Floristic Composition and Structural Analysis of Woodland Vegetation in Ilu Gelan District, West Shewa Zone of Oromia Region, Central Ethiopia

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June 2015

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A Thesis submitted to

The Department of Plant Biology and Biodiversity Management in Partial Fulfillment of the Requirements for the Degree of Master of Science

(Biology: Botanical Science)

Addis Ababa University

Addis Ababa, Ethiopia

June 2015

ADDIS ABABA UNIVERSITY

GRADUATE PROGRAMMES

This is to certify that the Thesis prepared by Zerihun Tadesse Gemeda, entitled: Floristic Composition and Structural Analysis of Woodland Vegetation in Ilu Gelan District, West Shewa Zone of Oromia Region, Central Ethiopia and Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science (Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Floristic Composition and Structural Analysis of Wooddland Vegetation in Ilu Gelan District, West Shewa Zone of Oromia Region, Central Ethiopia

Zerihun Tadesse, MSc Thesis

Addis Ababa University, 2015

This study was conducted on Dirki and Jato woodland in Ilu Gelan District, West Shewa Zone of Oromia Region, 195 km west of Addis Ababa, to identify floristic composition, structure and community types of the vegetation. Systematic sampling method was used to collect vegetation data from 54 (20 m x 20 m). To collect data for herbaceous plants, five 1 m x 1 m subplots were laid in each of the main plot, where four were at the corners and one at the center. Diameter at breast height was measured for woody species taller than 2 m while height and cover/abundance values were visually estimated. Shannon - Wiener Diversity Index was used to calculate species diversity, richness and evenness whereas Soresen's Similarity ratio was used to measure similarity between the vegetation and four other related woodlands. Two hundred and thirteen species were recorded from the sample plots, where Fabaceae, Asteraceae and Poaceae were the most dominant families with 23, 22 and 12 species respectively. Eleven endemic and two near endemic species were recorded from the study area. Based on IUCN Red Data List, nine species were least concern, three were near threatened while one was vulnerable. Three plant community types were recognized from the study area. Total density and basal area calculated for woody species were 5,145.83 individuals ha^{-1} and 18.96 m^2 ha^{-1} respectively. Population structure and regeneration status of selected woody species were assessed and results revealed that some species had regeneration problems and need management measures.

Key words/phrases: Endemic, floristic composition, plant community type, structural analysis, Woodland Vegetation.

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my advisors Prof. Ensermu Kelbessa and Dr. Tamrat Bekele for their continuous guidance, advice, constructive criticism, comments and motivations made to me during this work. I would also like to express my great acknowledge to my instructors Prof. Zemede Asfaw, Prof. Sileshi Nemomssa and Prof. Sebsebe Demissew who have given me constructive directions and encouragements during their actual class contact. My deepest gratitude also goes to Addis Ababa University for accepting me to follow my MSc study, Cheliya District Administration particularly the Education Office for facilitating to me financial support, and Ilu Gelan District for allowing me to carry out the study around there and providing me necessary information. I express my thanks to my friend Zewdie Kassa (PhD student) who prepared map of the study area and assisted me to use R software for data analysis. I would also share my thanks to my colleague, Deresa Abetu, with whom I was collecting data from the study area. I never forget my classmate students and my friends Desalegn Chala and Duguma Fulea with whom I have spent the lovely period. Finally, I am very much indebted to express my thanks to my wife w/ro Almaz Zelalem and my children Hire Zerihun, Nardos Zerihun, Fenayit Zerihun and Diribe Senbeto for their encouragements, technical and moral supports during my study.

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List of acronyms

AAU	Addis Ababa University
BA	Basal Area
CSA	Central Statistical Agency
DBH	Diameter At Breast Height
EFAP	Ethiopian Forestry Action Plan
EPA	Environmental Protection Agency
ETH	National Herbarium of Ethiopia
FAO	Food and Agriculture Organization
GPS	Geographical Positioning System
IBC	Institute of Biodiversity Conservation
IUCN	International Union for the Conservation of Nature and Natural Resources
IVI	Importance Value Index
LC	Least Concerned
ln	Natural logarithm
MOA	Ministry Of Agriculture
NBSAP	National Biodiversity Strategy and Action Plan
NT	Nearly Threatened
RD	Relative Density
RDo	Relative Dominance
RF	Relative Frequency
SIV	Species Importance Value
VU	Vulnerable

CHAPTER ONE

1 INTRODUCTION

1.1 Background

Ethiopia is a country found in the horn of Africa between the geographical coordinates of 3^o 24' and 14^o53' North and 32^o 42' and 48^o 12' East. According to MOA (2000), the total area of the land of the country is 1.12 million km^2. The country has different topographic land features such as mountains, deep gorges, low lands, valleys and flattened plateaus (Zerihun Woldu, 1999). These different topographic features assisted different types of flora and fauna that have been well adapted to their own geographical features and climatic conditions. According to Fayera Senbeta et al. (2007), the climate and topography of Ethiopia vary considerably and appear to have effects on the distribution of biological diversities. Thus, Ethiopia is considered a country having high biodiversity in Horn of Africa (NABSAP, 2005).

Large part of Ethiopia was believed to have been covered by forests and woodland vegetations in the past (Friis, 1992). However, due to continuous massive deforestation made on it, the vegetation cover has been reduced through time to what it looks like at the present (Yitebitu Moges et al., 2010). Different researchers have studied the vegetation of Ethiopia at different times (White, 1983; Friis, 1992; Demel Teketay, 1992; Tamrat Bekele, 1994; Abate Ayalew, 2003; Tesfaye Awas et al., 2001; Fayera Senbeta, 2006; 2007; Motuma Didita, 2007; Haile Adamu, 2012; Abyot Dibaba et al., 2014). The results of these studies could broadly categorize the vegetations of Ethiopia into nine major types. These include: Afroalpine and Subafroalpine Vegetation, Dry Evergreen Montane Vegetation, Moist Evergreen Montane Forest, Evergreen Scrub, *Combretum-Terminalia* (broad-leaved deciduous) woodland, *Acacia-Commmiphora* (Small-leaved deciduous) woodland, Wetlands, Lowland Dry forest, and Desert and semi-Desert scrub. Out of the nine vegetation types, four of them occur in the dryland regions. These include: 1) *Combretum-Terminalia* (Broud-leaved deciduous woodland), 2) *Acacia-Commiphora* (Small-leaved deciduous woodland), 3) Desert and semi-desert scrub land, and 4) Dry Evergreen Montane Vegetation.

The coverage of each of the vegetation category has been declining rapidly due to the anthropogenic impacts such as demand of land use for expansion of agriculture by local farmers, overgrazing, illegal exploitation of forests and forest products (Friis, 1992; Feyera Senbeta and Fekadu Tefera, 2001). Extensive agricultural investment and expansion of road construction through vegetation are also becoming other causes of deforestation. Currently, increasing rate of drought, desertification and shortage of food for both humans and animals are becoming serious problems that need attentions (Yitebitu Moges et al., 2010). These problems are directly related with the pressures exerted on vegetation by human beings, and thus need immediate solutions. Therefore, it is very important to study the current status of our vegetation to identify the problems and threats associated with them and make useful recommendation that is helpful for planning their future conservation and sustainable management.

The aim of this study was to identify and document floricitic composition and sturucture of the woodland vegetation in Ilu Gelan District, West Shewa Zone of Oromia Region.

1.2 Statement of the Problem

As described by Gardiner (2010), vegetation can be described as collection of plants which comprises all the structural layers of trees, shrubs, lianas and herbs. Vegetation provides different important services to living things found in our universe. It serves as source of food for both humans and animals, shelter for wildlife and source of different materials that humans can use for various purposes. In addition to these, it plays an important role in regulating the environmental climatic conditions and thus makes the environment suitable for living. So, whether it is a forest or woodland, it is very important to have knowledge of particular vegetation in detail to know its floristic composition, structure and relations it has with the ecological factors around it.

Floristic study can provide brief and basic information about particular vegetation in relation to its ecological region and thus indicates directions of future conservation measures the vegetation needs. However, no floristic study was conducted on the woodland vegetation found in Ilu Gelan District before this time. Therefore, this study was intended to generate basic scientific information on the floristic composition and structures of the woodland vegetation found in Ilu Gelan District.

In this regard, the species composition and structure of the *Combretum-Terminalia,* mixed with *Acacia,* woodland vegetation was studied in Ilu Gelan District of West Shewa Zone.

1.3 Objectives

1.3.1 General objective

General objective is to assess the floristic composition and vegetation structure of the woodlands in Ilu Gelan District.

1.3.2 Specific objectives

- The specific objectives of the study were to:
- Identify the plant species composition of the woodland vegetation;
- Identify the vegetation structure of the woodland in the study area ;
- Identify the plant community types of the woodland vegetation; and
- Identify threats associated with the vegetation in the study area.

1.4 Research Questions

- What plant species make the vegetation of the study area?
- What are the plant community types of the study area?
- What environmental factors are influencing the plant communities of the study area?
- What does the vegetation structure of the study area look like?
- What management measures are required to be undertaken to conserve the vegetation in the study area?

CHAPTER TWO

2 LITERATURE REVIEW

2.1 Vegetation

According to van der Maarel (1979), vegetation is defined as a system of spontaneously growing plants in a particular region. However, cultivated plants such as crops and weeds surrounding them are not considered as vegetation. Some experts define vegetation as a concrete stand of plants occurring in a uniform environment with relatively uniform floristic composition and structure (van der Maarel, 1979). The composition and structure makes it distinct from the surrounding environment (van der Maarel, 1979). In contrast to this, other experts explain it as an abstract nature characterized from all other relevant features of that vegetation (van der Maarel, 1979).

Vegetation is considered from plant community prospective as the sum total of its parts and this idea guided plant ecologists to develop the concepts of dominance and diversity in the study of vegetation ecology (van der Maaler, 1979). Vegetation characteristics are either derived from plant morphological characters, usually called structure, or from the plant species recognized, the floristic composition.

As stated by Grossman et al (1998), vegetation is dynamic, and often requires a high degree of variability. It is also measured for both inventory and monitoring purposes, and can be used as a strong indicator of the ecological functioning. Thus, classification of vegetation can serve as an important component of a larger strategy to understand and conserve this natural resource.

2.2 Vegetation Type of Ethiopia

Ethiopia is regarded as one of the most important countries in Africa with respect to endemism of plant and animal species (EFAP, 1994). The vegetation type of Ethiopia is considered extremely complex, where the complexity is due to the great variations in altitude. The difference in altitude in turn results in great variations of spatial distribution of vegetation in the country (Zerihun Woldu, 1999).

Recently, the depletion of vegetation resources and environmental degradation have become issues of national and global concern (Motuma Didita, 2007). This is due to the fact that the declining of vegetation cover and depletion of natural resources are closely associated with the drought and food shortage problems that are becoming great threat to the peoples of the world. Lack of protective vegetation policy is enabling rapid deforestation activity especially in countries like Ethiopia (Haile Adamu et al., 2012).

Different researchers have studied the vegetation of Ethiopia at different times (Demel Teketay, 1992; Tamrat Bekele, 1994; Abate Ayalew, 2003; Fayera Senbeta, 2006; 2007; Motuma Didita, 2007; Sisay Nune, 2008; Haile Adamu et al., 2012; Abyot Dibaba et al., 2014). Some scholars have classified the vegetation of Ethiopia into eight categories, whereas others classify into nine as:

1. Afroalpne and Subafroalpine Vegetation,
2. Dry Evergreen Montane Vegetation,
3. Moist Evergreen Montane Forest,
4. Evergreen Scrub,
5. *Combretum-Terminalia* (Broad-leaved deciduous) woodland,
6. *Acacia-Commmiphora* (Small-leaved deciduous) woodland,
7. Wetlands,
8. Lowland Dry forest, and
9. Desert and semi-Desert scrub.

2.3 Woodland Vegetation

Different definitions of woodland vegetation have been given by different scholars at different times. Woodland vegetation can be described as the vegetation which comprises all the structural layers of trees, shrubs and grasses (Gardiner, 2010). Woodland vegetation can also be defined as lands covered by the open stand of trees with a canopy cover of more than 20 %, but never with interlocking crowns and usually with a field layer of grasses (EFAP, 1994). On the basis of height, woodland vegetations may not be differentiated from forest vegetations, but woodland vegetations never have densely interlocking crowns (Kindt et al., 2011).

Woodlands are important sources of fuel wood and construction materials for the rural as well as for the urban community. Woodland vegetation is a good source of commercially important non-timber forest products such as natural gums, myrrh, frankincense and honey. In addition to these, woodland vegetation serves as habitat for large number of plant and animal species that are found in the area. So, attention should be given to the conservation and sustainable management of vegetation, especially for goods and services supplied by vegetation (Puldeng, 2012).

Unfortunately, forests and woodland vegetation have been declining both in size and quality as a result of anthropogenic pressures (EFAP, 1994). Land degradation and deforestation are the two most important causes for the decline of both the vegetation size and quality in the woodland area (UNDP, 2012).

Geographical gradients like altitude can play significant role in determining the general occurrence and distribution patterns of plant communities (Friis, 1992; Tamrat Bekele, 1994). Based on this concept, woodland vegetation can broadly be categorized into two forms. These include the broad-leaved deciduous (*Combretum-Terminalia*) woodland and the small-leaved deciduous (*Acacia-Commiphora)* woodland vegetation.

2.3.1 *Combretum-Terminalia* Woodland and Savannah

This vegetation is distributed from 500 –1900 m a.s.l. and named also as broad-leaved deciduous woodland, which is characterized by small to moderate sized trees with fairly large deciduous leaves (Demel Teketay, 1999; Zerihun Woldu, 1999; Sebsebe Demissew et al., 2004). The vegetation type is characterized by plant species like *Boswelia papyrifera*, *Lannea schimperi*, *Anogeissus leocarpus*, and *Stereospermum kunthianum*. Different stratum of tall perennial grasses like *Cymbopogon*, *Hyparrhenia*, *Echinochloa*, *Sorghum* and *Pennisetum* are included as understory in the vegetation. This vegetation is rich also in herbaceous plants in cover and species composition (Demel Teketay, 1999; Zerihun Woldu, 1999; Sebsebe Demissew et al., 2004). According to Sebsebe Demissew et al. (2004), this vegetation type occurs along the western escarpment of the Ethiopian Plateau, from the border regions of Ethiopia and Eritrea to western Kefa and the Omo Zone. It is the dominant vegetation in Gambella, Benshangul-Gumuz regions and Wollega around Dedessa valley (Sebsebe Demissew et al., 2004).

2.3.2 *Acacia-Commiphora* Woodland

This vegetation type is characterized by drought-resistant trees and shrubs, which are either deciduous or with small evergreen leaves (Motuma Didita, 2007). The vegetation is distributed along the Eastern and Southern lowlands, the Rift valley and Eastern slopes of the Northern plateau between 1000 and 1600 m a.s.l. The plant genera that characterize the vegetation type include *Acacia*, *Commiphora*, *Balanites*, *Capparis*, *Combretum* and *Terminalia* (Demel Teketay, 1999; Friis and Sebsebe Demissew, 2001; Sebsebe Demissew et al., 2004). Since the leaves of the plants are small in size, light can easily penetrate to the ground. The ground cover is rich in species of the genera like *Acalypha*, *Barleria*, *Aerva*, and other geophytes including a number of species of Chlorophytum and succulents including a number of Aloe species (Sebsebe Demissew et al., 2004). As a result of utilizing the plants for firewood and charcoal, this vegetation is becoming more vulnerable to human impacts and increasingly declining (Zerihun Woldu, 1999). The uniform appearance of *Acacia-Commiphora* Vegetation is considerable in floristic composition, even though it has largely been destroyed by human activities. This vegetation type is a notable center of endemism for mammals, particularly antelopes at the Horn of Africa. However, protected areas of the vegetation are being degraded by human activities, including the national parks that are well established.

2.4 Biodiversity and Threats on Biodiversity in Ethiopia

Ethiopia has a rich biodiversity in both domesticated and wild plant and animal species that occur in variable and unique ecosystems. Even though most of them are common with other countries of the world, some are endemic to the country (FAO, 1996; NBSAP, 2005, EPA, 2012). However, loss of biodiversity due to environmental degradation and continuous deforestation on most vegetation ecosystems is the serious environmental problem Ethiopia is facing at the present (FAO, 1996; NBSAP, 2005). This loss in biological diversity ultimately implies economic losses to the country and the world as a whole (Yitebitu Moges et al., 2010). According to Nebiyu Abesha (2009), loss of biodiversity caused as a result of deforestation is a serious problem in Ethiopia. The continued vegetation degradation can cause more and more loss of biodiversity unless management measures are designed and implemented (Million Bekele, 2011). Thus, clearing natural vegetation for agriculture is the most significant threat to ecosystem biodiversities.

In addition to the deforestation caused by understandable needs, negligence as well as the destruction such as by fire, do contribute to deforestation. These types of deforestation have become increasingly frequent in the last 20 years or so. According to EFAP (1994), vegetation resources, particularly forests, are disappearing at a very alarming rate in Ethiopia before we even have a chance to study and document them. If this trend of deforestation continues there may be a great danger of serious decline or loss of biodiversity. Most of the deforestation occurred during the period in which security of land tenure and access to natural resources were undermined by unpopular policy measures such as frequent redistribution of land and restrictions in cutting and utilizing trees, even in one's own backyard. Serious destruction of forests has occurred between the fall of the previous government and the stabilization of the present one (EPA, 1998). *Combretum-Terminalia* woodland is perhaps the least affected of the vegetation categories. However there are threats as a result of indiscriminate fire and settlement of refugees from our neighboring countries and people from the highlands and inappropriate agricultural practice in the country.

2.5 Plant Community Types

Plant communities are conceived as types of vegetation recognized by their floristic composition. The species compositions of the communities better express their relationships to one another and environment than any other characteristics (Kent and Cooker, 1992). It can be defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other (Kent and Cooker, 1992). Plant community type is part of the vegetation which shows certain remarkable features that identifies it from its surroundings (van der Maaler, 1979). Different plant community types found within particular vegetation have relatively their own uniform physiognomical appearance. According to Mueller-Dombois and Ellenberg (1974), a plant community can be understood as a combination of plants that are dependent on their environment and influence one another, and then can gradually modify their environment. However, the performance of the individual plant species, species numbers, plant characters (traits) and species abundance can play crucial roles to determine important characteristics of the plant community.

2.6 Plant Species Diversity, Species Richness and Evenness

Diversity has both an aspect of species richness, i.e. the number of species, and of evenness, the way species quantities are distributed (van der Maarel, 1979). Species richness is a simple measure, so it has been a popular diversity index in ecology, where abundance data are often not available for the datasets of interest. Because richness does not take the abundances of the types into account, it is not the same thing as diversity, which does take abundances into account. The value of a diversity index increases both when the number of types increases and when evenness increases.

According to Kent and Coker (1992), a diversity index is a mathematical measure of species diversity in a community. The diversity is measured by using diversity index, from the records of the number of species and their relative abundances within the community. A diversity index is a quantitative tool that helps to measure a quantity (for example, species) that presents in a dataset. It also takes into account measuring how evenly the basic entities (such as individual species) are distributed among the groups under discussion. Shannon-Wiener Diversity Index and Sorenson's Similarity ratio are important diversity measuring tools being used in plant ecology, because Shannon-Wienner Index can help to calculate species diversity, eqitability and richness of a community or vegetation while Sorensen's Similarity ratio helps to measure the degree of similarity among different plant community types or ecologically related vegetation (Kent and Coker, 1992).

The value of a diversity index from the Shannon-Wiener Diversity Index increases both when the number of types increases and when evenness increases. For a given number of types, the value of a diversity index is maximized when all types are equally abundant (Kent and Coker, 1992). Diversity indices provide more information about community composition than simply species richness (i.e., the number of species present); they also take the relative abundances of different species into account.

2.7 Importance Value Index (IVI) and Dominance

The concept of density, frequency and dominance is very useful tool in the study of plant ecology (van der Maarel, 1979). Species important value, which is measured on the basis of species density, frequency and dominance values permits 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 importantance value is a good index for summarizing vegetation characteristics and ranking the species for management and conservation practices. Species with lower IVI need high conservation efforts whereas those with higher IVI require wise management.

CHAPTER THREE

3 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

The study was conducted in Ilu Gelan District, West Shewa Zone of Oromia Regional State, central Ethiopia (Fig. 1). The District is located on the Addis Ababa-Nekemte main road about 200 km from Addis Ababa to the west. IJaji is the central town of the District and is located on geographical coordinates of 08^{o} 59’ 51’’N and 037^{o} 19’ 49’’E with the altitude of 1812 m a.s.l. The District is bordered on the north and the east by Cheliya, on the west by Bako Tibe, on the south by Dano districts. It is bordered also on the southwest by Nono Benja of Jimma Zone and Boneya Boshe of East Wollega Zone districts. Gibe River demarcates the boundary of the District on the southwest while Fato River separates it from Dano District on the south. According to the information obtained from the District, the area of Ilu Gelan District is 332.04 km^2.

This study was conducted in two nearby sites known as Dirki and Jato woodlands that are found south of the main road when driving from Gedo, the central town of Cheliya District, to Ijaji about 195 km from Addis Ababa to the west. The vegetation of Dirki lies on a steep mountain between the range of latitudes 08^{o}59’16.1’’ to 08^{o}59’50.8’’ N and longitudes 037^{o}22’45.50’’ to 037^{o}23’15.8’’E while that of Jato is found between 08^{o}58’41.5’’ to 08^{o}59’10.8’’ N and 037^{o}21’59.7’’ to 037^{o}22’50.6’’ E.

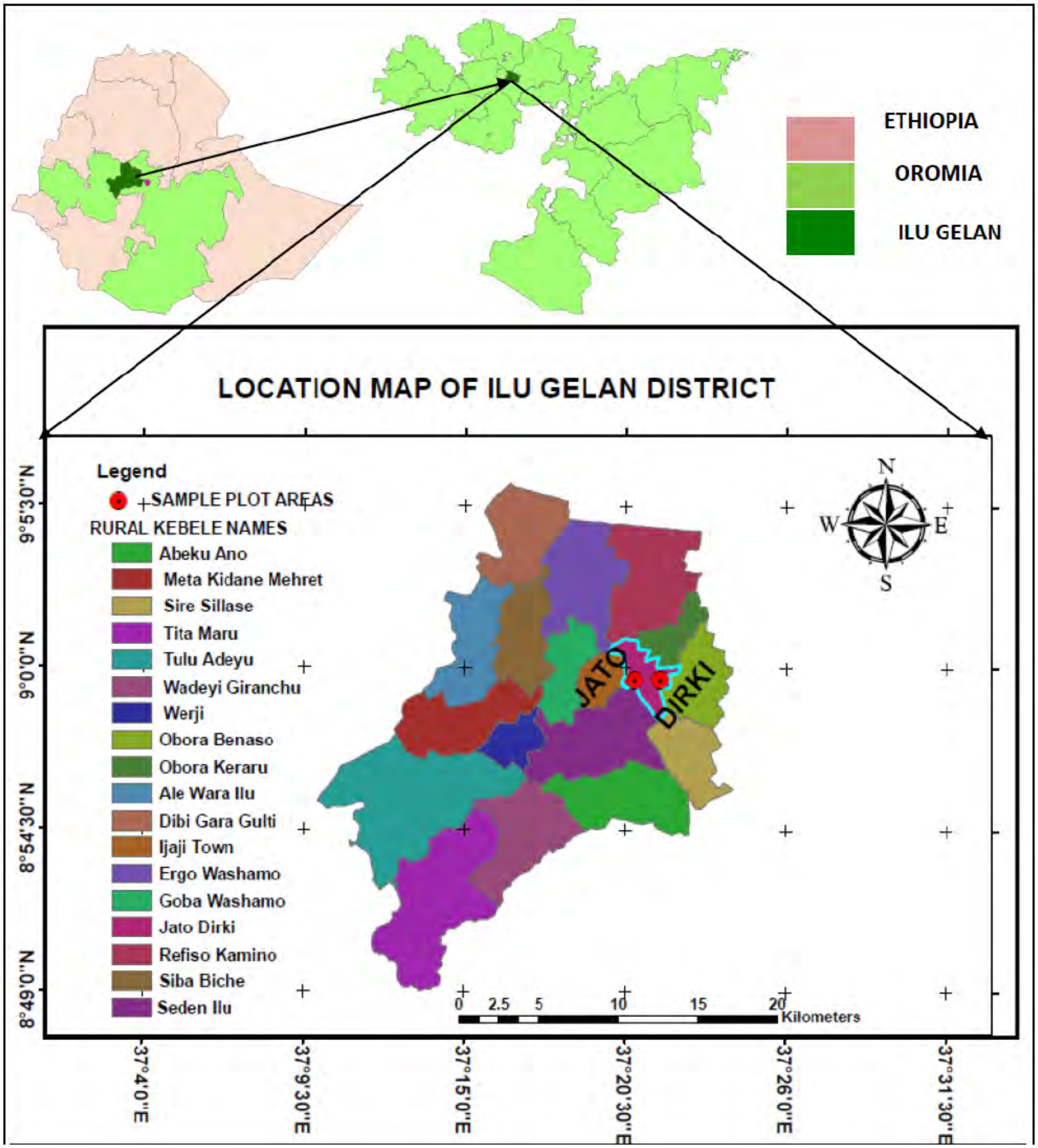


Fig. 1 Map of Ethiopia showing Regional States and the study area

3.1.2 Topography

Ilu Gelan District is generally characterized by rough topographic features. It has gorges, escarpments, mountains and plateaus. Mountains known as Tullu Dirki, Tullu Niti and Gara Habib are found in the District. Tullu Niti was believed traditionally as the place where the local female leader named 'Akkoo Manooyee/ Haadha Sonkooruu'' was living in the past. Gara Habib mountain is least covered with vegetation but almost with rocks. The altitudinal range of the District falls within 1500- 2200 m a.s.l. The altitudinal range of Dirki is found between 1795 and 2078 m a.s.l. while that of Jato is between 1870 and 2136 m a.s.l. The vegetation of Dirki lies on a steep mountain whereas that of Jato is located on a sloppy escarpment of land face. The vegetation is found on the north and northwest facing parts of the escarpment.

Four perennial rivers known as Alanga, Washamo, Bisil and Karsa rivers are flowing from the highlands into Gibe River by crossing the District in north to south direction. The water from these rivers provides services for drinking, washing and irrigation. Two mineral water sources, namely, Hora Ambo and Hora Dirki, where the local people use the water to drink their livestock are found in the District. In addition to these, Ilu Gelan District hosts ''Oda Bisil'', the historical place where the Oromo people celebrate every new year through praying to Waqa (God).

3.1.3 Climate

The climate of Ilu Gelan District is considered to belong to the Weina Dega and Kolla agro-ecological zones of Ethiopia. As most parts of the District are found in the low land, the mean annual temperature of the area is relatively high (Endalew Amenu, 2007). Meteorological data obtained from National Meteorology Service Agency (2015), indicates that Ilu Gelan area obtains high rainfall between May and September and low rainfall from December to February (Fig. 2). The Climadiagram figure shows that the study area is typical of forest vegetation rainfall distribution. This indicates that the woodland vegetation was resulted from cutting effects exerted on original forest in the past. According to the data, the highest mean annual rainfall of the study area recorded for twenty years (1995-2014) was 1351mm and recorded in July whereas the lowest mean annual rainfall was 11.2 mm and recorded in February. The mean maximum temperature over the twenty years was 28.1 C^{o} while the mean minimum temperature was 13.8 C°. The highest temperature, 31.7 C°, was recorded in February whereas the lowest temperature, 11.2 C°, was recorded in November.

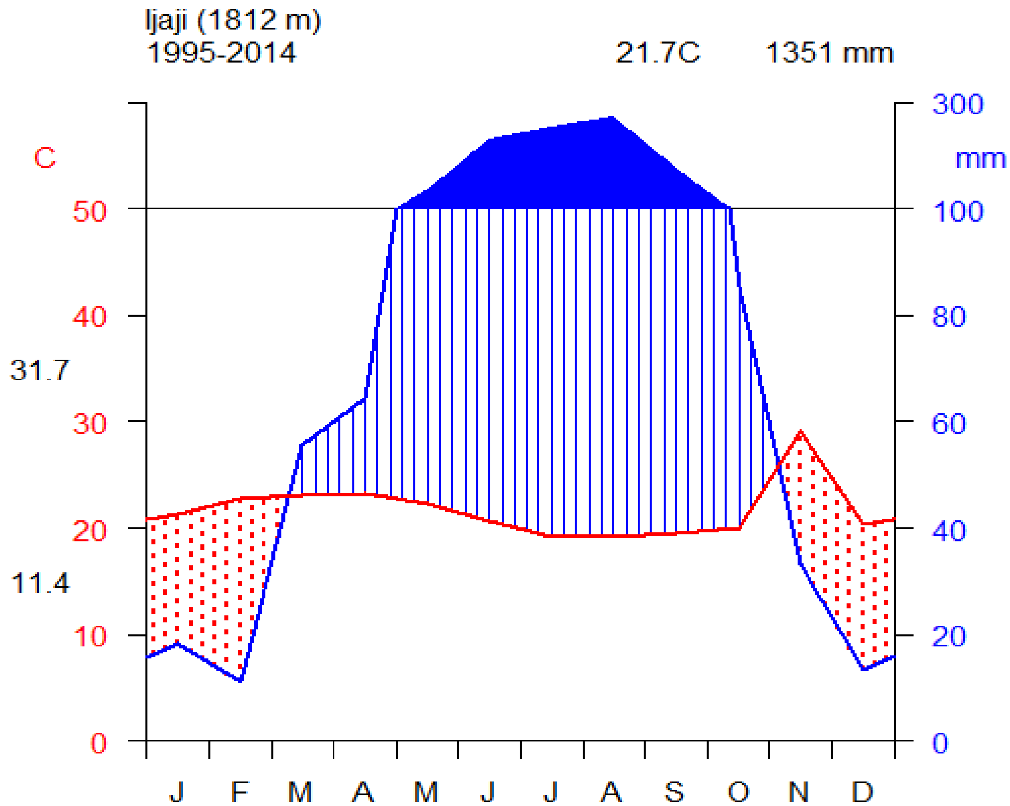


Fig. 2 Climadiagram showing rainfall distribution and temperature variation from 1995-2014 around Ijaji Town. Source: National Meteorological Service Agency (2015).

3.1.4 Soil

According to Endalew Amenu (2007), the soils types found in Ilu Gelan District can be classified into four categories. These are red soil (clay soil), black soil, sand soil and a mixture of all the three soil types. The information obtained from the Natural Resource Conservation and Management Office of Ilu Gelan District also reveals as these different types of soils have been identified in the District. The Office realizes that 70% of the proportions of the soils found in the District is categorized under the red soil type while the brown and black soil types cover 25.29% and 4.71% respectively.

The black soil (vertisols) is known to retain large amount of water during wet season while it cracks and looses its water contents during dry season. This type of soil is suitable for teff cultivation in the District. The red and brown soil types on which most crops production is being practiced in the District cover large proportions of the soil types. The information obtained from the District indicates that the red and brown soil types are used to cultivate different types of crops such as pepper, sweet potato, maize, sorghum and linseed in the District. Even though the red soil covers the largest portion of the soil types in the District, it is relatively considered poor soil.

3.1.5 Human population

According to the data obtained from the Central Statistical Agency (CSA), currently the total population of Ilu Gelan District is 77,332 where 39,107 (50.57%) of them are males and 38,225(49.43%) are females. From the total population, 66,318 (85.76%) are living in rural areas where, 33,718 (50.84%) of them are males and 32,600 (49.16%) are females. The rest 11,014 (14.24%) of the total population are urban dwellers where 5,389 (48.93%) of them are males and 5,625 (51.07%) are females.

3.1.6 Land use and agriculture

Mixed crop cultivation and livestock rearing are the main agricultural activities of the population of the District. According to the data obtained from the Agricultural Office of the District, different types of crops are cultivated by the farmers. The major crops that are cultivated in the Distric include *Zea mays* (maize), *Sorghum bicolor* (sorghum), *Eragrostis tef* (teff), *Triticum aestivum* (wheat), *Guizotia abyssinica* (Niger seed), *Hordeum vulgare* (barley), *Linum usitatissimum* (Linseed), *Pisum sativum* (Field pea) and *Vicia faba* (Faba bean). However, *Zea mays* (maize), *Eragrostis tef* (teff) and *Sorghum bicolor* (sorghum) are the leading crops cultivated in the District. Other field cash crops like *Capsicum annuum* and *Capsicum frutescens* (pepper), *Ipomoea batatas* (sweet potato) and *Catha edulis* (chat) are also highly cultivated in the District.

3.1.7 Livestock population

Data obtained from Ilu Gelan District Agricultural Office reveals that the District possesses 167,875 livestock population consisting of 105,420 cattle; 7,465 sheep; 8,750 goats; 635 horses; 950 mules; 3,370 donkeys and 41,285 poultry. As most parts of the land are currently occupied by farming, shortage of grazing and browsing land is the main problem for the livestock population. In addition to this, livestock diseases are the main problems of the animal biodiversities in the District (Endale Amenu, 2007).

3.1.8 Vegetation

The information obtained from Ilu Gelan District indicates that most parts of the lands currently observed as free in the District were covered with vegetation in the past. Today, few remnants of big trees are observed in the farm lands and road sides. For example, plant species like *Ficus vast*, *Albizia schimperiana*, *Cordia africana*, *Ficus sycomorus, Prunus africana, Croton macrostachyus, Podocarpus falcatus, Olea europaea* and *Ficus sur* are observed in the farm lands and on road sides. It can also be deduced from this respect that the vegetation cover of the District was larger in the past than what is realy observed at the present.

Currently, there are some vegetation areas of woodlands and forests found the District. These natural vegetation areas are known by the names: Dirki, Jato, Irgo Washamo, Ale Wara Ilu, Obora Benaso, Obora Keraru, Rafiso Kamino, Dibi Gara Gulti and Sire Sillase. They are separated by settlements and almost restricted to mountainous areas and slopes of escarpments. This indicates as most proportions of the vegetation of the woodlands and forests have been removed from areas that are suitable for expansion agriculture (i.e, bases of mountains and flat lands).

3.1.9 Wildlife

According to the information obtained from Ilu Gelan District Natural Resource Management Office, a variety of wildlife including monkeys, baboons, hyenas, wild pigs, bushbuck, porcupines, leopards, and different snake species are found in the District. Monkeys, baboons, wild pigs and snakes were observed in the vegetation during the data collection. Different types of bird species are also observed in Dirki and Jato Woodlands. However, according to the information obtained from local community surrounding the study sites, groups of baboons and hyenas are becoming great threats to their crops, livestock and own lives. According to the local society, demand of food resources by the wildlife is putting pressure on their field crops and the life of domestic animals.

3.2 Method

3.2.1 Reconnaissance Survey

Reconnaissance survey was made during the first week of October 2014 in order to obtain the impressions of the study site conditions and select sampling sites.

3.2.2 Sampling Design

Systematic transect sampling following Kent and Coker (1992) and Muller-Dombois and Ellenberg (1974) was used for the study. After the highest altitude was recorded, one 20 m x 20 m quadrat was first taken at the peak of Dirki and radiating transects were laid down from the top to the base of the mountain in four (N, W, S and E) directions. However, in case of Jato, vegetation cover is found only on the north and north-west facing aspects of extending escarpement. Thus, three transect lines were laid down from the top to the base of the escarpment on the north and north-west facing aspects, where the distance between the three consecutive transects was measured to be 300 m.

Along the transect lines of each study site, 20 m x 20 m (400 m^2) quadrats were laid down at every 25 m altitudinal drop to analyze species turnover. Each transect contains different numbers of plots depending on the length of each transect. In addition, five 1 m x 1 m subplots, one at each of the four corners and one at the center of the 20 m x 20 m main plot were also laid to sample herbaceous plants. A total of fifty four 20 m x 20 m quadrats were laid for vegetation data collection, where 32 were from Dirki and the rest 22 from Jato site. List of the number of plots in each transect along with their locations and altitude records is given in Appendix 1.

3.2.3 Environmental data collection

In each of the quadrat, altitude and geographical coordinates were measured using Garmin 72 GPS (Geographical Position System) and aspect was determined using Suunnto Compass. Codes were given to aspects following Zerihun Woldu et al. (1989) as:

North=0; East=2; South=4; West=2.5; and NW=1.3

Ecological disturbances such as grazing and impacts of human beings (cutting, collecting firewood, producing charcoal and trampling in the vegetation) were noticed and recorded as present or absent in the sampled plots (Appendix 2). Grazing intensity was estimated following Zerihun Woldu and Backeus (1991); and Kebrom Tekle et al. (1997) as: 0= nil; 1= slight; 2= moderate and 3= heavy.

The state of human interference was estimated following Gebremedhen Hadera (2000); Kumlachew Yeshitla and Tamrat Bekele (2002), and Leul Kidane et al. (2010); and codified using a 0-3 subjective scale to record the degree of the impacts (from cutting, fuelwood collection, charcoal production and sign of trampling) as: 0=nil; 1= low; 2= moderate; and 3=heavy.

3.2.4 Vegetation data collection

Data collection was conducted from November 06 to 20, 2014. A complete list of trees, shrubs, lianas, and herbs was made from the systematically selected plots laid down along each transect. Plant species that occur outside the sample plots, but inside the study area were recorded as present for floristic composition to produce a more complete list of the plants in the vegetation area.

DBH (Diameter at Breast Height) was measured at height of about 1.30 m above the ground and recorded for all woody species having DBH $\geq$ 2 cm and height $\geq$ 2 m. In addition to this, estimation of height and cover/abundance values for woody species was made and recorded in the field. If the tree branches at 1.30 m height or below, the diameter was measured separately for the branches and averaged.

To assess regeneration status of the vegetation, seedlings and saplings of the woody species encountered in the sample plots were counted. Young plants of woody species having height less than 50 cm were counted as seedlings while those having height in the range of 0.1 m and 2 m were counted as saplings.

Local name of each species, if present, was recorded during the field work. Specimens of all encountered woody and herbaceous plants were collected, pressed, dried and brought to the National Herbarium (ETH), Addis Ababa University, for taxonomic identification. The specimens were identified by comparing with authenticated specimens housed at ETH and by referring to the Flora of Ethiopia and Eritrea. Voucher specimens were kept at ETH.

Cover abundance data defined here as the proportion of area in a quadrat covered by every species recorded and gathered from each quadrat were converted to the 1-9 Braun- Blanquet scale, which was later modified by Van der Maarel (1979) as follows:

1: Rare, generally one individual;

2: Occasional, with less than 5% cover of the total;

3: Abundant, with less than 5% cover of the total;

4: Very abundant, with less than 5% cover of the total;

5: 5-12% cover of the total area;

6: 12-25% cover of the total area;

7: 25-50% cover of the total area;

8: 50-75% cover of the total area;

9: 75-100% cover of the total area;

3.2.5 Data Analysis

i) Vegetation classification

The computer program R software for windows 3.0.2 version was used to analyze the vegetation data through Agglomerative Hierachical Classification technique. Euclidean distance and Ward's method were used for clustering the vegetation data using the book in preparation by Prof. Zerihun Woldu. Three plant community types were obtained from the hierarchical clustering analysis and named using two characteristic species having the highest mean cover abundance values in their community.

ii) Vegetation structure

The vegetation structure was described using frequency distribution of Density, DBH, height and Importance Value Index (IVI). The density of woody species and basal area of the vegetation were computed on hectare basis. Important value index (IVI) was computed for all woody species based on relative density (RD), relative dominance (RDo) and relative frequency (RF) to determine their dominance position. Analysis of population structure for selected tree species was made on the basis of DBH class distribution to determine their regeneration and recruitment status. Seedlings (SE) and saplings (SA) of tree species were analyzed with their corresponding mature tree (MT) species on density basis to determine the status of their regeneration in the vegetation under the study area.

Importantanc Value Index (IVI) = Relative Density + Relative Dominance + Relative Frequency.
Where:

$$\text{Relative Density (RD)} = \frac{\text{total number of all individuals of a species}}{\text{total numbers of individuals of all species}} \times 100$$

$$\text{Relative Dominance (RDo)} = \frac{\text{total basal area of a species}}{\text{total basal area of all the species}} \times 100$$

$$\text{Relative Frequency (RF)} = \frac{\text{number of quadrats in which a species occurs}}{\text{total number of quadrats examined}} \times 100$$

Basal area (BA) will be calculated using DBH as:

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

Canonical Correspondence Analysis (CCA) is important parameter used to analyze the relationship between environmental variables and vegetation data. In this study, CCA was done to explore the relationship among the environmental variables and vegetation data by fitting the data into ordination scatter plot.

iii) Diversity analysis

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

$H = -\sum \mathbf{Pi} \ln \mathbf{Pi}$

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:

$$\text{Equitability } \mathbf{J} \text{ (Evenness)} = \frac{\mathbf{H'}}{\mathbf{H_{max}}} = \sum_{i=1}^{S} \frac{Pi \ln Pi}{\ln S}$$

Where S: the number of species

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

ln: log base

IV) Phytogeographical similarity

Sorenson's Similarity ratio was used to evaluate the similarity between the three plant community types of the vegetation in the study area and as well as the similarity between Dirki and Jato Woodland, and four 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

CHAPTER FOUR

4 RESULTS

4.1 Floristic Composition

The study has shown that Dirki and Jato Woodland Vegetation (Fig. 3) have high species richness in plants of different growth forms. Plant species of different growth forms (trees, shrubs, lianas and herbs) were recorded from the study area (Appendix 3). Out of the total plant spcies recorded from the study area, trees and herbs each comprise 32.71% while shrubs and lianas consitute 27.57% and 7.01% respectively.

A total of 69 families with 167 genera and 214 species were recorded from the study area (Table 1). Of all the families, Fabaceae, Asteraceae and Poaceae are the three most dominant families represented by 18, 15 and 11 genera, and 23, 22 and 12 species respectively. These three dominant families together constituted 57 (26.64%) of the total species richness in Dirki and Jato Woodland Vegetation. The next dominant families, Euphorbiaceae, Acanthaceae, Rubiaceae, Lamiaceae and Combretaceae were represented by 11, 9, 9, 9 and 7 species respectively and constituted 45 (21.03%) of the total species. Other four families which constituted 23 (10.75%) of the total species were Malvaceae, Moraceae and Rhamnaceae which constituted six species each, while Solanaceae was represented by five 5 species. Each of the families Oleaceae, Ranunculaceae and Rosaceae were represented by four species while Boraginaceae, Celastraceae, Loganiaceae, Sapindaceae and Verbenaceae were represented by three species each. These eight families constituted 27 (12.62%) species while other 13 families represented by 2 species each constituted 26 (12.15%) of the total species. The rest 36 families that contributed 16.82% of the total species were represented by one species each (Appendix 4). Out of the total 214 species identified from the study area, one hundred and six, which were collected from the 54 quadrats were used in floristic and structural analysis. The rest 108 plant species were collected from outside of the quadrats but inside the woodland vegetation, and included in floristc list to make the decription of the vegetation more reliable.

a) Dirki site

b) Jato site

Fig. 3 Photos showing North-facing slopes of Dirki and Jato Woodland Vegetation

Table 1: Proportions of family' species composition

Number of species	Number of species	% of species
Fabaceaes	23	10.75
Asteraceae	22	10.28
Poaceae	12	5.61
Euphorbiaceae	11	5.14
Acanthaceae	9	4.21
Rubiaceae	9	4.21
Lamiaceae	9	4.21
Combretaceae	7	3.27
Malvaceae	6	2.80
Moraceae	6	2.80
Rhamnaceae	6	2.80
Solanaceae	5	2.34
Oleace	4	1.87
Ranunculaceae	4	1.87
Rosaceae	4	1.87
Boraginaceae	3	1.40
Celastraceae	3	1.40
Loganiaceae	3	1.40
Sapindaceae	3	1.40
Verbenaceae	3	1.40
Other 13 families represented 2 species each	26	12.15
Other 36 families represented by one species each	36	16.82
Total of 69 families	214	100

4.1.1 Endemic plant species

Out of the total plant species identified from the study area, eleven species are endemic to Ethiopia while two are near endemic i.e, confined to Ethiopia and Eritrea (Table 2). Based on the

IUCN Criteria of level of threat, nine species are least concern (LC), three species have been assessed as near threatened (NT) while one species is vulnerable (VU).

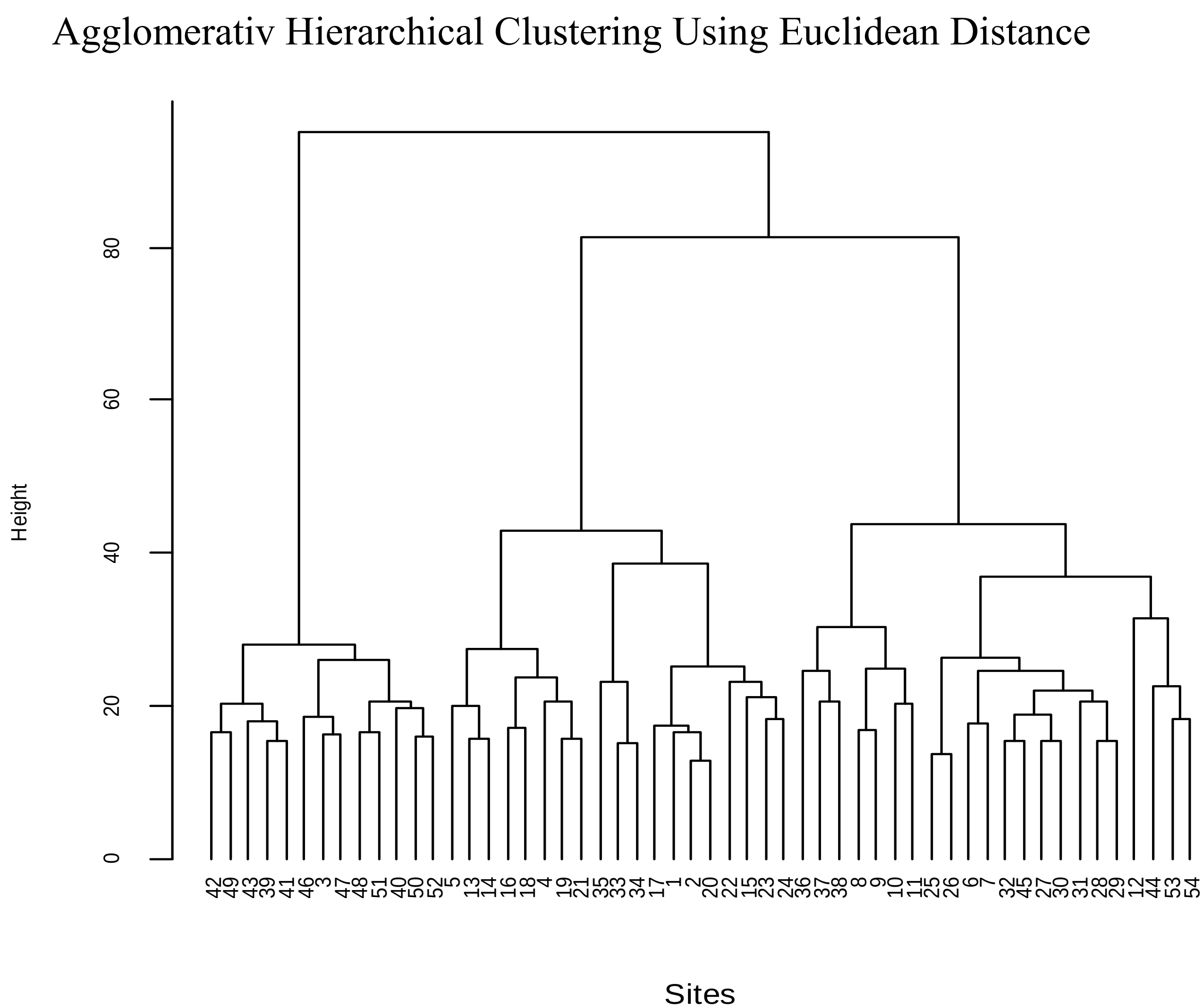
Table 2: List of endemic species in the study area with their habit (T= tree, S= shrub, L= liana, H= herb), IUCN Threat categories (NT= Near Threatened, LC= Least Concern, VU= Vulnerable) and distributions

Species	**Family**	**Habit**	**IUCN category**	**Distribution**
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
Bidens pachyloma (Oliv. & Hiern) Cufod.	Asteraceae	H	LC	GD,GJ,WU,SU,AR,GG
Cirsium schimperi (Valke) C. Jeffrey ex Cufod.	Asteraceae	H	LC	GO, GJ, SU, AR, BA
Clematis longicauda Steud.ex A. Rich.	Ranunculaceae	L	LC	GD, GJ, SU, WG, KF, IL, SD
Crotalaria rosenii (Pax) Milne-Redh.ex Polhill	Fabaceae	H	NT	SU, AR, BA, KF, SD
Echinops longisetus A. Rich.	Asteraceae	H	LC	GD, GJ, WU, SU, AR, WG,KF, GG,SD, BA, HA
Lippia adoensis Hochst. ex Walp	Verbenaceae	S	LC	EE, TU, GD,GJ,WU,SU, AR,WG, KF, GG, SD, HA
Millettia ferruginea (Hochst.) Bak.	Fabaceae	T	NT	TU, GD, GJ, SU, WG, HA, IL
Phyllanthus mooneyi M. Gilbert	Euphorbiaceae	S	VU	SU, AR, IL, KF, GO, SD
Pycnostachys abyssinica Fresen.	Lamiaceae	H	LC	IL, KF, GG, SD, WU, SU, AR, HA
Solanum marginatum L.f.	Solanaceae	S	LC	EW, TU, GD, GJ, SU, AR, GG, SD, BA, HA
Vernonia leopoldi (Sch. Bip. ex Walp.) Vatke	Asteraceae	S	LC	TU, GD, GJ,WU, SU, WG, KF, HA, GG

4.2 Vegetation Classification

4.2.1 Plant Community Types

Three plant community types were identified from the hierarchical cluster analysis using the computer software program R for windows version 3.0.2. The computer program for determining the optimal number of clusters was used to decide the number of plant community types. Ward's method and Euclidean distance were used to draw the dendrogram showing dissimilarity among the three clusters (Fig. 4). The vegetation classification was done by using the cover abundance value estimate of each species included in the analysis. Distribution of the three plant community types (C_1= Community Type 1, C_2= Community Type 2, and C_3= Community Type 3) along with their altitudinal range was given in Table 3. The plant community types were named by two characteristic species that have highest mean cover abundance estimate in each community (Table 4).



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

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

Table 3: Distribution of plots of the three plant communities with their altitudinal ranges

Community	**Altitude (m a.s.l.)**	**Total plots**	**List of plots**
C1	1920-2136	13	3, 39, 40, 41, 42, 43, 46, 47, 48, 49, 50, 51 and 52
C2	1950-2078	19	1, 2, 4, 5, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 33, 34 and 35
C3	1803-1953	22	6, 7, 8, 9, 10, 11, 12, 25, 26, 27, 28, 29, 30, 31, 32, 36, 37, 38, 44, 45, 53 and 54

Descriptions of the three plant Community types are given below.

i) *Acacia etbaica-Lantana trifolia* Community Type

This community type is distributed between the altitudinal range of 1920-2136 m a.s.l. It is represented by 13 plots comprising 62 plant species; out of which 50 are commonly shared with community two and 51 with community three. *Acacia etbaica* and *Lantana trifolia* are the characteristic species of this community. *Acacia abyssinica is a* dominant tree species in this community type while other common tree and shrub species associated with the community include: *Maesa lanceolata*, *Syzygium guineense*, *Combretum molle*, *Premna schimperi*, *Hypericum quartinianum*, *Rosa abyssinica*, *Stereospermum kunthianum* and *Nuxia congesta*. In this community, common herbaceous species covering the ground surface are *Bidens biternata*, *Bidens ghedoensis*, *Cynodon dactylon* and *Oplismenus hirtellus*.

ii) *Buddleja polystachya-Teclea nobilis* Community Type

This community is distributed between the altitudinal range of 1950-2078 m a.s.l. It is represented by 19 plots consisting of 73 species; out of which 50 are shared with community one while 66 species are shared with community three. *Buddleja polystachya* and *Teclea nobilis* are the characteristic species in the community. *Calpurnia aurea* is a dominant species whereas common tree and shrub plant species found in this community include *Osyris quadripartita, Albizia schimperiana, Rhus natalensis, Euclea divinorum, Olinia rochetiana and Schrebera alata*. *Helinus mystacinun* and *Dioscorea shimperiana* are common lianas recorded in this community type. *Hypoestes aristata*, *Panicum monticola*, *Justicia ladanoides* and *Cyperus sesquiflorus* are the dominant species at herbaceous level.

iii) *Combretum paniculatum- Rothmannia urcelliformis* Community Type

This community type is distributed between the altitudinal range of 1803-2080 m a.s.l. It is represented by 22 plots consisting of 95 species. *Combretum paniculatum* and *Rothmannia urcelliformis* are characteristic species of the community. Other dominant woody species of this community include: *Clausena anisata*, *Maytenus arbutifolia*, *Grewia ferruginea*, *Calpurnia aurea*, *Carissa spinarum*, *Croton macrostachyus*, *Millettia ferruginea*, *Acacia abyssinica*, *Bersama abyssinica*, *Vangueria apiculata* and *Rytigynia neglecta*. *Clematis longicauda* is a characteristic liana of this community whereas the characteristic herbaceous species covering the ground surface are *Achyranthes aspera*, *Cynodon nlemfuensis, Pycnostachys abyssinica* and *Setaria megaphylla.*

Table 4: Mean cover abundance estimates of species of the three communities

Species	Community one	Community two	Community three
Acacia abyssinica	4.15	2.21	3.59
Acacia etbaica	**0.08**	0.00	0.00
Albizia schimperiana	2.69	6.00	2.55
Bersama abyssinica	1.08	5.26	3.55
Buddleja polystachya	0.00	**0.11**	0.00
Calpurnia aurea	4.46	7.37	5.27
Carissa spinarum	2.92	6.00	4.5
Clausena anisata	2.08	7.05	6.59
Combretum molle	3.62	2.26	1.91
Combretum paniculatum	0.00	0.00	**1.09**
Croton macrostachyus	4.23	5.00	4.41
Euclea divinorum	0.08	5.16	0.36
Ficus sycomorus	0.00	0.00	0.23
Ficus vasta	0.00	0.00	0.09
Grewia ferruginea	3.92	4.47	5.59
Lantana trifolia	**0.08**	0.00	0.00
Maesa lanceolata	7.77	2.11	2.77

Mimusops kummel	0.00	0.00	0.23
Olea capensis	0.00	0.00	0.31
Olinia rochetiana	1.85	5.26	0.05
Osyris quadripartita	6.23	3.53	0.55
Premna schimperi	6.62	6.79	5.27
Rothmannia urcelliformis	0.00	0.00	**0.32**
Schrebera alata	0.38	3.94	0.05
Syzygium guineense	7.38	3.16	1.68
Teclea nobilis	0.00	**0.26**	0.00

4.3 Species richness, evenness and diversity of the Three Communities

Shannon-Wiener diversity index was computed for the three plant community types of the woodland vegetation of Ilu Gelan District (Table 5). Community three had the highest diversity followed by community two while community one showed the least diversity. Community type three had the highest species richness whereas the least species rich community is community type one. However, equitability (evenness) which measures the relative abundance of different species present in each community showed relatively the highest value for community two followed by community three and the lowest for community one.

Table 5: Shannon-Wiener diversity index for woodland vegetation of Ilu Gelan District

Community type	**Diversity index (H')**	**Species richness (S)**	**H_{max}**	**Equitability (J)**	**Average altitude (m a.s.l.)**
One	3.847	62	4.128	0.932	2045.50
Two	4.068	73	4.291	0.948	2014.00
Three	4.316	95	4.553	0.947	1941.50

Equitability (J)= H'/H_{max}, H_{max}= lnS

4.4 **Similarity between the Three Plant Community Types**

Sorensen's Coefficient Index was used to calculate the degree of similarity among the three plant community types. The highest similarity was observed between communities one and three while the least similarity was observed between communities two and three. The result from the analysis showed communities one and two, community one and three, and communities two and three shared about 74.63%, 64.97% and 78.57% similarity in species composition respectively.

a) *Mimusops kummel* (tree)

b) *Combretum paniculatum* (liana)

c) *Rothmannia urcelliformis* (tree)

d) *Acanthus polystachius* (shrub)

Fig. 5(a-d) Sample photographs of some woody species in Dirki and Jato Woodland Vegetation.

4.5 Importance Value Indices (IVI) of the Three Plant Communities

Importance value index is a useful parameter that helps to determine the ecological importance of species. It was calculated for the three communities from their corresponding relative density, relative frequency and relative dominance. Top ten woody species having the highest IVI value in each of the three communities were given in Table 6.

Table 6: Top ten woody species having the highest IVI value in each of the Three Community types of the woodlands of Ilu Gelan Distric

Community	Species	RD	RF	RDo	IVI
One	*Maesa lanceolata* Forssk.	14.06	4.49	14.39	32.95
	Syzygium guineense (Willd.) DC.	10.66	4.49	15.70	30.86
	Maytenus arbutifolia (A.Rich.) Wilczek	11.48	4.15	5.24	20.87
	Rhus natalensis Krauss	8.26	4.49	6.19	18.95
	Premna schimperi Baker	8.34	4.49	5.65	18.49
	Osyris quadripartita Decne	6.91	4.49	4.89	16.29
	Acacia abyssinica Hochst. ex Benth	1.89	3.46	10.23	15.59
	Calpurnia aurea (Ait.) Benth.	5.69	4.49	2.48	12.67
	Rhus vulgaris Meikle	4.01	3.81	3.03	10.85
	Croton macrostachyus Del.	0.07	4.15	6.23	10.45
Two	*Clausena anisata* (Willd). Benth.	18.46	3.87	7.07	29.39
	Calpurnia aurea (Ait.) Benth.	9.63	3.87	4.73	18.23
	Croton macrostachyus Del.	1.46	3.44	10.90	15.81
	Carissa spinarum L.	7.06	3.66	4.46	15.17
	Premna schimperi Baker	7.23	4.09	3.75	15.06
	Albizia schimperiana Oliv.	3.89	3.87	7.02	14.77
	Rhus natalensis Krauss	5.21	3.66	5.25	14.11
	Olinia rochetiana A.Juss.	5.66	3.66	4.49	13.81
	Maytenus arbutifolia (A.Rich.) Wilczek	6.29	3.87	2.91	13.07
	Euclea divinorum Hien	3.72	4.09	3.46	11.27

Three	*Clausena anisata* (Willd). Benth.	23.30	4.16	4.66	32.13
	Ficus vasta Forssk.	0.05	1.78	22.70	24.54
	Maytenus arbutifolia (A.Rich.) Wilczek	11.87	1.58	2.33	15.79
	Acacia abyssinica Hochst. ex Benth	1.03	2.77	10.27	14.07
	Calpurnia aurea (Ait.) Benth.	5.26	3.96	0.85	10.08
	Croton macrostachyus Del.	2.38	3.37	4.22	9.97
	Scutia myrtina (Burm. f.) Kurz	0.25	2.57	6.04	8.86
	Premna schimperi Baker	5.80	1.78	1.27	8.85
	Cordia africana L.	0.52	1.19	7.05	8.75
	Grewia ferruginea Hochst.ex A. Rich	5.58	1.39	1.78	8.75
	Carissa spinarum L.	3.76	3.96	0.87	8.59

4.6 Analysis of Vegetation Structures

4.6.1 Stem density

Density is expressed as the number of individuals present per hectare of an area. Species were classified into five density classes as: A= >100; B= 50.1-100; C= 10.1-50; D= 1.1-10; E= < 1. The total stem density calculated for individuals of woody species with DBH ≥ 2 cm was 5,145.83 ha^{-1} (Table 7). Seventeen species contributed 80.09% of the total density from the density class A where *Clausena anisata*, *Maytenus arbutifolia*, *Calpurnia aurea* and *Premna schimperi* constituted 15.99%, 9.59%, 6.96% and 6.93% respectively. Eighteen species from the density class E constituted only 0.22% of the total density. *Brucea antidysenterica*, *Buddleja polystachya*, *Clematis longicauda*, *Ficus vasta*, *Phoenix reclinata*, *Ricinus communis* and *Rubus apetalus* contributed 0.13% while the rest eleven species of this density class constituted 0.09% of the total density.

Table 7: Stem density ha^{-1} distribution of woody plants in different density classes.

Density class	Number of species	Number of stems	Stem density ha^{-1}	% density
A	17	8,902	4,121.30	80.09
B	5	689	318.98	6.20
C	20	1,147	531.02	10.32
D	34	352	162.96	3.17
E	18	25	11.57	0.22
Total	94	11,115	5,145.83	100

4.6.2 DBH distribution

Density distribution of individuals of woody species showed decreasing from lower to higher DBH classes (Table 8). Most of the species had the highest number of individuals in the lowest DBH class and proceeding with decreasing degree to the consecutive higher DBH classes. DBH classes: 1= 2.0-4.0 cm, 2= 4.0-6.0 cm, 3= 6.0-10.0 cm, 4= 10.0-20.0 cm, 5= 20.0-30.0 cm, 6= 30.0-40.0 cm, 7= 40.0-50.0 cm, 8= > 50 cm.

Table 8: Density ha^{-1} distribution of woody individuals in different DBH classes

	DBH Class (cm)	Above ground stem	Density ha^{-1}	% density ha^{-1}
1	< 10	10,742	4,973.15	96.64
2	10.1-20.0	231	106.94	2.08
3	20.1-30.0	69	31.94	0.62
4	30.1-40.0	38	17.59	0.34
5	40.1-50.0	22	10.19	0.20
6	> 50	13	6.02	0.12
	Total	11,115	5,145.83	100

4.6.3 Height class distribution

Individuals of woody species were classified into six height classes (Table 9) and density ha^{-1} was calculated on this basis. Highest density ha^{-1} (93.19%) was recorded in the lowest height class while in the second height class, density ha^{-1} was found to be 5.31%. For the next four height classes, density is 0.56%, 0.60%, 0.23% and 0.11% respectively.

Table 9: Density ha^{-1} of woody individuals in different height classes

Height class (m)	**Aboveground stems**	**Density ha^{-1}**	**% density ha^{-1}**
2.0-6.0	10,358	4,795.37	93.19
6.1-10.0	590	273.15	5.31
10.1-14.0	62	28.70	0.56
14.1-18.0	67	31.02	0.60
18.1-22.0	26	12.04	0.23
>22	12	5.50	0.11
Total	11,115	5,145.83	100

4.6.4 Frequency

Frequency is defined as the number of quadrats in which a particular species occurs in a study area. It is obtained by dividing the number of quadrats in which the species occurred by the total number of the quadrats from which all the species sampled in the area under the study. Results from the computed frequency values of different species were classified into five frequency classes as:

A= 1.0-20.0, B= 20.1-40.0, C= 40.1-60.0, D= 60.1-80.0, E= 80.1-100 (Fig. 6). The result showed that 60.64% of the total woody species were distributed in the lowest frequency class one whereas in the next four consecutive frequency classes, 12.77%, 14.89%, 3.19% and 8.51% of the species were distributed respectively.

Table 10: Top 25 most frequent woody species in the study area

Species	**% of Frequency**
Premna schimperi Engl.	96.30
Calpurnia aurea (Ait.) Benth.	94.44
Maytenus arbutifolia (A.Rich.) Wilczek	92.59
Carissa spinarum L.	87.04
Grewia ferruginea Hochst.ex A. Rich	87.04
Clausena anisata (Willd). Benth.	83.33
Croton macrostachyus Del.	83.33
Rhus natalensis Krauss	81.48
Albizia schimperiana Oliv.	75.93
Bersama abyssinica Fresen.	64.81
Rhus vulgaris Meikle	64.81
Acacia abyssinica Hochst. ex Benth	59.26
Maesa lanceolata Forssk.	59.26
Syzygium guineense (Willd.) DC.	59.26
Combertum molle R. Br. ex G.Don	57.41
Rytigynia neglecta (Hiern) Robyns	57.41
Osyris quadripartita Decne	55.56
Vangueria apiculata K. Schum.	51.85
Senna petersiana (Bolle) Lock	50.00
Euclea divinorum Hien	44.44
Phyllanthus ovalifolius Forssk.	44.44
Pterolobium stellantum (Forssk.) Brenan	44.44
Stereospermum kunthianum Cham.	44.44
Flacourtia indica (Burm.f.) Merr	42.59
Olinia rochetiana A.Juss.	42.59

The eight most frequent species (Table 10) in the vegetation studied were *Premna schimperi* (96.30%), *Calpurnia aurea* (94.44%), *Maytenus arbutifolia* (92.59%), *Carissa spinarum* (87.4%), *Grewia ferruginea* (87.04%), *Clausena anisata* (83.33%), *Croton macrostachyus* (83.33%) and *Rhus natalensis* (81.48).

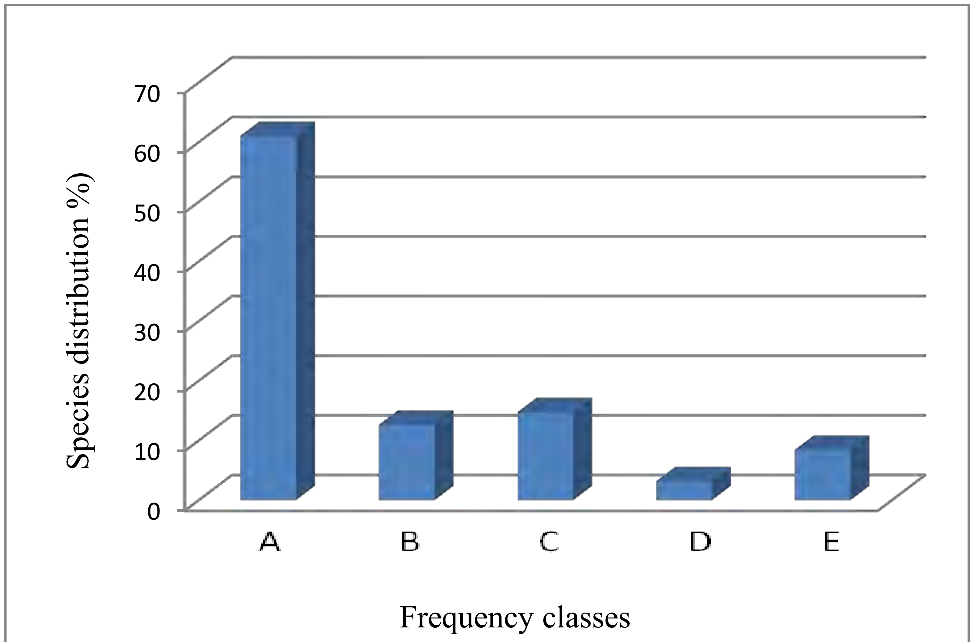


Fig. 6 Frequency distribution for woody species in Dirki and Jato Woodland Vegetation

4.6.5 Basal Area

Total basal area of the vegetation was 18.95 m^2 ha^{-1} for woody species >2 cm in DBH and >2 m in height (Table 11). It was 7.87 m^2 ha^{-1} for individuals 2.0-10.0 cm, 1.67 m^2 ha-1 for individuals 10.1-20.0 cm and 9.41 m^2 ha^{-1} for individuals ≥20 cm in DBH respectively. *Ficus vasta, Acacia abyssinica, Croton macrostachyus, Syzygium guineense* subsp. *guineense, Clausena anisata, Cordia africana, Combretum molle, Albizia schimperiana, Maesa lanceolata and Sapium ellipticum* constituted 60.46% of the total basal area.

Table 11: Basal area of woody species within different DBH classes

DBH (cm)	Aboveground stem	Basal area ha^{-1}	% Basal area
2.0-10.0	10,742	7.87	41.53
10.1-20.0	231	1.67	8.81
>20	142	9.41	49.66
Total	11,115	18.95	100

4.6.6 Importance Value Index (IVI)

Data from relative density (RD), relative frequency (RF) and relative dominance (RDo) was used to calculate the importance value index (IVI) of the vegetation (Table 12). Twenty one (22.11%) woody species having IVI greater than 5 constituted 221.18 (73.73%) from the total 300. Accordingly, the top 15 ecologically most dominant woody species in Dirki and Jato Woodland Vegetation are *Clausena anisata*, *Maytenus arbutifolia*, *Premna schimperi, Acacia abyssinica*, *Ficus vasta*, *Calpurnia aurea*, *Croton macrostachyus*, *Syzygium guineense* subsp. *guineense*, *Rhus natalensis*, *Maesa lanceolata*, *Carissa spinarum*, *Albizia schimperiana*, *Grewia ferruginea*, *Bersama abyssinica* and *Combretum molle*. These in turn, constituted 186.71 (62.24%) of the total 300 IVI of the vegetation studied.

Table 12: Relative Density, Relative Frequency, Relative Dominance and IVI of top 21woody species in Dirki and Jato Woodland Vegetation

S/N	**Species**	**RD**	**RF**	**RDo**	**IVI**
1	*Clausena anisata* (Willd). Benth.	15.99	3.56	4.77	24.32
2	*Maytenus arbutifolia* (A.Rich.) Wilczek	9.59	3.96	3.11	16.66
3	*Premna schimperi* Engl.	6.93	4.12	2.81	13.85
4	*Acacia abyssinica* Hochst. ex Benth	0.98	2.53	10.08	13.59
5	*Ficus vasta* Forssk.	0.02	0.16	13.07	13.25
6	*Calpurnia aurea* (Ait.) Benth.	6.96	4.04	2.24	13.24
7	*Croton macrostachyus* Del.	2.07	3.56	6.55	12.18
8	*Syzygium guineense* (Willd.) DC.	3.99	2.53	5.43	11.95

9	*Rhus natalensis* Krauss	4.78	3.48	3.21	11.48
10	*Maesa lanceolata* Forssk.	4.79	2.53	3.84	11.16
11	*Carissa spinarum* L.	4.59	3.72	1.88	10.19
12	*Albizia schimperiana* Oliv.	2.22	3.25	4.28	9.75
13	*Grewia ferruginea* Hochst.ex A. Rich.	3.89	3.72	1.81	9.42
14	*Bersama abyssinica* Fresen.	3.06	2.77	2.02	7.85
15	*Combretum molle* R. Br. ex G.Don	1.05	2.45	4.32	7.82
16	*Rhus vulgaris* Meikle	2.10	2.77	1.57	6.44
17	*Osyris quadripartita* Decne.	2.56	2.38	1.39	6.33
18	*Olinia rochetiana* A.Juss.	2.49	1.82	1.73	6.04
19	*Cordia africana* L.	0.24	0.71	4.49	5.45
20	*Rytigynia neglecta* (Hiern) Robyns	2.02	2.45	0.62	5.10
21	*Millettia ferruginea* (Hochst.) Bak.	2.07	1.11	1.92	5.10

4.6.7 Dominance

A species having value of IVI greater than 5.00 can be considered dominant because of the relative ecological role it plays in the ecosystem (Fekadu Gurmessa, 2010). Based on their relative importance value index, twenty one tree/and or shrub species were selected as dominant species in the woodland vegetation (Table 11). *Clausena anisata, Maytenus arbutifolia, Premna schimperi, Acacia abyssinica, Ficus vasta, Calpurnia aurea, Croton macrostachyus, Syzygium guineense* subsp. *guineense, Rhus natalensis, Maesa lanceolata, Carissa spinarum, Albizia schimperiana, Grewia ferruginea, Bersama abyssinica, Combretum molle, Rhus vulgaris, Osyris quadripartita, Olinia rochetiana, Cordia africana, Rytigynia neglecta* and *Millettia ferruginea* were dominant species in the vegetation.

4.6.8 Population structure of selected tree species in the woodland

The analysis of selected woody species in the study area resulted in six different patterns of population structures, and one species was taken to show its corresponding pattern (Fig. 7a-f).

The first population pattern was represented by species distributed only in the DBH class one and totally absent from the other DBH classes (Fig. 7a). *Calpurnia aurea* was taken as representative species in this pattern. The other species showing this pattern were *Allophylus macrobotrys*, *Apodytes dimidiata*, *Bridelia micrantha*, *Buddleja polystachya*, *Capparis tomentosa*, *Ehretia cymosa, Ekebergia capensis*, *Dalbergia lacteal, Diospyros abyssinica*, *Dovyalis abyssinica*, *Flacourtia indica*, *Ficus sycomorus*, *Ficus thonningii*, *Maytenus obscura*, *Pterolobium stellantum*, *Rothmannia urcilliformis* and *Vernonia amygdalina*.

The second population pattern was represented by species having the highest density in the first DHH class, and then decreasing and ending in the DBH class two or three (Fig. 7b). Species showing this pattern were *Clausena anisata, Dodonaea angustifolia, Euclea divinorum, Grewia ferruginea, Maytenus arbutifolia, Maesa laceolata*, *Olea europaea* subsp. *cuspidata, Osyris quadripartita, Rhus natalensis, Rhus vulgaris, Sapium ellipticum, Schrebera alata, Terminalia macroptera, Vangueria apiculata and Bersama abyssinica (the species* taken as representative to show the pattern).

The third population pattern represented by *Crotom macrostachyus* was shown by the species having relatively the highest density in the DBH class one and decreasing towards the higher DBH classes and then ending in the DBH class three or four (Fig. 7c). Species showing this pattern were *Ficus sur*, *Millettia ferruginea* and *Stereospermum kunthianum.*

The forth population pattern was represented by the species which had the highest density in the DBH class one and decreasing towards the highest DBH class (Fig. 7d). This population pattern was represented in all the DBH classes. Species showing this pattern were *Combretum molle, Albizia schimperiana* and *Syzygium guineense* subsp. *guineense*. *Combretum molle* was taken to represent the population structure shown by the species.

The fifth population pattern was shown by the species having the highest density in the DBH class two and relatively higher density of individuals in the first DBH class, but decreasing towards the higher DBH classes (Fig. 7e). *Acacia abyssinica* and *Ficus mucuso* showed this population pattern. But in the first DBH class, density was not far apart from the highest density recorded in the DBH class two, whereas it was gradually decreasing towards the higher classes.

The six population pattern represented by *Olinia rochetiana* was shown by species having relatively the highest density in the DBH class one and decreasing through interruptions towards the higher DBH classes (Fig. 7f). Species showing this pattern were *Carissa spinarum*, *Celtis africana, Cordia africana*, *Dombeya torrida*, *Ficus vasta, Olinia rochetiana*, *Podocarpus falcatus*, *Premna schimperi*, *Rytigynia neglecta* and *Senna petersiana.*

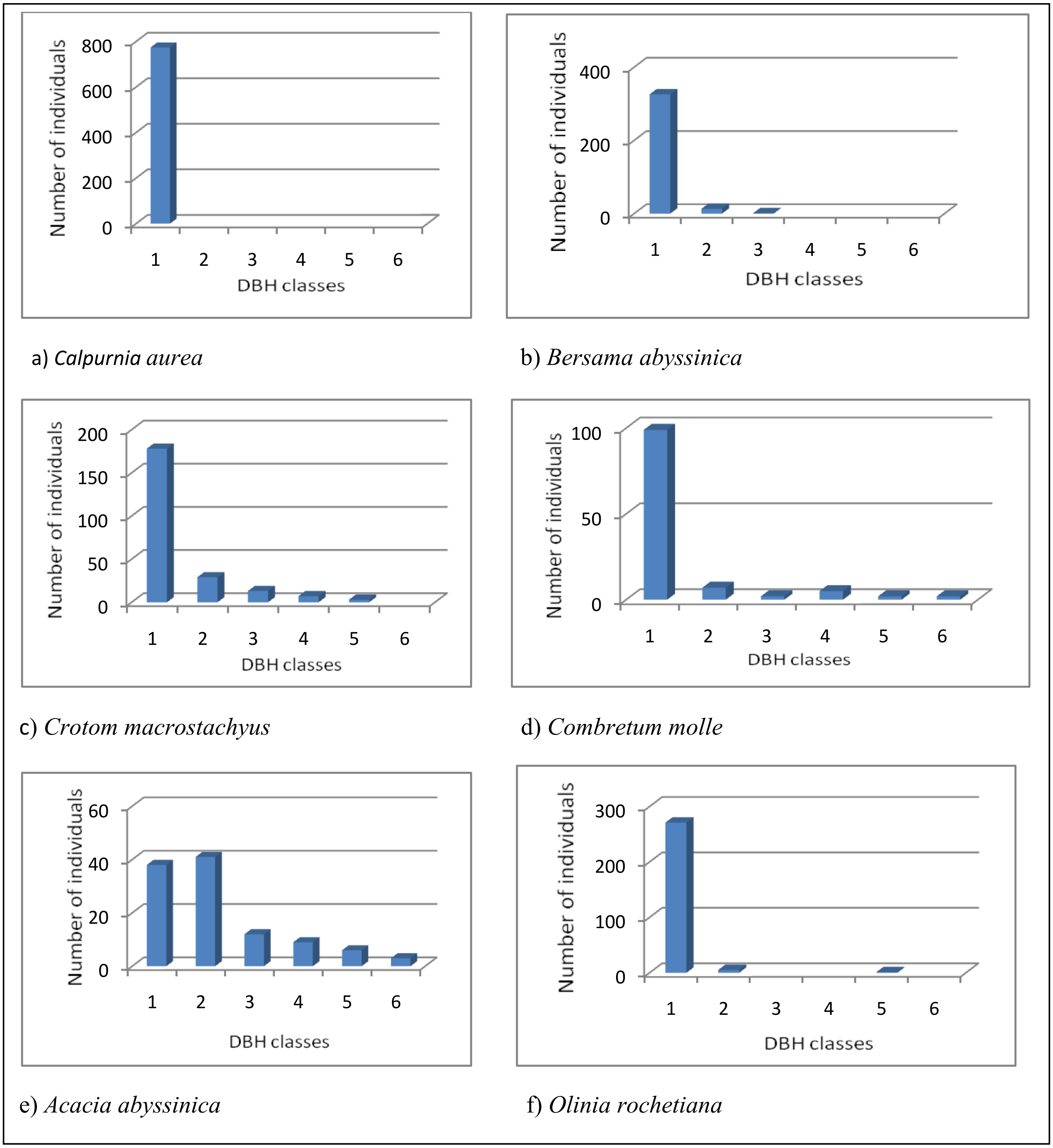


Fig. 7(a-f) Six representative population patterns of Dirki and Jato Woodland Vegetation. DBH classes: 1= <10 cm, 2= 10.1-20.0 cm, 3= 20.1-30.0 cm, 4= 30.1-40.0 cm, 5= 40.1-50.0 cm, 6= >50 cm.

4.6.9 Regeneration Status: Composition and density of seedlings and saplings

Analysis of sixty tree species was made to describe the regeneration status of the vegetation under the study. Total density of seedlings, saplings and mature tree species were 4,790.28 ha^{-1}, 4,219.91 ha^{1} and 4,685.18 ha^{-1} respectively (Table 13) and (Appendix 5).

Three species groups were obtained from the sixty tree species that were analyzed based on presence/absence of seedlings and saplings, comparing the total number of the seedlings and saplings together with the total number of the corresponding mature tree species. Fourteen (23.33%) species categorized under the first group were not represented by seedlings and saplings. *Acacia abyssinica, Apodytes dimidiata, Cordia africana, Ficus mucuso, Ficus sur, Mimusops kummel*, *Prunus africana* and *Rothmannia urcelliformis* were some of the species showed this condition. Twenty two *(36.67%)* species categorized under the second group were represented by less sum total of seedlings and saplings than the mature trees. The species showed this status were *Albizia schimperiana, Allophylus macrobotrys, Bersama abyssinica, Celtis africana, Croton macrostachyus, Dalbergia lacteal, Ehretia cymosa* and *Grewia ferruginea.* The rest 24 (40%) species put under the third group were represented by more sum total of seedlings and saplings than the mature trees in the vegetation. Species like *Bridelia micrantha, Calpurnia aurea, Clausena anisata, Combretum paniculatum, Dodonaea angustifolia, Dombeya torrida, Dovyalis abyssinica, Euclea divinorum* and *Flacourtia indica* were represented by this behavior.

Table 13: Density per hectare of seedlings (SE), saplings (SA), mature trees and shrubs (MW) and total density (TD) of 60 woody species

S/N	Species	Seedlings	Saplings	MW	TD	%TD
1	*Acacia abyssinica* Hochst. ex Benth	0	0	50.46	50.47	0.37
2	*Albizia schimperiana* Oliv.	38.46	18.98	114.35	171.76	1.25
3	*Allophylus macrobotrys* Gilg	3.70	3.70	22.69	30.09	0.22
4	*Apodytes dimidiata* E. Mey. ex Am.	0	0	4.63	4.63	0.03
5	*Bersama abyssinica* Fresen.	66.20	48.61	157.41	272.22	1.99
6	*Bridelia micrantha* (Hochst.) Baill.	2.78	12.04	11.57	26.39	0.19
7	*Calpurnia aurea* (Ait.) Benth.	750.93	453.24	358.33	1,562.5	11.41
8	*Celtis africana* Buerm.f.	2.31	2.31	20.83	25.46	0.19
9	*Chionanthus mildbraedii* (Gilg & Schellenb.)	0	0	6.02	6.02	0.04
10	*Clausena anisata* (Willd). Benth.	937.96	690.28	822.69	2,450.93	17.90
11	*Combretum molle* R. Br. Ex G.Don	19.91	26.85	54.17	100.93	0.74
12	*Combretum paniculatum* Vent.	1.39	1.39	5.56	8.33	0.06
13	*Cordia africana* L.	0	0	12.5	12.5	0.09
14	*Croton macrostachyus* Del.	37.96	59.26	106.48	203.70	1.49
15	*Dalbergia lactea* Vatke	7.87	10.19	26.39	44.44	0.32
16	*Diospyros abyssinica* (Hiern) F. White	0	0.93	5.09	6.02	0.04
17	*Dodonaea angustifolia* L.f.	6.94	6.94	4.63	18.52	0.14
18	*Dombeya torrida* (G.F. Gmel.) P. Bamps	100.92	65.28	8.33	174.54	1.27
19	*Dovyalis abyssinica* (A. Rich.) Warb.	11.11	13.89	15.74	40.74	0.30
20	*Ehretia cymosa* Thonn	0.46	0.93	6.94	8.33	0.06
21	*Ekebergia capensis* Sparrm.	0	0	5.09	5.09	0.04
22	*Euclea divinorum* Hien	121.76	163.89	76.39	362.04	2.64
23	*Ficus mucuso* (Miq.) Miq.	0	0	2.78	2.78	0.02
24	*Ficus sur* Forssk.	0	0	5.56	5.56	0.04
25	*Ficus sycomorus* L.	0	0	0.46	0.46	0.01
26	*Ficus thonningii* Blume	0	0	3.70	3.70	0.03
27	*Ficus vasta* Forssk.	0	0	0.93	0.93	0.01

28	*Flacourtia indica* (Burm.f.) Merr.	28.24	31.02	23.15	82.41	0.60
29	*Gnidia glauca* Steud. ex A. Rich.	17.59	24.07	11.11	52.78	0.39
30	*Grewia ferruginea* Hochst.ex A. Rich	106.02	47.69	200	353.70	2.58
31	*Hymenodictyon floribundum* (Hochst. & Steud.) Robinson	1.39	1.39	3.24	6.02	0.04
32	*Hypericum quartinianum* A. Rich.	6.02	11.11	45.37	62.5	0.46
33	*Maesa lanceolata* Forssk.	164.35	110.65	246.30	521.30	3.81
34	*Maytenus arbutifolia* (A.Rich.) Wilczek	165.74	106.02	493.52	765.28	5.59
35	*Millettia ferruginea* (Hochst.) Bak.	31.02	24.07	106.48	161.57	1.18
36	*Mimusops kummel* A. DC.	0	0	0.46	0.46	0.01
37	*Myrsine africana* L.	1057.87	950.93	37.96	2046.76	14.94
38	*Nuxia congesta* R.Br. ex Fresen.	2.31	2.31	26.85	31.48	0.23
39	*Olea capensis* L. subsp. *macrocarpa* (C.H. Wright) Verdc.	0.46	0.46	1.85	2.78	0.02
40	*Olea europaea* L. subsp. *cuspidata* (Wall.ex G.Don) Cif.	0.93	2.31	4.17	7.41	0.05
41	*Olinia rochetiana* A.Juss.	133.79	106.48	128.24	368.52	2.69
42	*Osyris quadripartita* Decne.	38.43	68.52	131.94	238.89	1.74
43	*Phyllanthus ovalifolius* Forssk.	34.72	69.44	62.5	166.67	1.22
44	*Podocarpus falcatus* (Thunb.) R.B. ex. Mirb.	13.43	14.81	6.02	34.26	0.25
45	*Premna schimperi* Baker	148.61	299.54	356.48	804.63	5.88
46	*Prunus africana* (Hook.f.) Kalkm.	0	0	0.46	0.46	0.01
47	*Psychotria orophila* Petit	12.04	13.89	6.02	31.94	0.23
48	*Rhamnus staddo* A.Rich.	51.39	39.37	2.78	93.52	0.68
49	*Rhus natalensis* Krauss	150	129.63	245.83	525.46	3.84
50	*Rhus vulgaris* Meikle	16.20	11.57	107.87	135.65	0.99
51	*Rothmannia urcelliformis* (Hiem) Robyns	0	0	1.85	1.85	0.01
52	*Rytigynia neglecta* (Hiern) Robyns	176.39	172.22	104.17	452.78	3.31
53	*Sapium ellipticum* (Krauss) Pax.	2.31	2.31	6.94	11.57	0.08
54	*Schrebera alata* (Hochst.) Welw.	11.11	22.69	38.89	72.68	0.53

55	*Senna petersiana* (Bolle) Lock	34.26	68.52	28.24	131.02	0.96
56	*Stereospermum kunthianum* Cham.	1.39	2.31	21.76	25.46	0.19
57	*Syzygium guineense* (Willd.) DC.	163.43	225	205.09	593.52	4.33
58	*Terminalia macroptera* Giull & Perr.	4.63	4.63	27.77	37.04	0.27
59	*Vangueria apiculata* K. Schum.	50.46	41.20	75.48	167.13	1.22
60	*Vernonia myriantha* Hook.f.	55.09	37.04	16.67	108.80	0.79
	Total	4,790.28	4,219.91	4,685.18	13,695.37	100

4.6.10 Phytogeographical similarity of vegetation of Dirki and Jato with four other woodlands

The vegetation of Dirki and Jato in Ilu Gelan District has been compared with four other relatively related woodlands studied at different times. These woodlands are found around Lake Abaya to Chencha highlands between the altitudinal range of 1177-2718 m a.s.l. (Desalegn Wana, 2002), Gamo Gofa between the altitudinal range of 600-1900 m a.s.l. (Teshome Soromessa et al., 2004), Koga irrigation between the altitudinal range of 1894-2344 m a.s.l. (Amare Mekonnen, 2009) and Gilgel Gibe III between the altitudinal range of 703-828 m a.s.l. (Fisseha Adugna, 2010). The first two and fourth studies were conducted in southern Ethiopia while the third one was done in the northewest part of the country. The species richness of of these four woodlands was compared with that of Dirki and jato to determine the phytogeographical impression of the study area (Table. 14).

Table 14: Comparison of the vegetation of Dirki and Jato with other woodland vegetations studied in Ethiopia.

Woodlands	**Reported by**	**a**	**b**	**c**	**Sc**
Lake Abaya to Chencha	Desalegn Wana (2002)	43	170	132	0.222
Gamo Gofa	Teshome Soromessa et al. (2004)	27	186	189	**0.126**
Koga irrigation area	Amare Mekkonen (2009)	35	178	36	**0.246**
Gilgel Gibe III area	Fisseha Adugna (2010)	20	193	66	0.134

Where

a = Species common to Dirki and Jato Woodlands, and the woodland in comparison.

b = Species unique to the vegetation of Dirki and Jato Woodlands.

c = Species found only in the vegetation in comparison with Dirki and Jato woodlands.

Sc = Sorensen's Similarity Coefficient.

4.6.11 Impacts of environmental variables on vegetation distribution

Relationship between vegetation data and environmental variables, as well as among the environmental variables themselves (such as altitude, aspect, human impacts and grazing) was calculated through fitting them onto CCA ordination scatterplots (Fig. 8).

The result showed that grazing and human impacts have been more pressurizing the vegetation than the other factors. North-facing aspect of the vegetation particularly in case of Dirki woodland was less influence by grazing as compared to the other aspects. However, since anthropogenic impacts are more or less associated with the whole vegetation, the variance is not markedly indicated. However, the effects of cutting trees and shrubs, collecting fuelwood and producing charcoal are well noticed as the main anthropogenic pressures on the vegetation of the study area (Fig. 9).

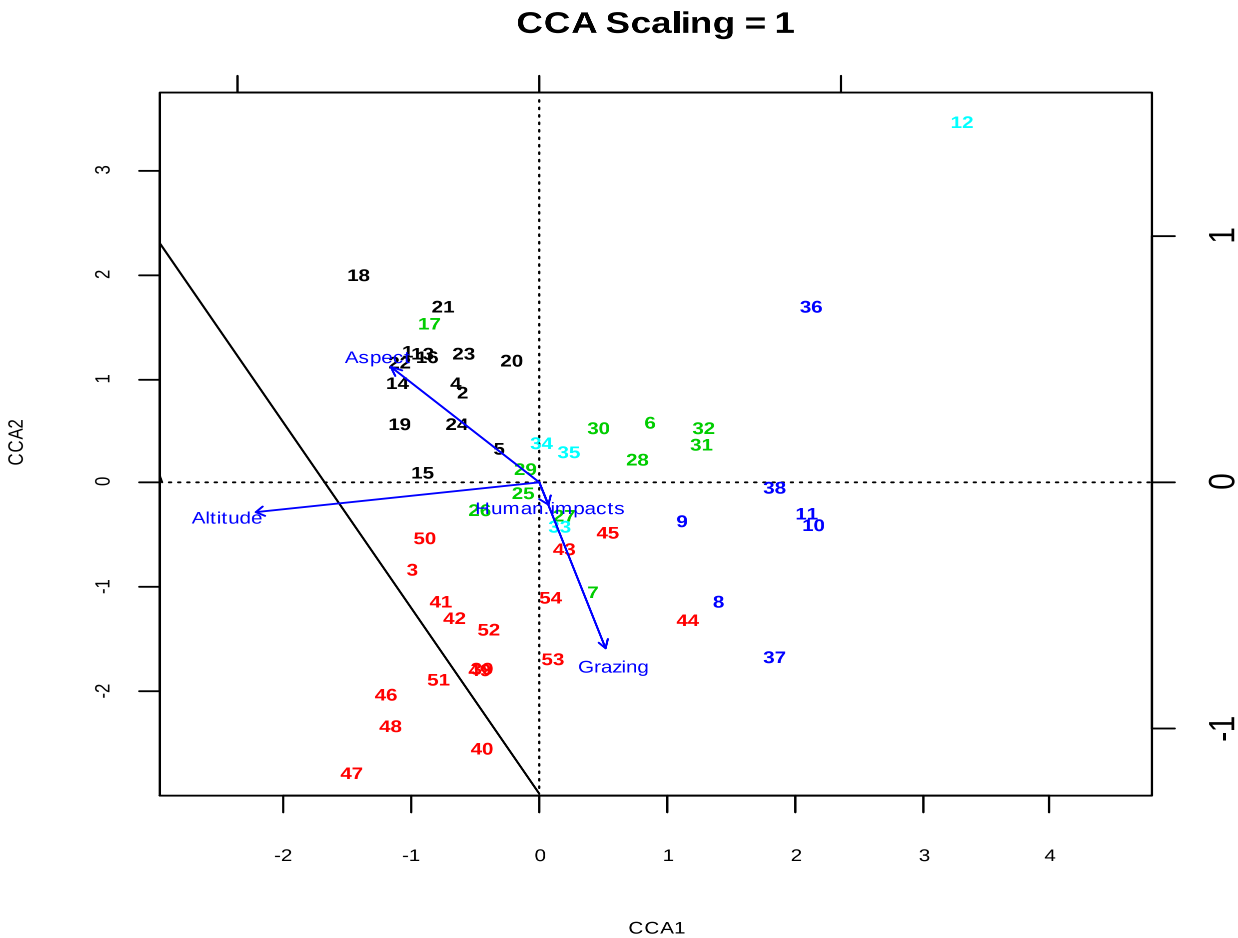


Fig. 8 Impact of altitude, Aspect and grazing on Dirki and Jato Woodland Vegetation

Fig. 9 Effects of human pressures on the vegetation (a-b cutting effect, c-d charcoal production)

CHAPTER FIVE

5 DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Description of Vegetation Structure of the Woodland

Dominance of Fabaceae and Asteraceae has been reported from different floristic studies done by different researchers at different times (Haile Yineger et al., 2008; Getachew Tadesse et al., 2008; Fayera Abdena, 2010; Birhanu Kebede, 2010; Motuma Didita et al., 2010); Shambel Alemu, 2011; Haile Adamu et al., 2012; Abiyot Dibaba, 2014). Similarly, the results from analyzed data showed that Fabaceae and Asteraceae are the most dominant species in Dirki and Jato Woodland Vegetation. Fabaceae and Asteraceae are represented by 23 and 22 species respectively, while Poaceae followed by 12 species. The dominance of these families is also in line with the assessment results that show their dominance positions in the Flora of Ethiopia and Eritrea. Fabaceae and Asteraceae might have got the top dominance position probably due to having efficient pollination and successful seed dispersal mechanisms that might have adapted them to a wide range of ecological conditions in the past (Ensermu Kelbessa and Teshome Soromessa, 2008). However, the variation in topography and environmental conditions like amount of rainfall and temperature could be the causes of variation in dominance positions of plants taxa. Ethiopia is considered one of the countries of east Africa known by plant endemism (Vivero et al., 2005). The diverse topographic land features having various climatic conditions assisted Ethiopia to be a country of high biodiversity (Kflay Gebrehiwot and Kitessa Hundera, 2014).

Results from data analysis showed that the woodland vegetation of Dirki and Jato consists of 13 endemic species of the flora of Ethiopia and Eritrea. From these, 11 species are endemic to Ethiopia while two are near endemic (*Lippia adoensis* and *Solanum marginatum* are confined to Ethiopia and Eritrea). Based on the IUCN Criteria of level of threat, nine species are least concern (LC), three species are near threatened (NT) while one species has been categorized under vulnerable (VU).

5.1.1 Plant community types

The results from cluster analysis showed that there are differences among the three plant communities in species composition. The differences could be attributed to variations in environmental gradients that can limit the ecological distributions of plant species (Ermias Lulekal, 2014). As described in Tamrat Bekele (1993), this variation in species composition could also be related to the effects of environmental factors such as altitude, aspect, soil contents and moisture, human impacts and grazing intensity. Lower altitudinal ranges, aspects more exposed to sun light directions, soils with sufficient moisture contents and part of vegetation less exposed to disturbance accesses can support relatively more biodiversity than the reverse of each component.

5.1.2 Density of woody species

Result from the analysis of the vegetation data shows that most proportion of the stem density is contributed by woody species having stem density in the density class greater than 100 (Density size class: A = >100; B= 50.1-100; C= 10.1-50; D= 1.1-10; E= <1). Only 17 (18.09%) woody species having many aboveground stems constituted 4,121.30 ha^{-1} (80.09%) of the total density of the vegetation studied. The five density wise most dominant plant species found in this class are *Clausena anisata* 822.69 ha^{-1} (15.99%), *Maytenus arbutifolia* 493.52 ha^{-1} (9.59%), *Calpurnia aurea* 358.33 ha^{-1} (6.96%), *Premna schimperi* 356.48 ha^{-1} (6.93%) and *Maesa lanceolata* 246.30 ha^{-1} (4.79%). This result is similar to the finding the study done by Birhanu Kebede (2010), as few individuals cover most proportion of the density classes of vegetations under secondary regeneration. However, stem density of 18 woody species with the density class less than one is only 11.57 ha^{-1} (0.22%). This indicates that the species are scarcely represented by 1-2 individuals in the vegetation.

5.1.3 DBH and height classes

The distribution of density ha^{-1} of individuals of woody species showed decreasing from lowest DGH class to the higher DBH classes. More than 96% of the density of the woody species is distributed in the lowest DBH class < 10 cm which shows that most proportion of the vegetation is represented by shrubs and small trees. However, as the DBH class increased, density was decreasing, that means, the vegetation has small number of big trees in the higher DBH classes as compared to shrubs and small trees concentrated in the lower DBH classes. This pattern indicates that Dirki and Jato Woodland Vegetation has good natural reproduction and recruitment potential. Similar results were reported by Kumelachew Yeshitela and Taye Bekele (2003); Abate Ayelew et al. (2006); Feyera Senbeta (2006; Woldeyohannes Enkosa, 2008). Most woody plants that could grow to big trees might have also been cut at early stage. This indicates that the Vegetation has been under anthropogenic influences.

Like the DBH class distribution, large proportion of the density ha^{-1} (93.19%) of the sampled woody plants is distributed in the lowest height class one. This result is similar to the findings of the studies done by Feyera Abdena (2010); Abyot Dibaba (2014); and Teshome Soremessa and Ensermu Kelbessa (2014). With increasing height classes, density ha^{-1} of the woody plants continued decreasing except the interruptions shown at the 3^{th} and 4^{th} height classes. The interruptions shown in density distribution at these height classes could be attributed to cut effect that might have exerted on the plants at certain development stage. Only few individual trees (0.11% of the total) were recorded in the highest height class (> 22 m). This indicates that the vegetation of Dirki and Jato can be categorized under secondary regeneration, i.e., most primary plants could be cut before growing into big trees. As a result, secondary young plants can regenerate and replace the primary generation.

5.1.4 Frequency

Result from frequency distribution showed that the highest number (60.64%) of the total species is distributed in the lowest frequency class A, and few (8.51%) species are distributed in the highest frequency class E while other species are distributed in between the two marginal frequency classes. This indicates that species in the lowest frequency class are recorded relatively from few plots whereas those found in the highest frequency class are the most frequent species recorded from most of the sampled quadrats. *Premna schimperi, Calpurnia aurea*, *Maytenus arbutifolia*, *Carissa spinarum*, *Grewia ferruginea*, *Clausena anisata*, and *Croton macrostachyus* have shown the highest values of relative frequency which indicates that these species have relatively good distribution status in the woodland vegetation. Few woody species have highest frequency value which shows that these species are relatively recorded from most sample plots and are well distributed in the vegetation. According to Leul Kidane et al. (2010), this situation indicates dominance position of the species in the vegetation.

5.1.5 Importance Value Index

Importance Value Index (IVI) combines data from three parameters, which include Relative Frequency, Relative Density and Relative Basal area (Kent and Coker, 1992). It is a useful tool to make comparison of the ecological significance of species (Lamprecht, 1989).

Importance Value Index (IVI) calculated for the three plant community types indicated that the five most important woody species having the highest IVI are *Maesa lanceolata*, *Syzygium guineense*, *Maytenus arbutifolia*, *Rhus natalensis* and *Premna schimperi* in Community One while *Clausena anisata*, *Calpurnia aurea*, *Croton macrosthachyus*, *Carissa spinarum* and *Premna schimperi* have the highest IVI in Community Two. In Community Three, highest IVI were calculated for *Clausena anisat*, *Ficus vasta*, *Matenus arbutifolia*, *Acacia abyssinica* and *Calpurnia aurea.*

Species like *Aacacia abyssinica* and *Ficus vasta* are ecologically more important in one community while other species such as *Clausena anisata*, *Calpurnia aurea* and *Maytenus arbutifolia* are distributed relatively in more than one community and ecologically play more important roles than the species restricted to one community type.

Analysis of the Importance Value Index (IVI) of the Vegetation indicated that 21 (22.34%) of the total woody species have IVI greater than 5.00 and constitute 221.18 (73.73%) of the total 300 IVI of the vegetation. *Clausena anisata*, *Maytenus arbutifolia*, *Premna schimperi, Acacia abyssinica*, *Ficus vasta*, *Calpurnia aurea* and *Croton macrostachyus* are the species relatively having higher IVI than the rest of the species. *Clausena anisata* could attain the highest IVI due to its highest relative density that was attributed from its highest stem density. Similar trend was shown by *Maytenus arbutifolia* while the IVI of *Ficus vasta* was contributed from the highest value of its basal area. But since *Ficus vasta* was restricted to only one community type, ecologically it is not considered as most important role playing species in the woodland vegetation.

5.1.6 Population structures of selected trees and shrubs

Population structures of trees have significant implications to their management, sustainable use and conservation strategies (Simon Shibru and Girma Balcha, 2004). Population pattern is helpful to understand the population density, regeneration and recruitment status of particular vegetation (Demel Teketay, 2005; Asmamaw Alemu, 2011). Based on this concept, six population patterns of tree species were observed from the data analyzed.

The first population pattern represented by *Calpurnea aurea* as shown in (Fig. 7a), indicates that all individuals of the species were distributed in the DBH class one and totally absent from the higher DBH classes. This might be attributed to shrubby nature of the species or cutting effects practiced on trees before growing to big size. Even though this was the case, this population pattern indicates as the vegetation has good reproduction and recruitment capacity (Getachew Demie et al., 2013).

The second population pattern represented by *Bersama abyssinica* as shown in (Fig. 7b) was represented by species having the highest frequencies of individuals in the first DBH class and then ending in the DBH class two. This pattern is related to the first population structure but shows relatively inverted J-shape which indicates as the vegetation is in good regeneration and recruitment status (Haile Yineger et al., 2008).

The third population structure was shown in (Fig. 7c) and represented by *Croton macrostachyus*. In this pattern, the highest frequencies of individuals of the species were distributed in the DBH class one. However, the frequency showed gradual decrease towards the higher DBH classes and then ended in the DBH class three or four. This pattern indicates also good regenetation status of the Vegetation.

The fourth population pattern was indicated in (Fig. 7d) and represented by *Combretum molle*. Here, the highest frequency of individuals of the species was relatively distributed in the DBH class one and decreased towards the higher DBH classes without interruption. All the individuals of the species showing this pattern were distributed in all the six DBH classes. This indicates that the Vegetation is in a good regenetion status.

In the fifth population pattern represented by *Acacia abyssinica* (Fig. 7e), higher frequencies of individuals of the species were observed in the DBH class two and decreasing towards the higher DBH classes. This population pattern indicates good regeneration and recruitment capacity of the species as relatively few numbers of individuals are present in the higher DBH classes than in the lower classes (Tamrat Bekele, 1993; Feyera Senbeta et al., 2007; Getachew Demie et al., 2013). This structure indicates good regeneration and recruitment status of the woody species represented by this population pattern.

The six population pattern represented by *Olinia rochetiana* as shown in (Fig. 7f), was represented by species having the highest frequencies of individuals in the first DBH class and then showed gradual decrease towards the higher DBH classes. But in some DBH classes, no individuals representing the species were recorded. This might be because of selective cutting applied on the species at certain important development age by the local communities. Even though this is the case, this population pattern shows a good reproduction and recruitment status of the species (Haile Yineger et al., 2008).

5.1.7 Regeneration status of the woodland vegetation

Comparison made on total densities of seedlings, saplings and mature trees and shrubs of selected 60 species showed slight variations among them. The total density of seedlings (4,790.28 ha^{-1}) exceeded the total density of the saplings (4,219.91 ha^{-1}) and the total density of mature trees and shrubs (4685.18 ha^{-1}) that were included in the analysis. Ratios of seedlings to saplings =1.135, seedlings to mature trees and shrubs = 1.022, saplings to mature trees and shrubs= 0.900 also indicated as less number of saplings were recorded than that of the mature trees and shrubs. Even though the density of seedlings which is greater than that of the saplings and the mature trees and shrubs indicates as the vegetation is in a normal regeneration status, the density of saplings has not followed similar trend. According to Shambel Alemu (2011), this distribution pattern where the density of the mature trees and shrubs exceeded the total density of the saplings shows that the regeneration status of the studied vegetations is at a low state.

According to Dereje Denu (2006), regeneration status of any vegetation can be explained on the basis of number and type of seedlings and saplings associated with that vegetation. With this regard, out of the 60 analyzed trees and shrubs (Appendix 5), 14 (23.33%) species had neither seedlings nor saplings, 36 (36.67%) species had total number of seedlings and saplings together less than the total number of mature trees and shrubs while 24 (40%) had total number of seedlings and saplings together greater than the total number of the corresponding mature trees and shrubs.

5.1.8 Phytogeographical description of Dirki and Jato Woodland Vegetation

Phytogeographical comparison is used to determine similarity between different vegetation areas in respect of species composition. Vegetation of the study area was compared with other four woodlands (Table. 13) with respect to species richness and the result from the comparison showed that Dirki and Jato Woodland Vegetation has 24.6% similarity with Koga woodland while it has 22.2% similarity with the woodland extending from Lake Abaya to Chencha highlands. The result of the comparison also showed that Dirki and Jato Woodland Vegetation shares least similarity (12.6%) with the woodland vegetation around Gamo Gofa.

The woodlands of Lake Abaya to Chencha highlands, Gamo Gofa and Gilgel Gibe III area are found in the southern part of Ethiopia, whereas that of Koga irrigation area is found in the northwest. The most similarity observed between the woodland around Koga and the vegetation of Dirki and Jato could be due to they share common altitudinal range and found relatively in related ecological climatic zones i.e., northwest of the country. But, the reason for the less similarity shown between the three woodlands and the vegetation under the study could be attributed to their geographical diferences. This conclusion is in line with the findings given in Birhanu Kebede (2010) and Abyot Dibaba (2014).

5.1.9 Environmental variables

Variations in environmental gradients such as altitude and aspect can have remarkable effects on distribution of plant species in vegetation. In addition to this, grazing and anthropogenic impacts (cutting, fuelwood collecting, charcoal producing) can affect the natural distribution patterns of plant species. The overall assessment made in the vegetation revealed that anthropogenic impacts have been affecting its natural regeneration. The act of cutting made especially on small to medium sized trees and shrubs and destruction of the vegetation as a result of the demand for fuelwood and charcoal producing by the local people (Fig. 9), indicates that the vegetation has been under serious threats. The impacts were almost widely distributed in Dirki Woodland and were not limited to altitude and the sampled plots.

Grazing was another problem identified in the study area where cattle encroached into the vegetation. Accordingly, the vegetation of Dirki Woodland has been more affected particularly from the east, south and west facing sides as the vegetation is being rapidly changing into grazing land through gradual deforestation. The situation of Jato is also not far apart from this fact. Because it is found between settlements from the top and bottom, it is suffering from similar problems too.

The result obtained from the correlation analysis made (CCA) for the vegetation data and environmental variables shows the plant species were constrained by some environmental factors (altitude, aspect, human impacts and grazing (Fig. 8). This condition is consistent with the result explained in Leul kidane et al. (2010). Accordingly, vegetation of Dirki and Jato Woodland has been highly disturbed from grazing at lower altitudinal ranges than relatively at higher altitudes. However, the effect of aspect might have been overweighted due to the north-facing part of Dirki Woodland has been bordered by a river that protects the vegetation relatively from grazing and agricultural expansion.

5.2 Conclusion

The results from this study showed that plant species of different life forms (trees, shrubs, lianas and herbs) were identified from the woodland vegetation of Dirki and Jato in Ilu Gelan District (for example, Fig. 5a-d). Out of the total plant species recorded from the woodland, most proportions (65.42%) were trees and herbs while the rest 27.57% and 7.01% were shrubs and lianas respectively.

Plants recorded from the study area belong to 69 families, 167 genera and 214 species where Fabaceae, Asteraceae and Poaceae are the most dominant families with 23, 22 and 12 species respectively. These three dominant families constitute 26.64% of the total species richness of the study area. Euphorbiaceae and Acanthaceae are the fourth and fifth dominating families while Rubiaceae, Lamiaceae and Combretaceae are the next three consecutive dominant families in the vegetation. These five species are represented by 11, 9, 9, 9 and 7 species respectively, and constitute 45 (21.03%) of the total species recorded from the study area. Families Malvaceae, Moraceae, Rhamnaceae and Solanaceae constitute 23 (10.75%) of the total species and the first three families were represented by six species each while Solanaceae contributed five species. Families Oleaceae, Ranunculaceae and Rosaceae were represented by four species each while families represented by three species each in the vegetation were Boraginaceae, Celastraceae, Loganiaceae, Sapindaceae and Verbenaceae. These eight families together contribute 27

(12.62%) of the total species while other 13 families represented by two species each constituted 26 (12.15%) of the total species. The rest 36 (16.82%) families were represented by only one species each.

Of the total 214 species identified from the study area, 11 are endemic to Ethiopia while two species are near endemic (*Lippia adoensis* and *Solanum marginatum* are found in Ethiopia and Eritrea only). According to the IUCN Red Data List, nine of these species were included in least concern (LC), two were considered near threatened (NT) whereas one species has been put under vulnerable (VU) category.

Based on the cover abundance values of the identified species, three plant community types were recognized from the study area and named by two characteristic species having highest mean cover abundance estimate in each community. The three communities are *Acacia etbaica-Lantana trifolia* Community Type, *Buddleja polystachya-Teclea nobilis* Community Type and *Combretum paniculatum- Rothmannia urcelliformis* Community Type. Community three had the highest diversity and species richness than the two communities. Communities one and two were more similar in species composition than communities one and three or two and three.

Density ha^{-1} of the woody species used in the analysis was more concentrated in the lower DBH size class. This was also true for height and frequency classes and indicated that most of the woody species recorded during this study were small-sized plants.

Species like *Clausena anisata*, *Maytenus arbutifolia* and *Premna schimperi* attained the highest value of IVI due to their highest relative density even though most of their individual plants were included in the lower DBH classes. In contrary to this, *Acacia abyssinica* and *Ficus vasta* which have lower relative density could get higher value IVI due to the highest value of their relative dominance (basal area). But since *Ficus vasta* is restricted to only one community type, it can not be taken as a species ecologically playing most important roles better than the other species.

Dependence of the local people for collecting fuelwood, charcoal production, requirement of different materials and grazing is highly affecting the diversity and size of the vegetation of Dirki and Jato Woodland (Appendix 2). Some plant species like *Ficus sur*, *Cordia africana, Apodytes dimidiata, Acacia abyssinica, Ficus mucuso* and few others were not represented by either seedlings or saplings while *Albizia schimperiana, Allophylus macrobotrys, Bersama abyssinica, Celtis africana* and few other species were represented by less number of seedlings and saplings than mature plants. However, species such as *Bridelia micrantha, Calpurnia aurea, Clausena anisata, Myrsine africana, Premna schimperi* and others were represented by more numbers of seedlings and saplings than mature plants and thus they were in a good regeneration status. However, causes of the former two cases require further study to forward solutions.

5.3 Recommendation

It is clear that vegetation can provide a lot of important services to living things found in our world. Being sources of different materials, foods, homes of different living things and regulating microclimate conditions are some of the important services provided by vegetation. Even though this is the case, natural vegetation has been declining from time to time due to human pressures exerted on it.

Local communities surrounding the area are highly affecting the remnant vegetation through cutting, firewood collection and charcoal production as well as exposing them to continuous grazing. As a result, trees and shrubs found there are put under heavy pressures from the local people. Due to these human admissions, all the plants including the eleven endemic and two near endemic species recorded from study area may be lost. This destruction could change the vegetation into bare land in the coming few years unless alternative measures are taken.

Concerned governmental and or non-governmental bodies that give priority to conservation of vegetation and forest resources should give attention to these species rich area and seek immediate solutions to save the biodiversity. It is important for concerned bodies to educate the local people to plant alternative economical plants such as eucalyptus and others on small plots of their own private land and use in the long run instead of showing complete dependence on these nearby natural vegetation. Rather than designing strict controlling mechanisms for protecting the vegetation from the stated problems, it is important to design community based participatory planning with the local people in conservation and management of the natural resources. Awareness that would help for seeking alternative income generating mechanisms should be given to those individuals who are using the vegetation for various purposes.

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Appendices

Appendix 1: Location of vegetation data collection in Ilu Gelan District of West Shewa Zone, Oromia Region

Site	Transect	Number of plots	Altitude	Latitude	Longitude	Aspect
Dirki	Peak	1	2078 m a.s.l.	08°59’31.7’’	037°23’07.1’’	Peak
	1	11	2053 m a.s.l.	08°59’33.5’’	037°23’07.7’’	North-facing
			2028 m a.s.l.	08°59’34.7’’	037°23’08.7’’	
			2003 m a.s.l.	08°59’35.5’’	037°23’10.4’’	
			1978 m a.s.l.	08°59’39.3’’	037°23’08.7’’	
			1953 m a.s.l.	08°59’41.2’’	037°23’07.8’’	
			1928 m a.s.l.	08°59’44.9’’	037°23’04.7’’	
			1903 m a.s.l.	08°59’45.8’’	037°23’04.2’’	
			1878 m a.s.l.	08°59’46.6’’	037°23’03.6’’	
			1853 m a.s.l.	08°59’47.4’’	037°23’03.9’’	
			1828 m a.s.l.	08°59’49.1’’	037°23’03.2’’	
			1803 m a.s.l.	08°59’50.8’’	037°22’59.5’’	
	2	4	2053 m a.s.l.	08°59’27.2’’	037°23’10.7’’	East-facing
			2028 m a.s.l.	08°59’26.7’’	037°23’12.5’’	
			2003 m a.s.l.	08°59’27.0’’	037°23’14.1’’	
			1978 m a.s.l.	08°59’29.9’’	037°23’15.8’’	
	3	5	2053 m a.s.l.	08°59’29.3’’	037°23’06.7’’	South-facing
			2028 m a.s.l.	08°59’24.5’’	037°23’07.9’’	
			2003 m a.s.l.	08°59’20.8’’	037°23’09.6’’	
			1978 m a.s.l.	08°59’18.7’’	037°59’10.3’’	
			1953 m a.s.l.	08°59’16.1’’	037°23’13.9’’	
	4	11	2053 m a.s.l.	08°59’34.1’’	037°23’05.0’’	West-facing
			2028 m a.s.l.	08°59’36.4’’	037°23’02.6’’	
			2003 m a.s.l.	08°59’37.9’’	037°23’01.3’’	
			1978 m a.s.l.	08°59’37.5’’	037°22’58.9’’	

			1953 m a.s.l.	08°59’37.6’’	037°22’56.9’’	
			1928 m a.s.l.	08°59’39.6’’	037°22’55.4’’	
			1903 m a.s.l.	08°59’40.0’’	037°22’52.1’’	
			1878 m a.s.l.	08°59’40.3’’	037°22’50.6’’	
			1853 m a.s.l.	08°59’40.0’’	037°22’49.1’’	
			1828 m a.s.l.	08°59’41.0’’	037°22’46.4’’	
			1803 m a.s.l.	08°59’42.0’’	037°22’45.5’’	
Jato	5	6	2000 m a.s.l.	08°59’05.0’’	037°22’05.3’’	North-facing
			1975 m a.s.l.	08°59’06.3’’	037°22’06.4’’	
			1950 m a.s.l.	08°59’08.5’’	037°22’05.3’’	
			1925 m a.s.l.	08°59’08.4’’	037°22’07.6’’	
			1900 m a.s.l.	08°59 09.6’’	037°22’08.6’’	
			1875 m a.s.l.	08°59’10.8’’	037°22’10.0’’	
	6	7	2020 m a.s.l.	08°58’56.0’’	037°21’46.1’’	North-facing
			1995 m a.s.l.	08°58’55.7’’	037°21’43.1’’	
			1970 m a.s.l.	08°58’57.3’’	037°21’42.7’’	
			1945 m a.s.l.	08°58’56.6’’	037°21’40.6’’	
			1920 m a.s.l.	08°58’57.0’’	037°21’38.8’’	
			1895 m a.s.l.	08°58’57.5’’	037°21’36.6’’	
			1870 m a.s.l.	08°59’00.5’’	037°21’34.6’’	
	7	9	2136 m a.s.l.	08°58’42.8’’	037°21’53.7’’	Northwest-facing
			2080 m a.s.l.	08°58’41.5’’	037°21’51.7’’	
			2055 m a.s.l.	08°58’41.9’’	037°21’50.0’’	
			2030 m a.s.l.	08°58’42.9’’	037°21’48.8’’	
			2005 m a.s.l.	08°58’43.2’’	037°21’47.2’’	
			1980 m a.s.l.	08°58’42.2’’	037°21’45.4’’	
			1955 m a.s.l.	08°58’42.5’’	037°21’43.5’’	
			1930 m a.s.l.	08°58’43.9’’	037°21’41.6’’	
			1905 m a.s.l.	08°58’42.8’’	037°21’53.7’’	

Appendix 2: Environmental factors associated with Dirki and Jato Woodland Vegetation

Plots	Altitude	Aspect	Human impacts	Grazing effect
1	2078 m a.s.l.	0	3	2
2	2053 m a.s.l.	0	3	2
3	2028 m a.s.l.	0	3	2
4	2003 m a.s.l.	0	3	2
5	1978 m a.s.l.	0	2	2
6	1953 m a.s.l.	0	3	2
7	1928 m a.s.l.	0	3	3
8	1903 m a.s.l.	0	3	3
9	1878 m a.s.l.	0	3	3
10	1853 m a.s.l.	0	3	3
11	1828 m a.s.l.	0	3	3
12	1803 m a.s.l.	0	2	2
13	2053 m a.s.l.	2	3	2
14	2028 m a.s.l.	2	3	3
15	2003 m a.s.l.	2	3	3
16	1978 m a.s.l.	2	1	1
17	2053 m a.s.l.	4	2	2
18	2028 m a.s.l.	4	3	2
19	2003 m a.s.l.	4	3	3
20	1978 m a.s.l.	4	3	3
21	1953 m a.s.l.	4	3	2
22	2053 m a.s.l.	2.5	3	2
23	2028 m a.s.l.	2.5	3	2
24	2003 m a.s.l.	2.5	3	3
25	1978 m a.s.l.	2.5	3	3
26	1953 m a.s.l.	2.5	3	3
27	1928 m a.s.l.	2.5	3	3
28	1903 m a.s.l.	2.5	3	3

29	1878 m a.s.l.	2.5	3	3
30	1853 m a.s.l.	2.5	3	3
31	1828 m a.s.l.	2.5	3	3
32	1803 m a.s.l.	2.5	3	3
33	2000 m a.s.l.	0	3	3
34	1975 m a.s.l.	0	2	2
35	1950 m a.s.l.	0	2	2
36	1925 m a.s.l.	0	3	2
37	1900 m a.s.l.	0	3	3
38	1875 m a.s.l.	0	3	3
39	2020 m a.s.l.	0	3	3
40	1995 m a.s.l.	0	2	3
41	1970 m a.s.l.	0	2	2
42	1945 m a.s.l.	0	1	2
43	1920 m a.s.l.	0	2	2
44	1895 m a.s.l.	0	3	3
45	1870 m a.s.l.	0	3	3
46	2136 m a.s.l.	1.3	3	3
47	2080 m a.s.l.	1.3	3	3
48	2055 m a.s.l.	1.3	3	3
49	2030 m a.s.l.	1.3	3	2
50	2005 m a.s.l.	1.3	3	2
51	1980 m a.s.l.	1.3	3	3
52	1955 m a.s.l.	1.3	3	3
53	1930 m a.s.l.	1.3	3	3
54	1905 m a.s.l.	1.3	3	3

Appendix 3: List of plant species collected from woodland vegetation of Dirki and Jato sites in Ilu Gelan District.

Habit : (T= tree, S= shrub, L=liana, H= herb); Col.code= collection code, Ha= habit

No	Species name	Family	Local name	Ha	Col. code
1	*Abutilon longicuspe* Hoehst. ex A. Rich.	Malvaceae	Hincinnii	S	Z192
2	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	Laaftoo	T	Z023
3	*Acacia etbaica* Schweinf.	Fabaceae	Doddota	T	Z197
4	*Acacia persiciflora* Pax	Fabaceae	Laaftoo	T	Z204
5	*Acanthus polystachius* Delile	Acanthaceae	Sokorruu adii	S	Z176
6	*Acanthus sennii* Chiov.	Acanthaceae	Sokorruu	S	Z013
7	*Achyranthes aspera* L.	Amaranthaceae	Maxxannee	H	Z118
8	*Acmella caulirhiza* Del.	Asteraceae		H	Z182
9	*Adiantum poiretii* Wikstr.	Adiantaceae		H	Z027
10	*Albizia schimperiana* Oliv.	Fabaceae	Imalaa	T	Z005
11	*Allophylus macrobotrys* Gilg	Sapindaceae	Sarara	T	Z125
12	*Allophylus africanus* P. Beauv.	Sapindaceae	Qarxammee	T	Z162
13	*Aloe macrocarpa* Tod.	Aloaceae	Hargisa	S	Z178
14	*Andropogon abyssinicus* Fresen.	Poaceae	Baallammii	H	Z179
15	*Apodytes dimidiata* E. Mey. ex Am.	Icacinaceae	Qumbaala	T	Z157
16	*Argyrolobium fischeri* Taub.	Fabaceae		H	Z016
17	*Aspilia mossambicensis* (Oliv.) Wild	Asteraceae	Keelloo	S	Z165
18	*Asystasia mysorensis* (Roth) T. Anders.	Acanthaceae		H	Z166
19	*Bersama abyssinica* Fresen.	Melianthaceae	Lolchiisaa	T	Z008
20	*Bidens biternata* (Lour.) Merr. & Sherfft.	Asteraceae	Keelloo	H	Z183
21	*Bidens ghedoensis* Mesfin	Asteraceae	Keelloo	H	Z120
22	*Bidens pachyloma* (Oliv. & Hiern) Cufod.	Asteraceae	Keelloo	H	Z153

23	*Bridelia micrantha* (Hochst.) Baill.	Euphorbiaceae	Agiraabaa	T	Z094
24	*Brucea antidysenterica* J.F.Mill.	Simaroubaceae	Qomonyoo	S	Z185
25	*Buddelja davidii* Franch.	Loganiaceae	Qawwwisa	S	Z151
26	*Buddleja polystachya* Fresen.	Loganiaceae	Qawwisa	T	Z075
27	*Caesalpinia decapetala* (Roth) Alston	Fabaceae	Arangamaa	L	Z149
28	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Ceekaa	S	Z001
29	*Capparis tomentosa* Lam.	Capparidaceae	Arangamaa	S	Z142
30	*Carissa spinarum* L.	Apocynaceae	Agamsa	S	Z051
31	*Celtis africana* Burm.f.	Ulmaceae	Cayii	T	Z108
32	*Chionanthus mildbraedii* (Gilg & Schellenb.) Stearn	Oleaceae	Karra waayyuu	T	Z199
33	*Cirsium schimper* (Valke) C. Jeffrey ex Cufod.	Asteraceae		H	Z152
34	*Cissampelos pareira* L.	Menispermaceae	Hidda kalaalaa	L	Z018
35	*Clausena anisata* (Willd). Benth.	Rutaceae	Ulmaayii	S	Z003
36	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae		L	Z144
37	*Clematis longicauda* Steud.ex A. Rich.	Ranunculaceae	Hidda fiitii	L	Z063
38	*Clematis simensis* Fresen.	Ranunculaceae	Hidda fiitii	L	Z020
39	*Clerodendrum myricoides* (Hochst.) Vatke	Lamiaceae		S	Z131
40	*Clutia abyssinica* Jaub. &- Spach.	Euphorbiaceae		S	Z085
41	Combretum adenogonium Steud. ex A. Rich.	Combretaceae	Rukeessa	T	Z212
42	*Combretum collinum* Fresen.	Combretaceae		T	Z080
43	*Combretum molle* R. Br. ex G.Don	Combertaceae	Rukeessa	T	Z041
44	*Combretum nigrican* Lepr. ex Guill. & Perr.	Combretaceae		T	Z055
45	*Combretum paniculatum* Vent.	Combretaceae	Hidda baggii	L	Z137
46	*Commelina benghalensis* L.	Commelinaceae	Gororaa	H	Z168

47	*Cordia africana* L.	Boraginaceae	Waddeessa	T	Z114
48	*Crassocephalum macropappum* (Sch.Bip.ex A. Rich) S. Moore	Asteraceae		H	Z170
49	*Crassocephalum x picridifolium* (DC) S. Moore	Asteraceae		H	Z169
50	*Crassula alata* (Viv.) Berger	Crassulaceae		H	Z145
51	*Crepis rueppelli* Sch. Bip.	Asteraceae		H	Z136
52	*Crotalaria pallida* Ait.	Fabaceae		H	Z200
53	*Crotalaria quartiniana* A. Rich.	Fabaceae		H	Z132
54	*Crotalaria rosenii* (Pax) Milne-Redh.ex Polhill	Fabaceae		S	Z123
55	*Croton macrostachyus* Del.	Euphorbiaceae	Bakkanniissa	T	Z030
56	*Cucumis dipsaceus* Ehrenb. ex Spach	Cucurbitaceae		H	Z113
57	*Cyathula polycephala* Bale.	Amaranthaceae		H	Z135
58	*Cymbopogon commutatus* (Steud.) Stapf	Poaceae	Jajjaba	H	Z101
59	*Cynodon dactylon* (L.) Pers.	Poaceae	Coqorsa	H	Z103
60	*Cynodon nlemfuensis* Vanderyst	Poaceae	Waratii	H	Z207
61	*Cyperus sesquiflorus* (Torr.) Mattf. & KUk.	Cyperaceae	Qeexamaa	H	Z052
62	*Dalbergia lactea* Vatke	Fabaceae	Sarxee	T	Z107
63	*Desmodium repandum* (Vahl) DC.	Fabaceae		H	Z213
64	*Diaphananthe candida* Cribb	Orchidaceae	Digaluu	H	Z062
65	*Dicranopteris linearis* (Burm.f.) Underw.	Gleicheniaceae	Fern	H	Z034
66	*Dioscorea schimperiana* Hochst. ex Kunth	Dioscoreaceae		H	Z047
67	*Diospyros abyssinica* (Hiern) F. White	Ebenaceae	Ilkee	T	Z089
68	*Dodonaea angustifolia* L. f.	Sapindaceae	Ittacha	S	Z088
69	*Dombeya torrida* (G.F. Gmel.) P. Bamps	Sterculiaceae	Daannisa	T	Z116
70	*Dovyalis abyssinica* (A. Rich.) Warb.	Flacourtiaceae	Koshommii	T	Z045
71	*Dracaena steudneri* Engl.	Dracaenaceae	Meerqoo	S	Z150

72	*Drimia altissima* (L.f.) Ker-Gawl.	Hycinthaceae	Qullubbii waraabessaa	H	Z209
73	*Echinops longisetus* A. Rich.	Asteraceae	Qoraattii harree	S	Z058
74	*Ehretia cymosa* Thonn.	Boraginaceae	Ulaagaa	T	Z021
75	*Ekebergia capensis* Sparrm.	Meliaceae	Somboo	T	Z095
76	*Englerina woodfordioides* (Schweinf.)M. Gilbert	Loranthaceae	Digaluu	S	Z119
77	*Entada abyssinica* Steud. ex A. Rich.	Fabaceae	Ambaltaa	T	Z196
78	*Erythrococca abyssinica* Pax	Euphorbiaceae	Geelloo	S	Z067
79	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Baargamoo diimaa	T	Z068
80	*Euclea divinorum* Hiern	Ebenaceae	Mi'eessaa	T	Z038
81	*Euphorbia schimperiana* Scheele	Euphorbiaceae		S	Z011
82	*Ficus mucuso* Ficalho.	Moraceae	Qilinxoo	T	Z141
83	*Ficus salicifolia* A. Rich.	Moraceae	Qilinxoo	T	Z167
84	*Ficus sur* Forssk.	Moraceae	Harbuu	T	Z164
85	*Ficus sycomorus* L.	Moraceae	Odaa	T	Z130
86	*Ficus thonningii* Blume	Moraceae	Dambii	T	Z128
87	*Ficus vasta* Forssk.	Moraceae	Qilxuu	T	Z122
88	*Flacourtia indica* (Burm.f.) Merr	Flacourtaceae	Akuukkuu	T	Z066
89	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae		T	Z040
90	*Gardenia ternifolia* Schumach. &Thonn.	Rubiaceae	Gambeela	T	Z033
91	*Geranium arabicum* Forssk.	Geraniaceae		H	Z070
92	*Girardinia diversifolia* (Link) Friis	Urticaceae	Doobbii	H	Z124
93	*Glycine wightii* (Wight& Am.) Verdc.	Fabaceae		H	Z115
94	*Gnidia glauca* (Fresen.) Gilg	Thymelaeaceae	Qaqaroo	S	Z175
95	*Gouania longispicata* Engl.	Rhamnaceae		L	Z195

96	*Grewia ferruginea* Hochst.ex A. Rich.	Tiliaceae	Dhoqonuu	T	Z056
97	*Guizotia schimperi* Sch. Bip. ex Walp.	Asteraceae	Tuufoo	H	Z069
98	*Helinus mystacinus* (Ait.) E. Mey. ex Steud.	Rhamnaceae	Hidda hoomachoo	L	Z050
99	*Heliotropium zeylanicum* (Burm f.) Lam.	Boraginaceae	Maxxannee	H	Z029
100	*Hygrophila schulli* (Hamilt.) M.R. & S.M Almeida	Acanthaceae	Qoraatii saree	H	Z096
101	*Hymenodictyon floribundum* (Hochst. & Steud.) Robinson	Rubiaceae	Gaarrii	T	Z154
102	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich) Stapf	Poaceae	Sanbaleeta	H	Z090
103	*Hypericum quartinianum* A. Rich.	Guttiferae	Hinnee	T	Z181
104	*Hypoestes aristata* (Vahl) Nees	Acanthaceae	Darguu	H	Z092
105	*Ilex mitis* (L.) Radlk.	Aquifoliaceae		T	Z206
106	*Ipomoea plebeia* Meeuse	Convolvulaceae		H	Z081
107	*Justicia ladanoides* Lam.	Acanthaceae		H	Z083
108	*Justicia schimperiana* (Hochst. ex Nees) T. Anders.	Acanthaceae	Dhummuugaa	S	Z171
109	*Kalanchoe marmorata* Bak.	Crassulaceae	Bosoqqee	H	Z048
110	*Laggera crispata* (Vahl) Hepper & Wood	Asteraceae		H	Z189
111	*Landolphia buchananii* (Hall.f.) Stapf	Apocynaceae	Hidda geeboo	L	Z208
112	*Lantana trifolia* L.	Verbenaceae		S	Z198
113	Leonotis ocymifolia (Burm. f.) Iwarsson	Lamiaceae		S	Z211
114	*Lippia abyssinica* (Otto & Dietr.)	Verbenaceae		S	Z078
115	*Lippia adoensis* Hochst. ex Walp	Verbenaceae	Kusaayee	S	Z006
116	*Loudetia flavida* (Stapf) C. E. Hubb.	Poaceae		H	Z043
117	*Maesa lanceolata* Forssk.	Myrsinaceae	Abbayyii	T	Z059
118	*Malva verticillata* L.	Malvaceae	Hincinnii	H	Z044

119	*Maytenus arbutifolia* (A.Rich.) Wilczek	Celastraceae	Kombolcha	S	Z007
120	*Maytenus gracilipes* (Welw. ex Oliv.) Exell	Celastraceae	Acaacii	S	Z100
121	*Maytenus obscura* (A. Rich.) Cuf.	Celastraceae	Kombolcha	S	Z073
122	*Medicago polymorpha* L.	Fabaceae	Siddisa	H	Z074
123	*Microglossa pyrifolia* (Lam.) O. Kuntze	Asteraceae		S	Z110
124	*Mikaniopsis clematoides* (Sch. Bip. ex A. Rich.) Milne-Redh.	Asteraceae		H	Z091
125	*Millettia ferruginea* (Hochst.) Bak.	Fabaceae	Sootalloo	T	Z117
126	*Mimosa pigra* L.	Fabaceae	Arangamaa	S	Z214
127	*Mimusops kummel* A. DC.	Sapotaceae	Qolaatii	T	Z140
128	*Monechma debile* (Forssk.) Nees	Acanthaceae		H	Z028
129	*Myrsine africana* L.	Myrsinaceae	Qacama	S	Z065
130	*Nuxia congesta* R.Br. ex Fresen.	Loganiaceae	Qawwisa	T	Z194
131	*Ocimum lamiifolium* Hochst. ex. Benth.	Lamiaceae	Ancabbii diimaa	S	Z014
132	*Ocimum urticifolium* Roth.	Lamiaceae	Ancabbii adii	S	Z084
133	*Olea capensis* L. subsp. *macrocarpa* (C.H. Wright) Verdc.	Oleaceae	Gagamaa	T	Z147
134	*Olea europaea* L. subsp. *cuspidata* (Wall.ex G.Don) Cif.	Oleaceae	Ejersa	T	Z097
135	*Olinia rochetiana* A.Juss.	Oliniaceae	Daalachoo	T	Z025
136	*Ophrestia radicosa (A. Rich.)* Verde.	Fabaceae	Hidda bofaa	H	Z017
137	*Oplismenus hirtellus* (L.) P. Beauv.	Poaceae	Ashuffee	H	Z053
138	*Oreosyce africana* Hook.f.	Cucurbitaceae		H	Z186
139	*Osyris quadripartita* Decne	Santalaceae	Waatoo	T	Z026
140	*Panicum monticola* Hook.f.	Poaceae	Marga gogorrii	H	Z105
141	*Pavetta abyssicica* Fresen.	Rubiaceae		S	Z024

142	*Pellaea calomelanos* (Sw.) Link	Sinopteridaceae		H	Z071
143	*Pennisetum thunbergii* Kunth	Poaceae	Migira saree	H	Z102
144	*Periploca llnearlfolia* Quart.-Dill. & A. Rich.	Asclepiadaceae	Hidda aannannoo	L	Z160
145	*Phaulopsis imbricata* (Forssk.) Sweet	Acanthaceae		H	Z049
146	*Phoenix reclinata* Jacq.	Arecaceae	Meexxii	T	Z129
147	*Phyllanthus mooneyi* M. Gilbert	Euphorbiaceae		S	Z187
148	*Phyllanthus ovalifolius* Forssk.	Euphorbiaceae	Qacamoo	T	Z104
149	*Phymatosorus scolopendria* (Burn.f.) Pic. Serm	Polypodiaceae		H	Z184
150	*Phytolacca dodecandra* L'Herit.	Phytolaccaceae	Andoodee	S	Z148
151	*Pittosporum viridiflorum* Sims	Pittosporaceae	Soolee adii	T	Z210
152	*Plectranthus punctatus* (L.f.) L'H'er.	Lamiaceae		H	Z205
153	*Pliostigma thonningii* (Schumach.) Milne-Redh	Fabaceae		T	Z127
154	*Podocarpus falcatus* (Thunb.) R.B. ex. Mirb.	Podocarpaceae	Birbirsa	T	Z098
155	*Polypogon schimperianus* (Hochst. ex Steud.) Cope	Poaceae	Daggala	H	Z042
156	*Premna schimperi* Engl.	Lamiaceae	Urgeessaa	S	Z009
157	*Prunus africana* (Hook.f.) Kalkm.	Rosaceae	Hoomii	T	Z203
158	*Pseudognaphalium luteo-album* (L.) Hilliard & Burtt	Asteraceae		H	Z022
159	*Psychotria orophila* Petit	Rubiaceae		S	Z099
160	*Pterolobium stellantum* (Forssk.) Brenan	Fabaceae	Arangamaa	L	Z138
161	*Pycnostachys abyssinica* Fresen.	Lamiaceae	Bokkolluu	H	Z121
162	*Rhamnus prinoides* L’Herit.	Rhamnaceae	Geeshoo	S	Z087
163	*Rhamnus staddo* A.Rich.	Rhamnaceae	Qadiidaa	T	Z093
164	*Rhoicissus revoilii* Planch.	Rhamnaceae	Indirifaa	L	Z061
165	*Rhus natalensis* Krauss	Anacardiaceae	Xaaxessaa	T	Z019

166	*Rhus vulgaris* Meikle	Anacardiaceae	Xaaxessaa	T	Z002
167	*Ricinus communis* L.	Euphorbiaceae	Qobboo	S	Z202
168	*Rosa abyssinica* Lindley	Rosaceae	Qaqawwii	S	Z060
169	*Rothmannia urcelliformis* (Hiem) Robyns	Rubiaceae	Qola-gurraa	T	Z146
170	*Rubia cordifolia* L.	Rubiaceae	Maxxannee	H	Z036
171	*Rubus apetalus* Poir.	Rosaceae	Goraa	L	Z201
172	*Rubus steudneri* Schweinf.	Rosaceae	Goraa	L	Z188
173	*Rumex nepalensis* Spreng.	Polygonaceae	Timijjii	H	Z191
174	*Rytigynia neglecta* (Hiern) Robyns	Rubiaceae	Mixoo	S	Z079
175	*Salix mucronata* Thunb. (S. subserrata Willd)	Salicaceae	Alaltuu	T	Z193
176	*Sapium ellipticum* (Krauss) Pax.	Euphorbiaceae	Bosoqa	T	Z139
177	*Satureja abyssinica* (Benth.) Briq.	Lamiaceae		H	Z174
178	*Satureja punctata* (Benth.) Briq.	Lamiaceae		S	Z106
179	*Schefflera abyssinica* (Hochst. ex A. Rich.) Harms	Araliaceae	Gatamaa	T	Z086
180	*Schrebera alata* (Hochst.) Welw.	Oleaceae	Qana'ee	T	Z004
181	*Scutia myrtina* (Burm. f.) Kurz	Rhamnaceae	Kombolcha adii	S	Z111
182	*Senna petersiana* (Bolle) Lock	Fabaceae	Gaafatoo	T	Z072
183	*Senna septemtrionalis* (Viv.) Irwin & Bameby	Fabaceae		S	Z190
184	*Setaria megapbylla* (Steud.) Th. Dur. & Schinz	Poaceae	Jajjaba	H	Z054
185	*Sida ternata* L.f.	Malvaceae	Hincinnii	H	Z082
186	*Sida rhombifolia* L.	Malvaceae	Karabaa	S	Z156
187	*Sida schimperiana* Hochst. ex A. Rich.	Malvaceae	Cirfiggii	S	Z012
188	*Sida urens* L.	Malvaceae	Hincinnii	S	Z035
189	*Solanum aculeatissimum* Jacq.	Solanaceae	Hiddii waraabessaa	S	Z037

190	*Solanum anguivi* Lam.	Solanaceae	Hiddii saree	S	Z133
191	*Solanum giganteum* Jacq.	Solanaceae		S	Z046
192	*Solanum macracanthum* A. Rich.	Solanaceae	Hiddii	S	Z015
193	*Solanum marginatum* L.f.	Solanaceae	Hiddii hongorcaa	S	Z155
194	*Sphaerantuhs suaveolens* (Forssk) DC.	Asteraceae	Bokkolluu	H	Z112
195	*Sporobolus africanus* (Poir.) Robyns & Tourny	Poaceae	Murii	H	Z010
196	*Stereospermum kunthianum* Cham.	Bignoniaceae	Botoroo	T	Z077
197	*Syzygium guineense* (Willd.) DC.	Myrtaceae	Baddeessaa	T	Z076
198	*Tagetes minuta* L.	Asteraceae		H	Z032
199	*Tapinanthus heteromorphus* (A. Rich.] Danser	Loranthaceae	Digaluu	S	Z057
200	*Teclea nobilis* Del.	Rutaceae	Hadheessa	T	Z159
201	*Teramnus labialis* (L. f.) Spreng.	Fabaceae		H	Z158
202	*Terminalia macroptera* Guill & Perr.	Combretaceae	Dabaqqaa	T	Z161
203	*Terminalia schimperiana* Hochst.	Combretaceae	Gaarrii	T	Z126
204	*Thalictrum rhynchocarpum* Dill. & A.Rich.	Ranunculaceae	Sire bizuu	H	Z163
205	*Thunbergia alata* Boj. ex Sims	Convolvulaceae		H	Z143
206	*Tragia ashiae* M.Gilbert	Euphorbiaceae	Gurgubbee	H	Z039
207	*Tragia brevipes* Pax	Euphorbiaceae	Gurgubbee	H	Z031
208	*Urera hypselodendron* (A.Rich,) Wedd.	Urticaceae	Laanqisaa	L	Z172
209	*Vangueria apiculata* K. Schum.	Rubiaceae	Buruurii	S	Z064
210	*Vernonia amygdalina* Del.	Asteraceae	Eebicha	T	Z177
211	*Vernonia hochstetteri* Sch.Bip. ex Walp.	Asteraceae	Sooyyoma	S	Z173
212	*Vernonia hymenolepis* A. Rich.	Asteraceae	Sooyyoma	S	Z180
213	*Vernonia leopoldi* (Sch. Bip. ex Walp.) Vatke	Asteraceae		S	Z109
214	*Vernonia myriantha* Hook.f.	Asteraceae	Reejjii	T	Z134

Appendix 4: Proportions of species recorded in each plant families from Dirki and Jato Woodland Vegetation

Family	Number of genera	Number of species	% of species
Fabaceae	18	23	10.75
Asteraceae	15	22	10.28
Poaceae	11	12	5.61
Euphorbiaceae	9	11	5.14
Acanthaceae	7	9	4.21
Rubiaceae	9	9	4.21
Lamiaceae	7	9	4.21
Combertaceae	2	7	3.27
Malvaceae	3	6	2.80
Moraceae	1	6	2.80
Rhamnaceae	5	6	2.80
Solanaceae	1	5	2.34
Oleaceae	3	4	1.87
Ranunculaceae	2	4	1.87
Rosaceae	3	4	1.87
Boraginaceae	3	3	1.40
Celastraceae	1	3	1.40
Loganiaceae	2	3	1.40
Sapindaceae	2	3	1.40
Verbenaceae	2	3	1.40
Amaranthaceae	2	2	0.93
Anacardiaceae	1	2	0.93
Apocynaceae	2	2	0.93
Convolvulaceae	2	2	0.93
Crassulaceae	2	2	0.93
Cucurbitaceae	2	2	0.93

Ebenaceae	2	2	0.93
Flacourtaceae	2	2	0.93
Loranthaceae	2	2	0.93
Myrsinaceae	2	2	0.93
Myrtaceae	2	2	0.93
Rutaceae	2	2	0.93
Urticaceae	2	2	0.93
Adiantaceae	1	1	0.47
Aloaceae	1	1	0.47
Aquifoliaceae	1	1	0.47
Araliaceae	1	1	0.47
Arecaceae	1	1	0.47
Asclepiadaceae	1	1	0.47
Bignoniaceae	1	1	0.47
Capparidaceae	1	1	0.47
Commelinaceae	1	1	0.47
Cyperaceae	1	1	0.47
Dioscoreaceae	1	1	0.47
Dracaenaceae	1	1	0.47
Geraniaceae	1	1	0.47
Gleicheniaceae	1	1	0.47
Guttiferae	1	1	0.47
Hycinthaceae	1	1	0.47
Icacinaceae	1	1	0.47
Meliaceae	1	1	0.47
Melianthaceae	1	1	0.47
Menispermaceae	1	1	0.47
Oliniaceae	1	1	0.47
Orchidaceae	1	1	0.47

Phytolaccaceae	1	1	0.47
Pittosporaceae	1	1	0.47
Podocarpaceae	1	1	0.47
Polygonaceae	1	1	0.47
Polypodiaceae	1	1	0.47
Salicaceae	1	1	0.47
Santalaceae	1	1	0.47
Sapotaceae	1	1	0.47
Simaroubaceae	1	1	0.47
Sinopteridaceae	1	1	0.47
Sterculiaceae	1	1	0.47
Thymelaeaceae	1	1	0.47
Tiliaceae	1	1	0.47
Ulmaceae	1	1	0.47
	167	214	100

Appendix 5: Regeneration status of woodland vegetation of Dirki and Jato under three categories (SE= seedling, SA= sapling, MA= mature tree)

Category one	**Category two**	**Category three**
No SE and SA at all	**SE + SA < MT**	**SE + SA > MT**
Acacia abyssinica	*Albizia schimperiana*	*Bridelia micrantha*
Apodytes dimidiata	*Allophylus abyssinicus*	*Calpurnia aurea*
Chionanthus mildbraedii	*Bersama abyssinica*	*Clausena anisata*
Cordia africana	*Celtis africana*	*Combretum paniculatum*
Diospyros abyssinica	*Combertum molle*	*Dodonaea angustifolia*
Ekebergia capensis	*Croton macrostachyus*	*Dombeya torrida*
Ficus mucuso	*Dalbergia lactea*	*Dovyalis abyssinica*
Ficus sur	*Ehretia cymosa*	*Euclea divinorum*
Ficus sycomorus	*Grewia ferruginea*	*Flacourtia indica*
Ficus thonningii	*Hymenodictyon floribundum*	*Gnidia glauca*
Ficus vasta	*Hypericum quartinianum*	*Maesa lanceolata*
Mimusops kummel	*Maytenus arbutifolia*	*Myrsine africana*
Prunus africana	*Millettia ferruginea*	*Olinia rochetiana*
Rothmannia urcelIiformis	*Nuxia congesta*	*Phyllanthus ovalifolius*
	Olea capensis subsp. *macrocarpa*	*Podocarpus falcatus*
	Olea europaea subsp. *cuspidata*	*Premna oligotricha*
	Osyris quadripartita	*Psychotria orophila*
	Rhus vulgaris	*Rhamnus staddo*
	Sapium ellipticum	*Rhus natalensis*
	Schrebera alata	*Rytigynia neglecta*
	Stereospermum kunthianum	*Senna petersiana*
	Terminalia macroptera	*Syzygium guineense*
		Vangueria apiculata
		Vernonia myriantha

Declaration

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

Name Zerihun Tadesse Gemeda Signature__________ Date_________________

This work has been done under our supervision.

Prof. Ensermu Kelbessa Signature______________ Date ________________

Dr. Tamrat Bekele Signature______________ Date_________________