was used to detect dissimilarities among plant communities. Based on this, similarity in species composition slightly varied among communities (Table 4).

Table 4 Sorensen's similarity coefficient among communities

Communities	I	II	III	IV
I	1			
II	0.67	1		
III	0.83	0.62	1	
IV	0.69	0.55	0.68	1

The highest similarity (least dissimilarity) was observed between communities I and III (83%) due to the communities having close altitudinal similarity and adaptation. The least similarity (highest dissimilarity) was observed between community II and IV (55%), followed by community II and III and community I and II. i.e., 62% and 67% respectively (Table 6); this may be due to conservational variation and variation in disturbance due to anthropogenic activities. i.e., one area which is better protected varies from the one which is highly exposed to deforestation resulting in communities' variation. Overall similarity coefficient ranges from 55-83% among all the communities (Table 7). Thus, species composition dissimilarities account for 17% for the most similar communities i.e., 83% similarity (community I and III) and 45% for those that share least similarity (community II and IV). The similarity between community I and II (67%), II and III (69%) and III and IV (68%) are nearer to each other. This is may be due to the fact that communities having almost similar altitudinal range which results in similar species composition.

4.4 Species diversity, richness and equitability

Shannon-Wiener (1949) diversity index was computed for the four communities from the vegetation data of Gedo Forest (Table 8). Community IV had the highest species diversity followed by community III and community I. Community II had the least species diversity than others (Table 5).

Table 5 Shannon–Wiener Diversity Index

	Communities			
	I	II	III	IV
Diversity index (H`)	3.996	3.774	4.155	4.21
Species richness (S)	97	71	104	114
Equitability (J)	0.8734	0.8853	0.8946	0.889
Average altitude (m)	2417	2501.09	2412.05	2500.46

Note: Equitability (J) = H`/H`max where H`max= lnS

Community IV had the highest species richness while community II exhibited the least species richness comparatively because of the local people highly threatened the forest for agricultural expansion (Fig. 6), construction materials, fuelwood and rearing domestic animals (Fig. 7). The reason why community IV has the highest species richness is that it is relatively better protected under the District Agricultural Office, later under Oromia Forest and Wildlife Enterprise. The four communities have almost the same species distribution (equitability or evenness) but comparatively community III has the highest species evenness and community I has the least species evenness while the middle communities (communities II and III) have intermediate evenness.

Fig. 6 Agricultural expansion in the forest (Photo by Birhanu Kebede, March 2010)

Fig. 7 Domestic animals reared in the plantation part of the forest (Photo by Birhanu Kebede)

4.5 Vegetation structure

4.5.1 Tree density

The density of tree individuals of Gedo Forest with DBH greater than 2, 10, and 20 cm was shown in Table 6. The Density of trees with DBH greater than 2 cm in the study area is 781.94/ha. The number of stems with DBH >10 cm was found to be 832 and those with DBH >20 cm was 464. The ratio of DBH > 10 cm to DBH > 20 cm is high (1.79). The ratio of tree density > 10 cm DBH to > 20 cm DBH is taken as a measure of the size classes (Grubb *et al*., 1963). Therefore, the a/b ratio in Gedo Forest indicates the predominance of small sized tree individuals which indicates the forest was under heavy degradation and in a stage of secondary development.

Table 6 Density of species with DBH >10 cm, between 10 and 20 cm, and > 20 cm and their percentages

DBH (cm)	**Density ha^{-1}**	**Percentage (%)**
>10	956	42.45
10<DBH<20	832	36.94
>20	464	20.60

Tree densities with DBH greater than 10 and 20 cm in Gedo Forest were compared with that of fourteen different forests in Ethiopia (Table 7). The ratio of tree densities with DBH >10 cm to tree densities > 20 cm is also included in the comparison.

In this comparison, the ratio of tree densities with DBH 10<DBH<20 cm to density >20 cm in Gedo Forest showed that there is very close similarity with Jima and Magada Forests and has close similarity to Dindin, Denkoro and Bibita forests. The ratio A/B indicated that Gedo Forest has more trees in the lower DBH classes than in the higher classes when compared to Wof Washa, Dodolla, Alata- Bolale and Egdu (Menagesha Amba Mariam) forests. Five forests in the comparison (Jibat, Menagesha, Chilimo, Mena Angetu, and Masha Anderacha) have more A/B ratio values than Gedo Forest indicating that there are more predominance of trees in the lower DBH class in these forests than in Gedo Forest although the recent study and the present status of some of the forests are not well known. There reason behind these are geographical location, the nature of the forest (whether it is moist or dry), altitudal variation, age of the forest, degree of

conservation and exposure to disturbance.

Table 7 Comparison of tree densities with DBH between 10 and 20, and > 20 cm from Gedo Forest with other forests in Ethiopia arranged in increasing order of X/Y

Forest	**10<DBH>20 (X)**	**DBH>20 (Y)**	**X/Y**	**Forest types**
Egdu (MAM)[11]	155	197	0.8	Dry Afromontane
Wof-Washa[1]	329	215	1.5	Dry Afromontane
Dodola[3]	521	351	1.5	Dry Afromontane
Alata- Bolale[10]	365	219	1.7	Moist Afromontane
Gedo[12]	832	464	1.79	Dry Afromontane
Magada[5]	608	332	1.8	Dry Afromontane
Jima[9]	335	184	1.8	Moist Afromontane
Denkoro[6]	526	285	1.9	Dry Afromontane
Bibita[7]	500	265.6	1.9	Moist Afromontane
Dindin[4]	437	219	1.99	Dry Afromontane
Jibat[1]	565	287	2	Humid Afromontane
Menna Angetu[8]	292.59	139.78	2.08	Moist Afromontane
Menagesha[1]	484	208	2.3	Dry Afromontane
Masha Anderacha[2]	385.7	160.5	2.4	Moist Afromontane
Chilimo[1]	638	250	2.6	Dry Afromontane

Source: [1]Tamrat Bekele (1993), [2]Kumelachew Yeshitela and Taye Bekele (2003), [3]Kitessa Hundera (2003), [4]Simon Shibru and Girma Balcha (2004), [5]Genene Bekele (2005), [6]Abate Ayalew *et al.,* (2006), [7]Dereje Denu (2007), [8]Ermias Lulekal *et al.,* (2008), [9]Fufa Kenea (2008), [10]Woldeyohannes Enkossa (2008), [11]Abiyou Tilahun (2009), [12]Birhanu Kebede (Present study).

4.5.2 Diameter at Breast Height (DBH)

The distribution of trees in different DBH classes is given in Table 8 with their percentages and density per hectare.

Table 8 Distribution of DBH classes

DBH class	Density	Density ha^{-1}	%
2-8	761	264.24	33.79
8-14	654	227.08	29.04
14-20	373	129.51	16.56
20-26	143	49.65	6.35
26-32	93	32.29	4.13
32-38	48	16.67	2.13
38-44	61	21.18	2.71
44-50	35	12.15	1.56
50-56	18	6.25	0.78
>56	55	19.09	2.44

Class 1 (2-8 cm), 2 (8-14 cm), 3 (14-20 cm), 4 (20-26 cm), 5 (26-32 cm), 6 (32-38 cm), 7 (38-44 cm), 8 (44-50 cm), 9 (50-56) 10 (>56)

Distribution of all individuals in different DBH size classes showed an inverted J-shaped distribution. This pattern indicates that the majority of the species had the highest number of individuals in lower DBH which in turn shows that the forest vegetation has good reproduction and recruitment potential. Similar results were reported by Kumelachew Yeshitela and Taye Bekele (2003); Abate Ayelew *et al*. (2006); Feyera Senbeta (2006); Woldeyohannes Enkossa (2008).

Gedo Forest is similar to Bibita and Menna Angetu Forests in the number of individuals of woody species in lower DBH class (I & II) and lower than the rest of the forests under comparison. The percent of trees in DBH class III in Gedo Forest is similar to that of Chilimo Forest and but lower than the others. The percentage of trees in DBH class V in Gedo Forest is lower than in Magada, Bibita and Mena Angetu and higher than the rest of the forests under comparisons. The percentage of trees in DBH class VI in Gedo Forest is greater than that of Menagesha, Wof-Washa, and Chilimo and less than the other forests in the comparison. Therefore Gedo Forest is higher than the Dry Afromontane Forests of the central Shewa in higher DBH classes i.e it has more mature tree

species.

Table 9 Comparison of Gedo Forest with other seven forests in Ethiopia regarding percentage distribution of tree species in different DBH classes (I = 10-20 cm, II = 20-50 cm, III = 50-80 cm, IV = 80-110 cm, V = 110-140 cm, VI = >140 cm)

Forest	**DBH classes**					
	I	II	III	IV	V	VI
Menagesha1	56.9	32.8	06.5	02.5	0.00	0.00
Wof-Washa[1]	32.6	31.7	14.6	17.7	0.00	0.00
Chilimo[1]	60.08	36.5	02.6	0.00	0.00	0.00
Magada[2]	45.4	44.1	06.3	02.6	1.0	0.7
Denkoro[3]	46.0	46.0	06.3	01.1	0.2	0.4
Bibita[4]	30.2	24.4	06.2	01.7	0.5	1.4
Mena Angetu[5]	32.0	25.5	08.9	02.4	0.7	1.1
Gedo[6]	36.94	16.92	02.53	0.49	0.36	0.31

Source: [1]Tamrat Bekele (1993), [2]Genene Bekele (2005), [3]Abate Ayalew *et al.* (2006), [4]Dereje Denu (2007)**,** [5]Ermias Lulekal *et al.,* (2008), [6]Birhanu Kebede (Present study).

4.5.3 Tree height

The trees in the study area could be conveniently divided into 9 height classes.

Table 10 Percentage distribution of trees in height classes in m

Height class	Density ha^{-1}	Percentage
3-6	308.68	39.47
6-9	311.81	39.87
9-12	90.63	11.59
12-15	28.82	3.69
15-18	15.63	2.00
18-21	11.81	1.51
21-24	5.90	0.75
24-27	4.86	0.62
>27	3.82	0.49

Class I (3-6 m), II (6-9 m), III (9-12 m), 3 (12-15 m), IV (15- 18 m), V (18-21 m), VI (21-24 m), VII (24-27 m), VIII (>27 m)

The density of trees decreased with increasing height classes (Table 10). This means, there are higher number of individuals in the lower size and a gradual decrease towards the middle and upper size trees indicating continuous representation of individuals in all height classes. The highest number of individual trees was found to be 308.68 ha^{-1} representing the height class I. Trees in height class I and II have almost equal individuals and together make 79.34%. Trees in the height classes III and IV together are found to be 15.28 %. Height can be used as an indicator of age of the forest. The old trees are found in the height class above 24 m and their percentage distribution is 1.11%.

The height class I (6-9) of the Dry Afromontane Forests of the forests in Table 11 (Chilimo, Menagesha, Wof-Washa and Denkoro) is almost similar to Gedo Forest which is also Dry Afromontane but different from Jibat Forest which is the Humid Afromontane Forest. Gedo Forest has similar percent of individuals with Menagesha in class VI, with Denkoro and Menagesha in class VII and with Denkoro and Chilimo in IX. But less value than all except Menagesha in class

III and less value than all in class IV showing less number of individuals in medium height of the tree species than the forests under comparisons which shows selective cutting of individuals at some stage of the plant.

Table 11 Height class (m) Percentage distribution of trees in some Afromontane forests of Ethiopia taking class I (6-9), class II (9-12), class III (12-15) class IV (15-18), class V (18-21), class VI (21-24), class VII (24-27), class VIII (27-30) and class IX (>30)

Height class in m	**Jibat[1]**	**Chilimo[1]**	**Menagesha[1]**	**Wof-Washa[1]**	**Denkoro[2]**	**Gedo[3]**
6-9	25.5	42.1	38.5	23.3	39.3	39.47
9-12	24.0	30.8	32.0	21.3	28.3	39.87
12-15	15.2	15.3	10.8	13.7	18.9	11.59
15-18	14.0	7.5	11.0	13.1	6.7	3.69
18-21	7.2	3.4	2.2	6.1	3.2	2.00
21-24	3.7	<1	2.2	1.6	1.7	1.51
24-27	3.5	-	1.0	8.0	1.2	<1
27-30	2.5	-	<1	8.0	<1	<1
>30	4.3	-	2.0	4.8	-	-

Source: [1]Tamrat Bekele (1993), [2]Abate Ayalew *et al.,* (2006), [3]Birhanu Kebede (Present study).

4.5.4 Vertical structure

The vertical structure of trees in Gedo Forest was described following the International Union for Forestry Research Organization (IUFRO) classification scheme (Lamprecht, 1989). According to the scheme, three vertical structures were distinguished in tropical forests. These are: upper storey (tree height > 2/3 of top height), middle storey (tree height between 1/3 and 2/3 of top height) and lower storey (< 1/3 of top height). Consequently since the tallest tree in Gedo Forest observed was *Prunus africana* with 33 m height, trees in the lower, middle and upper storey were those in the height range < 11 m, 11-22 m and >22 m respectively. The description was given in Table 12.

Table 12: Density, species number and ratios of individuals to species by storey in Gedo Forest

Storey	Density ha^{-1}(A)	Density %	Species no.(B)	Species %	Ratio of A to B
Lower	678	86.7	38	97.44	17.84:1
Middle	90	11.5	23	58.97	3.91:1
Upper	14	1.79	13	33.33	1.08:1

Almost all woody species were found in the lower storey (97.44%) and middle storey contains about 23 woody species (58.97%), while upper storey was occupied by 13 species of which 27.5% is covered by *Prunus africana. Ficus sur, Ekebergia capensis* and *Erythrina brucei* covered 17.5%, 10%, and 7.5% respectively and four species namely *Olea europaea* subsp. *cuspidata, Olinia rochetiana, Apodytes dimidiata* and *Syzygium guineese* subsp. *afromontanum* covered 5% each and the rest four species covered 4% of the upper layer. The only species in the analysis which does not have a representative from the lower and middle storey is *Cordia africana,* which shows the plant has no regeneration status and is highly endangered in the forest. Even in the upper layer its density is very low, this might also indicate that *Cordia africana,* was probably selectively exploited from Gedo Forest through the past severe exploitation.

Height classes of trees are categorized under the following six figures (Fig 8a-f). The first pattern was formed by the species with the highest density in the first and second class decreasing with increasing height class forming inverted J shape (Fig. 11a). Some species in this class include *Olinia rochetiana, Olea capensis, Prunus africana* and *Bersama abyssinica*. The second pattern was indicated by the species which have no representative in higher class (Fig. 8b). Some of the species of this class are *Teclea nobilis, Chionanthus mildbraedii, Dovyalis abyssinica, Hagenia abyssinica* and *Dombeya torrida*. The third pattern has the highest density in the second class but relatively lower in third class and decreasing towards higher classes. Representative examples are *Olea europaea* subsp. *cuspidata*, *Allophylus abyssinicus*, *Apodytes dimidiata* and *Rhus glutinosa* (Fig. 8c). The fourth pattern has reprensatative in the whole class with variable densities (*Ficus sur* type) (Fig. 8d). The fifth pattern was formed by few species like *Cordia africana* (Fig.8e) which has representative individuals only in class six and seven. The last pattern was formed by the species which have no representative individuals in the first class, in intermideate classes (class 5 & 6) and in higher class (class 8). The height class of *Erythrina brucei* shows this types of pattern (Fig. 8f).

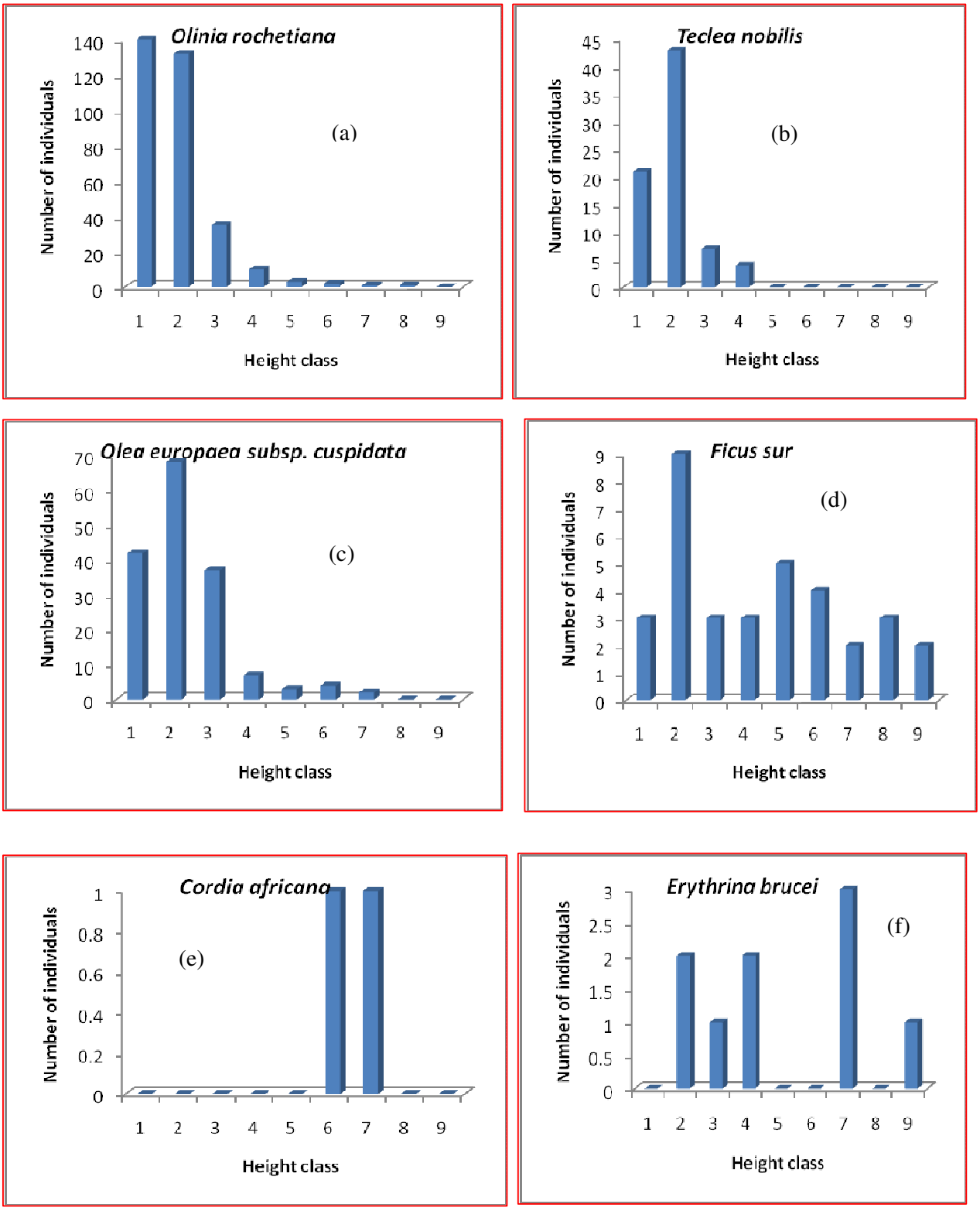

Fig. 8 (a-f): Six representative patterns of tree height structures in Gedo Forest Class 1 (3-6), 2 (6-9), 3 (9-12), 4 (12-15), 5 (15-18), 6 (18-21), 7 (21-24), 8 (24-27), 9 (>27)

4.5.5 Basal Area

The total Basal Area of Gedo Forest was 35.45 m^2 ha^{-1}. *Ficus sur, Podocarpus falcatus, Prunus africana, Olea europaea* subsp. *cuspidata, Olinia rochetiana* and *Apodytes dimidiata* constitute 61.87% of total BA in the Gedo Forest. Species like *Chionanthus mildbraedii, Bersama abyssinica, Olea capensis* subsp. *macrocarpa, Brucea antidysenterica* and *Rhus glutinosa* although they have high density; their basal area is not as high as their density (Tanle 13). This is due to the nature of the plants not to grow to higher Basal Area. This also indicates that species with the highest basal area do not necessarily have the highest density, indicating size difference between species (Tamrat Bekele, 1994; Simon Shibru and Girma Balcha, 2004; Dereje Denu, 2007).

Table 13 Total BA, BA m^2 ha^{-1}, % BA in increasing order and habit of the species in Gedo Forest

Scientific name	**BA**	**BA ha^{-1}**	**% BA**	**Habit**
Celtis africana	0.001	0.00	0.00	T
Juniperus procera	0.02	0.01	0.02	T
Schrebera alata	0.02	0.01	0.02	T
Rhamnus staddo	0.03	0.01	0.03	T
Hagenia abyssinica	0.03	0.01	0.03	T
Pittosporum viridiflorum	0.06	0.02	0.06	T
Syzygium guineense subsp. *guineense*	0.07	0.02	0.07	T
Calpurnia aurea	0.11	0.04	0.11	T
Dombeya torrida	0.16	0.06	0.16	T
Maesa lanceolata	0.22	0.08	0.22	T/S
Nuxia congesta	0.22	0.08	0.22	T
Gnidia glauca	0.27	0.09	0.26	T
Buddleja polystachya	0.33	0.11	0.32	T
Rhus vulgaris	0.36	0.13	0.35	T
Dovyalis abyssinica	0.58	0.20	0.57	T
Erythrina brucei	0.72	0.25	0.71	T
Acacia abyssinica	0.73	0.25	0.72	T

Scientific name	BA	BA ha^{-1}	% BA	Habit
Cordia africana	0.74	0.26	0.72	T
Croton macrostachyus	0.89	0.31	0.87	T
Brucea antidysenterica	0.9	0.31	0.88	T
Albizia schimperiana	0.98	0.34	0.96	T
Millettia ferruginea subsp. *ferruginea*	0.98	0.34	0.96	T
Teclea nobilis	1.38	0.48	1.35	T
Chionanthus mildbraedii	1.41	0.49	1.38	T/S
Bersama abyssinica	1.49	0.52	1.46	T
Scolopia theifolia	1.56	0.54	1.53	T
Rhus glutinosa	2.19	0.76	2.15	T
Maytenus arbutifolia	2.31	0.80	2.26	T
Olea capensis subsp. *macrocarpa*	2.73	0.95	2.67	T
Myrica salicifolia	3.39	1.18	3.32	T
Allophylus abyssinicus	4.54	1.58	4.45	T
Syzygium guineese subsp. *afromontanum*	4.56	1.58	4.47	T
Ekebergia capensis	4.99	1.73	4.89	T
Apodytes dimidiata	5.23	1.82	5.12	T
Olinia rochetiana	6.38	2.22	6.25	T
Olea europaea subsp. *cuspidata*	9.31	3.23	9.12	T
Prunus africana	11.28	3.92	11.05	T
Podocarpus falcatus	13.84	4.81	13.56	T
Ficus sur	17.12	5.94	16.77	T

It was reported that BA provides a better measure of the relative importance of the species than simple stem count (Cain and Castro, 1959; cited in Tamrat Bekele, 1994). Thus, species with the largest contribution to BA can be considered the most important species in the forest. Consequently, the most important tree species in Gedo Forest were *Ficus sur, Podocarpus falcatus, Prunus africana, Olea europaea* subsp. *cuspidata, Olinia rochetiana, Apodytes dimidiata, Ekebergia capensis, Syzygium guineese* subsp. *afromontanum, Allophylus abyssinicus* and *Myrica salicifolia.* Their BA, density, IVI and frequency values ha-^{1} were in given (Table 14).

According to Lamprecht (1989), high density and high frequency coupled with high BA indicate the overall dominant species of the forest. Accordingly, *Olinia rochetiana*, *Olea europaea* subsp. *cuspidata* and *Prunus africana* are the top three dominant species of the forest since all the three are found in the top five of the ranks of basal area, relative density, relative frequency and IVI per hectare of the ten top dominant species.

Table 14 Basal Area, Relative Density, Relative Frequency and IVI values per hectare of ten top dominant Species of Gedo Forest

Species name	BA	RD	RF	IVI
Ficus sur	5.94	1.51	1.95	20.22
Podocarpus falcatus	4.81	2.31	3.76	19.62
Prunus africana	3.92	6.17	5.29	22.51
Olea europaea subsp. *cuspidata*	3.23	7.24	6.68	23.04
Olinia rochetiana	2.22	14.39	8.07	29.20
Apodytes dimidiata	1.82	4.04	5.07	14.87
Ekebergia capensis	1.73	1.20	1.53	7.62
Syzygium guineese subsp. *afromontanum*	1.58	5.42	4.73	14.61
Allophylus abyssinicus	1.58	4.57	3.76	12.77
Myrica salicifolia	1.18	0.93	1.39	5.64

Gedo Forest is almost similar to Menagesha Suba Forest, higher than Chilimo Forest and lower than all the other forests under comparisons with respect to basal area per hectare (Table 15). This may be due to variations in the conservation of the forests, exposure to deforestation and geographical location of the forests.

Table 15 Comparison of Gedo Forest, with other 12 afromontane forests in Ethiopia with respect to basal area per hectare (Note: MA = Menna Angetu, MG = Magada, DN = Dindin, MAN = Masha Anderacha, DK = Donkoro, MN = Menagesha, CH = Chilimo, JB = Jibbat, WW = Wof -Washa, DD = Dodolla, BF= Bibita Forest (Gura Ferda,), EG=Egdu (MAM), GD= Gedo Forest*).*

Forest	[2]MG	[1]MN	[3]DN	[4]DK	[5]MAN	[6]MA	[1]CH	[1]JB	[1]WW	[7]DD	[8]BF	[9]EG	[10]GD
BA ha^{-1}	68.52	36.1	49.0	45.0	81.90	94.22	30.1	47.5	101.8	129.0	69.9	84.17	35.45

Source: [1]Tamrat Bekele (1993), [2]Genene Bekele (2005), [3]Simon Shibru and Girma Balcha (2004), [4]Abate Ayalew *et al.,* (2006), [5]Kumilachew Yeshitela and Taye Bekele (2003), [6]Ermias Lulekal *et al*., (2008), [7]Kitessa Hundera (2003), [8]Dereje Denu (2007), [9]Abiyou Tilahun (2009), [10]The present study

4.5.6 Frequency

Frequency is the number of quadrats in which a given species occurred in the study area. Frequency is the indication of homogeneity and heterogeneity of given vegetation in which the higher number of species in higher frequency classes and low number of species in lower frequency classes show similar species composition while large number of species in lower frequency classes and small number of species in higher frequency classes indicates higher heterogeneity (Lambrecht, 1989). The frequency of all the tree species in this Forest is given in Table 17. The three most frequently observed species are *Olinia rochetiana* 58 times out of 72 quadrats possessing 80.56 % occurrence and 8.07 relative frequency. The second and the third were *Bersama abyssinica* with 79.17 % occurrence and 7.73 relative frequency and *Olea europaea* subsp. *cuspidata was* with 66.67 % occurrence and 6.68 relative frequency. The ten least occurred species were *Hagenia abyssinica, Dombeya torrida, Millettia*

ferruginea subsp. *ferruginea, Erythrina brucei, Syzygium guineense* subsp. *guineense, Schrebera alata, Juniperus procera, Cordia africana, Pittosporum viridiflorum* and *Celtis africana,* each constituting less than 1 relative frequency and a total of 3.62 relative frequency.

4.5.7 Importance Value Index (IVI)

Importance Value Index combines data from three parameters which include RF, RD and RDO (Kent and Coker, 1992). It is crucial to compare the ecological significance of species (Lamprecht, 1989). It was also stated that species with the greatest importance value are the leading dominant of specified vegetation (Simon Shibru and Girma Balcha, 2004). Accordingly, the 10 leading dominant and ecologically most significant trees in Gedo Forest are *Olinia rochetiana, Olea europaea* subsp. *cuspidata, Prunus africana, Ficus sur, Podocarpus falcatus, Bersama abyssinica, Syzygium guineese* subsp. *afromontanum, Chionanthus mildbraedii, Allophylus abyssinicus* and *Myrica salicifolia.* They contribute 185.86 (61.98%) from a total of 299.85 IVI value. The reason why they have higher IVI value is that they have higher relative density, relative frequency and relative abundance relative to other species in the forest. Tree species, their IVI and priority for conservation is given in Table 17 in decreasing order of IVI values. The leading dominant and ecologically most significant species might also be the most successful species in regeneration, pathogen resistance, preference by browsing animals (least preferred), attraction of pollinators and attraction of seed predators that facilitate seed dispersal within the existing environmental conditions (Fufa Kenea, 2008).

Priority for conservation of these species should be given based on their IVI values. i.e. the first priority for species with least IVI value and the last priority of conservation for species with highest IVI values. Concerning the IVI species that grouped under class 4 (Table 16) should get the uppermost conservation priority because these are at risk of local extinction.

Table 16 List of species under each IVI class

Class 1	**Class 3**
Olinia rochetiana	*Maytenus arbutifolia*
Olea europaea subsp. *cuspidata*	*Teclea nobilis*
Prunus africana	*Olea capensis* subsp. *macrocarpa*
Ficus sur	*Ekebergia capensis*
	Scolopia theifolia
Class 1	**Class 3**
	Brucea antidysenterica
	Rhus vulgaris
Class 2	*Myrica salicifolia*
Podocarpus falcatus	*Calpurnia aurea*
Bersama abyssinica	*Maesa lanceolata*
Apodytes dimidiata	*Nuxia congesta*
Syzygium guineese subsp. *afromontanum*	*Croton macrostachyus*
Chionanthus mildbraedii	*Albizia schimperiana*
Allophylus abyssinicus	*Dovyalis abyssinica*
Rhus glutinosa	*Rhamnus staddo*
	Acacia abyssinica
	Gnidia glauca
Class 4	*Buddleja polystachya*
Syzygium guineense subsp. *guineense*	*Hagenia abyssinica*
Schrebera alata	*Millettia ferruginea* subsp. *ferruginea*
Pittosporum viridiflorum	*Erythrina brucei*
Juniperus procera	*Dombeya torrida*
Celtis africana	*Cordia africana*

Table 17 The importance value index (IVI) and priority class for conservation of tree species in Gedo Forest (RD = Relative density, RDO = Relative Dominance, RF = Relative frequency.

	Scientific name	**RD**	**RDO**	**RF**	**IVI**	**IVI%**	**Priority**
1	*Olinia rochetiana*	14.39	6.74	8.07	29.20	9.74	4
2	*Olea europaea* subsp.*cuspidata*	7.24	9.12	6.68	23.04	7.68	4
3	*Prunus africana*	6.17	11.05	5.29	22.51	7.51	4
4	*Ficus sur*	1.51	16.77	1.95	20.22	6.75	4
5	*Podocarpus falcatus*	2.31	13.55	3.76	19.62	6.54	3
6	*Bersama abyssinica*	6.39	1.46	7.93	15.79	5.26	3
7	*Apodytes dimidiata*	4.04	5.12	5.70	14.87	4.96	3
8	*Syzygium guineese* subsp. *afromontanum*	5.42	4.47	4.73	14.61	4.87	3
9	*Chionanthus mildbraedii*	7.68	1.39	4.17	13.24	4.42	3
10	*Allophylus abyssinicus*	4.57	4.45	3.76	12.77	4.26	3
11	*Rhus glutinosa*	4.17	2.15	3.76	10.08	3.36	3
12	*Maytenus arbutifolia*	3.15	2.26	3.76	9.17	3.06	2
13	*Teclea nobilis*	3.64	1.35	3.76	8.75	2.92	2
14	*Olea capensis* subsp. *macrocarpa*	2.58	2.67	2.50	7.75	2.58	2
15	*Ekebergia capensis*	1.20	4.89	1.53	7.62	2.54	2
16	*Scolopia theifolia*	2.71	1.52	2.50	6.74	2.25	2
17	*Brucea antidysenterica*	2.58	0.09	4.03	6.70	2.23	2
18	*Rhus vulgaris*	2.44	0.36	3.06	5.86	1.95	2
19	*Myrica salicifolia*	0.93	3.32	1.39	5.64	1.88	2
20	*Calpurnia aurea*	2.40	0.11	2.78	5.29	1.76	2
21	*Maesa lanceolata*	1.78	0.22	2.64	4.63	1.55	2
22	*Nuxia congesta*	1.82	0.22	1.95	3.99	1.33	2
23	*Croton macrostachyus*	1.29	0.87	1.67	3.83	1.28	2
24	*Albizia schimperiana*	1.02	0.96	1.39	3.37	1.12	2
25	*Dovyalis abyssinica*	1.11	0.57	1.67	3.35	1.12	2
26	*Rhamnus staddo*	1.15	0.02	1.95	3.13	1.04	2
27	*Acacia abyssinica*	1.02	0.71	1.25	2.98	1.00	2
28	*Gnidia glauca*	1.20	0.26	1.39	2.85	0.95	2

	Scientific name	RD	RDO	RF	IVI	IVI%	Priority
29	*Buddleja polystachya*	0.89	0.33	1.25	2.47	0.82	2
30	*Hagenia abyssinica*	0.93	0.29	0.70	1.92	0.64	2
31	*Millettia ferruginea* subsp. *ferruginea*	0.40	0.96	0.56	1.91	0.64	2
32	*Erythrina brucei*	0.36	0.71	0.28	1.34	0.45	2
33	*Dombeya torrida*	0.40	0.15	0.70	1.25	0.42	2
34	*Cordia africana*	0.09	0.72	0.28	1.09	0.36	2
35	*Syzygium guineense* subsp. *guineense*	0.27	0.07	0.28	0.61	0.20	1
36	*Schrebera alata*	0.22	0.02	0.28	0.52	0.17	1
37	*Pittosporum viridiflorum*	0.27	0.06	0.14	0.47	0.16	1
38	*Juniperus procera*	0.13	0.02	0.28	0.43	0.14	1
39	*Celtis africana*	0.13	0.00	0.14	0.27	0.09	1
	Total	100.00	100.00	100.00	299.85	100.00	

4.5.8 Population structure for some selected woody species

Population structures of trees have significant implications to their management, sustainable use and conservation (Simon Shibru and Girma Balcha, 2004).The analysis of population structure of selected woody species resulted in six different patterns (Fig. 9a-f) and represented by one species from the group.

The first pattern was formed by the species having high number of individuals in the second class and relatively lower in first and third class then decrease with increasing DBH towards the higher classes (Fig. 9a) The species in this group are *Olinia rochetiana, Syzygium guineense* subsp. *afromontanum, Rhus glutinosa, Croton macrostachyus, Maytenus arbutifolia, Olea capensis* and *Scolopia theifolia.* The second pattern contains high number of individuals in the first and third DBH classes, medium in the second class, decreasing in the fourth and fifth classes and none in the rest DBH classes (Fig. 9b). These species contain good regeneration status but less recruitment. Species which show this pattern are *Teclea nobilis*, *Hagenia abyssinica, Rhus vulgaris, Dovyalis abyssinica, Gnidia gluca* and *Nuxia congesta.* The third pattern is inverted J-shape in which species have good reproduction and recruitment. Species exhibiting this normal diameter class

distribution were *Acacia abyssinica* (Fig. 9c), *Chionanthus mildbraedii, Olea europaea* subsp. *cuspidata, Allophylus abssinicus, Albizia schimperiana* and *Podocarpus falcatus.*

The species in the fourth pattern were restricted to DBH class of 1, 2 and 3 (Fig. 9d). They didn`t have individuals in the higher DBH classes some of them due to the nature of the species (they do not grow to higher DBH class e.g *Brucea antidysenterica*) and some of them due to removal of the plant for different activities. The species which show this pattern were *Brucea antidysenterica, Syzygium guineense* subsp. *guineense, Pittosporum viridiflorum, Celtis africana, Millettia ferruginea* subsp. *ferruginea, Juniperus procera, Maesa lanceolata* and *Rhamnus staddo*. The fifth pattern shows up and down (decrease to some extent with increasing DBH class then increase in the next class and continue like this covering the whole DBH classes). There may be selective cutting of the trees in the different DBH classes for domestic use (Fig. 9e). The species in this group include *Ekebergia capensis, Apodytes dimidiata, Ficus sur* and *Prunus africana*. In the last pattern, (Fig. 9f) there were no individuals in the first DBH class (2-8 cm), may be due to low regeneration status of the species and removal of the young individuals of the species for construction materials like for making bee hives as well as browsing by domestic animals. They also have few or no representative individuals in higher DBH classes. The species in this class include *Dombeya torrida, Cordia africana.*

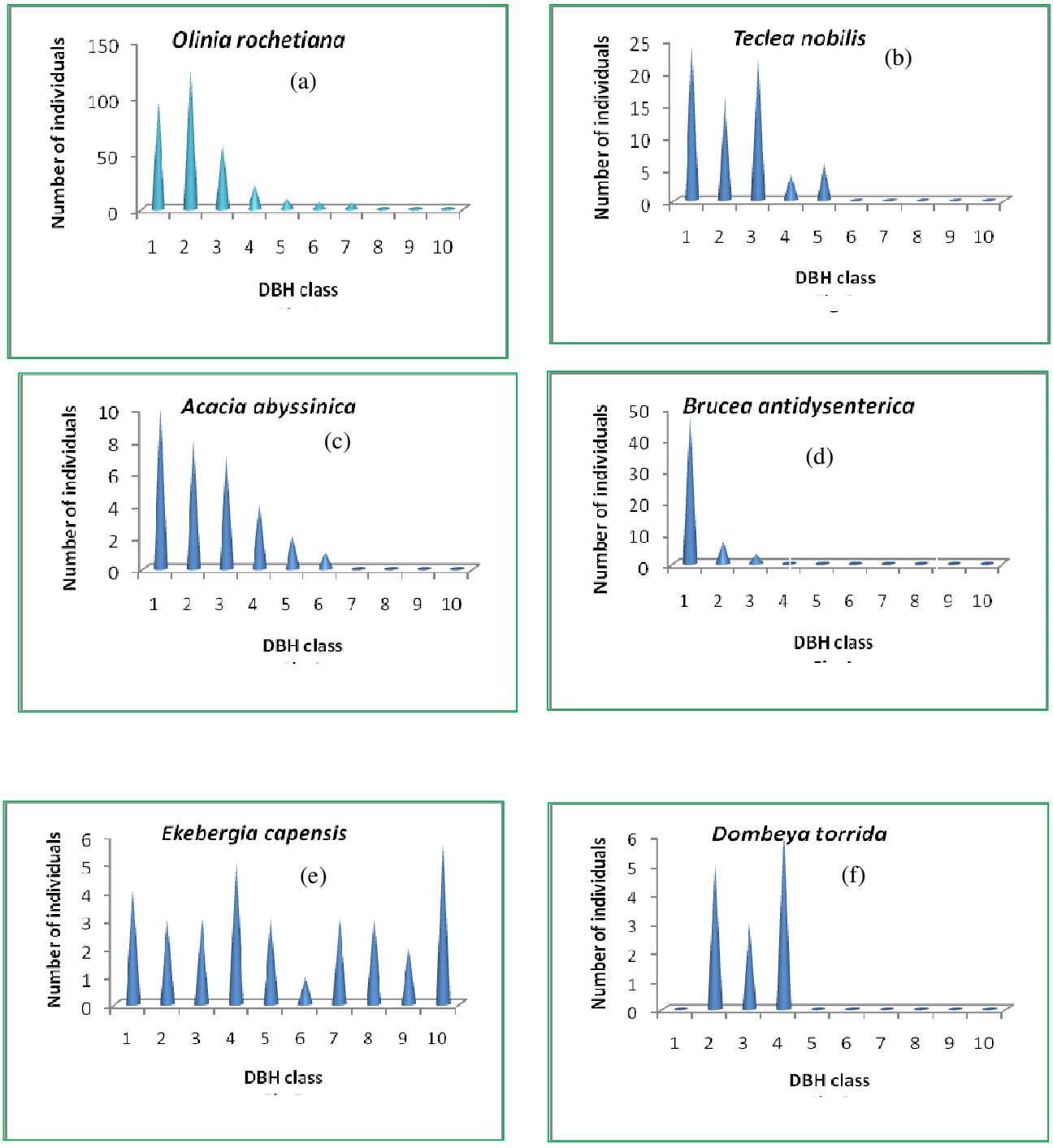

Fig. 9 (a_f) Six representative patterns of tree species population structures in Gedo Forest where DBH classes are: 1) 2-8 cm, 2) 8-14 cm, 3) 14-20 cm, 4) 20-26 cm, 5) 26-32 cm 6) 32-38 cm, 7) 38-44 cm, 8) 44-50 cm, 9) 50-56 cm, 10) >56 cm.

4.5 Regeneration Status of Gedo Forest

Composition and density of seedlings and saplings would indicate the regeneration status of that forest. The composition and density of seedlings and saplings of tree species in Gedo Forest were included in this study. Density of seedlings, saplings and mature trees and shrubs of woody species is given in Table 18**.**

The total density of seedlings, saplings and trees were 1068.21 ha^{-1}, 837.51 ha^{-1} and 738.55 ha^{-1} respectively (Fig. 10).

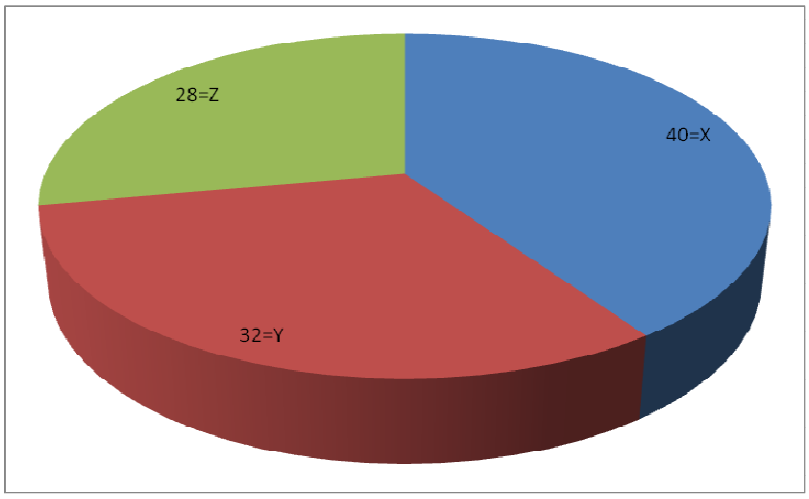

Fig. 10 Density percentage of seedlings (X), saplings (Y) and mature (Z) of tree and shrub species in the study area.

The ratio of seedlings to saplings was 1.3, seedlings to mature trees was 1.5 and saplings to mature trees was 1.1. These shows that the distribution of seedlings as a whole is greater than that of saplings and mature trees and that of saplings is greater than mature trees. The tree species in the study area were categorized into two groups based on the number of seedlings and saplings encountered during the study. Group "1" = species with ≥1 seedlings, Group "2" = species with no seedling at all (Table 19).

Table 18 Density per hectare of seedlings (SE), saplings (SA) and mature tree (T) species in the study area arranged in decreasing order of TD (TD= Total Density)

Species list	**SE/ha**	**SA/ha**	**T/ha**	**TD**	**%TD**
Olinia rochetiana	110.74	82.29	107.64	300.67	11.37
Calpurnia aurea	88.19	29.17	16.32	133.68	5.06
Bersama abyssinica	73.61	70.83	48.96	193.4	7.31
Olea europaea subsp. *cuspidata*	65.26	62.36	50.69	178.31	6.74
Chionanthus mildbraedii	61.21	57.83	53.13	172.17	6.51
Prunus africana	50.01	34.03	44.1	128.14	4.85
Syzygium guineense subsp. *afromontanum*	48.54	36.39	40.97	125.9	4.76
Rhus glutinosa	42.15	39.9	33.33	115.38	4.36
Apodytes dimidiata	41.81	36.04	29.86	107.71	4.07
Podocarpus falcatus	38.36	27.36	18.06	83.78	3.17
Teclea nobilis	37.99	31.88	25.35	95.22	3.60
Rhus vulgaris	36.32	31.94	24.31	92.57	3.50
Brucea antidysenterica	35.56	30.21	20.49	86.26	3.26
Allophylus abyssinicus	33.75	29.61	30.9	94.26	3.56
Maytenus arbutifolia	29.03	32.57	25.69	87.29	3.30
Ficus sur	27.29	13.42	11.81	52.52	1.99
Maesa lanceolata	25.24	21.18	12.5	58.92	2.23
Olea capensis subsp. *macrocarpa*	24.86	19.54	19.44	63.84	2.41
Nuxia congesta	19.72	18.4	12.85	50.97	1.93
Croton macrostachyus	18.68	12.33	8.68	39.69	1.50
Rhamnus staddo	18.29	13.68	8.68	40.65	1.54
Scolopia theifolia	17.64	15.28	16.32	49.24	1.86
Gnidia glauca	17.64	14.93	8.33	40.9	1.55
Ekebergia capensis	16.25	10.6	9.03	35.88	1.36
Acacia abyssinica	14.72	9.94	7.29	31.95	1.21
Hagenia abyssinica	14.17	7.29	6.6	28.06	1.06
Myrica salicifolia	13.13	11.11	8.68	32.92	1.24
Dovyalis abyssinica	12.43	11.64	9.03	33.1	1.25
Albizia schimperiana	8.12	5.78	7.99	21.89	0.83
Buddleja polystachya	7.74	7.21	6.94	21.89	0.83
Schrebera alata	7.74	2.08	1.04	10.86	0.41
Erythrina brucei	5.08	3.43	2.08	10.59	0.40
Dombeya torrida	4.86	3.43	2.78	11.07	0.42
Juniperus procera	2.08	2.04	1.04	5.16	0.20
Syzygium guineense subsp. *guineense*	0	0	1.39	1.39	0.05
Millettia ferruginea subsp. *ferruginea*	0	0	3.47	3.47	0.13
Pittosporum viridiflorum	0	1.04	1.74	2.78	0.11

Species list	SE/ha	SA/ha	T/ha	TD	%TD
Celtis africana	0	0.75	0.35	1.1	0.04
Cordia africana	0	0	0.69	0.69	0.03
Total	1068.21	837.51	738.55	2644.27	100.00

The composition, distribution and density of seedlings and saplings indicate the future status of the forest. Coming to the conservation priorities, the tree species in group one whose seedlings are absent (Table 19) should be given the first priority for conservation because they are at higher risk of local extinction and some of them are included in national priority species list and also have commercial importance for economic development of the country.

Table 19 Regeneration status of some tree species in Gedo Forest

Group 1	Group 2
Species list	**Species list**
Olinia rochetiana	*Syzygium guineense subsp. guineense*
Calpurnia aurea	*Millettia ferruginea subsp. ferruginea*
Bersama abyssinica	*Pittosporium viridiflorum*
Olea europaea subsp. *cuspidata*	*Celtis africana*
Chionanthus mildbraedii	*Cordia africana*
Prunus africana	
Syzygium guineense subsp. *afromontanum*	
Rhus glutinosa	
Apodytes dimidiata	
Podocarpus falcatus	
Teclea nobilis	
Rhus vulgaris	
Brucea antidysenterica	
Allophylus abyssinicus	
Maytenus arbutifolia	
Ficus sur	
Maesa lanceolata	
Olea capensis subsp. *macrocarpa*	
Nuxia congesta	
Croton macrostachyus	
Rhamnus staddo	
Scolopia theifolia	
Gnidia glauca	
Ekebergia capensis	
Acacia abyssinica	

Group 1	
Species list	
Myrica salicifolia	
Dovyalis abyssinica	
Albizia schimperiana	
Buddleja polystachya	
Schrebera alata	
Erythrina brucei	
Dombeya torrida	
Juniperus procera	

4.6 Phytogeographical Comparison

The result obtained shows Gedo Forest is one of the most diversified dry evergreen forests in the country containing a minimum of 235 species of plants. Direct comparison of the species diversity with other forests is not feasible due to differences in size of forests, survey methods, and objective of the study (Tadesse Woldemariam, 2003). However, the over all species richness of the forest can give more or less a general impression of their diversity and phytogeographical similarity.

Gedo Forest is compared with five Dry Evergreen Afromontane Forests in Ethiopia. These include Biteyu, Denkoro, Egdu (Menagesha Amba Mariam), Menagesha Suba and Bale Mountain National Park Dry Evergreen Forests.

Beteyu Forest is found in altitudinal range of 2590-2890 m and 8^0 13' N and 38^0 21' E at the edge of the western escarpment of the Gurage mountain chain in the Southern Nations, Nationalities and Peoples` Region, 17 km northwest of Butajira town. Biteyu Forest is one of the relict patches of forests, which is probably a remnant forest that was once widespread on the Central plateau of Shewa (Mekonnen Biru, 2003). Denkoro Forest is found in South Wello Zone between Debresina and Saint distrcts approximately between 10^0 47' – 10^0 50'N and 38^0 35' – 38^0 42'E. It is generally characterized by rough topography with mountains, deeply incised valleys, escarpments and plateau (Abate Ayalew *et al*., 2006). Egdu Forest is found 30 km west of Addis Ababa, 20 km from Holeta 5 km South of Menagesha town approximately between $9^0$01`-$09^0$03`N and $38^0$35`-$38^0$36`E within altitudinal varation of 2574-2948 m (Abiyou Tilahun, 2009).

Menagesha Suba State Forest could be considered 'the Oldest Park in Africa', which is better protected and located in central part of the country 30 km southwest of Addis Ababa. It is found between $38^0$31´and $38^0$35´ E and 9^0 89´ and $9^0$00´ N (Abate Zewdie, 2006). Bale Mountains National Park Forest is located in Bale Zone, between $07^0$05.98'–$07^0$08.99'N and $39^0$43.43'–$39^0$45.39'E. The altitudinal range of this area lies between 3010–3410 m a.s.l. (Haile Yineger *et al*., 2008). Four of the forests in comparison are found in Oromia National Regional State, one in Amahara National Regional State (Denkoro) and one in Southern Nations Nationalities` Region and Peoples (Biteyu).

These forests were compared with Gedo Forest based on similarities in species composition. Tree and shrub species were used in this similarity analysis. The similarity index used to evaluate the similarity of Gedo Forest with these forests is Sorensen's similarity index. Table 20 shows the floristic composition similarity between Gedo Forest and the other five Dry Afromontane Forests in Ethiopia. Where: a = common to Gedo and the forest in comparison, b = found only in Gedo Forest, c = found only in the forest in comparison with Gedo, Sc = Sorensen`s similarity coefficient, Ds = Dissimilarity coefficient.

Table 20 Comparison of Gedo Forest with other six dry evergreen forests in Ethiopia based on their similarities/differences

Forest	**a**	**b**	**c**	**Sc**	**Dc**
Biteyu[1]	38	61	19	0.48	0.52
BMNP[2]	11	90	17	0.17	0.83
Denkoro[3]	48	54	16	0.57	0.43
Egdu[4]	42	63	13	0.63	0.37
Menagesha[5]	40	63	15	0.51	0.49

*BMNP (Bale Mountains National Park)

Source: [1]Mekonnen Biru (2003), [2]Haile Yineger *et al*., (2008), [3]Abate Ayalew *et al*., (2006), [4]Abiyou Tilahun (2009), [5]Abate Zewdie (2006).

From the Sorensen`s similarity coefficient Gedo Forest share highest similarity with Egdu (Menagesha Amba Mariam) Forest (63%) due to geographical similarity and the altitude of Egdu Forest is totally found in the altitudinal range of Gedo Forest (2300-3000 m). The least similarity is shared with Bale Mountains National Park Forest; This is due to geographical difference between the forests as well as the altitude of Gedo Forest is totally out of Bale

Mountains National Park Forest since the lowest altitude of BMNP Forest is greater than the highest altitude of Gedo Forest in addition it may be due to anthropogenic influence or other factors such as climatic condition and environmental variables which affect vegetation. However, they share 11 species in common due to both are dry evergreen forest. Next to Egdu Forest Gedo Forest shared high similarity with Denkoro (57%) having 48 tree and shrub species in common.

Menagesha Subba shared 51% with Gedo Forest which is less when compared wirh Egdu Forest which is adjacent to Menagesha Forest, This is due the fact that Menagesha State Forest is well protected as a result anthropogenic effect is less, trees are very matured as well as species diversity is less due to the shade effect of mature trees. Biteyu Forest shared the least similarity with Gedo Forest (48%) next to BMNP. The dissimilarities between forests may arise from the different sample sizes and methods of the study, altitudinal differences, degree of human impact (anthropogenic) action, over grazing and climatic conditions.

Asparagus africanus, Erica arborea, Juniperus procera and *Rosa abyssinica* are among some tree and shrub species common to the six forests in comparison. *Hagenia abyssinica, Pittosporum viridiflorum, Rubus apetalus, Rubus steudneri, Olinia rochetiana, Olea europaea* subsp. *cuspidata* and *Allophylus abyssinicus* were among the species which are found in most of the dry evergreen forests in comparison.

5. CONCLUSION AND RECOMMENDATIONS

5.1 CONCLUSION

Results of the present study showed that 235 specimens of plants (herbs, shrubs, lianas and trees) were collected. The specimens identified belong to 190 genera and 78 families. Asteraceae is the most dominant family with 36 species and 24 genera, Fabaceae is the second dominant family with 16 species and 14 genera. The third species rich family was Lamiaceae with 16 species and 13 genera. The next were Acanthaceae (10 species and 6 genera), Rubiaceae (10 species and 10 genera) and Poaceae (7 species and 7 genera). The proportion of families represented only by one species each were 51.28%, 2-5 species 32.05%, 5-10 species 10.26% and with more than 10 species were 6.41%.

Out of the plants identified in this study, 25 were endemic species which are included in the IUCN Red Data List, of which 1 species is Critically Endangered (*Kniphofia hildebranditii*), 18 species in Least Concern, four species Nearly Threatened and two species Vulnerable. From the endemic IUCN red list in the study area herbs, shrubs, trees and climbers constitute 48%, 32%, 12%, and 8% respectively. Fourty eight percent of the endemic species in the study area were from the family Asteraceae. Two species are found at subspecies level *Millettia ferruginea* subsp. *ferruginea* and *Justicia diclipteroides* subsp. *aethiopica.*

Four plant communities were identified and described with varying degree of species richness, evenness and diversity. Variability in population structure, which implies vegetation dynamic, was recognized from the analysis of tree species DBH. In addition, density class description of the forest indicated the dominance of small sized individuals asserting Gedo Forest is in a stage of secondary development. Some economically and ecologically important species had population structures that showed abnormal recruitment patterns with poor reproduction, where, *Cordia africana* and *Celtis africana* are examples. Therefore, there is a need to develop and implement effective management systems in the area to facilitate optimal regeneration that assures the sustainable use of these species at present and in the future. Moreover, on the basis of species population structures, IVI and regeneration status, the tree species of Gedo Forest were objectively prioritized for conservation. Among them *Cordia africana*, *Celtis africana, Syzygium*

guineense subsp. *guineense* and *Schrebera alata* should get the uppermost conservation priority.

The density of woody species in Gedo Forest decreases with increasing height classes. The Forest is characterized by high density of trees in the lower class than in the higher. Thus, the forest is in good state of recruitment. Three layers (lower, middle and upper) of tree canopies were identified from the study of vertical stratification of Gedo Forest. Almost all woody species were found in the lower storey (97.44%) and middle storey contains about 23 woody species (58.97%), while upper storey was occupied by 13 woody species of which 27.5% is covered by *Prunus africana.* *Ficus sur, Ekebergia capensis, Erythrina brucei* covered 17.5%, 10%, and 7.5% respectively and four species namely *Olea europaea* subsp. *cuspidata, Olinia rochetiana, Apodytes dimidiata* and *Syzygium guineese* subsp. *afromontanum* covered 5% each and the rest four species covered 4% of the upper layer.

5.2 RECOMMENDATIONS

Forests regulate microclimate, protect water resources, provide forest products and are homes to plant and animal species. Therefore, it is must to protect and pass to the next generation. In the area where this study has been conducted cattle are putting heavy pressure on the forest. Shrubs as well as trees are cut for fuel and timber frequently. Animal rearing in the forest and timber cutting from the forest should be stopped if possible or at least controlled by the concerned body.

It is essential to create awareness among the local community about forest conservation and wise utilization. Extension program including forest management should be extended so as to increase awareness on people for wise utilization of the forest. One of the major threats to the forest vegetation is expansion of farmland surrounding the forest and illegal logging. To reduce this and use the forest sustainably, participatory forest management can be used as an alternative.

Gedo Forest has a significant number of endemic taxa. Therefore, high conservation should be given as well as research on the soil seed bank, seed physiology, population dynamics, biology and ecology of endemic species as well the forest as whole are recommended.

The forest is a good recreational area for the community in and around the Distict especially during weeding and holy day celebration. Therefore development of hotels and tourism is beneficial.

Modern beekeeping and marketing should be initiated in the area to improve income of local community.

Ethnobotanical studies to explore the indigenous knowledge on the diverse uses of plants and its conservation is recommended

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7. APPENDICES

Appendix 1 Species list collected from Gedo Forest. (Ha = habit, T = tree, S = shrub, H = herb, T/S = tree/shrub=S/T, L= liana, L/T= liana/tree, C = climber, C/H= climber/ herb, E = epiphyte, F = fern, Ver. name = Vernacular name in Afan Oromo)

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	T	Laaftoo	BR086
2	*Acacia melanoxylon* R.Br.	Fabaceae	T	'Akeeshiya'	BR187
3	*Acanthus polystachius* Delile	Acanthaceae	S	Kosorruu	BR219
4	*Acanthus sennii* Chiov.	Acanthaceae	S	Kosoruu	BR044
5	*Achyranthes aspera* L.	Amaranthaceae	H	Maxxanne	BR103
6	*Adiantum poiretii* Wikstr.	Adiantaceae	H	Misira hantuuta	BR171
7	*Ageratum conyzoides* L.	Asteraceae	H		BR223
8	*Albizia schimperiana* Oliv.	Fabaceae	T	Imalaa	BR049
9	*Alepidea peduncularis* Steud. ex A. Rich	Apiaceae	H		BR224
10	*Allophylus abyssinicus* (Hochst.) Radlk.	Sapindaceae	T		BR030
11	*Andropogon abyssinicus* Fresen.	Poaceae	H	Baallammii	BR132
12	*Anthospermum herbaceum* L. f.	Rubiaceae	H		BR176
13	*Apodytes dimidiata* E. Mey. ex Arn.	Icacinaceae	T	Qumbaala	BR013
14	*Arisaema schimperianum* Schott	Araceae	H	Boqolloo warabeessaa	BR147
15	*Artemisia afra* Jacq. ex Willd.	Asteraceae	H	Xiroo	BR125
16	*Asparagus africanus* Lam.	Asparagaceae	S	Sariitii	BR052
17	*Aspilia mossabicensis* (Oliv.) Wild	Asteraceae	S		BR114
18	*Bartsia trixago* L.	Scrophulariaceae	H		BR225
19	*Bersama abyssinica* Fresen.	Melianthaceae	T	Lolchiisaa	BR009
20	*Berula erecta* (Hudson) Coville	Apiaceae	H	Dammaallasee	BR121
21	*Bidens ghedoensis* Mesfin	Asteraceae	H	Keelloo	BR134
22	*Bidens prestinaria* (Sch. Bip.) Cufod	Asteraceae	S	Keelloo boyyee	BR115
23	*Brucea antidysenterica* J. F.Mill	Simaroubaceae	T	Qomoonyoo	BR011
24	*Buddleja madagascariensis* Lam.	Loganiaceae	S		BR137
25	*Buddleja polystachya* Fresen.	Loganiaceae	T	Qawwisaa	BR089

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
26	*Caesalpinia decapetala (*Roth) Alston	Fabaceae	S	Haraangamaa faranjii	BR183
27	*Calpurnia aurea (*Ait.) Benth.	Fabaceae	T	Ceekaa	BR010
28	*Canthium oligocarpum* Hiern subsp. *Oligocarpum*	Rubiaceae	S/T		BR002
29	*Carduus nyassanus* (S. Moore) R. E. Fries	Asteraceae	H	Qoree harree	BR151
30	*Carduus schimperi* Sch. Bip. ex A. Rich subsp. *Schimperi*	Asteraceae	H	Baalawaraantii	BR112
31	*Carex brunnea* Thunb.	Cyperaceae	H		BR210
32	*Carissa spinarum* L.	Apocynaceae	S	Agamsa	BR027
33	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae	H	Haraangama faraanjii	BR196
34	*Caylusea abyssinica* (Fresen.) Fish. & Mey	Resedaceae	H	Reencii	BR164
35	*Celtis africana* Burm.f.	Ulmaceae	T	Caayii	BR142
36	*Cerastium octandrum* A. Rich.	Caryophyllaceae	H		BR226
37	*Cheilanthes farinosa* (Forssk.) Kaulf.	Sinopteridaceae	H		BR092
38	*Chenopodium ambrosioides* L.	Chenopodiaceae	H	Xiroo	BR136
39	*Chionanthus mildbraedii* (Gilg & Schellenb.) Stearn	Oleaceae	S/T	Karra Wayyuu	BR005
40	*Cineraria deltoidea* Sond.	Asteraceae	H		BR227
41	*Cirsium dender* Friis	Asteraceae	H	Ludata	BR203
42	*Cirsium vulgare* (Savi.) Ten.	Asteraceae	H		BR218
43	*Cissampelos pareira* L.	Menispermaceae	C	Hidda kalaalaa	BR156
44	*Clausena anisata* (Willd.) Benth.	Rutaceae	S	Ulumaayii	BR017
45	*Clematis longicauda* Steud. ex A. Rich.	Rununculaceae	C	Hidda fiitii	BR195
46	*Clematis simensis* Fresen.	Rununculaceae	C	Hidda fiitii	BR069
47	*Clerodendrum myricoides* (Hochst.) Vatke	Lamiaceae	S	'Misiriichii'	BR182
48	*Clutia lanceolata* Forssk. subsp *lanceolata*	Euphorbiaceae	S	Ulee foonii	BR126
49	*Commelina africana* L.	Commelinaceae	H		BR228
50	*Commelina benghalensis* L.	Commelinaceae	H	Gorora fardaa	BR098
51	*Convolvulus kilimandschari* Engl.	Convolvulaceae	C	Hidda	BR211

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
52	*Conyza abyssinica* Sch. Bip. ex A. Rich.	Asteraceae	S		BR128
53	*Conyza stricta* Willd.	Asteraceae	H	Kisee	BR067
54	*Cordia africana* Lam.	Boraginaceae	T	Waddeessa	BR177
55	*Crotalaria lachnophora* Hochst. ex A. Rich.	Fabaceae	S		BR068
56	*Crotalaria mildbraedii* Bak .f.	Fabaceae	S	Ribuu Kuruphee	BR120
57	*Croton macrostachyus* Del.	Euphorbiaceae	T	Bakkaaniisa	BR001
58	*Cupressus lusitanica* Mill.	Cupressaceae	T	Gaattiraa	BR180
59	*Cyathula cylindrica* Moq.	Amaranthaceae	H		BR229
60	*Cyathula uncinulata (*Schrad.) Schinz	Amaranthaceae	H	Maxxannee	BR161
61	*Cynodon dactylon* (L.) Pers.	Poaceae	H	Coqorsa	BR104
62	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	H		BR230
63	*Cyperus niveus* Retz.	Cyperaceae	H	Qunnii	BR105
64	*Dalbergia lactea* Vatke	Fabaceae	S	Baggii	BR050
65	*Datura stramonium* L.	Solanaceae	H	Asangira	BR118
66	*Desmodium repandum* (Vahl) DC.	Fabaceae	H		BR208
67	*Digitaria abyssinica* (Hochst. Ex A. Rich.) Stapf	Poaceae	H		BR070
68	*Dilphinium dasycaulon* Fresen.	Rununculaceae	H		BR207
69	*Discopodium penninervium* Hochst.	Solanaceae	S	Aja`aa	BR167
70	*Dodonaea angustifolia* L.f.	Sapindaceae	S	Ittacha	BR063
71	*Dombeya torrida* (J.F. Gmel.) P. Bamps	Sterculiaceae	T	Daannisaa	BR124
72	*Dovyalis abyssinica (*A. Rich.) Warb.	Flacourtiaceae	T	Komishoo Qamalee	BR004
73	*Dregea schimperi* (Decne.) Bullock	Asclepidaceae	C	Hidda goorriissaa	BR095
74	*Drynaria volkensii* Hieron.	Polypodiaceae	H	Baala balleessaa	BR102
75	*Echinops giganteus* A. Rich.	Asteraceae	H	Mata bokkee	BR220
76	*Echinops kebericho* Mesfin	Asteraceae	H	Qarabichoo	BR168
77	*Echinops longisetus* A. Rich.	Asteraceae	S	Kosorruu	BR204
78	*Echinops macrochaetus* Fresen.	Asteraceae	S	Qoraattii harree	BR110
79	*Ekebergia capensis* Sparrm.	Meliaceae	T	Somboo	BR051

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
80	*Embelia schimperi* Vatke	Myrsinaceae	T/L	Aanquu	BR036
81	*Emilia serpentinus* Mesfin & Beentje	Asteraceae	H		BR214
82	*Englerina woodfordioides* (Schweinf.) M. Gilbert	Loranthaceae	L	Digaaluu	BR101
83	*Ensete ventricosum* (Welw.) Cheesman	Musaceae	H	Warqee	BR122
84	*Erica arborea* L.	Ericaceae	S		BR189
85	*Eriosema scioanum* Avetta	Fabaceae	H		BR202
86	*Erythrina brucei* Schweinf.	Fabaceae	T	Waleensuu	BR169
87	*Erythrococca trichogyne* (Muell. Arg.) Prain	Euphorbiaceae	S	Cakkoo	BR145
88	*Eucalyptus amygdalina* Labill.	Myrtaceae	T	Bargamoo urgooftuu	BR206
89	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	T	Bargamoo diimaa	BR107
90	*Eucalyptus globulus* Labill.	Myrtaceae	T	Bargamoo adii	BR106
91	*Euclea divinorum* Hiern	Ebenaceae	S	Mi`eesssaa	BR127
92	*Euphorbia ampliphylla* Pax	Euphorbiaceae	T	Adaamii	BR170
93	*Euphorbia schimperiana* Scheele	Euphorbiaceae	H	Annannoo Baddaa	BR213
94	*Ficus sur* Forssk.	Moraceae	T	Harbuu	BR041
95	*Ficus thonningii* Blume	Moraceae	T	Qilxuu	BR221
96	*Flacourtia indica* (Burm.f.) Merr.	Flacourtiaceae	T	Akukkuu	BR085
97	*Foeniculum vulgare* Mill.	Apiaceae	H	Angaa Qamalee	BR072
98	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	S/T	Mixoo	BR038
99	*Galium spurium* L. subsp. *africanum*	Rubiaceae	H	Maxxannee	BR157
100	*Girardinia bullosa* (Steudel) Wedd.	Urticaceae	H	Doobbii	BR087
101	*Gnidia glauca* (Fresen.) Gilg.	Thymelaeaceae	T	Qaqaroo	BR076
102	*Grevillea robusta* R. BR.	Proteaceae	T	'Giraavilliyaa'	BR181
103	*Grewia ferruginea* Hochst. ex A. Rich.	Tiliaceae	S/T	Dhoqonuu	BR135
104	*Grewia mollis* A. Juss.	Tiliaceae	S		BR077
105	*Guizotia schimperi* Sch. Bip. ex Walp.	Asteraceae	H	Tuufoo	BR148
106	*Hagenia abyssinica* (Bruce) J. F. Gmel.	Rosaceae	T	Heexoo	BR140

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
107	*Haplocarpha schimperi* (Sch. Bip.) Beauv.	Asteraceae	H		BR231
108	*Helichrysum schimperi* (Sch. Bip.) Beauv.	Asteraceae	H		BR053
109	*Hibiscus micranthus* L. f.	Malvaceae	H	Hincinnii	BR111
110	*Hippocratea goetzei* Loes.	Celastraceae	L	Hidda gafarsaa	BR184
111	*Hygrophila schulli* (Hamilt.) M. R. & S. M.Almeida	Acanthaceae	H	Biichee	BR113
112	*Hyparrhenia dregeana* (Nees) Stent	Poaceae	H	Daggala	BR090
113	*Hypericum peplidifolium* A. Rich.	Guttiferae	H		BR232
114	*Hypericum quartinianum* A.Rich.	Guttiferae	S	Ulee foonii	BR042
115	*Hypoestes forskaolii* (Vahl) R. Br.	Acanthaceae	H	Darguu	BR023
116	*Hypoestes triflora* (Forssk.) Roem. & Schult.	Acanthaceae	H	Darguu	BR024
117	*Ilex mitis* (L.) Radlk.	Aquifoliaceae	T		BR084
118	*Indigofera macrantha* Harms	Fabaceae	S	Ceekaa Qamalee	BR215
119	*Isoglossa somalensis* Lindau	Acanthaceae	S		BR217
120	*Jacaranda mimosifolia* D. Don	Bignoniaceae	T	'Jakaarandaa'	BR185
121	*Jasminum abyssinicum* Hochst. ex DC.	Oleaceae	C	Hidda Ichilibe	BR031
122	*Juniperus procera* Hochst. ex Endl.	Cupressaceae	T	Gaattiraa	BR129
123	*Justicia diclipteroides* Lindau subsp. *aethiopica* Hedren	Acanthaceae	H		BR150
124	*Justicia ladanoides* Lam.	Acanthaceae	H	Qoraattii	BR166
125	*Justicia schimperiana* (Hochst. ex Nees) T. Anders.	Acanthaceae	S	Dhummuugaa	BR188
126	*Kalanchoe petitiana* A.Rich.	Crassulaceae	H	Bosoqqee	BR048
127	*Kleinia abyssinica* (A.Rich) A. Berger	Asteraceae	H		BR193
128	*Kniphofia hildebranditii* Cufod.	Asphodelaceae	H		BR100
129	*Kosteletzkya begoniifolia* (Ulbr.) Ulbr.	Malvaceae	S	Haadha ormaa	BR094
130	*Lactuca inermis* Forssk.	Asteraceae	H		BR233
131	*Laggera crispata* (Vahl) Hepper & Wood	Asteraceae	H		BR234
132	*Leucas martinicensis* (Jacq.) R. Br.	Lamiaceae	H	Ashuuffee	BR022
133	*Lippia adoensis* Hochst. ex Walp.	Verbenaceae	S	Kusaayee	BR153

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
134	*Lysimachia ruhmeriana* Vatke	Primulaceae	H		BR061
135	*Maesa lanceolata* Forssk.	Myrsinaceae	S/T	Abbayyii	BR025
136	*Maytenus addat* (Loes.) Sebsebe	Celastraceae	T		BR192
137	*Maytenus arbutifolia* (A.Rich.) Wilczek	Celastraceae	T	Kombolcha	BR078
138	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	Celastraceae	S	Hacaacii	BR016
139	*Maytenus undata* (Thunb.) Blakelock	Celastraceae	T		BR200
140	*Medicago polymorpha* L.	Fabaceae	H	Siddisa	BR099
141	*Mentha aquatica* L.	Lamiaceae	H	Qoricha lagaa	BR058
142	*Mikaniopsis clematoides* (Sch.Bip. ex A.Rich.) Milne-Redh.	Asteraceae	C	Hidda hantuutaa	BR082
143	*Millettia ferruginea* (Hochst.) Bak. subsp. f*erruginea*	Fabaceae	T	Sootalloo	BR108
144	*Mimulopsis solmsii* Schweinf.	Acanthaceae	S		BR059
145	*Momordica foetida* Schumach.	Cucurbitaceae	C	Qorii simbiraa	BR026
146	*Myrica salicifolia* A.Rich.	Myricaceae	T	Baroodoo	BR054
147	*Myrsine africana* L.	Myrsinaceae	S/T	Qacama	BR028
148	*Myrsine melanophloeos* (L.) R. Br.	Myrsinaceae	T	Qaraaruu	BR075
149	*Notholaena marantae (*L.) Desv.	Sinopteridaceae	H	Kaarroo	BR062
150	*Nuxia congesta* R.Br.ex Fresen.	Loganiaceae	T	Anfaaree	BR056
151	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	S	Qoricha michii	BR046
152	*Ocimum urticifolium* Roth	Lamiaceae	S	Qoricha michii	BR160
153	*Oenanthe palustris* (Chiov.) Norman	Apiaceae	H		BR209
154	*Olea capensis* L. subsp. *macrocarpa* (C.H. Wright) Verdc.	Oleaceae	T	Gagamaa	BR021
155	*Olea europaea* L. subsp. *cuspidata* (Wall.ex G.Don) Cif.	Oleaceae	T	Ejersa	BR035
156	*Olinia rochetiana* A. Juss.	Oliniaceae	T	Soolee	BR007
157	*Orobanche minor* Smith	Orobanchaceae	H		BR073
158	*Osyris quadripartita* Decn.	Santalaceae	S	Waatoo	BR043
159	*Otostegia intergrifolia* Benth.	Lamiaceae	S	Ciingiitii	BR066
160	*Otostegia tomentosa* A. Rich.	Lamiaceae	S		BR019

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
161	*Panicum monticola* Hook.f.	Poaceae	H	Marga gogoorii	BR139
162	*Pavetta abyssinica* Fresen.	Rubiaceae	S	Buniitii	BR190
163	*Pavonia glechomifolia* (A. Rich.) Garcke	Malvaceae	S	Hincinnii	BR158
164	*Pavonia urens* Cav.	Malvaceae	S	Liitii	BR144
165	*Pennisetum riparium* Hochst. ex A. Rich.	Poaceae	H	Migira	BR088
166	*Pentas schimperiana* (A. Rich.) Vatke	Rubiaceae	S		BR191
167	*Periploca linearifolia* Quart.-Dill & A.Rich.	Asclepidaceae	C	Hidda Annannoo	BR033
168	*Phagnalon abyssinicum* Sch. Bip. ex A. Rich.	Asteraceae	H		BR212
169	*Phoenix reclinata* Jacq.	Arecaceae	S/T	Meexxii	BR034
170	*Physalis peruviana* L.	Solanaceae	S	Xixxiyyee	BR152
171	*Phytolacca dodecandra* L` Herit.	Phytolaccaceae	S	Handoodee	BR154
172	*Pinus patula* Schiede ex Schltdl. & Cham.	Pinaceae	T	'Shuwshuwwee'	BR186
173	*Pittosporum viridiflorum* Sims	Pittosporaceae	T	Qasammee	BR074
174	*Plantago lanceolata* L.	Plantaginaceae	H	Qorxoobbii	BR174
175	*Platostoma rotundifolium* (Briq.) A. J. Paton	Lamiaceae	H		BR080
176	*Plectranthus punctatus* (L.f.) L` Her.	Lamiaceae	H		BR116
177	*Podocarpus falcatus*(Thunb.) R. B. ex. Mirb.	Podocarpaceae	T	Birbirsa	BR006
178	*Premna schimperi* Engl.	Lamiaceae	S	Urgeessaa	BR199
179	*Prunus africana* (Hook.f.) Kalkm.	Rosaceae	T	Hoomii	BR032
180	*Psychotria orophila* Petit	Rubiaceae	S	Hudduu fardaa	BR012
181	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	S	Haraangamaa	BR146
182	*Pycnostachys abyssinica* Fresen.	Lamiaceae	H		BR071
183	*Rhamnus prinoides* L` Herit.	Rhamnaceae	S	Geeshoo	BR130
184	*Rhamnus staddo* A.Rich.	Rhamnaceae	T	Qadiidaa	BR064
185	*Rhus glutinosa* A. Rich.	Anacardiaceae	T	Laboobessaa	BR037
186	*Rhus vulgaris* Meikle	Anacardiaceae	T	Xaaxxessaa	BR018
187	*Ricinus communis* L.	Euphorbiaceae	S/T	Qobboo	BR097
188	*Rosa abyssinica* Lindley	Rosaceae	S	Qaqawwee	BR047
189	*Rubia cordifolia* L.	Rubiaceae	H		BR149
190	*Rubus apetalus* Poir.	Rosaceae	S	Goraa arbaa	BR014

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
191	*Rubus steudneri* Schweinf.	Rosaceae	S	Goraa	BR055
192	*Rumex nepalensis* Spreng.	Polygonaceae	H	Tuultii	BR165
193	*Rumex nervosus* Vahl	Polygonaceae	S	Dhangaggoo	BR093
194	*Rytigynia neglecta* (Hiern) Robyns	Rubiaceae	S	Mixoo	BR216
195	*Salix mucronata* Thunb. (*S. subserrata* Willd.)	Salicaceae	T	Alaltuu	BR172
196	*Salvia leucantha* Cav.	Lamiaceae	S		BR173
197	*Salvia nilotica* Jacq.	Lamiaceae	H	Dabbaqitii	BR119
198	*Satureja punctata* (Benth.) Briq.	Lamiaceae	H	Urgooftuu	BR091
199	*Schefflera abyssinica* (Hochst. ex A. Rich.) Harms	Araliaceae	T/L	Arfattuu	BR123
200	*Schrebera alata* (Hochst.) Welw.	Oleaceae	T	Qana`ee	BR131
201	*Scolopia theifolia* Gilg	Flacourtiaceae	T	Gaallee	BR020
202	*Senecio myriocephalus* Sch. Bip. ex A. Rich.	Asteraceae	S		BR222
203	*Senecio schimperi* Sch. Bip. ex A. Rich.	Asteraceae	H		BR235
204	*Sida schimperiana* Hochst. ex A. Rich.	Malvaceae	S	Borkottee	BR163
205	*Sida tenuicarpa* Vollesen	Malvaceae	S		BR205
206	*Smilax aspera* L.	Smilacaceae	C		BR040
207	*Solanecio gigas(*Vatke) C. Jeffrey	Asteraceae	S	Jirma Jaldeessaa	BR003
208	*Solanum anguivi* Lam.	Solanaceae	H	Hiddii	BR029
209	*Solanum incanum* L.	Solanaceae	S	Hiddii saree	BR138
210	*Solanum marginatum* L.f.	Solanaceae	S	H/ hongorcaa	BR081
111	*Spathodea campanulata* P. Beauv.	Bignoniaceae	T	'Ispatodiyaa'	BR179
212	*Sphaeranthus suaveolens* (Forssk.) DC.	Asteraceae	H		BR057
213	*Sporobolus africanus* (Poir.) Robyns & Tournay	Poaceae	H	Murii	BR133
214	*Stephania abyssinica* (Dillon & A. Rich.) Walp.	Menispermaceae	L	Hidda	BR159
215	*Stereospermum kunthianum* Cham.	Bignoniaceae	T	Botoroo	BR143
216	*Syzygium guineense (*Willd.) DC. subsp. *guineense*	Myrtaceae	T	Goosuu	BR141
217	*Syzygium guineese* (Willd.) DC. subsp. *afromontanum* F.White	Myrtaceae	T	Baddeessaa	BR008

No.	Scientific name	Family	Ha	Ver. name	Coll.no.
218	*Tagetes minuta* L.	Asteraceae	H		BR197
219	*Teclea nobilis* Del.	Rutaceae	T	Hadheessa	BR015
220	*Teucrium scordium* L.	Lamiaceae	H	Fosikoo beeraa	BR117
221	*Thalictrum rhynchocarpum* Dill. & A. Rich	Runnunculaceae	H	Sarariitii	BR096
222	*Thymus schimperi* Ronniger	Lamiaceae	H		BR060
223	*Trifolium rueppellianum* Fresen.	Fabaceae	H		BR201
224	*Triumfetta rhomboidea* Jacq.	Tiliaceae	H		BR198
225	*Urera hypselodendron* (A.Rich.) Wedd.	Urticaceae	L	Laanqisaa	BR045
226	*Urtica simensis* Steudel	Urticaceae	H	Gurgubbee	BR178
227	*Vangueria apiculata* K. Schum.	Rubiaceae	S	Buruurii	BR175
228	*Verbascum sinaiticum* Benth.	Scrophulariaceae	H	Gurra harree	BR162
229	*Vernonia amygdalina* Del.	Asteraceae	T	Eebicha	BR083
230	*Vernonia auriculifera* Hiern.	Asteraceae	S	Reejjii	BR065
231	*Vernonia bipontini* Vatke	Asteraceae	S	Sooyyama	BR109
232	*Vernonia hochstetteri* Sch. Bip. ex Walp.	Asteraceae	S	Sooyyama	BR155
233	*Vernonia leopoldi* (Sch. Bip. ex Walp.) Vatke	Asteraceae	S	Sooyama	BR039
234	*Vigna ambacensis* Bak.	Asteraceae	S		BR194
235	*Zehneria scabra* (Linn.f.) Sond.	Cucurbitaceae	C	Hidda adii	BR079

Appendix 2: Families and their species and genera percentage in Gedo Forest

Family	Species	% species	Genera	% Genera
Asteraceae	36	15.32	24	12.63
Fabaceae	16	6.81	14	7.37
Lamiaceae	16	6.81	13	6.84
Acanthaceae	10	4.26	6	3.16
Rubiaceae	10	4.26	10	5.26
Poaceae	7	2.98	7	3.68
Euphorbiaceae	6	2.55	5	2.63

Family	Species	% species	Genera	% Genera
Malvaceae	6	2.55	4	2.11
Solanaceae	6	2.55	4	2.11
Celastraceae	5	2.13	2	1.05
Myrtaceae	5	2.13	2	1.05
Oleaceae	5	2.13	4	2.11
Rosaceae	5	2.13	4	2.11
APiaceae	4	1.70	4	2.11
Myrsinaceae	4	1.70	3	1.58
Rununculaceae	4	1.70	3	1.58
Amaranthaceae	3	1.28	2	1.05
Bignoniaceae	3	1.28	3	1.58
Flacourtiaceae	3	1.28	3	1.58
Loganiaceae	3	1.28	2	1.05
Tiliaceae	3	1.28	2	1.05
Urticaceae	3	1.28	3	1.58
Anacardiaceae	2	0.85	1	0.53
Asclepidaceae	2	0.85	2	1.05
Boraginaceae	2	0.85	2	1.05
Commelinaceae	2	0.85	1	0.53
Cucurbitaceae	2	0.85	2	1.05
Cupressaceae	2	0.85	2	1.05
Cyperaceae	2	0.85	2	1.05
Guttiferae	2	0.85	1	0.53
Menispermaceae	2	0.85	2	1.05
Moraceae	2	0.85	1	0.53
Polygonaceae	2	0.85	1	0.53
Rhamnaceae	2	0.85	1	0.53
Rutaceae	2	0.85	2	1.05
Sapindaceae	2	0.85	2	1.05
Scrophulariaceae	2	0.85	2	1.05

Family	Species	% species	Genera	% Genera
Sinopteridaceae	2	0.85	2	1.05
Adiantaceae	1	0.43	1	0.53
Apocynaceae	1	0.43	1	0.53
Aquifoliaceae	1	0.43	1	0.53
Araceae	1	0.43	1	0.53
Araliaceae	1	0.43	1	0.53
Arecaceae	1	0.43	1	0.53
Asparagaceae	1	0.43	1	0.53
Asphodelaceae	1	0.43	1	0.53
Caryophyllaceae	1	0.43	1	0.53
Chenopodiaceae	1	0.43	1	0.53
Convolvulaceae	1	0.43	1	0.53
Crassulaceae	1	0.43	1	0.53
Ebenaceae	1	0.43	1	0.53
Ericaceae	1	0.43	1	0.53
Icacinaceae	1	0.43	1	0.53
Loranthaceae	1	0.43	1	0.53
Meliaceae	1	0.43	1	0.53
Melianthaceae	1	0.43	1	0.53
Musaceae	1	0.43	1	0.53
Myricaceae	1	0.43	1	0.53
Oliniaceae	1	0.43	1	0.53
Orobanchaceae	1	0.43	1	0.53
Phytolaccaceae	1	0.43	1	0.53
Pinaceae	1	0.43	1	0.53
Pittosporaceae	1	0.43	1	0.53
Plantaginaceae	1	0.43	1	0.53
Podocarpaceae	1	0.43	1	0.53
Polypodiaceae	1	0.43	1	0.53
Primulaceae	1	0.43	1	0.53

Family	Species	% species	Genera	% Genera
Proteaceae	1	0.43	1	0.53
Resedaceae	1	0.43	1	0.53
Rhizophoraceae	1	0.43	1	0.53
Salicaceae	1	0.43	1	0.53
Santalaceae	1	0.43	1	0.53
Simaroubaceae	1	0.43	1	0.53
Smilacaceae	1	0.43	1	0.53
Sterculiaceae	1	0.43	1	0.53
Thymelaeaceae	1	0.43	1	0.53
Ulmaceae	1	0.43	1	0.53
Verbenaceae	1	0.43	1	0.53

Appendix 3 Quadrats and their characteristics

Quadrat	Transect	Altitude (m)	Species no.	Latitude	Longitude
1	1	2408	24	$09^0$02’23.4’’N	$37^0$25’53.4’’E
2		2444	25	$09^0$02’25.7’’N	$37^0$25’57.6’’E
3		2447	19	$09^0$02’31.5’’N	$37^0$26’00.6’’E
4		2418	36	$09^0$02’32.5’’N	$37^0$25’54.5’’E
5		2438	31	$09^0$02’36.1’’N	$37^0$25’56.4’’E
6		2479	30	$09^0$02’36.9’’N	$37^0$25’52.1’’E
7		2587	26	$09^0$02’39.6’’N	$37^0$26’06.6’’E
8	2	2319	29	$09^0$02’34.4’’N	$37^0$25’36.2’’E
9		2411	1	$09^0$02’41.4’’N	$37^0$25’34.1’’E
10		2471	28	$09^0$02’45.0’’N	$37^0$25’35.3’’E
11		2554	25	$09^0$02’49.7’’N	$37^0$25’40.1’’E
12	3	2357	28	$09^0$02’39.8’’N	$37^0$25’24.2’’E
13		2399	21	$09^0$02’44.0’’N	$37^0$25’25.3’’E
14		2469	22	$09^0$02’47.5’’N	$37^0$25’25.0’’E
15		2507	23	$09^0$02’54.8’’N	$37^0$25’26.9’’E
16		2554	17	$09^0$03’01.1’’N	$37^0$25’27.3’’E

Quadrat	Transect	Altitude (m)	Species no.	Latitude	Longitude
17	4	2345	21	$09^0$02’35.6’’N	$37^0$25’07.0’’E
18		2379	29	$09^0$02’38.5’’N	$37^0$25’07.3’’E
19		2422	14	$09^0$02’41.7’’N	$37^0$25’07.8’’E
20		2473	26	$09^0$02’52.6’’N	$37^0$25’10.7’’E
21		2502	24	$09^0$02’01.7’’N	$37^0$25’11.4’’E
22	5	2323	19	$09^0$02’25.8’’N	$37^0$24’54.8’’E
23		2400	19	$09^0$02’32.3’’N	$37^0$24’53.3’’E
24		2425	24	$09^0$02’39.9’’N	$37^0$24’55.8’’E
25		2473	18	$09^0$02’47.1’’N	$37^0$24’57.0’’E
26		2493	27	$09^0$02’56.2’’N	$37^0$24’57.7’’E
27		2329	25	$09^0$02’15.9’’N	$37^0$24’44.8’’E
28		2375	14	$09^0$02’26.3’’N	$37^0$24’45.7’’E
29		2431	30	$09^0$02’36.0’’N	$37^0$24’49.8’’E
30		2474	25	$09^0$02’43.1’’N	$37^0$24’50.9’’E
31		2509	20	$09^0$02’55.1’’N	$37^0$24’52.9’’E
32	6	2279	23	$09^0$02’33.1’’N	$37^0$24’21.9’’E
33		2320	23	$09^0$02’36.4’’N	$37^0$24’26.0’’E
34		2340	24	$09^0$02’39.9’’N	$37^0$24’29.4’’E
35		2388	25	$09^0$02’47.3’’N	$37^0$24’34.7’’E
36		2431	29	$09^0$02’51.3’’N	$37^0$24’41.1’’E
37		2483	22	$09^0$03’01.9’’N	$37^0$24’48.5’’E
38		2574	24	$09^0$03’08.0’’N	$37^0$24’52.3’’E
39		2585	17	$09^0$03’00.7’’N	$37^0$24’55.6’’E
40		2458	21	$09^0$03’06.3’’N	$37^0$24’39.6’’E
41		2514	25	$09^0$03’11,7’’N	$37^0$24’45.9’’E
42	7	2374	34	$09^0$02’08.4’’N	$37^0$24’53.0’’E
43		2416	20	$09^0$02’14.5’’N	$37^0$24’57.1’’E
44		2459	24	$09^0$02’20.7’’N	$37^0$26’02.4’’E
45		2500	27	$09^0$02’31.0’’N	$37^0$26’15.5’’E
46		2580	26	$09^0$02’38.1’’N	$37^0$26’20.8’’E
47		2414	29	$09^0$03’03.3’’N	$37^0$24’30.6’’E
48		2485	19	$09^0$03’09.1’’N	$37^0$24’36.9’’E
49		2501	18	$09^0$03’12.7’’N	$37^0$24’40.0’’E
50		2541	21	$09^0$03’18.9’’N	$37^0$24’44.6’’E

Quadrat	Transect	Altitude (m)	Species no.	Latitude	Longitude
51		2565	23	$09^0$03’26.1’’N	$37^0$24’35.6’’E
52		2515	22	$09^0$03’24.9’’N	$37^0$24’32.6’’E
53		2596	22	$09^0$03’39.3’’N	$37^0$24’23.3’’E
54		2538	24	$09^0$03’44.8’’N	$37^0$24’15.2’’E
55	8	2366	19	$09^0$04’03.1’’N	$37^0$23’09.4’’E
56		2419	24	$09^0$04’13.5’’N	37^0 23’14.0’’E
57		2520	23	$09^0$04’22.4’’N	37^0 23’18.1’’E
58		2600	18	$09^0$04’33.5’’N	$37^0$24’22.6’’E
59		2764	20	$09^0$04’33.5’’N	$37^0$23’22.6’’E
60	9	2298	24	$09^0$04’04.3’’N	$37^0$22’56.5’’E
61		2350	25	$09^0$04’09.0’’N	$37^0$23’01.9’’E
62		2456	20	$09^0$04’23.0’’N	$37^0$23’04.2’’E
63		2594	19	$09^0$04’29.8’’N	$37^0$23’11.0’’E
64	10	2330	26	$09^0$04’13.0”N	$37^0$22’51.7”E
65		2359	24	$09^0$04’22.7’’N	$37^0$22’52.7’’E
66		2421	17	$09^0$04’29.4”N	$37^0$22’55.4”E
67		2595	18	$09^0$04’36.5”N	$37^0$23’00.9”E
68	11	2361	23	$09^0$04’23.6”N	$37^0$22’35.3”E
69		2468	17	$09^0$04’37.6”N	$37^0$22’44.4”E
70		2553	19	$09^0$04’42.0”N	$37^0$22’49.1”E
71	12	2364	40	$09^0$01’57.1”N	$37^0$26’01.6”E
72		2387	22	$09^0$01’54.8”N	$37^0$26’09.1”E

Appendix 4 Summary of plant communities and their characteristics

Community types	Major species in the community	Species richness	No. of quadrats	Quadrats in each community	Altitudinal range (m)
C1	*Olea capensis* subsp. *macrocarpa* *Chionanthus mildbraedii* *Galiniera saxifraga* *Carissa spinarum* *Podocarpus falcatus* *Scolopia theifolia* *Psychotria orophila* *Hypoestes triflora* *Phoenix reclinata* *Teclea nobilis* *Calpurnia aurea*	97	17	1,3,5,9,12,13,14, 17,19,21,29,32, 33,35,41,54,66	2279-2538
C2	*Allophylus abyssinicus* *Brucea antidysenterica* *Solanecio gigas* *Hypoestes forskaolii* *Prunus africana* *Periploca linearifolia* *Rubus apetalus* *Acokanthera schimperi* *Bersama abyssinica* *Apodytes dimidiata* *Dregea scimperi*	71	11	2,11,15,16,50,51, 57,61,62,69,70	2350-2565
C3	*Maesa lanceolata* *Vernonia auriculifera* *Olea europaea* subsp. *cuspidata* *Albizia schimperiana* *Rosa abyssinica* *Mikaniopsis clematoides* *Ficus sur*	104	22	4,6,8,18,22,24, 26,27,28,34,36, 37,40,45,47,55, 59,60,65,68,71,	2319-2764

Community types	Major species in the community	Species richness	No. of quadrats	Quadrats in each community	Altitudinal range (m)
	Croton macrostachyus *Vernonia amygdalina* *Rhus glutinosa* *Rhus vulgaris*			72	
C4	*Olinia rochetiana* *Gnidia glauca* *Rhamnus staddo* *Echinops macrochaetus* *Osyris quadripartita* *Myrsine africana* *Maytenus arbutifolia* *Nuxia congesta* *Buddleja polystachya* *Helichrysum schimperi*	114	22	7,10,20,23,25,30, 31,38,39,42,43,44, 46,48,49,52,53,56, 58,63,64,67	2330-2600

Appendix 5 Indicator values of each species for each community and Mounte Carlo test of significance observed for each species

Community 1	Indicator values in Communities					
Species name	**C1**	**C2**	**C3**	**C4**	**P* Value**	**Habit**
Allophylus abyssinicus	4	61	4	3	0.0002	T
Brucea antidysenterica	20	45	7	0	0.0002	T
Chionanthus mildbraedii	**45**	20	4	0	0.0002	T/S
Olea capensis subsp. *macrocarpa*	**38**	1	3	0	0.0016	T
Solanecio gigas	19	41	1	3	0.0016	S
Galiniera saxifraga	**28**	0	1	1	0.0064	S/T
Carissa spinarum	**34**	5	15	19	0.008	S
Echinops macrochaetus	1	0	25	32	0.0088	S
Vernonia auriculifera	2	0	28	8	0.0094	S

Species name	C1	C2	C3	C4	P* Value	Habit
Podocarpus falcatus	**31**	2	18	1	0.0152	T
Olea europaea subsp. *cuspidata*	22	2	33	14	0.0164	T
Scolopia theifolia	26	4	0	8	0.0216	T
Thymus schimperi	20	0	0	1	0.0216	H
Osyris quadripartita	2	7	14	29	0.026	S
Olinia rochetiana	21	24	6	32	0.0262	T
Hypoestes forskaolii	2	27	5	9	0.0266	H
Smilax aspera	**19**	0	0	1	0.034	C
Prunus africana	14	30	20	1	0.0348	T
Psychotria orophila	**18**	0	0	2	0.042	S
Periploca linearifolia	9	30	14	10	0.0446	C
Mikaniopsis clematoides	1	1	20	3	0.0452	C
Myrsine africana	11	18	4	29	0.0486	S/T
Achyranthes aspera	2	17	0	2	0.0548	H
Ficus sur	4	5	20	0	0.06	T
Calpurnia aurea	22	15	2	2	0.0648	T
Croton macrostachyus	5	1	18	0	0.068	T
Phoenix reclinata	19	1	6	1	0.0716	T/S
Nuxia congesta	4	5	0	20	0.072	T
Girardinia bullosa	12	0	0	0	0.073	H
Teclea nobilis	24	23	2	3	0.0814	T
Mentha aquatica	12	0	0	0	0.0838	H
Vernonia amygdalina	1	0	16	4	0.0882	T
Rubus apetalus	7	21	4	6	0.095	S
Hypoestes triflora	23	5	3	12	0.1038	H
Bersama abyssinica	21	29	19	13	0.112	T
Mimulopsis solmsii	12	3	0	0	0.1126	S
Rhus glutinosa	8	2	22	11	0.15	T
Satureja punctata	1	0	0	11	0.154	H
Rhus vulgaris	10	0	19	8	0.163	T
Clematis simensis	2	1	16	6	0.1728	C

Species name	C1	C2	C3	C4	P* Value	Habit
Apodytes dimidiata	12	25	12	12	0.1868	T
Flacourtia indica	8	0	0	1	0.2326	T
Helichrysum schimperi	1	2	0	10	0.2496	H
Millettia ferruginea subsp. *ferruginea*	2	0	10	0	0.2793	T
Panicum monticola	9	0	2	1	0.3259	H
Dovyalis abyssinica	1	13	5	5	0.3403	T
Syzygium guineese subsp. *afromontanum*	20	17	9	3	0.3405	T
Vernonia leopoldi	2	0	6	0	0.3441	S
Cissampelos pareira	1	12	5	15	0.3507	C
Sphaeranthus suaveolens	7	0	0	4	0.3793	H
Pavonia urens	6	0	0	0	0.3805	S
Bidens ghedoensis	1	0	8	1	0.3943	H
Hygrophila schulli	6	0	0	0	0.3951	H
Myrica salicifolia	10	5	2	1	0.4239	T
Clausena anisata	8	5	17	8	0.4349	S
Digitaria velutina	2	0	0	6	0.4443	H
Capparis tomentosa	2	0	6	0	0.4505	S
Asparagus africanus	2	11	6	2	0.4513	S
Medicago polymorpha	1	0	3	7	0.4745	H
Cyperus niveus	5	3	0	1	0.4913	H
Ricinus communis	2	6	0	0	0.5161	S/T
Lantana trifolia	5	3	1	0	0.5229	S
Pennisetum riparium	2	0	0	6	0.5471	H
Sesbania sesban	2	0	0	6	0.5523	S
Acacia abyssinica	2	0	8	5	0.5913	T
Ekebergia capensis	9	6	1	2	0.5951	T
Ocimum lamiifolium	2	0	5	1	0.6133	S
Plectranthus punctatus	4	0	2	0	0.6705	H
Artemisia afra	1	5	1	1	0.6815	H
Carduus schimperi	2	0	4	1	0.7103	H
Lysimachia ruhmeriana	2	0	1	4	0.7319	H

Species name	C1	C2	C3	C4	P* Value	Habit
Solanum marginatum	2	3	4	0	0.7738	S
Embelia schimperi	6	1	9	10	0.7756	T/L
Clutia lanceolata subsp. *lanceolata*	2	0	4	1	0.7844	S
Leucas martinicensis	2	0	4	3	0.7904	H
Jasminum abyssinicum	3	7	2	2	0.7976	C
Thalictrum rhynchocarpum	1	3	4	0	0.7984	H
Commelina diffusa	3	0	0	2	0.8026	H
Platostoma rotundifolium	3	0	0	2	0.8104	H
Micractis bojeri	3	0	2	0	0.8118	H
Teucrium scordium	3	0	0	2	0.8198	H
Grewia mollis	3	0	0	2	0.8212	S
Hyparrhenia dregeana	1	4	0	3	0.8344	H
Maytenus gracilipes	21	21	19	12	0.837	S
Pycnostachys abyssinica	2	3	1	0	0.862	S
Rubus steudneri	1	3	2	5	0.8894	S
Dodonea angustifolia	7	2	2	5	0.8972	S
Galium spurium subsp. *africanum*	3	0	1	1	0.909	H
Kalanchoe petitiana	6	7	9	5	0.9272	H
Canthium oligocarpum subsp. *oligocarpum*	5	2	4	3	0.9546	S/T
Solanum anguivi	4	2	3	2	0.9702	H
Berula erecta	2	4	1	1	0.9798	H
Bidens camporum	2	0	2	2	1	H
Crotalaria karagwensis	2	0	1	1	1	H
Otostegia tomentosa	3	0	0	2	1	S
Community2						
Allophylus abyssinicus	4	**61**	4	3	0.0002	T
Brucea antidysenterica	20	**45**	7	0	0.0002	T
Chionanthus mildbraedii	45	20	4	0	0.0002	T/S
Olea capensis subsp. *macrocarpa*	38	1	3	0	0.0016	T
Solanecio gigas	19	**41**	1	3	0.0016	S
Maesa lanceolata	0	4	33	3	0.005	T/S

Species name	C1	C2	C3	C4	P* Value	Habit
Carissa spinarum	34	5	15	19	0.008	S
Podocarpus falcatus	31	2	18	1	0.0152	T
Olea europaea subsp. *cuspidata*	22	2	33	14	0.0164	T
Scolopia theifolia	26	4	0	8	0.0216	T
Osyris quadripartita	2	7	14	29	0.026	S
Olinia rochetiana	21	24	6	32	0.0262	T
Hypoestes forskaolii	2	**27**	5	9	0.0266	H
Albizia schimperiana	0	2	21	0	0.0298	T
Rosa abyssinica	0	8	29	19	0.031	S
Prunus africana	14	**30**	20	1	0.0348	T
Periploca linearifolia	9	**30**	14	10	0.0446	C
Mikaniopsis clematoides	1	1	20	3	0.0452	C
Myrsine africana	11	18	4	29	0.0486	S/T
Hypericum quartinianum	0	1	23	17	0.05	S
Achyranthes aspera	2	17	0	2	0.0548	H
Maytenus arbutifolia	0	6	13	25	0.0552	T
Ficus sur	4	5	20	0	0.06	T
Calpurnia aurea	22	15	2	2	0.0648	T
Croton macrostachyus	5	1	18	0	0.068	T
Phoenix reclinata	19	1	6	1	0.0716	T/S
Nuxia congesta	4	5	0	20	0.072	T
Dregea schimperi	0	14	1	1	0.0744	C
Teclea nobilis	24	23	2	3	0.0814	T
Rubus apetalus	7	21	4	6	0.095	S
Acokanthera schimperi	0	12	1	1	0.0998	T
Hypoestes triflora	23	5	3	12	0.1038	H
Bersama abyssinica	21	29	19	13	0.112	T
Mimulopsis solmsii	12	3	0	0	0.1126	S
Rhus glutinosa	8	2	22	11	0.15	T
Clematis simensis	2	1	16	6	0.1728	C
Apodytes dimidiata	12	25	12	12	0.1868	T

Species name	C1	C2	C3	C4	P* Value	Habit
Helichrysum schimperi	1	2	0	10	0.2496	H
Lippia adoensis	0	3	0	9	0.2647	S
Urera hypselodendron	0	9	10	0	0.2647	L
Conyza abyssinica	0	4	0	8	0.3093	S
Dovyalis abyssinica	1	13	5	5	0.3403	T
Syzygium guineese subsp. *afromontanum*	20	17	9	3	0.3405	T
Cissampelos pareira	1	12	5	15	0.3507	C
Myrica salicifolia	10	5	2	1	0.4239	T
Clausena anisata	8	5	17	8	0.4349	S
Caylusea abyssinica	0	6	2	0	0.4393	H
Foeniculum vulgare	0	6	2	0	0.4411	H
Kosteletzkya begoniifolia	0	6	0	2	0.4449	S
Asparagus africanus	2	11	6	2	0.4513	S
Vernonia bipontini	0	5	2	0	0.4843	S
Cyperus niveus	5	3	0	1	0.4913	H
Ricinus communis	2	6	0	0	0.5161	S/T
Lantana trifolia	5	3	1	0	0.5229	S
Ekebergia capensis	9	6	1	2	0.5951	T
Artemisia afra	1	5	1	1	0.6815	H
Rumex nervosus	0	2	6	5	0.7299	H
Acanthus sennii	0	3	4	3	0.7582	S
Solanum marginatum	2	3	4	0	0.7738	S
Embelia schimperi	6	1	9	10	0.7756	T/L
Jasminum abyssinicum	3	7	2	2	0.7976	C
Thalictrum rhynchocarpum	1	3	4	0	0.7984	H
Hyparrhenia dregeana	1	4	0	3	0.8344	H
Maytenus gracilipes	21	21	19	12	0.837	S
Pycnostachys abyssinica	2	3	1	0	0.862	S
Rubus steudneri	1	3	2	5	0.8894	S
Dodonea angustifolia	7	2	2	5	0.8972	S
Kalanchoe petitiana	6	7	9	5	0.9272	H

Species name	C1	C2	C3	C4	P* Value	Habit
Canthium oligocarpum subsp. *oligocarpum*	5	2	4	3	0.9546	S/T
Solanum anguivi	4	2	3	2	0.9702	H
Berula erecta	2	4	1	1	0.9798	H
Community 3						
Allophylus abyssinicus	4	61	4	3	0.0002	T
Brucea antidysenterica	20	45	7	0	0.0002	T
Chionanthus mildbraedii	45	20	4	0	0.0002	T/S
Olea capensis subsp. *macrocarpa*	38	1	3	0	0.0016	T
Solanecio gigas	19	41	1	3	0.0016	S
Rhamnus staddo	0	0	5	31	0.0042	T
Maesa lanceolata	0	4	**33**	3	0.005	T/S
Galiniera saxifraga	28	0	1	1	0.0064	S/T
Carissa spinarum	34	5	15	19	0.008	S
Echinops macrochaetus	1	0	25	32	0.0088	S
Vernonia auriculifera	2	0	**28**	8	0.0094	S
Podocarpus falcatus	31	2	18	1	0.0152	T
Olea europaea subsp. *cuspidata*	22	2	**33**	14	0.0164	T
Osyris quadripartita	2	7	14	29	0.026	S
Olinia rochetiana	21	24	6	32	0.0262	T
Hypoestes forskaolii	2	27	5	9	0.0266	H
Albizia schimperiana	0	2	**21**	0	0.0298	T
Rosa abyssinica	0	8	**29**	19	0.031	S
Prunus africana	14	30	20	1	0.0348	T
Periploca linearifolia	9	30	14	10	0.0446	C
Mikaniopsis clematoides	1	1	**20**	3	0.0452	C
Myrsine africana	11	18	4	29	0.0486	S/T
Hypericum quartinianum	0	1	23	17	0.05	S
Maytenus arbutifolia	0	6	13	25	0.0552	T
Ficus sur	4	5	20	0	0.06	T
Calpurnia aurea	22	15	2	2	0.0648	T
Croton macrostachyus	5	1	18	0	0.068	T

Species name	C1	C2	C3	C4	P* Value	Habit
Phoenix reclinata	19	1	6	1	0.0716	T/S
Dregea schimperi	0	14	1	1	0.0744	C
Buddleja polystachya	0	0	5	15	0.0806	T
Teclea nobilis	24	23	2	3	0.0814	T
Vernonia amygdalina	1	0	16	4	0.0882	T
Rubus apetalus poir.	7	21	4	6	0.095	S
Acokanthera schimperi	0	12	1	1	0.0998	T
Hypoestes triflora	23	5	3	12	0.1038	H
Bersama abyssinica	21	29	19	13	0.112	T
Cussonia ostinii	0	0	3	12	0.1144	T/L
Rhus glutinosa	8	2	22	11	0.15	T
Rhus vulgaris	10	0	19	8	0.163	T
Clematis simensis	2	1	16	6	0.1728	C
Apodytes dimidiata	12	25	12	12	0.1868	T
Conyza stricta	0	0	3	9	0.2262	H
Combretum paniculatum	0	0	9	0	0.2517	L
Juniperus procera	0	0	9	0	0.2569	T
Momordica foetida	0	0	9	0	0.2581	C
Urera hypselodendron	0	9	10	0	0.2647	L
Cordia africana	0	0	9	0	0.2649	T
Dombeya torrida	0	0	3	9	0.2673	T
Millettia ferruginea subsp. *ferruginea*	2	0	10	0	0.2793	T
Echinops kebericho	0	0	1	7	0.2895	S
Panicum monticola	9	0	2	1	0.3259	H
Dovyalis abyssinica	1	13	5	5	0.3403	T
Syzygium guineese subsp. *afromontanum*	20	17	9	3	0.3405	T
Vernonia leopoldi	2	0	6	0	0.3441	S
Cissampelos pareira	1	12	5	15	0.3507	C
Bidens ghedoensis	1	0	8	1	0.3943	H
Otostegia intergrifolia	0	0	4	8	0.3949	S
Verbascum sinaiticum	0	0	6	2	0.4165	H

Species name	C1	C2	C3	C4	P* Value	Habit
Myrica salicifolia	10	5	2	1	0.4239	T
Clausena anisata	8	5	17	8	0.4349	S
Caylusea abyssinica	0	6	2	0	0.4393	H
Foeniculum vulgare	0	6	2	0	0.4411	H
Capparis tomentosa	2	0	6	0	0.4505	S
Asparagus africanus	2	11	6	2	0.4513	S
Acanthus eminens	0	0	2	6	0.4551	S
Medicago polymorpha	1	0	3	7	0.4745	H
Vernonia bipontini	0	5	2	0	0.4843	S
Lantana trifolia	5	3	1	0	0.5229	S
Zehneria scabra	0	0	5	4	0.5231	C
Acacia abyssinica	2	0	8	5	0.5913	T
Ekebergia capensis	9	6	1	2	0.5951	T
Ocimum lamiifolium	2	0	5	1	0.6133	S
Plectranthus punctatus	4	0	2	0	0.6705	H
Artemisia afra	1	5	1	1	0.6815	H
Carduus schimperi	2	0	4	1	0.7103	H
Rumex nervosus	0	2	6	5	0.7299	H
Lysimachia ruhmeriana	2	0	1	4	0.7319	H
Acanthus sennii	0	3	4	3	0.7582	S
Solanum marginatum	2	3	4	0	0.7738	S
Embelia schimperi	6	1	9	10	0.7756	T/L
Clutia lanceolata subsp *lanceolata*	2	0	4	1	0.7844	S
Leucas martinicensis	2	0	4	3	0.7904	H
Jasminum abyssinicum	3	7	2	2	0.7976	C
Thalictrum rhynchocarpum	1	3	4	0	0.7984	H
Micractis bojeri	3	0	2	0	0.8118	H
Maytenus gracilipes	21	21	19	12	0.837	S
Crotalaria lachnophora	0	0	3	2	0.8472	S
Pycnostachys abyssinica	2	3	1	0	0.862	S
Rubus steudneri	1	3	2	5	0.8894	S

Species name	C1	C2	C3	C4	P* Value	Habit
Dodonea angustifolia	7	2	2	5	0.8972	S
Galium spurium subsp. *africanum*	3	0	1	1	0.909	H
Kalanchoe petitiana	6	7	9	5	0.9272	H
Canthium oligocarpum subsp. *oligocarpum*	5	2	4	3	0.9546	S/T
Solanum anguivi	4	2	3	2	0.9702	H
Berula erecta	2	4	1	1	0.9798	H
Bidens camporum	2	0	2	2	1	H
Crotalaria karagwensis	2	0	1	1	1	H
Cyathula uncinulata	0	0	2	2	1	H
Hibiscus micranthus	0	0	3	2	1	H
Justicia schimperiana	0	0	2	3	1	S
Schrebera alata	0	0	2	2	1	T
Community 4						
Allophylus abyssinicus	4	61	4	3	0.0002	T
Gnidia glauca	0	0	0	**45**	0.0002	T
Solanecio gigas	19	41	1	3	0.0016	S
Rhamnus staddo	0	0	5	**31**	0.0042	T
Maesa lanceolata	0	4	33	3	0.005	T/S
Hagenia abyssinica	0	0	0	23	0.0058	T
Galiniera saxifraga	28	0	1	1	0.0064	S/T
Carissa spinarum	34	5	15	19	0.008	S
Echinops macrochaetus	1	0	25	**32**	0.0088	S
Vernonia auriculifera	2	0	28	8	0.0094	S
Podocarpus falcatus	31	2	18	1	0.0152	T
Olea europaea subsp. *cuspidata*	22	2	33	14	0.0164	T
Scolopia theifolia	26	4	0	8	0.0216	T
Thymus schimperi	20	0	0	1	0.0216	H
Osyris quadripartita	2	7	14	**29**	0.026	S
Olinia rochetiana	21	24	6	**32**	0.0262	T
Hypoestes forskaolii	2	27	5	9	0.0266	H
Rosa abyssinica	0	8	29	19	0.031	S

Species name	C1	C2	C3	C4	P* Value	Habit
Smilax aspera	19	0	0	1	0.034	C
Prunus africana	14	30	20	1	0.0348	T
Psychotria orophila	18	0	0	2	0.042	S
Periploca linearifolia	9	30	14	10	0.0446	C
Mikaniopsis clematoides	1	1	20	3	0.0452	C
Myrsine africana	11	18	4	**29**	0.0486	S/T
Hypericum quartinianum	0	1	23	17	0.05	S
Achyranthes aspera	2	17	0	2	0.0548	H
Maytenus arbutifolia	0	6	13	25	0.0552	T
Calpurnia aurea	22	15	2	2	0.0648	T
Phoenix reclinata	19	1	6	1	0.0716	T/S
Nuxia congesta	4	5	0	20	0.072	T
Dregea schimperi	0	14	1	1	0.0744	C
Buddleja polystachya	0	0	5	15	0.0806	T
Teclea nobilis	24	23	2	3	0.0814	T
Vernonia amygdalina	1	0	16	4	0.0882	T
Rubus apetalus	7	21	4	6	0.095	S
Acokanthera schimperi	0	12	1	1	0.0998	T
Hypoestes triflora	23	5	3	12	0.1038	H
Bersama abyssinica	21	29	19	13	0.112	T
Cussonia ostinii	0	0	3	12	0.1144	T/L
Sida schimperiana	0	0	0	14	0.1256	S
Rhus glutinosa	8	2	22	11	0.15	T
Satureja punctata	1	0	0	11	0.154	H
Rhus vulgaris	10	0	19	8	0.163	T
Clematis simensis	2	1	16	6	0.1728	C
Apodytes dimidiata	12	25	12	12	0.1868	T
Conyza stricta	0	0	3	9	0.2262	H
Flacourtia indica	8	0	0	1	0.2326	T
Helichrysum schimperi	1	2	0	10	0.2496	H
Euclea racemosa	0	0	0	9	0.2539	T

Species name	C1	C2	C3	C4	P* Value	Habit
Phytolacca dodecandra	0	0	0	9	0.2543	S
Erythrina brucei	0	0	0	9	0.2551	T
Syzygium guineense subsp. *guineense*	0	0	0	9	0.2629	T
Lippia adoensis	0	3	0	9	0.2647	S
Dombeya torrida	0	0	3	9	0.2673	T
Echinops kebericho	0	0	1	7	0.2895	S
Conyza abyssinica	0	4	0	8	0.3093	S
Panicum monticola	9	0	2	1	0.3259	H
Dovyalis abyssinica	1	13	5	5	0.3403	T
Syzygium guineese subsp. *afromontanum*	20	17	9	3	0.3405	T
Cissampelos pareira	1	12	5	15	0.3507	C
Sphaeranthus suaveolens	7	0	0	4	0.3793	H
Bidens ghedoensis	1	0	8	1	0.3943	H
Otostegia intergrifolia	0	0	4	8	0.3949	S
Verbascum sinaiticum	0	0	6	2	0.4165	H
Myrica salicifolia	10	5	2	1	0.4239	T
Clausena anisata	8	5	17	8	0.4349	S
Digitaria velutina	2	0	0	6	0.4443	H
Kosteletzkya begoniifolia	0	6	0	2	0.4449	S
Asparagus africanus	2	11	6	2	0.4513	S
Acanthus eminens	0	0	2	6	0.4551	S
Medicago polymorpha	1	0	3	7	0.4745	H
Cyperus niveus	5	3	0	1	0.4913	H
Zehneria scabra	0	0	5	4	0.5231	C
Pennisetum riparium	2	0	0	6	0.5471	H
Sesbania sesban	2	0	0	6	0.5523	S
Acacia abyssinica	2	0	8	5	0.5913	T
Ekebergia capensis	9	6	1	2	0.5951	T
Ocimum lamiifolium	2	0	5	1	0.6133	S
Artemisia afra	1	5	1	1	0.6815	H
Carduus schimperi	2	0	4	1	0.7103	H

Species name	C1	C2	C3	C4	P* Value	Habit
Rumex nervosus	0	2	6	5	0.7299	H
Lysimachia ruhmeriana	2	0	1	4	0.7319	H
Acanthus sennii	0	3	4	3	0.7582	S
Embelia schimperi	6	1	9	10	0.7756	T/L
Clutia lanceolata subsp *lanceolata*	2	0	4	1	0.7844	S
Leucas martinicensis	2	0	4	3	0.7904	H
Jasminum abyssinicum	3	7	2	2	0.7976	C
Commelina diffusa	3	0	0	2	0.8026	H
Platostoma rotundifolium	3	0	0	2	0.8104	H
Teucrium scordium	3	0	0	2	0.8198	H
Grewia mollis	3	0	0	2	0.8212	S
Hyparrhenia dregeana	1	4	0	3	0.8344	H
Maytenus gracilipes	21	21	19	12	0.837	S
Crotalaria lachnophora	0	0	3	2	0.8472	S
Rubus steudneri	1	3	2	5	0.8894	S
Dodonea angustifolia	7	2	2	5	0.8972	S
Galium spurium subsp. *africanum*	3	0	1	1	0.909	H
Kalanchoe petitiana	6	7	9	5	0.9272	H
Canthium oligocarpum subsp. *oligocarpum*	5	2	4	3	0.9546	S/T
Solanum anguivi	4	2	3	2	0.9702	H
Berula erecta	2	4	1	1	0.9798	H
Andropogon schirensis	0	0	0	5	1	H
Bidens prestinaria	2	0	2	2	1	H
Crotalaria karagwensis	2	0	1	1	1	H
Cyathula uncinulata	0	0	2	2	1	H
Hibiscus micranthus	0	0	3	2	1	H
Justicia schimperiana	0	0	2	3	1	S
Ocimum urticifolium	0	0	0	5	1	S
Otostegia tomentosa	3	0	0	2	1	S
Pittosporum viridiflorum	0	0	0	5	1	T
Schrebera alata	0	0	2	2	1	T

Declaration

I, the undersigned, declare that this thesis is my original work and all that sources of materials used for the thesis have been dully acknowledged. I also confirm that this work has not been submitted any where else for the same purpose.

Name Birhanu Kebede Kuris Signature_____

This thesis has been submitted for examination with my approval as University advisor.

Prof. Ensermu Kelbessa Signature_____
Date _____

Dr. Teshome Soromessa Signature_____
Date_____

Place and date of submission
Addis Ababa University
June, 2010

Dedication

To those who passed away, jailed and persecuted struggling for freedom hating superiority and privilege of time being but loving their people forever. You were, are and will be loved and remembered in history.