Jimma University

School of graduate studies

Floristic composition of Doprar forest, Jekow district, Gambella National Regional State, Ethiopia

By

Pul Deng Lul

May, 2019

Jimma, Ethiopia

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Acronyms

CSA: Central Statistical Agency

EFAP: Ethiopian Forestry Action Program

ETH: National Herbarium

EWNH: Ethiopian wild life and natural history

EWNHS: Ethiopian Wildlife and Natural History Society

m.a.s.l: meter above sea level

NBSAP: National Biodiversity Strategy and Action Plan

Abstract

The study was carried out at Doprar Forest, Southwestern Ethiopia to determine floristic composition and to identify community types in the study area. A total of 60 plots, 20 m x 20 m along horizontal distance were laid to collect the data on cover–abundance, DBH, height, and density for trees and shrub. The data on herbaceous species were collected from five, 1 m x 1 m subplots laid at four corners each and one at the center of the large plot. A total of 79 plant species belonging to 57genera and 32 families were identified. The five most dominant families were: Fabaceae 21 species, Combretaceae and Vitaceae are each represented by 5 species Commelinaceae and Convolvulaceae are each represented by 4 species. Four communities were derived from the PC-ORD by clustering the plots into groups, based on the abundance of the species. The name for each community type was given based on high synoptic values of tree and/or shrub species. Grewia mollis – Combratum collinum type community, Flueggea virosa – Acacia seyal type community, Ficus sur – Cadaba heterotrica type community and Acacia hockii – Cadaba heterotricha type community are the communities in Doprar forest. The study on vegetation and population structure showed that the density of tree species was high at the lower class levels. Tree density was 737.56 *individuals per hectare and the basal area was* 52.17*m2/ha, frequency of all the tree species (*762*/ha) and the respective IVI values for each tree species were also calculated. The species with highest important value index was Ficus sur (27.61) followed by Ficus sycomorus (23.16). The comparison of Doprar forest with other forests in Ethiopia with respect to tree densities, percentage distribution of tree species, and basal area was done. Two general patterns of population structure were recognized, the J-inverted shape and bell shaped population structure.*

Key words/Phrases: Doprar, Floristic composition, Plant community type, and Vegetation structure

1. INTRODUCTION

1.1 Background of the study

Forests worldwide are known to be critically important habitats for the biodiversity they contain and for the ecological functions they serve (Pearce and Pearce, 2001). People living in or around forests depend on the forests for many forest products and environmental services. However, the increasing population demands additional land for agriculture which in most cases can be met by forest conversion.

Tropical forests are the most diverse ecosystems and are often considered as the reservoirs of biodiversity and Ethiopia is a country with diverse and many important biological resources with estimation of higher plants is about 6000 species with 10–12% endemism (Hedberg, 2009). Studies made by (Friis and Demissew, 2001; Awas *et al.*, 2001; Yeshitela and Bekele, 2002, and Ayalew *et al.*, 2006) are some of the main vegetation surveys in different parts of Ethiopia aimed at describing community types and their relationship with some natural feature and anthropogenic features.

The Ethiopian vegetation is broadly divided by (Friis *et al.*, 2011) as desert and semi-desert scrubland, Acacia-Commiphora woodland and wooded grassland of the Rift valley, wooded grassland of the western Gambella region, Combretum–Terminalia woodland and wooded grassland, dry evergreen Afromontane forest and grassland complex, Moist evergreen Afromontane forest, transitional rainforest, ericaceous belt, Afroalpine vegetation, riverine vegetation, freshwater lakes (including lake shores, marshes, swamps and floodplain vegetation), and salt water lakes (including lake shores, salt marshes and pan vegetation).

The historical sources show that extensive forest was once covered by 35% of Ethiopia's land and these forests have dramatically declined in size and quality in the last century by 19 million hectares or 16% of the total land area in the beginning of the early 1950's, and further reduced to 3.6 % by the early 1980's and continued on reduction to 2.7% by 1989 (Million Bekele and Leykun Berhanu, 2001). The sharp decline in forest cover of the country is thus very serious threat to the conservation of biological diversity. The most important reason which derived the rapid deforestation rate in the country is an increase in human population growth. This rapid increment 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 (Feyera Senbeta and Demel Teketay, 2003;Teshome Soromessa *et al*., 2004). Loss of such forest resources would have great implication for the environment, biological diversity and socio-economic setup of the communities.

Most of the less accessible forests in Ethiopia are confined to the south and southwest parts of Ethiopia, (Kumelachew Yeshitela and Tamrat Bekele, 2002). Nowadays, human being is putting serious threat on these remnant natural forests in the areas. A study had been carried out to document and describes the floristic composition of Mejengir Forest in Gelesha, Gambella. The forest in Mejang zone is considered as one of the forest priority areas (FPA) in Ethiopia, with a total area of about 12,000 hectares and is under serious threat due to rapid human population growth, the demand for new settlement area and the expansion of investment for coffee and crop cultivation. It has been continuously exploited by the surrounding people for agricultural land expansion, timber harvesting (logging), firewood collection and charcoal production, wood cutting for construction and other purposes (Bilew Alemu *et al.,* 2015).

Knowledge of floristic composition and structure of forest is useful in identifying ecologically and economically important plants and their diversities protecting threatened and economical important plant species (Addo-Fordjour *et al.*, 2009)., the sustainable use of natural forest was the aim of the study for Doprar forest.

1.2. Statement of the problem

Doprar Forest is near to the Gambella National Park which is found in southwestern Ethiopia. Gambella National Park is one of the Forest Priority Areas (FPA) in Ethiopia with some of its parts threatened by cotton plantation and camps of refugees. Doprar Forest is among the forests in the country, which have not been studied before and it is the concern of this study. For effective management and conservation of this irreplaceable forest in the country, there is an urgent need to develop a successful management plan and this in turn requires detailed baseline information regarding the floristic composition to identify the most threatened species from the study area.

The rise in population, absence of law enforcements, the need for new settlement area and the expansion of unexpected investment for different plantations are some of the serious threats to the southwestern Ethiopia where the remnants of natural forests are found. The problem is also seen in the study area, and causes damage to the natural forest of Doprar.

1.3 Research Questions

- What are the plant species found in the study area?
- What are the plant community types of the study area?
- What does the vegetation structure of the study area look like?

1.4. OBJECTIVES

1.4.1 General Objective

The general objective of the study was to investigate the floristic composition of Doprar forest, Jekow District, Gambella National Regional State, Ethiopia.

1.4.2 Specific Objectives

The specific objectives of this study were:

- To identify plant species of Doprar Forest
- To determine plant community types of Doprar Forest.
- To identify the vegetation type and structure of Doprar Forest.
- To compare the similarity of Doprar Forest with some other forests of Ethiopia regarding its floristic composition

1.4.3. Scope of the study

The study was mainly focusing on investigation of the floristic composition, structure and diversity of Doprar forest plant communities and was compared to other forests community. Other environmental parameters were considered but, the rate of deforestation was not a concern of this study.

2. LITERATURE REVIEW

2.1 Overview of Ethiopian Vegetation (History)

Vegetation is defined as collection of plants growing together in a particular location, or it is an area in a particular location that is covered by plant community (Jennings *et al.,* 2003). Ethiopia is the tenth largest country in Africa and is located in the tropics in the Horn of Africa between 3^o24' to 15^oN latitude and 33^o00' and 48^o00'E longitude and covers a land surface area of 1,113,000 km2 (Friis *et al.,* 2010).

Ethiopia has great variation in its topography with high mountains, river valleys, rolling plains, and with great variation of altitude from 126 meters below sea level to 4620 m a.s.l. (Girma Balcha *et al.,* 2003 and Tesfaye Awas, 2007). It has extreme variations in climate and landscape and the wide range of ecological systems. Ethiopia's flora consists of about 6,000 species of higher plants of which about 10% is considered endemic and also has over 300 tree species of which a few are important for industry and construction (Million Bekele and Leykum Berhanu, 2001). The plant species are distributed from below 100 up to 4500 m a.s.l. Species distribution reaches a maximum of 1600 taxa between 1200 and 1500 m. a.s.l., but shows decline below and above this altitudinal range (Friis and Sebsebe Demissew, 2001). Similarly, the highest numbers of endemic or near-endemic taxa are found in the same zone. But, the sum of near-endemic and strict endemic plants is still relatively high in between 0 and 305 m a.s.l. (Friis and Sebsebe Demissew, 2001). According to Friis and Sebsebe Demissew (2001), the flora composition and richness varies from region to region.

2.2 The vegetation type of Ethiopia

The vegetation type of Ethiopia is considered as extremely complex, where the complexity is due to the great variations in altitude and this difference in altitude in turn results in great variations of spatial distribution of vegetation in the country (Abate Ayalew, 2003).

Different researchers have studied the vegetation of Ethiopia at different times (Abate Ayalew, 2003; Fayera Senbeta, 2006; Motuma Didita, 2007; Sisay Nune, 2008; Haile Adamu *et al*., 2012; Abyot Dibaba *et al.,* 2014) and some of them have classified the vegetation of Ethiopia into eight categories, whereas others classify them into nine but the recent research by Friis *et al.,* 2010 have classified them in to twelve. These are:-

1) Desert and semi-desert scrubland, 2) *Acacia-commiphora* woodland and bushland, 3) Wooded grassland of the western Gambela region, 4) *Combretum-Terminalia* woodland and wooded grassland, 5) Dry evergreen Afromontane forest and grassland complex, 6) Moist evergreen Afromontane forest, 7) Transitional rain forest, 8) Ericaceous belt, 9) Afroalpine belt, 10) Riverine vegetation, 11) Salt lakes, salt-lake shores, marsh and pan vegetation and 12) Freshwater lakes, lake shores, marsh and floodplain vegetations. The description of vegetation that occurs in Gambella and a type of vegetation that occurs in the entire country is shortly described below.

2.2.1. Wooded grasslands of the western Gambella region

This type of vegetation occur only in Gambella region and it is characterized by a tall grass stratum that burns annually, and a canopy layer of trees that can both tolerate burning and temporary flooding. This vegetation is suffered from frequent occurrence of flood and fire (Friis *et al*., 2010).

2.2.2. Riverine vegetation

This type of vegetation is highly variable in structure and density, and the floristic composition dependent on altitude and geographical location. As described by (Friis *et al*., 2010), this vegetation is found almost in all parts of the country with permanent or temporary rivers and other streams below 1800m. However, it is relatively rare in the driest parts of Afar, Harerge and Sidama floristic regions.

2.3 Threats to Biodiversity in Ethiopia

Ethiopia is considered as a country having high biodiversity in Horn of Africa due to wide variations in climate, geology and topography working on different time scales (NBASAP, 2005). Historical sources indicates that, Ethiopia’s land area was once covered with forest and reduced sharply due to clearance of natural vegetation, increase in human population, increasing in demand for agricultural land that resulted in extensive forest clearing for agricultural use, the increasing livestock population resulted in overgrazing, and an increasing demand for fire wood and charcoal resulted that in exploitation of existing forests for fuel wood, and construction materials (Fayera Senbeta and Demel Teketay, 2003; Teshome Soromessa *et al*., 2004).

Ecological and environmental problems such as soil degradation, soil erosion and alteration of natural resources are just some of the negative effects resulting from the destruction of these habitats (Kitessa Hundera *et al*., 2007). Loss of such forest resources would have great implication for the environment, biological diversity and socio-economic setup of the communities.

2.4. Plant Community

The definition of Plant community is known to be groups of plants that occur together in repeating groups of associated plants. According to Kent and Coker (1992), plant communities are also defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other. A particular community is characterized by the identity and growth forms of the richest species, the largest species, or the most characteristic species. Plant communities cannot reproduce in environmentally different habitats or different climates without losing their identity (Mueller-Dombois and Ellenberg, 1974).

Plant communities are largely based on physical appearance or the growth form of the vegetation Kent and Coker (1992). Certain species are found growing together in certain locations and environments more frequently than would be expected by chance. This is because they have similar requirements for existence in terms of environmental factors such as light, temperature, water, drainage and soil.

2.5 Plant Species Diversity, Species Richness and Evenness

According to (van der Maarel, 1979), diversity has both an aspect of species richness, i.e. the number of species, and of evenness, the way species quantities are distributed. The description of a plant community includes the study of species diversity, evenness and similarity. The diversity and equitability of species in a given plant community is used to interpret the relative variations between and within the community and help explain the underlying reasons for differences. The idea of species diversity involves two relatively distinct concepts: species richness and evenness. Species richness refers to the total number of species in a community while evenness is the relative abundance of species within the sample or community (Kent and Coker, 1992). Patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes that are important for management (Lovett *et al*., 2000; cited in Feyera Senbeta, 2006).

Species diversity can be viewed from different perspectives: alpha, beta and gamma diversity. Alpha diversity refers to the diversity of species within a particular habitat or community. Beta diversity is a measure of the rate and extent of change in species composition along a gradient from one habitat to another. Between-habitat diversity is used as a measure of turnover rates. Beta diversity is sometimes called habitat diversity (Kent and Coker, 1992). Gamma diversity is the diversity of species in comparable habitats along a geographical transects and it depends on the alpha and beta diversity (Kent and Coker, 1992). A species diversity index provides information about community composition rather than simply species richness.

Measures of species diversity are usually seen to be key indicators for the safety of ecological systems. The most widely used index that combines species richness with evenness is Shannon Diversity Index, which varies between 1.5 and 3.5 and rarely, exceeds 4.5 and Sorenson's Similarity ratio are important diversity measuring tools for ecology (Kent and Coker, 1992).

2.6. Abundance and frequency

According to (Kent and Coker, 1992), Abundance is the number of individual plants of a given species per unit area. It can be used to show spatial distribution and sorts over time. Frequency is the proportion of plots in which a species occurs. It is used to measure the occurrence of a given species in a given area. This indicates how the species are dispersed and is an ecologically meaningful parameter.

2.7 Importance Value Index (IVI)

Species important value is measured on the basis of species density, frequency and dominance values to permit a comparison of species in the vegetation being studied and reflects the occurrence, dominance and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Therefore, measuring the species importance value is a good index for summarizing vegetation features and ranking the species for management and conservation practices.

3. METHODOLOGY

3.1. Description of study area

Doprar forest is located in Jekow District, Southwestern Ethiopia, about 916 km away from Addis Ababa, capital of the country. The District as whole has a total area of 1,081.04 km^2 with sixteen rural villages. The geographical location of the District lies between latitude and longitude of 08°18′N 33°49′E to $08^0$28′N $33^0$53′E. Its altitudinal ranges between 300 to 600 meters above sea level. According to 2007 Census conducted by the Central Statistical Agency of Ethiopia (CSA, 2007), the District has a total population of 35,556, of whom 19,134 are men and 16,422 women. Jekow district is categorized under tropical rainy climatic zone. Its vegetation type is wooded grassland with an extensive plain topographic feature (PADS, 2004). The annual rainfall and mean annual temperature in the district are 1,247 mm and 34.37 0C, respectively (GRS, 2003). The rainfall regime is unimodal, referred to as the “Sudan Type”, occurs in the lowlands along the border with South Sudan (PADS, 2004).

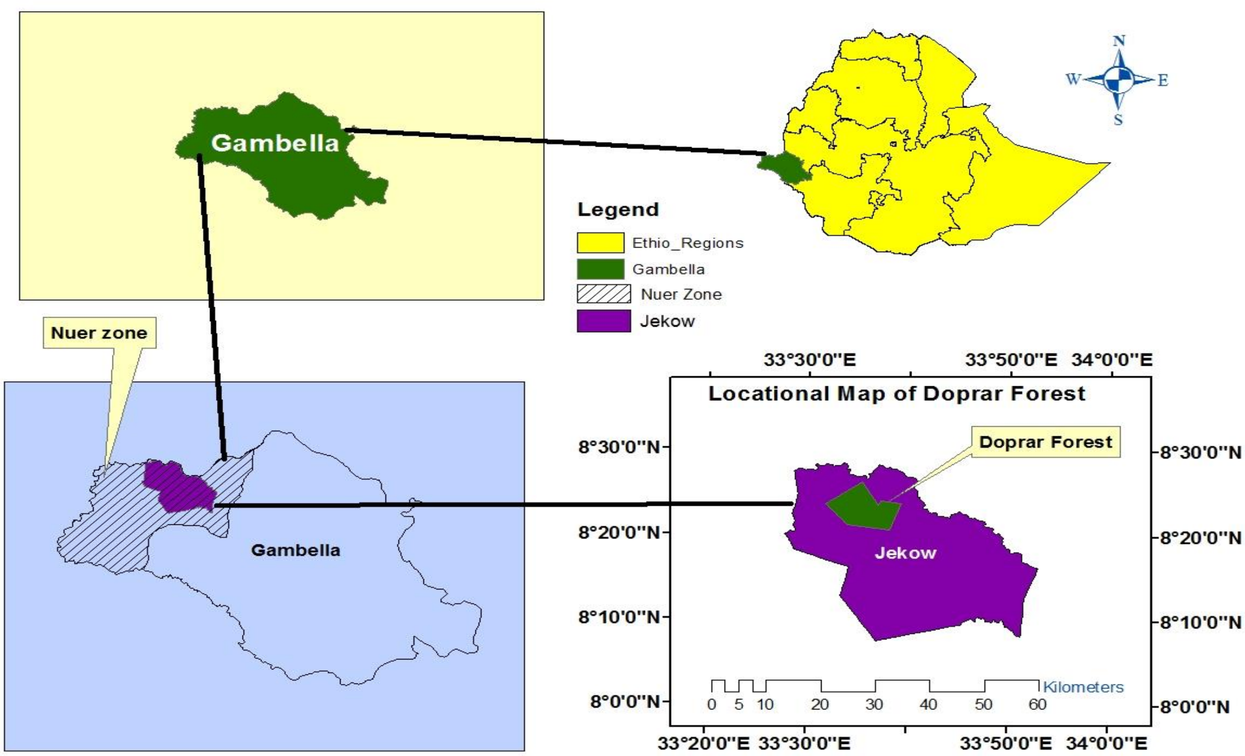


Figure 1: Map of Doprar Forest

3.2. Vegetation Survey and sampling design

3.2.1 Vegetation survey

A reconnaissance survey was made before the actual data collection to obtain information about the general vegetation forms of the study area. The data collection was conducted from March-April-2018.

3.2.2 Sampling design

A systematic sampling technique was used to collect vegetation data in the Forest. A total of 60 sampling plots of size 20m x 20m (400m^2) were used for collecting trees, shrubs and lianas. For the ground flora (herb), five 1m x 1m sub plot were established within the main sampling plot. Sampling plots was laid systematically at every 200m along four transect lines established parallel to the road that pass through the forest along horizontal distance. The distance between each transect was 400m apart from each other.

3.3 Vegetation Data collection

Plant species including, tree, shrubs and lianas in each quadrat was recorded in established plots along transects. Additional plant species occurring outside the quadrat, but inside the study area was also documented but only as “present”, they were not used in the cluster and ordination of data analysis. The plant specimens were assigned by tentative field identifications and local name (Nuer and/or Amharic) and then brought to Jimma University Herbarium where voucher specimens are deposited. Taxonomic identification was made following the Flora of Ethiopia and Eritrea Vol. 4(2) (Hedberg *et al.*, 2004) by consulting experts. Cover-abundance values of trees and shrubs was estimated following modified 1–9 Braun-Blanquette scale as converted by Van der Maarel (1979). Height and diameter at breast height (DBH) was measured for any woody plant species with height ≥ 2 m and DBH ≥ 2 cm. Individuals having height <2 m and DBH <2 cm was not counted. Height and DBH was measured by using diameter tape.

3.4. Data analysis

i. Vegetation classification

The vegetation data analysis was conducted following Gauch (1982), Jongman *et al.* (1987) based on species abundances (the number of individuals). PC-ORD window version 5.31 software was used for plant community analysis. Sørensen (Bray-Curtis) was taken as distance measure and Flexible β as group linkage model with a flexible β of -0.50 was used on the vegetation data. The communities were refined into a synoptic table and the community name was derived based on the tree or shrub with high synoptic value.

ii. Vegetation structure

Structural analysis was performed on the basis of density, frequency, DBH and basal area per hectare. Ten DBH classes (2-10, 10-20, 20-30, 30-50, 50-70, 70-90, 90-110, 110-130, 130-150, and >150 cm) were constructed. The distribution of the size classes was evaluated by computing the density of individuals with DBH >10 cm and > 20.

Structural parameters were computed following Mueller-Dombois and Ellenberg (1974), and Martin (1995) as follow;

- Basal area (m^2) = $\pi d^2 /4$, where π=3.14 and d= DBH in (cm)
- Percent frequency of a species = (the number of plots in which that species occurs / total number of plots) * 100.
- Relative frequency = (Frequency of species A / total frequency of all species) * 100
- Density of a species = number of individuals of that species / area sampled.
- Relative density = (Density of species A / total density of all species) * 100
- Dominance = Total of basal area / area sampled
- Relative dominance = (Dominance of species A / total dominance of all species) * 100
- Importance value index = Relative density + Relative frequency + Relative dominance

iii. Diversity analysis

Shannon -Wiener Diversity Index was used to analyze the species diversity, species richness and evenness of the vegetation as:

$H= - \sum PilnPi$

Where **H**: Shannon-Wiener Index.

Pi: proportion of individual tree species.

ln: log $base_n$

The equitability or evenness of the species in each quadrat was computed using the formula:

Equitability $J = H'/H' max$, where;

J = Evenness,

H′ = Shannon-Wiener diversity index and

H′ max = lns, where **s** is number of species

iv. Similarity

The similarity index that was used for comparison was **Sorenson's Similarity Index.** It was used to evaluate the similarity between the four plant community types of the vegetation in the study area as well as the similarity between and other previously studied woodlands on the basis of their species composition.

Ss = $\frac{2a}{2a+b+c}$

Where: **Ss** = Sorensen's similarity coefficient

a = number of species common to both samples /communities/ study areas

b = number of species in sample 1

c = number of species in sample 2

4. RESULTS AND DISCUSSIONS

4.1 Result

4.1.1 Floristic Composition

A total of 79 plant species were recorded which belong to 57 genera and 32 families (Annex 1). Out of 79 species of plants recorded, 24 species were trees, 23 species were herbs, 17 species were shrubs, and climbers are represented by 14 species (Figure 2) is referred to their respective percentage.

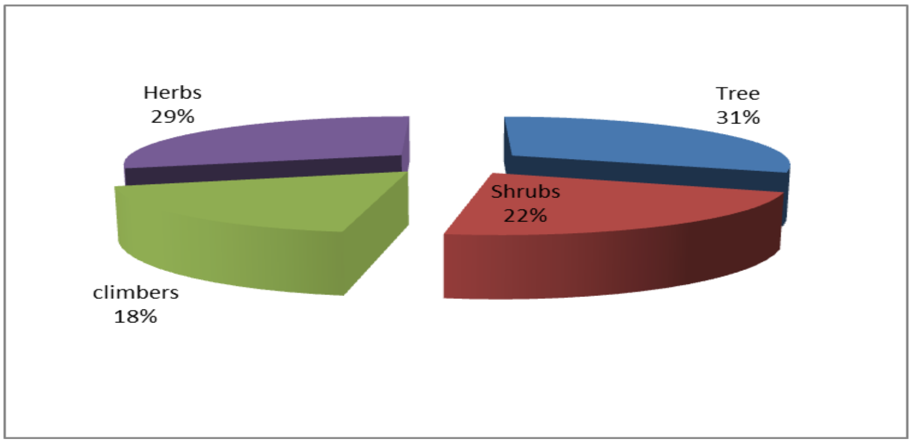


Figure 2: Composition of plant species in the various life forms identified in Doprar forest.

Out of 32 families identified the major families in decreasing orders are: Fabaceae represented by 21 species (26.58%), Combretaceae and Vitaceae are each by 5 species (6.32%), Commelinaceae and Convolvulaceae are each represented by 4 species (5.06%), Anacardiaceae, Capparidaceae, Cyperaceae, Euphorbiaceae and Rhamnaceae are each represented by 3species (3.79%), Lamiaceae, and Moraceae and Tilliaceae are each represented by 2 species (2.53%). The remaining families altogether account for 25.3% of the total species composition each family is represented by 1 species (Annex 2)

Among the identified 57 genera, the most diverse were *Acacia*, *Combratum*, *Crotolera* and *Ipomoea* each represented by 4 species, followed by *Cisscus*, *Convolvus*, *Cyperus* and *Zizypus* each represented by 3 species, *Cadaba, Ficus, Grewia*, and *Indigofera*, each represented by 2 species. The rest of the genera were represented each by 1 species (Annex 2).

4.1.2 Plant community types

A total of four clusters were derived from the PC-ORD to repeatedly cluster the plots into groups, based on the abundance of the species (Figure 3) and the name for each community type was given based on high synoptic values of tree and/or shrub species (Annex 5). Plots with their characteristics and communities with the number of Plots they contained are given in Annex 3 and 4 respectively.

I. *Grewia mollis* - *Combratum collinum* type Community

This community type is distributed between the altitudinal ranges of 408-453 m a.s.l. It is dominated by *Grewia mollis, Ficus sur, Combretom molle, Balanite aegyptica, Ficus sycomorus, Flueggea virosa, Acacia seyal, Crateva adansoni, Meyna tetraphylla* among tree species *and Cadaba heterotricha, Senna septemtrinalis, Bridelia scleuromeura, Indigofera brevicalyx, Lannea barteri* are among the shrub species. The herb layer is dominated by *Cyperus eleusinoides, Cissus quadrangular, Crotolaria brevidens, Aeschynomenna abyssinica, Convolvulus siculus, Ipomoea purpurea, Ipomoea eriocarpa, Ipomoea aquatic, Leucas mollis, Erucastrum arebicum* and the common Climbers/lianas of this community are *Coccinia grandis, Plumbago zeylanica, Cissus petiolata, Dioscoria prehensilis,* and *Opilia amentacea.*

II. *Flueggea virosa* - *Accacia seyal* type Community

This community is found between 409-441 m a.s.l. The most dominant species in the upper canopy of this community are *Accacia seyal, Ficus sycomorus, Grewia mollis, Ficus sur* and *Lannea welwitschii, Balanite aegyptica, Maytenus senegalensis, Crateva adansoni* are the other tree species of the community. The dominant climbers are *Ampelocissus schimperiana, Coccinia grandis, Cyphostemma adenocuale, Dioscoria prehensilis, Teramus labialis*.

The shrub layer includes *Lannea barteri, Cadaba heterotricha, Combratom collinum, Combratum adenogonium*. The dominant herbs are *Erucastrum arebicum, Crotolaria brevidens, Leucas mollis, Cyperus eleusinoides, Convolvulus sagittatus, Cyperus esculentus, Aeschynomenna abyssinica, Cyperus rotundus, Indigofera preureana, Convolvulus olitorius, Leonotis raineriana, Ipomoea purpurea, Desmodium dichotunum.*

III. *Ficus sur – Cadaba heterotricha* type community

This community is found between 412-450 m a.s.l. The most dominant tree species of this community are *Ficus sur, Acacia hockii, Ficus sycomorus, Grewia tenax, Balanite aegyptica, Grewia mollis, Lannea welwitschii, Maytenus senegalensis, and Acacia seyal*. The shrub species dominating this community are *Cadaba heterotricha, Chlorophytum tordense, Combretom molle, Crotolaria bongenisis* .The climbers dominating this community are *Teramus labialis, Peripeloca linearifolia, Coccinia grandis, Plumbago zeylanica.*

The dominant herbs of this community are *Cyperus esculentus, Convolvulus olitorius, Crotolaria goreensis, Cyperus rotundus, Ipomoea eriocarpa, Crotolaria ochroleuca, Convolvulus siculus, Ipomoea aquatic.*

IV. *Acacia hockii – Cadaba hetrotricha* type Community

The plots in this community are distributed in the altitude range of 406 - 439 m a.s.l. The dominant tree species in the community are *Acacia hockii, Flueggea virosa, Ficus sur, Cadaba farinose, Grewia mollis, Grewia tenax, Maytenus senegalensis, Ziziphus spinachrstichrsti, Lannea welwitschii.*

Combretom adenogonium, Combratum collinum, Indigofera brevicalyx, Chlorophytum tordense, Bridelia scleuromeura are the common shrubs of this community. *Combretum molle, Solanum nigrum, Crotolaria bongenisis, Rhynchosia malacaphylla, Gutenbergia corditolia, Senna septemtrinalis* are also among the shrubs of this community.

The climbers found in this community type are *Ampelocissus schimperiana, Coccinia grandis, Vigna ambacensis, Peripeloca linearifolia, Plumbago zeylanica*.

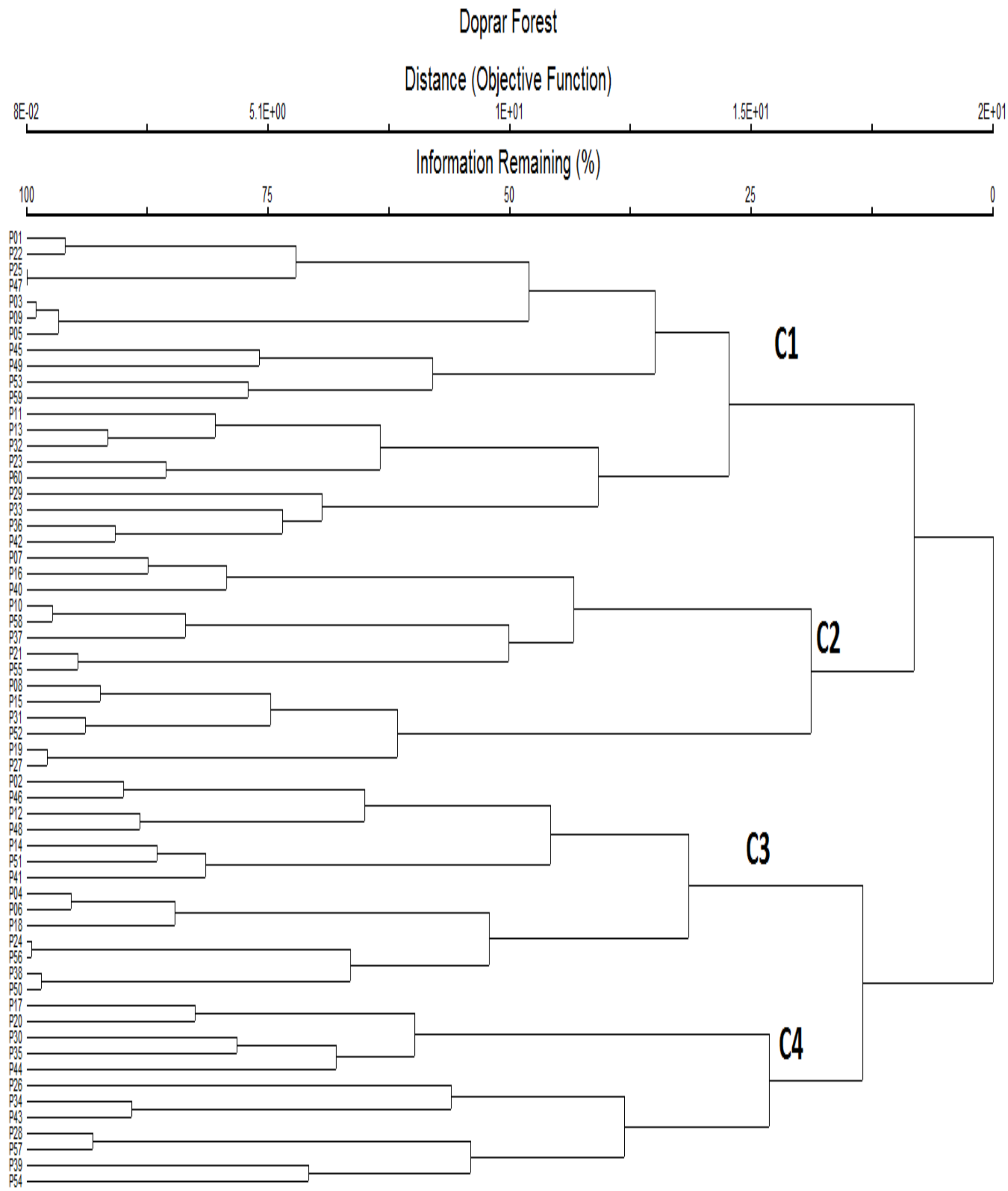


Figure 3: Dendrogram showing plant community types of the study area.

4.1.3 Species diversity, richness and equitability

The Shannon-Wiener Diversity index computation of vegetation data from Doprar Forest is shown in Table 1.

Table 1: Shannon–Wiener Diversity Index

Communities Types	Richness	Diversity(H')	H'max	Shannon Eveness(H'/H'max)
1	77	3.91	4.34	0.90
2	74	2.62	4.30	0.61
3	74	2.62	4.30	0.61
4	73	2.44	4.29	0.57

Community 1 have diversity index above 3.0. This community attained a species evenness index (J) of 0.90 showing the highest even distribution of species and the next communities 2 (J = 0.61) and 3 (J = 0.61) have diversity index of 2.62 respectively. Community 4 got a diversity index of 2.44 and is less diversified when compared to the others with (J=0.57).

4.1.4. Similarity between the community types

The Sorensen’s similarity coefficient of the four communities shows that, community 1 and 2 have the highest similarity (49%) followed by community 1 and 3, 1 and 4, 2 and 3, 2 and 4 then 3 and 4 which have equal similarity ratios of 48%. The overall communities have showed relatively nearest/the same similarity amongst each other. This might be due to that many of the species are distributed throughout the communities and due to small variation in altitude.

Table 2: The Sorensen's similarity of the communities

Community	C1	C2	C3	C4
C1	—	0.49	0.48	0.48
C2		—	0.48	0.48
C3			—	0.48
C4				—

4.1.5 Vegetation structure

4.1.6 Tree density

Density is expressed as the number of individuals present per hectare of an area. The density of tree species with DBH greater than 2, 10, and 20 cm is shown in Table 3. The Density of trees with DBH greater than 2 cm in the study area is 543.12/ha. The number of stems with DBH >10 cm was found to be 290.62/ha and those with DBH >20 cm was 145.62. *Flueggea virosa* and *Ficus sur* alone contributed to 21% of the total density. Other tree species namely *Lannea welwitschii* (6.72%), *Maytenus senegalensis* (6.61%), *Crateva adansoni* (6.04%), *Balanite aegyptica* (5.70%), *Grewia tenax* (5.35%) and *Ziziphus spinachrstichrsti* (5.13%) contributed to 33.55% of the total density of tree with DBH greater than 2 cm. Regarding trees with DBH class greater than 10 cm, *Ficus sur* contributed 11.37%, *Balanite aegyptica* 10.72%, *Ficus sycomorus* 8.53%, *Grewia tenax* 7.87%, *Cadaba farinosa* 6.56%, *Maytenus senegalensis* 5.90%, *Ziziphus abyssinica* 5.25%, *Zizyphus pubescens* 5.03% and the others are less than 5 per cent . Concerning trees with DBH > 20 cm *Crateva adansoni* contributed to 12.01%, *Ficus sycomorus* (9.01%), *Balanite aegyptica* 7.72 %, *Sclerocarya birrea* 7.72%, *Flueggea virosa* 6.34%, *Grewia tenax* 6.43%, *Lannea welwitschii* 6%, *Cadaba farinosa* 5.15%, *Ziziphus spinachrstichrsti* 4.72%, *Zizyphus pubescens* 4.72%, *Ficus sur* 4.29% *Maytenes senegalensis* 4.29%, *Vachellia seyal* 4.29% and the rest are less than 4 per cent.

Table 3: Density of tree species and DBH classes of Doprar forest

		DBH		
No	**Species**	**>2**	**>10**	**>20**
1	*Balanite aegyptica*	31.25	30.62	11.25
2	*Cadaba farinosa*	26.25	18.75	07.50
3	*Crateva adansoni*	33.12	11.87	17.50
4	*Ficus sur*	52.50	32.50	06.25
5	*Ficus sycomorus*	38.12	24.37	13.12
6	*Flueggea virosa*	62.50	11.87	09.37
7	*Grewia tenax*	29.37	22.50	09.37
8	*Lannea welwitschii*	36.87	13.75	08.75
9	*Lonchocarpus laxiflorus*	20.00	09.37	04.37
10	*Maytenus senegalensis*	36.25	16.87	06.25
11	*Meyna tetraphylla*	23.12	11.87	05.00
12	*Sclerocarya birrea*	26.25	11.25	11.25
13	*Tamarindus indica*	08.75	13.75	05.62
14	*Terminalia macroptera*	06.87	03.12	02.50
15	*Vachellia seyal*	21.87	11.87	06.25
16	*Ximenia americana*	25.62	06.87	02.50
17	*Ziziphus abyssinica*	20.62	15.00	05.00
18	*Ziziphus spinachrstichrsti*	28.12	10.00	06.87
19	*Zizyphus pubescens*	15.62	14.37	06.87
Total		**543.12**	**290.62**	**145.62**

A comparison was made for tree densities with DBH greater than 10 cm and 20 cm in Doprar Forest with that of five different forests in Ethiopia (Table 4). The ratio of tree densities with DBH >10 cm to tree densities > 20 cm is also included in the comparison.

Table 4: Comparison of tree densities with DBH >10 and 20 cm from Doprar Forest with other forests.

Forest	DBH class (cm)		Ratio
	DBH >10 (A)	DBH >20 (B)	A/B
Masha Anderacha[1]	385.70	160.50	2.40
Dodola[2]	521.00	351.00	1.50
Dindin[3]	437.00	219.00	1.99
Magada[4]	608.00	332.00	1.80
Bibita[5]	500.50	265.60	1.90
Doprar Forest	**285.62**	**145.62**	**1.96**

Source: [1]Kumelachew Yeshitela and Taye Bekele (2003), [2]Kitessa Hundera (2003), [3]Simon Shibru and Girma Balcha (2004), [4]Genene Bekele (2005), [5]Dereje Denu (2007)

The comparison showed that, the ratio of tree densities with DBH >10 cm to density >20 cm in Doprar forest is nearly similar with Bibita and Dindin forests. The ratio A/B indicated that Doprar Forest has more trees in lower DBH classes than in the higher classes when compared to Dodolla, Magada and Bibita. Two forest types in the comparison (Masha Anderacha and Dindin) have more A/B ratio values than Doprar Forest indicating that there is more predominance of trees in the lower DBH class in these forests than in Doprar. Even though it is not as large as in the two forests with A/B ratio >2, the study shows that there is high proportion of tree density in the lower DBH class.

4.1.7 Diameter at breast height (DBH)

The diameter at breast height (DBH) class distribution of the tree species is given in Fig. 4. The density of DBH class less than 10 cm is 250/ha (25.7%) and the distribution of tree species in different DBH classes is 25.1/ha (23.12%) in 10-20 cm, 198.12/ha (20.36%) in 20-30 cm, 140.62/ha (14.45%) in 30-50 cm, and 78.12/ha (8.02%) in 50–70 cm, 37.5/ha (3.85%) in 70-90 cm, 25.03 (2.56%) in 90-110 cm, 12.5/ha (1.28%) in 110-130cm, 7.5/ha (0.77%) in 130-150 and the last class was found to be 10.62 (1.09%) of the total in the DBH class >150 cm. The distribution of trees in DBH class from lower to higher showed a decreasing inclination. Lower value of density was observed at higher DBH classes and this may be attributed to selective removal of mature trees for various purposes and this indicate that, the forest is secondary stage of regeneration. Doprar Forest is also compared with other forests in Ethiopia regarding percentage distribution of tree species in different DBH Classes (Table 5)

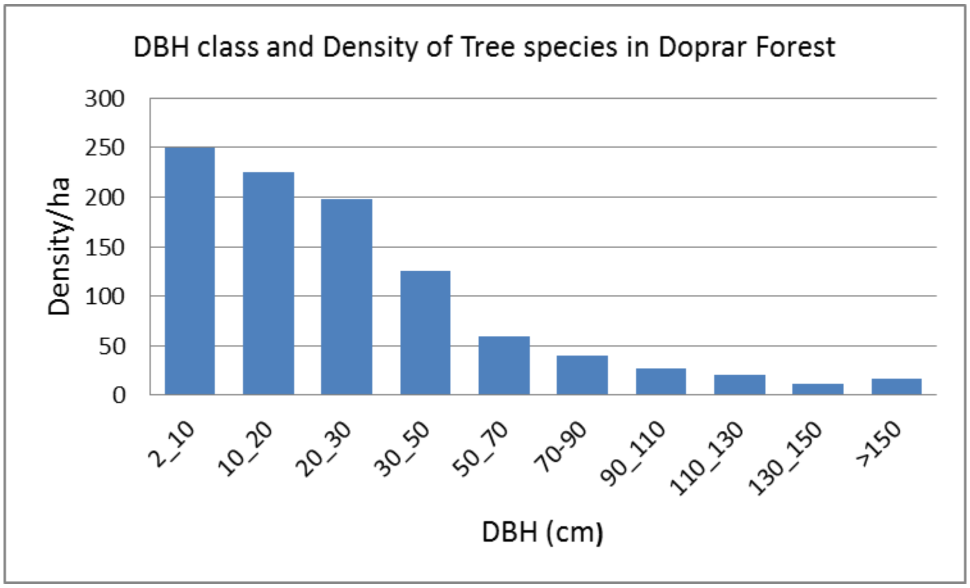


Figure 4: DBH Class and Density of Tree species

Table 5: The comparison of Doprar Forest with other four forests in Ethiopia regarding percentage distribution of tree species in different DBH classes

(I = 10-20, II = 20-50, III = 50-80, IV = 80-110, V = 110-140, VI = >140. i.e- the DBH class is similar for all forests)

Forest	DBH Classes (cm)					
	I	**II**	**III**	**IV**	**V**	**VI**
Menagesha[1]	56.9	32.8	06.5	02.5	0.0	0.0
Denkoro[2]	46.0	46.0	06.3	01.1	0.2	0.4
Menna Angetu[3]	32.8	25.5	08.9	02.4	0.7	1.1
Bibita[4]	30.2	24.4	06.2	01.7	0.5	1.4
Doprar forest	23.1	20.3	14.4	2.5	0.7	1.1

Source: 1 = Tamrat Bekele (1993), 2 = Abate Ayalew (2003), 3 = Ermias Lulekal (2005), 4=Dereje Denu (2007)

In DBH class (I), Doprar forest is lower than all other forests and in DBH class (II), Doprar Forest show slight similarity to Bibita and Menna Angetu. The percent of trees in DBH class (III) in Doprar Forest is higher than all other forests. The percent of trees in DBH class IV in Doprar Forest is similar to that of Menagesha and Menna Angetu and higher than that of Denkoro and Bibita. The percent of trees in DBH class (V) in Doprar forest is similar to Menna Angetu and higher than that of Menagesha (has no tree in this DBH class), Denkoro and Bibita. The percent of trees in DBH class (VI) in Doprar Forest is similar to that of Menna Angetu and higher than that of Menagesha (has no tree in this DBH class) and Denkoro, but lower than Bibita. This shows that Doprar forest is characterized by middle sized trees than others.

4.1.8 Tree height

The trees in the study area were divided into six height classes. The percent of trees decreased with increasing height classes (Table. 6). The height class (I) represents the highest number of individual of trees 246.87/ha (33.5%) and most of the tree species are found in this class. The height class (I) and (II) alone makes 417/ha (56.5%). Trees in the height classes III and IV together are found to be 231.87 (31.5%). The trees in height class (V) and (VI) together are found to be 88.72/ha (12%) and it is represented by only few species. The trees representing the height class VII are *Ficus sur* (70.45%), *Lannea welwechii* (18.32%) and *Vachellia seyal*(12.32%).

As height rises from one class to the other, the density of individuals drops dramatically. This clearly reveals the dominance of small sized individuals and the presence of high regeneration but lower recruitment and absence of matured individuals and this could be caused by different factors including influx of people and selective cutting at larger size class. Fekadu Gurmessa (2010) stated that the density decreasing with increasing height could be attributed to a high rate of regeneration but irregular recruitment potential.

Table 6: The class distribution for trees higher than 5 m in Doprar Forest

Height class	Density/ha	%	Class
5-10	246.87	33.5	I
10-15	170.1	23	II
15-20	159.37	21.5	III
20-25	72.5	10	IV
25-30	70	9.5	V
<30	18.72	2.5	VI
Total	737.56	100	

4.1.9 Basal area

Basal area is an important parameter for measuring relative importance of plant species (Tamrat Bekele, 1994). Hence, plant species with larger basal area in a forest is considered as the most important species in that forest. The basal area in m^2/ha and percentage contribution of all tree species was determined in Doprar Forest. The basal area of all tree species in Doprar Forest as calculated from DBH data is found to be 52.17 m^2/ha (Table 7). *Ficus sur* took the largest share in the percentage contribution of basal area (11.38%) of this forest. Other large trees in this forest such as *Ficus sycomorus* (9.20%), *Maytenus senegalensis* (7.66%), *Balanite aegyptica (*6.84%), *Sclerocarya birrea* (6.80%), *Vachellia seyal* (6.25%), *Ziziphus spinachrstichrsti* (6.24%), *Grewia tenax* (5.86%), *Tamarindus indica* (5.57%) and *Ximenia americana* (5.50%) together with *Ficus sur* contributed to 71.24% of the total basal area. The trees with highest densities such as *Lonchocarpus laxiflorus, and Flueggea virosa* with basal area values of 1.66 and 1.07 each did not contribute much to the total basal area of this forest, as area depends on the size of the tree. The plant species with highest basal area was *Ficus sur* which is about 1.23 times more important than *Ficus sycomorus*, and the second plant species with high basal area (*Ficus sycomorus*) was about 1.20 times more important than *Maytenus senegalensis*. The other tree species produced the highest basal area, but less density. The basal area of this forest is compared with the basal area of other 8 forests in Ethiopia (Table 8).

Table 7: Basal area (BA) of all tree species in Doprar Forest

Species	BA/ha	Relative BA
Balanite aegyptica	03.57	6.84
Cadaba farinose	01.29	2.50
Crateva adansoni	02.60	5.00
Ficus sur	05.94	11.38
Ficus sycomorus	04.80	9.20
Flueggea virosa	00.56	1.07
Grewia tenax.	03.06	5.87
Lannea welwitschii	02.03	3.90
Lonchocarpus laxiflorus	00.87	1.67
Maytenus senegalensis	04.00	7.66
Meyna tetraphylla	01.95	3.73
Sclerocarya birrea	03.55	6.80
Tamarindus indica	02.91	5.60
Terminalia macroptera	01.53	2.93
Vachellia seyal	03.26	6.25
Ximenia americana	02.82	5.40
Ziziphus abyssinica	02.27	4.35
Ziziphus spinachrstichrsti	03.26	6.25
Zizyphus pubescens	01.90	3.64
Total	52.17	100

Table 8: Comparison of Doprar forest with other 8 forests in Ethiopia with respect to basal area

Forest	**Basal Area**
Bibita[1]	69.9
Magada[2]	68.52
Dindin[3]	49
Donkoro[4]	45
Masha Anderacha[5]	81.9
Menagesha[6]	36.1
Chilimo[6]	30.1
Wof Washa[6]	101.8
Doprar	52.17

Source: 1 = Dereje Denu (2007), 2 = Ermias Lulekal (2005), 3 = Simon Shibru and Girma Balcha (2004), 4 = Abate Ayalew (2003), 5 = Kumilachew Yeshitela and Taye Bekele (2003), 6 = Tamrat Bekele (1993)

Dindin Forest has almost the same Basal area with Doprar forest. Some forests such as Bibita, Magada, Masha Anderacha and Wof Washa have higher basal area while Dindin, Donkoro, Menagesha, and Chilimo have much less basal area than Doprar forest. When compared to Wof Washa and Masha Anderacha forests, Doprar Forest is much lower in its basal area. This may be due to the presence of plant species with larger DBH than the mentioned forests. The basal area and density of 10 tree species with their respective percentage contribution is given in Table 9.

Table 9: Basal area, density, and percentage contribution of ten (10) tree species in Doprar Forest

Species	BA/ha	%	Density	%
Ficus sur	05.94	11.38	91.75	16.95
Ficus sycomorus	04.80	9.20	75.62	13.97
Maytenus senegalensis	04.00	7.66	59.37	11.01
Balanite aegyptica	03.57	6.84	73.12	13.51
Sclerocarya birrea	03.55	6.80	45.12	10.00
Vachellia seyal	03.26	6.24	31.87	05.88
Ziziphus spinachrstichrsti	03.26	6.24	44.37	08.19
Grewia tenax.	03.06	5.86	56.87	10.50
Tamarindus indica	02.91	5.57	28.12	05.19
Ximenia americana	02.82	5.40	35.00	06.46

4.1.10 Frequency

Frequency is the proportion of plots in which a species occurs. It is a measure of the occurrence of a given species in a given area. It indicates how the species are dispersed and is an ecologically meaningful. The frequency of all the tree species in this forest is given in Table 10. Two tree species were most frequently occurring. These tree species are *Ficus sur* 86.67% (52 plots), *Balanite aegyptica* 83.33% (in 50 plots. All other tree species have more than 50% in their occurrence except the least frequent species which is *Terminalia macroptera* 20% (occur only in 12 plots).

Table 10: Frequency distribution of tree species in Doprar forest

(Fr = frequency, %Fr = % frequency, RFr = relative frequency).

Species	**Fr**	**%Fr**	**RFr**
Balanite aegyptica	50	83.33	6.56
Cadaba farinose	42	70.00	5.51
Crateva adansoni	49	81.67	6.43
Ficus sur	52	86.67	6.82
Ficus sycomorus	47	78.33	6.16
Flueggea virosa	45	75.00	5.90
Grewia tenax.	42	70.00	5.51
Lannea welwitschii	45	75.00	5.90
Lonchocarpus laxiflorus	34	56.67	4.46
Maytenus senegalensis	48	80.00	6.29
Meyna tetraphylla	41	68.33	5.38
Sclerocarya birrea	44	73.33	5.77
Tamarindus indica	32	53.33	4.19
Terminalia macroptera	12	20.00	1.57
Vachellia seyal	34	56.67	4.46
Ximenia Americana	34	56.67	4.46
Ziziphus abyssinica	37	61.67	4.85
Ziziphus spinachrstichrsti	38	63.33	4.98

Zizyphus pubescens	36	60.00	4.72
Total	762	1270	100

4.1.11 Importance Value Index (IVI)

Important Value Index reflects the combination of relative dominance, relative abundance and relative density of a given species in relation to other associated species in an area (Kent and Coker, 1992). It is important to compare the ecological significance of species. The importance value index for tree species in Doprar forest is shown in Table 11. Shibru and Balcha (2004) stated that, species with the greatest importance value are the leading dominant in specified vegetation. *Ficus sur* (27.61), *Ficus sycomorus* (23.16), *Balanite aegyptica* (20.94), *Maytenus senegalensis* (20.08), *Crateva adansoni* (17.85), *Grewia tenax* (17.75), *Sclerocarya birrea* (17.28), *Lannea welwitschii* (15.91), *Ziziphus spinachrstichrsti* (15.87), and *Flueggea virosa* (15.61) are ten most dominant tree species with IVI value greater than 15. They contribute 192.11 (64.03%) from a total of 300 IVI value. The reason why they have higher IVI value is that they have higher relative density, relative frequency and relative abundance in relation to other species in the Forest. The reason for dominance of *Ficus sur* in the forest may be due to its low demand for construction purposes.

Table 11: Importance value index of tree species in Doprar Forest (RF = Relative frequency, RD = Relative density, RA = Relative abundance, IVI = Importance value index)

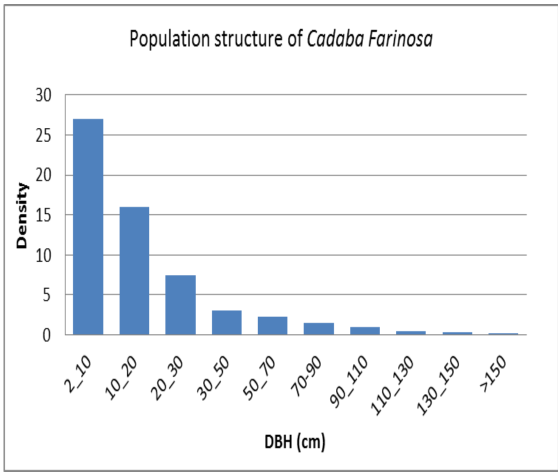
No	**Species**	**RF**	**RD**	**RA**	**IVI**
1	*Balanite aegyptica*	6.56	7.53	6.84	20.94
2	*Cadaba farinosa*	5.51	5.41	2.47	13.39
3	*Crateva adansoni*	6.43	6.44	4.98	17.85
4	*Ficus sur*	6.82	9.40	11.38	27.61
5	*Ficus sycomorus*	6.16	7.79	9.20	23.16
6	*Flueggea virosa*	5.90	8.63	1.07	15.61
7	*Grewia tenax.*	5.51	6.37	5.86	17.75
8	*Lannea welwitschii*	5.90	6.12	3.89	15.91
9	*Lonchocarpus laxiflorus*	4.46	3.47	1.66	9.60

10	*Maytenus senegalensis*	6.29	6.12	7.66	20.08
11	*Meyna tetraphylla*	5.38	4.25	3.73	13.37
12	*Sclerocarya birrea*	5.77	4.70	6.80	17.28
13	*Tamarindus indica*	4.19	2.89	5.57	12.67
14	*Terminalia macroptera*	1.57	1.28	2.93	5.79
15	*Vachellia seyal*	4.46	3.28	6.24	13.99
16	*Ximenia americana*	4.46	3.60	5.40	13.47
17	*Ziziphus abyssinica*	4.85	4.18	4.35	13.39
18	*Ziziphus spinachrstichrsti*	4.98	4.63	6.24	15.87
19	*Zizyphus pubescens*	4.72	3.80	3.64	12.16
	Total	100	100	100	300

4.1.12 Population structure

The patterns of diameter class distribution indicate the general trends of population dynamics and recruitment processes for a given species. Analysis of all tree species in the study site shows two general patterns (Figure 5A & 5B). The first pattern was positively skewed or an inverted J-shape, which has a high number of species in the lower DBH classes and the number of individuals in the species showed a gradual reduction at the highest DBH classes. This pattern was represented by the species *Cadaba farinosa*. The species that are in this population are *Balanite aegyptica, Crateva adansoni, Ficus sur, Ficus sycomorus, Flueggea virosa, Grewia tenax, Lannea welwitschii, Lonchocarpus laxiflorus, Meyna tetraphylla, Maytenus senegalensis, Sclerocarya birrea, Terminalia macroptera, Vachellia seyal, Ximenia americana, Ziziphus abyssinica, Ziziphus spinachrstichrsti* and *Zizyphus pubescens.* The species *Terminalia macroptera* and *Ximenia americana* failed only in the first lower DBH class. Thus these species are under recruitment.

The second type of population pattern was bell shaped and is characterized by the species *Tamarindus indica*. It shows a fairly high number of individuals of the species in the middle DBH classes but lower numbers of individuals of the species in the lower and higher DBH classes. This species has poor recruitment potential which might be due to intense competition between the other species found in its surroundings.



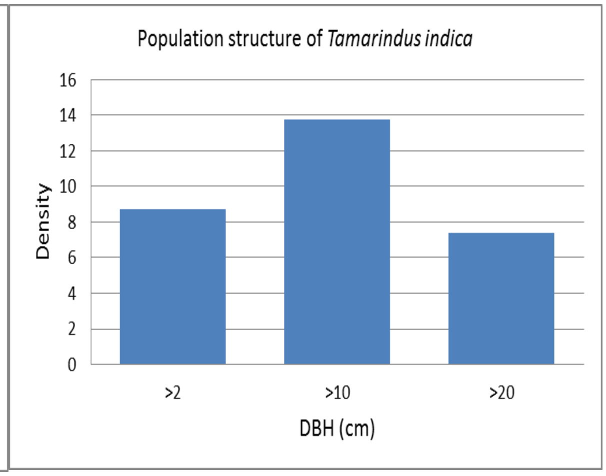


Figure 5A

Figure 5B

Figure 5A & 5B: Population structure of tree species in Doprar forest.

4.2 Discussion

4.2.1 Floristic composition of Doprar Forest

Doprar forest which is woody grassland in the south-west Ethiopia is rich in biodiversity. In Ethiopia, the available floristic data are either site specific (Yeshitela and Bekele, 2002) or covering a wide range of vegetation types (Friis, 2001); hence, it is difficult to make direct comparison with other similar studies. However, the overall species richness of a given vegetation type can give a general impression of their diversity. The species richness of Doprar forest (79 species) was less comparable with the Afromontane and transitional rainforest vegetation in southwestern Ethiopia, that is, 130 species (Kumelachew Yeshitela and Taye Bekele, 2003) and the Bibita (Gura Ferda) forest, also in southwestern Ethiopia, that is, 196 species (Dereje Denu, 2007).

4.2.2 Community structure

From the four plant communities identified in Doprar forest, community I was relatively far from human encroachment and has relatively higher diversity and species richness. However, community IV was less rich in species composition as it was located near to the human settlement, and vulnerable to human interference. It was observed that people from the surrounding village cut trees for construction of house and fence. They also let their domestic animals into the forest for grazing/browsing. Plant community distribution is the manifestation of physical gradients (elevation, soil heterogeneity and microclimate), biotic response to these gradients and historical disturbances (Urban *et al.*, 2000). Horizontal distance influences the growth and development of plants and their distribution patterns. In addition to altitude, factors like slop and soil characters might have influenced the plant communities in Doprar forest. The patterns of diameter class distribution indicate the general trends of population dynamics and recruitment processes in plant communities. Accordingly, the plant communities in Doprar forest showed good recruitment except for community IV, which had less recruitment when compared with the other plant communities. The species richness among the plant communities in the Doprar forest varied significantly. These differences were a function of differences in habitat heterogeneity and human disturbance. It was observed that burning and grazing were common in areas where community IV was located. The low species richness in this community might be due to anthropogenic disturbances, which had significantly reduced species richness.

4.2.3 Plant diversity and species richness

Species evenness shows the relative abundance of a species in plots. Lower evenness in community IV indicates the dominance of a few species such as *Acacia hockii, Flueggea virosa, Ficus sur, Cadaba farinosa, Grewia mollis, Grewia tenax, Maytenus senegalensis, Ziziphus spinachrstichrsti* and *Lannea welwitschii* in the community. On the other hand, high evenness in community I indicates little dominance by any single species but repeated coexistence of species over all plots in a community. When there is a high evenness value in a given forest, the location of conservation sites might not be of such important compared with when the evenness value of the forest is low (Feyera Senbeta, 2006). Accordingly, conservation might not be of such important for community I to community III, which has the highest evenness value. The overall plant diversity in Doprar forest is high and its evenness is low with 3.91 and 0.90, respectively. The four plant communities in Doprar forest showed relative variation in their species richness, evenness and diversity. Human influence and effects of local climactic variation of the forest might have contributed to the variation to the plant communities at Doprar forest as also given by Feyera Senbeta (2006).

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Results of the Floristic Composition of Doprar forest shows that, a total of 79 plants species were recorded, and these belong to 57 genera and 32 families. Fabaceae was the dominant family with 21 species followed by Combretaceae and Vitaceae each by 5 species. Of all the species recorded trees have got the highest share followed by herbs. Among the identified 57 genera, *Acacia*, *Combratum, Crotolera* and *Ipomoea* were represented by 4 species each, followed by *Cissus Cyperus* and *Zizypus* each represented by 3 species.

The vegetation was grouped into four community types each of which had varying degrees of species richness, diversity and evenness. Plant community type one has the highest species richness, diversity, and species evenness followed by community type two and three. The least evenness and diversity was observed for community type four.

The density and DBH class description of the forest indicated the dominance of small sized individuals declaring Doprar Forest is in a stage of secondary development. Thus, the forest is in good state of recruitment.

The population structure of tree species showed different dynamics. Most of the species have high population in the lower DBH and Height classes. Few species occur in all DBH and Height classes showing variation in population size.

5.2. Recommendation

Doprar Forest is one of the remnant forests in Ethiopia. It provides important economic and social value to the rural communities living around the area in different ways. To minimize the present human influence on this important resource for the future, developing management plan for the forest conservation and sustainable utilization is mandatory to have the following recommendations:

- Management programs should be introduced and implemented so that the local communities should get sense of responsibility for the management and conservation of the area.
- Awareness on the use and benefits of the vegetation should be given in different programs by agricultural officers to the public.
- More investigation on community types and regeneration of potential in the forest is needed.
- To promote the sustainable use of the area, ethno-botanical studies and exploration of indigenous knowledge on the diverse uses of the plants should be undertaken.

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PPENDICES

Annex1: Species list collected from Doprar Forest.

No	Scientific name	Family	Life form	Collection No
1	*Acacia senegal* Willd.	Fabaceae	Tree	PD40
2	*Accacia hecatophylla* A.Rich.	Fabaceae	Tree	PD28
3	*Acacia hockii* De Wild	Fabaceae	Tree	PD18
4	*Acacia seyal*	Fabaceae	Tree	PD55
5	*Aeschynomenna abyssinica* (A.Rich.) Vatke	Fabaceae	Herb	PD15
6	*Ampelocissus schimperiana* Planch.	Vitaceae	Climber	PD03
7	*Balanite aegyptica* Wall.	Balanitaceae	Tree	PD01
8	*Bridelia scleuromeura* Muell.Arg.	Euphorbiaceae	Shrub	PD44
9	*Cadaba farinosa* Frossk.	Cadabaceae	Tree	PD57
10	*Cadaba hetrotrica* Frossk	Capparidaceae	Shrub	PD06
11	*Chlorophytum tordense* Chiov.	Anthericaceae	Shrub	PD37
12	*Cissus sp.* (Baker) Planch	Vitaceae	Shrub	PD24
13	*Cissus petiolata* hook. F.	Vitaceae	Climber	PD67
14	*Cissus quadrangular*	Vitaceae	Herb	PD72
15	*Coccinia grandis* Voigt.	Cucurbitaceae	Climber	PD52
16	*Combratum collinum* Fresen.	Combretaceae	Shrub	PD48
17	*Combretom adenogonium*	Combretaceae	Shrub	PD29
18	*Combretom molle* R.Br. ex G.Don	Combretaceae	Shrub	PD61
19	*Commelina spp.* L.	Commelinaceae	Herb	PD64
20	*Convolvulus olitorius* L.	Convolvulaceae	Herb	PD07
21	*Convolvulus sagittatus* L.	Convolvulaceae	Herb	PD75
22	*Convolvulus siculus* L.	Convolvulaceae	Herb	PD31
23	*Crateva adansoni* DC.	Capparidaceae	Tree	PD27
24	*Crotolaria bongenisis* Benth.	Fabaceae	Shrub	PD78
25	*Crotolaria brevidens* Benth.	Fabaceae	Herb	PD08
26	*Crotolaria goreensis* Guill. & Perr.	Fabaceae	Herb	PD71

27	*Crotolaria ochroleuca* Pohill.	Fabaceae	Herb	PD39
28	*Cyperus eleusinoides* Kunth.	Cyperaceae	Herb	PD32
29	*Cyperus esculentus* L.	Cyperaceae	Herb	PD76
30	*Cyperus rotundus* L.	Cyperaceae	Herb	PD20
31	*Cyphostemma adenocuale* A. Rich.	Vitaceae	Climber	PD10
32	*Desmodium dichotunum* Willd.	Fabaceae	Herb	PD25
33	*Dioscoria prehensilis* Benth.	Dioscoreaceae	Climber	PD73
34	*Erucastrum arebicum* L.	Brassicaceae	Herb	PD66
35	*Euphorbia abyssinica* J.F.Gmel.	Euphorbiaceae	Shrub	PD17
36	*Ficus sur* Forssk.	Moraceae	Tree	PD79
37	*Ficus sycomorus* L.	Moraceae	Tree	PD41
38	*Flueggea virosa* (Willd.) Voigt	Euphorbiaceae	Tree	PD63
39	*Grewia mollis* Juss.	Tilliaceae	Tree	PD26
40	*Grewia tenax* L.	Tilliaceae	Tree	PD43
41	*Gutenbergia corditolia* O. Hoffm.	Asteraceae	Shrub	PD56
42	*Hygrophylla auricula* Schumach	Acanthaceae	Herb	PD21
43	*Indigofera brevicalyx* Baker f.	Fabaceae	Shrub	PD49
44	*Indigofera preureana* L.	Fabaceae	Herb	PD77
45	*Ipomoea aquatic* Parham.	Commelinaceae	Herb	PD65
46	*Ipomoea blepharophylla* Hallier f. ex Engl.	Convolvulaceae	Liana	PD35
47	*Ipomoea eriocarpa* Brown, R.	Commelinaceae	Herb	PD51
48	*Ipomoea purpurea* (L.) Roth	Commelinaceae	Herb	PD11
49	*Jasminum streptopus* E. Mey. Ex. DC	Oliaceae	Liana	PD68
50	*Lannea barteri* Engl.	Anacardiaceae	Shrub	PD36
51	*Lannea welwitschii* (Hiern) Engl.	Anacordiaceae	Tree	PD16
52	*Leonotis raineriana* Burm. f.	Labiateae	Herb	PD58
53	*Leucas mollis* Baker.	Lamiaceae	Herb	PD74
54	*Lonchocarpus laxiflorus* Guill. & Perr.	Fabaceae	Tree	PD09
55	*Maytenes senegalensis* (Lam.)	Celastraceae	Tree	PD23
56	*Meyna tetraphylla* Robyns	Rubiaceae	Tree	PD54
57	*Neorantanenia mitis* (A. Rich) Verdc.	Fabaceae	Climber	PD12

58	*Ociumum basilicum* L.	Lamiaceae	Herb	PD22
59	*Opilia amentacea* Roxb.	Opiliaceae	Climber	PD45
60	*Peripeloca linearifolia* A. Rich.	Asclepiadaceae	Climber	PD05
61	*Plumbago zeylanica* L.	Plumbaginaceae	Climber	PD38
62	*Portulaca oleracea* L.	Portulaceae	Shrub	PD62
63	*Pterocarpus lucens* Lepr. Ex. Guill. & Perr.	Fabaceae	Shrub	PD30
64	*Rhynchosia malacaphylla* L.	Fabaceae	Shrub	PD42
65	*Sclerocarya birrea* A.Rich.	Anacordiaceae	Tree	PD02
66	*Senna septemtrinalis* Willd.	Fabaceae	Shrub	PD34
67	*Sida ovata* Guill. & Perr.	Malvaceae	Herb	PD46
68	*Solanum nigrum* L.	Solonaceae	Shrub	PD69
69	*Tamarindus indica* L.	Fabaceae	Tree	PD50
70	*Terminalia macroptera* Guill. & Perr.	Combretaceae	Tree	PD19
71	*Tephrosia liniaris* Willd.	Fabaceae	Herb	PD14
72	*Teramus labialis* Spreng.	Combritaceae	Climber	PD59
73	*Tylosema fasoglensis* Torre & Hillc.	Caesalpiniaceae	Climber	PD13
74	*Vachellia seyal*(Delile) P.J.H.Hurter	Fabaceae	Tree	PD04
75	*Vigna ambacensis* Welwe. Ex Bak	Fabaceae	Climber	PD53
76	*Ximenia americana* Linn.	Olacaceae	Tree	PD70
77	*Ziziphus abyssinica* Hochst.	Rhamnaceae	Tree	PD33
78	*Ziziphus spinachrstichrsti* L.	Rhamnaceae	Tree	PD47
79	*Zizyphus pubescens* Oliver.	Rhamnaceae	Tree	PD60

Annex 2: Proportions of family and genus

Family	Species	%	Genus	%
Fabaceae	21	26.58228	14	24.5614
Combretaceae	5	6.329114	3	5.263158
Vitaceae	5	6.329114	3	5.263158
Commelinaceae	4	5.063291	2	3.508772
Convolvulaceae	4	5.063291	2	3.508772
Anacardiaceae	3	3.797468	2	3.508772
Capparidaceae	3	3.797468	2	3.508772
Cyperaceae	3	3.797468	1	1.754386
Euphorbiaceae	3	3.797468	3	5.263158
Rhamnacaea	3	3.797468	1	1.754386
Lamiaceae	2	2.531646	2	3.508772
Moraceae	2	2.531646	1	1.754386
Tilliaceae	2	2.531646	1	1.754386
Acanthaceae	1	1.265823	1	1.754386
Anthericaceae	1	1.265823	1	1.754386
Asclepiadaceae	1	1.265823	1	1.754386
Asteraceae	1	1.265823	1	1.754386
Balanitaceae	1	1.265823	1	1.754386
Brassicaceae	1	1.265823	1	1.754386
Caesalpiniaceae	1	1.265823	1	1.754386
Celastraceae	1	1.265823	1	1.754386
Cucurbitaceae	1	1.265823	1	1.754386
Dioscoreaceae	1	1.265823	1	1.754386
Labiateae	1	1.265823	1	1.754386
Malvaceae	1	1.265823	1	1.754386
Olacaceae	1	1.265823	1	1.754386
Oliaceae	1	1.265823	1	1.754386

Opiliaceae	1	1.265823	1	1.754386
Plumbaginaceae	1	1.265823	1	1.754386
Portulaceae	1	1.265823	1	1.754386
Rubiaceae	1	1.265823	1	1.754386
Solonaceae	1	1.265823	1	1.754386
Total	79	100	57	100

Annex 3 Plots with their characteristic

Pilots	Altitude	latitude	Longitude
P01	408	8.37699	33.68149
P02	412	8.38209	33.67705
P03	409	8.36048	33.69059
P04	414	8.36015	33.69045
P05	405	8.36065	33.69016
P06	421	8.35968	33.68932
P07	418	8.35992	33.68883
P08	410	8.36056	33.68835
P09	420	8.36098	33.68752
P10	417	8.35953	33.68961
P11	411	8.36009	33.68654
P12	424	8.35929	33.68561
P13	420	8.36008	33.68367
P14	431	8.35897	33.68282
P15	409	8.35779	33.68346
P16	412	8.35602	33.68296
P17	431	8.35685	33.68284
P18	430	8.35901	33.68276
P19	410	8.36037	33.68369
P20	433	8.36181	33.68462

P21	424	8.35609	33.68536
P22	403	8.35728	33.68762
P23	427	8.35569	33.68401
P24	430	8.36023	33.68992
P25	418	8.35495	33.68358
P26	439	8.36183	33.67855
P27	432	8.36469	33.68325
P28	426	8.36295	33.68397
P29	425	8.36498	33.68596
P30	413	8.36457	33.68933
P31	441	8.36379	33.96045
P32	430	8.36521	33.69007
P33	424	8.36426	33.68549
P34	411	8.36023	33.68986
P35	407	8.35781	33.68852
P36	438	8.35666	33.68565
P37	420	8.35631	33.68413
P38	440	8.35764	33.68521
P39	435	8.35721	33.68748
P40	421	8.35097	33.68878
P41	415	8.35167	33.68344
P42	409	8.35112	33.69652
P43	406	8.35322	33.68169
P44	413	8.35575	33.67453
P45	432	8.36377	33.68602
P46	446	8.34021	33.69494
P47	453	8.33656	33.69279
P48	450	8.34055	33.69103
P49	441	8.33815	33.70063
P50	434	8.34982	33.68856

P51	430	8.36845	33.68742
P52	421	8.35355	33.66124
P53	417	8.35047	33.68994
P54	436	8.33584	33.72546
P55	434	8.35442	33.68987
P56	423	8.36429	33.68924
P57	425	8.37554	8.384701
P58	419	8.36471	33.35142
P59	425	8.35472	33.68901
P60	420	8.35724	33.66021

Annex 4. Communities and plots they contain

Community	Plots it contains	Altitudinal Range
I	01,03,05,09,11,13,22,23,25,29,32,33,36,42,45,47,49,53,59,60	408-453
II	07,08,10,15,16,19,21,27,31,37,40,52,55,58	409-441
III	02,04,06,12,14,18,24,38,41,46,48,50,51,56	412-450
IV	17,20,26,28,30,34,35,39,43,44,54,57	406-439

Annex 5. Synoptic Table

	Communities			
Species	I	II	III	IV
Acacia Senegalensis	0.17	0.06	0.2	1.17
Acacia hecatophylla	0.32	0.61	1.5	0.5
Acacia hockii	0.38	0.1	**2.13**	**2.6**
Acacia seyal	0.84	**1.9**	0.84	1.3
Aeschynomenna abyssinica	4.8	3.26	0.00	0.7
Ampelocissus schimperiana	0.2	1.27	0.00	3.15
Balanite aegyptica	1.08	1.2	1.29	1.11
Bridelia scleuromeura	0.72	0.8	0.6	1.11
Cadaba farinose	0.1	0.6	0.4	1.7
Cadaba heterotricha.	0.8	1.19	1.75	**3**
Chlorophytum tordense	0.1	0.2	1.45	1.23
Cissus heterotricha.	0.1	0.61	0.64	1.66
Cissus petiolata	0.42	0.82	0.11	0.8
Cissus quadrangular	5.25	1.32	1.83	0.86
Coccinia grandis	0.84	0.6	0.45	1.8
Combratum collinum	**2.71**	1.15	0.61	1.85
Combretom adenogonium	2.3	1.11	0.3	1.9
Combretom molle	1.23	0.16	1.2	0.9
Commelina spp.	2.41	6.44	4.7	2.2
Convolvulus olitorius	1.9	2.4	6.34	3.1
Convolvulus sagittatus	2.5	4.3	2.25	2.1
Convolvulus siculus	4.1	0.41	3.3	5.12
Crateva adansoni	0.84	0.9	0.7	1.11
Crotolaria bongenisis	0.1	0.16	0.8	0.5
Crotolaria brevidens	5.2	6.02	0.64	1.4
Crotolaria goreensis	2.5	1.7	4.85	3.7
Crotolaria ochroleuca	1.05	0	3.74	0.00

Cyperus eleusinoides	6.03	5	2	0.00
Cyperus esculentus	0.12	3.6	6.5	2.3
Cyperus rotundus	2.7	2.8	4.4	4
Cyphostemma adenocuale	0.12	0.53	0.1	0.00
Desmodium dichotunum	0.6	2.02	0.8	5.7
Dioscoria prehensilis	0.42	0.5	0.1	0.37
Erucastrum arebicum	2.77	7.5	0.53	3.6
Euphorbia abyssinica	0.15	0.08	0.07	0.12
Ficus sur	1.3	1.3	**2.3**	2
Ficus sycomorus	1.08	1.5	1.45	0.8
Flueggea virosa	1.02	**2**	1	2.03
Grewia mollis	**1.4**	1.3	1.2	1.6
Grewia tenax	0.6	0.53	1.45	1.5
Gutenbergia corditolia	0.27	0.3	0.15	0.24
Hygrophylla auricular	1.5	0	1.2	0.74
Indigofera brevicalyx	0.5	0.6	0.15	1.35
Indigofera preureana	0.54	2.5	2.1	1.05
Ipomoea aquatic	3	1.11	2.36	0.9
Ipomoea blepharophylla	0.15	0.37	0.2	0.37
Ipomoea eriocarpa	3.4	0.53	4.1	0.6
Ipomoea purpurea	4.1	2.14	2.02	0.6
Jasminum streptopus	0.3	0.45	0.00	0.43
Lannea barteri	0.5	**1.32**	0.72	0.43
Lannea welwitschii	0.42	1.27	1	1.42