Floristic Composition and Diversity Analysis of Vegetation of Awash Melka Kunture Prehistoric Archaeological Site, Ethiopia

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This is to certify that the thesis prepared by Mekbib Fekadu, entitled: *Floristic Composition and Diversity Analysis of Vegetation of Awash Melka Kunture Prehistoric Archaeological Site*, *Ethiopia* and submitted in partial fulfilment of the requirements for the Degree of Master of Science (Plant Biology and Biodiversity Management: Plant Biodiversity and 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 Diversity Analysis of Vegetation of Awash Melka Kunture Prehistoric Archaeological Site, Ethiopia

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The study was conducted at Awash Melka Kunture Prehistoric Archaeological Site (AMKPAS), in Awash Melka District, Oromia National Regional State, Ethiopia. This study presents the floristic composition, plant community, regeneration status of the area, and recommends further conservation methods. Sixty quadrats of 10 m x 10 m (100 m^2) were laid along ten line transects for vegetation data collection. In addition, 1 m x 1 m subplots were laid within the main plot to sample herbaceous plants. A total of 139 plant species in 114 genera and 45 families were identified. Family Poaceae had 24 (14.27%) species followed by Fabaceae 23 (16.55%) species, Asteraceae 16 (11.51) species and Lamiaceae nine (6.47%) species. Out of the 139 plant species collected from the area six species and one subspecies are endemic to Ethiopia. Vegetation classification following R-2.11.1 software package resulted in five communities, namely, Ocimum lamiifolium - Rhus natalensis, Grewia ferruginea – Acacia abyssinica, Acacia seyal - Jasminum grandiflorum, Carissa spinarum - Acacia persiciflora and Acacia lahai - Euclea racemosa. Sorensen's similarity among the communities revealed that communities 1 and 5 have the highest similarity (71%) followed by communities 1 and 4, and 4 and 5, both exhibited 69% similarity. From nine selected woody species, a total of 183.9 seedlings/ha, 154.79 saplings/ha and 54.38 mature individuals/ha were counted in the sample plots. The study revealed the occurrence of small sized individuals in the study site. Two population distribution patterns were revealed i.e. inverted J and bell -shaped. Moreover, there were more seedlings than saplings which could be attributed to factors that prevent the seedlings from reaching sapling stage. These factors may include expansion of farmlands, browsing by animals and prolonged dry period. On the other hand, some woody species lacked seedlings and saplings in the AMKPAS. Based on the current study clear demarcation and raising awareness among the surrounding community is deemed necessary.

Key words/Phrases: Awash Melka Kunture, Community similarity, Floristic composition, Plant community, and Regeneration

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DEDICATION

This paper is dedicated to my late, biological father Fekadu Gelaw, biological mother Zufan Sitotaw and my Grand mothers Temalda W/Kidan, Doris Coward and aunt Nigiste Mekuanint. I wish for you all that your souls rest peacefully in heaven.

ACRONYMS

AAU	Addis Ababa University
AMKPAS	Awash Melka Kunture Prehistoric Archaeological Site
DBH	Diameter at Breast Height
ENMSA	Ethiopian National Meteorological Station Agency
ETH	National Herbarium
GTZ	German Technical Cooperation
IAG	International Association of Geomorphologists
IBC	Institute of Biodiversity Conservation
IBCR	Institute of Biodiversity Conservation and Research
IVI	Important value index
m	meter
m.a.s.l	meters above sea level
RD	Relative density
RF	Relative frequency
SIV	Species important value
SIVI	Species Important Value Index
USAID	United States Agency for International Development

1. INTRODUCTION

Ethiopia is the tenth largest country in Africa and is located in the tropics in the Horn of Africa between 3°24' to 15°N latitude and 33°00' and 48°00'E longitude and covers a land surface area of 1,113,000 km^2 (Zemede Asfaw, 1997; IBC, 2005 and Friis *et al*., 2010). Ethiopia has great topographical diversity with flat-topped plateaus, high mountains, river valleys, deep gorges, rolling plains, and with great variation of altitude from 126 meters below sea level to 4620 m a.s.l. (Girma Balcha *et al*., 2003; IBC, 2005 and Tesfaye Awas, 2007). With extreme variations in climate and terrain and the wide range of ecological systems, Ethiopia possesses one of the largest and most diverse plant genetic and wildlife genetic resources in the world (Ensermu Kelbessa *et al*., 1992; Million Bekele and Leykum Berhanu, 2001).

Ethiopia's flora consists of about 6,000 species of higher plants of which about 10% is considered endemic to the flora area (Ensermu Kelbessa, per.commun.). The country also has over 300 tree species of which a few are important for industry and construction (Ensermu Kelbessa, pers. commun.; Million Bekele and Leykum Berhanu, 2001). The plant species are distributed from below 100 up to 4500 m a.s.l. Species distribution reaches a maximum of 1600 taxa between 1200 and 1500 m. a.s.l., but shows decline below and above this altitudinal range (Friis and Sebsebe Demissew, 2001). Similarly, the highest numbers of endemic or near-endemic taxa are found in the same zone. But, the sum of near-endemic and strict endemic plants is still relatively high in between 0 and 305 m a.s.l. (Friis and Sebsebe Demissew, 2001).

According to Friis and Sebsebe Demissew (2001), the flora composition and richness varies from region to region and one of the southern floristic regions rank first both in taxon richness and endemism. Sidamo floristic region has the highest number of taxa and the highest single floristic region endemics, but Shewa floristic region has the highest number of country endemics. The highland regions from Shewa and northward form a center of diversity and endemism in Ethiopian plants. Among the uplands, Shewa, Tigray and Gonder contain the highest number of taxa. Tigray has a relatively higher number of taxa than Gonder. Whereas Gojam and particularly Wello are under studied. Also the south-western region, centered in Kefa, has the smallest taxa richness and total number of flora endemics, including forests.

Historical sources depict that extensive forest once covered some 35% of Ethiopia's land area. If the savanna woodland is included, two-thirds of the country was probably forested or was covered with woodland. These habitats have dramatically declined in size and quality in the last century. By the beginning of the early 1950's, high forest areas were reduced to 16% of the total land area; by the early 1980's, land area covered by forest had declined to 3.6 %; by 1989, it was reduced to about 2.7% (Million Bekele and Leykum Berhanu, 2001).

Estimates by Reusing (1998; 2000), who used LANDSAT/MSS, showed for the first time the extent of forest/vegetation cover in Ethiopia based on density classes, i.e., closed high forest (80% of the polygon is covered by forest), slightly disturbed high forest and heavily disturbed high forest. He recorded the percent cover of these different categories of forests in 1996-1997, i.e, 0.16% of closed high forest, 0.65% of slightly disturbed high forest and 0.92% of heavily disturbed high forest. Therefore, the forest cover of Ethiopia, including all the three types was 1.41% in 1996 – 1997.

Forest reduction in Ethiopia is mostly attributable to anthropogenic factors. The most prominent ones are deforestation, expansion of agricultural land, overgrazing, unsustainable utilization and invasion of exotic species (Chaffey, 1980; Shibru Tedla, 1995; Feyera Senbeta and Demel Teketay, 2003; Million Bekele and Leykum Berhanu, 2001; Teshome Soromessa *et al.*, 2004). Ensermu Kelbessa *et al.* (1992) also stated that in Ethiopia limitations to opportunities for income generation caused by ecological and socioeconomic constraints force people to cultivate marginal lands and allow over grazing and the felling of trees, thus catalyzing environmental degradation and deforestation.

On the other hand, lack of integration of the local people living around the conservation areas into the conservation efforts, is the major constraint to the overall conservation effort in Ethiopia (Feyera Senbeta and Demel Teketay, 2003). Because of this, it has now been realized that unless the local community is involved in the conservation effort, the sustainability of forest resource will always be uncertain (Aklilu Ameha, 2002). Hartmann (2004) also emphasized that the different efforts of the Ethiopian government for reforestation and protection of the remaining forests, failed due to lack of participation of the local communities in resource management.

Melka Kunture is a valley site formed mainly of fluvial sediments, extending for over 5 km along the banks of the Awash River. The fluvial sediment deposits attain a maximum depth of 100 m and are interspersed with tuff and cinerite, which provide important chronological markers (Andrea *et al*., 2002). Melka Kunture Prehistoric Site has an area of around 3000 km^2 in surface area and its altitude varies from 2000 to 2050 m. It is characterized by Pliocene volcanoes, especially Wachacha and Furi in the north, and Boti and Agoiabi in the south (Bardin *et al*., 2004). It contains a sequence of Palaeolithic sites with lithic industries, and faunal and Hominid remains distributed over *in situ* living floors. The area was discovered in 1963 by G. Decker. Since then Bailloud in 1963 and Chavaillon in 1965 -1981 and 1992-1995 carried out surveys and extensive archaeological excavations in the area, with the help of local workers and Ethiopian authorities (Berthelet *et al*., 2001).

Although many archaeological studies have been undertaken in Awash Melka Kunture Prehistoric Archaeological Site, no previous studies have addressed the botanical and ecological aspects of the area. In light of this, the generation of sound biodiversity and ecological data on the remaining high quality habitat area is necessary for subsequent conservation activities. Therefore, this study investigates the floristic composition and vegetation analysis of the area in the framework of other studied natural forests of Ethiopia.

1.1. Statement of the Problem

Awash Melka Kunture is one of the archaeological sites in Ethiopia where one finds a high level of plant species diversity and remarkable vegetation stands. This area is highly valued for its high archaeological, economic and other ecological services. Despite all these services, plant vegetation decline will apparently continue for some time to come for the simple reason that plants are still the principal sources of construction and timber materials for the rural and urban population and for the cut flower industry. Therefore, detailed botanical and ecological studies are needed to understand the ecosystem services of this biodiversity assemblage and to undertake appropriate conservation measures. The absence of any previous ecological or botanical study is also a reason for immediate and timely scientific interventions.

1.2. Objectives of the Study

1.2.1. General Objective

- To document and describe the floristic composition and make a vegetation analysis of Awash Melka Kunture Prehistoric Archaeological Site

1.2.2. Specific Objectives

- To document the floristic composition of Awash Melka Kunture;
- To classify the vegetation into plant community types;
- To estimate the diversity of the different community types;
- To analyze the vegetation structure of Awash Melka Kunture;
- To determine the regeneration status of some woody species;
- To make management and conservation recommendations for the area.

2. LITERATURE REVIEW

2.1. Vegetation of Ethiopia

Vegetation refers to an assemblage of plants growing together in a particular location, or the collective plant cover of an area (Jennings *et al*., 2003). The vegetation resources of Ethiopia, including forests, woodlands and bushlands have been studied by several scholars. Most of the studies, including identification and descriptions of the vegetation, were undertaken by foreign travellers between the beginning of the 19th century and the mid 20th century. For instance, Pichi-Sermolli (1957) identified 23 vegetation types and Breitenbach (1963) published the indigenous trees of Ethiopia. Attempts to describe this vegetation were also conducted by many Ethiopian scholars of which Hailu Sharew (1982), Lissanework Nigatu (1987), Tamrat Bekele (1994), Sebsebe Demissew *et al*., (1996), Kumilachew Yeshitela (1997), Teshome Soromessa (1997), Sebsebe Demissew (1998) and Zerihun Woldu (1999) were a few. These authors have described the vegetation of Ethiopia by taking factors like climate, slope, aspect, altitude, soil, etc., into consideration.

The vegetation of Ethiopia has been classified into twelve vegetation types (Friis *et al*., 2010). These are: 1) Desert and semi-desert scrubland, 2) *Acacia-Commiphora* woodland and bushland, 3) Wooded grassland of the western Gambela region, 4) *Combretum-Terminalia* woodland and wooded grassland, 5) Dry evergreen Afromontane forest and grassland complex, 6) Moist evergreen Afromontane forest, 7) Transitional rain forest, 8) Ericaceous belt, 9) Afroalpine belt, 10) Riverine vegetation, 11) Salt lakes, salt-lake shores, marsh and pan vegetation and 12) Freshwater lakes, lake shores, marsh and floodplain vegetations.

2.1.1. Wooded grasslands

This vegetation type occurs only in western part of Gambella region. The vegetation is characterized by a tall grass stratum that burns annually, and a canopy layer of trees that can both tolerate burning and temporary flooding. The most dominant species in tree stratum are species of *Acacia seyal* and *A. nilotica*. The palms *Hyphaene thebaica* and *Borassus aethiopum*, may also occur, either singly or together. In grass stratum species of *Echinochloa*, *Setaria*, *Hyparrhenia*, *Cymbopogon*, and *Sorghum* are common. This vegetation is suffered from frequent occurrence of flood and fire (Friis *et al*., 2010).

2.1.2. Dry evergreen Afromontane forest and grassland complex

This is a very complex vegetation type occurring between 1500 m and 3000 m in altitude, with an average temperature and rainfall 14-45^{o}C and 700-1100 millimetre, respectively (Friis, 1992 and Zerihun Woldu, 1999).

The Ethiopian highlands contribute to more than 50 % of the land area with Afromontane vegetation, of which dry montane forests form the largest part (Tamrat Bekele, 1994). The evergreen scrubland vegetation occurs in the highlands of Ethiopia either as an intact scrub or usually as secondary growth after deforestation of the dry evergreen montane forest (USAID, 2008). The drier eastern and higher altitude forests mostly consist of *Juniperus procera* and/or *Olea europaea* subsp. *Cuspidatea* as the main trees with *Acacia abyssinica* or *Acacia negrii*. Other large trees, including *Podocarpus falcatus, Olea capensis* subsp. *Hochstetteri, Prunus africana, Apodytes dimidiatea,* also occur. The species *Discopodium penninervium, Myrsine africana*, *Calpurnia aurea* and *Dovyalis abyssinica* constitute the shrub layers. Various species of grasses from the genera of *Hyparrenia*, *Andropogon*, *Chloris*, *Pennisetum* and many more are present. Many other herbs including geophytes also occur (Zerihun Woldu, 1999 and Friis *et al*., 2010).

2.1.3. Riverine vegetation

The riverine forest vegetation is highly variable in structure and density, and the floristic composition is dependent on altitude and geographical location. There are some number of species of woody plants that are only recorded from riverine forest in Ethiopia. Typical specie include: *Acacia polyacantha*, *Celtis africana*, *Ficus sycomorus*, *Mimusops kummel*, *Mimusops laurifolia* and *Breonadia salicina* (Friis *et al*., 2010).

As described by Friis *et al*. (2010), this vegetation is found almost in all parts of the country with permanent or temporary rivers and other streams below 1800 m. However, it is relatively rare in the driest parts of Afar, Harerge and Sidama floristic regions.

2.2. Threats to Ethiopian Vegetation

Trees, woodlands, and forests can be seen as an environment's lungs. They play a crucial role in tempering the effects of climate and help protect vital water catchments. Trees provide a wide range of products, including food and fruit, fodder for livestock, and medicines for both people and livestock. Forests supply goods of commercial, cultural, and sacred value, and they comprise a vital safety net in times of need. The trees and forests of Ethiopia are under tremendous pressure with a drastic decline in mature forest cover due to the continual pressures of population increase, rudimentary farming techniques, land use competition, land tenure, and forest degradation and conversion (USAID, 2008). Environmental problems such as soil degradation, erosion, decrease in biodiversity and the loss of potential natural resources are negative effects resulting from the destruction of forests. Also, indigenous knowledge on medicinal and other useful plants is eroded with the destruction of the forests (Kitessa Hundera and Tsegaye Gadissa, 2008*)*. To address these threats, it is critical to raise government decision makers' awareness of the importance of natural resource policies to Ethiopia; facilitate dialogue among the government, civil society, and national and international organizations; and to closely examine and revise those policies requiring clarification or harmonization. Family planning can also help to reduce family size and slow population growth, and efforts toward generating alternative livelihood activities can give people options other than farming or herding that are less dependent on limited natural resources (Regassa Feyissa, 2001). Other key actions include increased enforcement of rules and boundaries; environmental education; and efforts to strengthen the relationships among protected areas and communities, with emphasis on returning the benefits of the protected areas to those communities. Taking the lost opportunities into account, foresters and conservationists have to develop new initiatives to respond to the convergence of local communities and forests (Regassa Feyissa, 2001).

2.3. Plant Community

Plant communities are groups of plants that occur together in repeating groups of associated plants. A particular community is characterized by the identity and growth forms of the most abundant species, the largest species, or the most characteristic species. Plant communities cannot reproduce in environmentally different habitats or different climates without losing their identity (Mueller-Dombois and Ellenberg, 1974).

Plant communities are largely based on physiognomy or the growth form of the vegetation, for example woodland as opposed to scrub or grassland. According to Kent and Coker (1992), plant communities are also defined as the collection of plant species growing together in a particular location that show a definite association or affinity with each other. Certain species are found growing together in certain locations and environments more frequently than would be expected by chance. This is because they have similar requirements for existence in terms of environmental factors such as light, temperature, water, drainage and soil.

2.3.1. Species diversity, richness and similarity

The description of a plant community involves the study of species diversity, evenness and similarity. The diversity and equitability of species in a given plant community is used to interpret the relative variations between and within the community and help explain the underlying reasons for differences. The idea of species diversity involves two relatively distinct concepts: species richness and evenness. Species richness refers to the total number of species in a community while evenness is the relative abundance of species within the sample or community (Kent and Coker, 1992). Diversity is thus measured by recording the number of species and their relative abundances. The two components may be examined separately or combined in some form of index like the Shannon Diversity Index. Patterns of plant species diversity have often been noted for prioritizing conservation activities because they reflect the underlying ecological processes that are important for management (Lovett *et al*., 2000; cited in Feyera Senbeta, 2006).

Species diversity can be viewed from different perspectives: alpha, beta and gamma diversity. Alpha diversity refers to the diversity of species within a particular habitat or community. Beta diversity is a measure of the rate and extent of change in species composition along a gradient from one habitat to another. Between-habitat diversity is used as a measure of turnover rates. Beta diversity is sometimes called habitat diversity (Kent and Coker, 1992). Gamma diversity is the diversity of species in comparable habitats along a geographical transect and it depends on the alpha and beta diversity (Kent and Coker, 1992). A species diversity index provides information about community composition rather than simply species richness. Measures of species diversity are usually seen to be key indicators for the wellbeing of ecological systems. Among many species diversity indices, diversity and evenness are often calculated using the Shannon Diversity Index, which varies between 1.5

and 3.5 and rarely, exceeds 4.5 (Kent and Coker, 1992). It is the most widely used index that combines species richness with evenness.

2.3.2. Abundance and frequency

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

2.3.4. Species importance value index (SIV) and dominance

SIV permits a comparison of species in a given location and reflects the dominance, occurrence and abundance of a given species in relation to other associated species in an area (Kent and Coker, 1992). Therefore, for setting conservation priority, it is a good index for summarizing vegetation characteristics and ranking species for management and conservation practices.

3. MATERIALS AND METHODS

3.1. The Study Area

3.1.1. Location and description

The study was conducted in the Awash Melka Kunture Prehistoric Archaeological Site Southwest Shewa Zone of Oromia National Regional State, Ethiopia (Figure 1). Awash Melka Kunture Prehistoric Archaeological Site (with central coordinates of $8^{o}41'00''$N and $37^{0}41'00''$E) is located 50 kilometres south of Addis Ababa. The area is a valley site which extends for almost 5 km on both Awash River banks, with superimposed terraces whose remains are preserved to a maximum of 100 m of sediments (Piperno, 2001). The basin surface is around 3,000 km^2 and its altitude varies from 2000 to 2050 m (Bardin *et al.*, 2004).

The name of Awash Melka Kunture comes from a ford on the Awash River found southwest of the town (Bulgarelli and Piperno, 2000; OUPICB, 2008). The site was discovered and brought to the attention of the Ethiopian Archaeological Service for the first time in 1963 by G. Dekker. Then G. Bailloud in 1963, and J. Chavaillon in 1965–1981 and 1992–1995, carried out surveys and excavations in the area, with the help of local workers and the Ethiopian Authorities. They have collected important lithic materials and faunal remains (Berthelet *et al.*, 2001; Piperno, 2001; IAG, 2011).

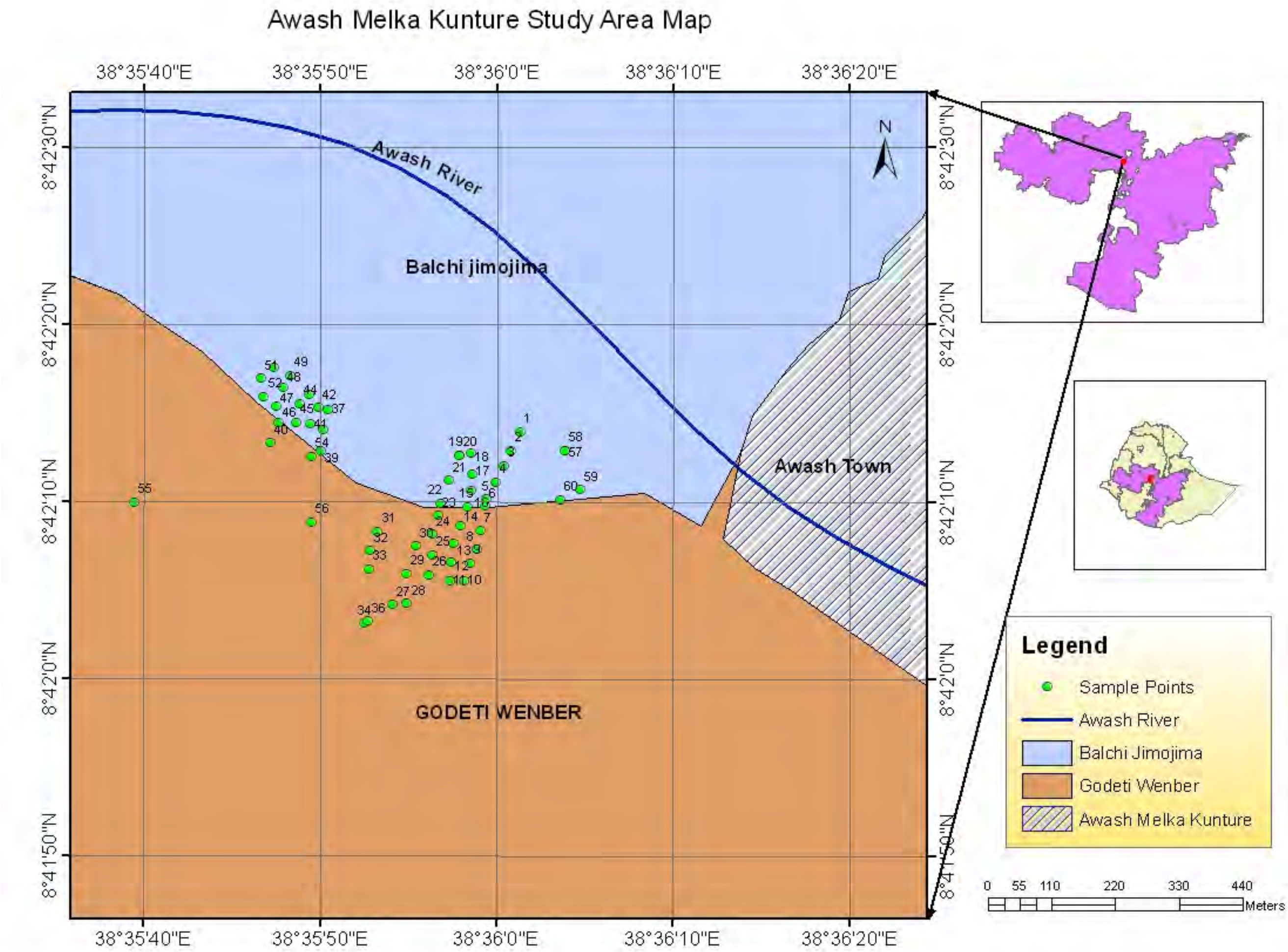

Figure 1: Location map of Awash Melka Kunture Archaeological Site

3.1.2. Topography

Awash Melka Kunture town has plain landform structure except to the west of the town, which is up and down, and there is a gorge in the northeast (OUPICB, 2008).

3.1.3. Drainage

The Awash River that originates in West Shewa Zone, Dendi District highland, forms a boundary of the town in the south direction. The Mulate seasonal river bounds the town in the north direction (OUPICB, 2008). The regional drainage pattern is defined by a large variety of graphic characters and the Awash River is the main drainage feature. It flows either west to east or northwest to southeast. Many of its tributaries flow in directions almost orthogonal to its route. Dilu, Geber and Haro-Dila plains are grouped on an east-west line; they also function as reservoirs and as a source of river supplies (Bardin *et al.*, 2004).

3.1.4. Land use and population

According to OUPICB (2008), the present total land surface area of the town Awash Melka Kunture is 14,233 km^2. About 90.38 % of it is cultivable land, of which 87.18 % was cultivated and 3.2 % was not cultivated yet. The other 4.16 % is for grazing, and 2.9 % constitute forest, bush and scrub land. The remaining 2.56 % was used for construction, roads, houses and others. Wheat, sorghum, teff (small) crops and maize are the most cultivated crops in the town. The majority of the urban households possess oxen, cows, heifers, sheep, goats and poultry. Additionally, fuel wood and charcoal contribute to the local community income generation (OUPICB, 2008).

Awash Melka Kunture town has a total population of 4,782, of which 2,018 (42.2%) are males and 2,764 (57.8%) are females. From the total population, those under the age of 15 accounted for 43.85 %; 15-64 accounted for 51.72 % and age 65 and above accounted for 4.43 %. This population consists of different ethnic groups, and the majorities are Oromo (77.7 %) and Amhara (17.9 %); Gurage, Tigre, Silte and others make 4.32 % (Table 1).

Table 1: Awash Melka Kunture ethnic composition

No.	Ethnic group	Number of population	%
1	Oromo	3719	77.78
2	Amhara	856	17.9
3	Gurage	52	1.09
4	Tigre	20	0.42
5	Silte	131	2.73
6	Others	4	0.08
	Total	4782	100

3.1.5. Geology

Awash Melka Kunture is a valley site, which extends for about five km on both Awash River banks. It is delimited by Pliocene volcanoes the main ones being Wachacha and Furi in the north and Boti and Agoiabi in the south (Bardin *et al*., 2004). It is mainly made up of valleys with inner terraces which have resisted erosion (Bardin *et al*., 2004). The valley of the Awash River has been a focus of hominid occupation since four to five Million years ago. The water flow of this river and its tributaries provided the sedimentary content of reworked volcanic materials that buried and preserved the archaeological sites within Melka Kunture formation (Hovers and Braun, 2009).

3.1.6. Archaeology

About 1,700,000 years a go, *Homo erectus,* began living on the banks of the Awash, at Melka Kunture and populated the surrounding tributary river banks and savannas. They remained there for several thousand years developing a refined lithic technology using obsidian, other volcanic rocks and the pebble beaches lining the course of Awash River (Bulgarellii and Piperno , 2000). Numerous and varied faunal remains are found. The highest percentage is hippopotamus bones, which are identified as *Hippopotamus amphibious*. The faunal remains also include large Giraffe, Antelope, Gazelle and a substantial number of Equidae. These bone fragments include fragments of pelvis, vertebrae, ribs and limbs; as well as a few fragments of horns (Chavaillon and Piperno, 2004).

3.1.7. Climate

There is no meteorological station in the study area. The climate data for Awash Melka Kunture is taken from Addis Ababa, which is the nearest station to the study area. Addis Ababa is mainly characterized by a dry climate (Shimelis Behailu, 2004). The mean and total annual rainfall is 107 and 1284 mm, respectively. It receives the highest and the lowest annual rainfall during the rainy period March to September, and January, February, November and December; respectively. The mean maximum temperature of the area is 17.2 °C and the lowest mean annual temperature is 8.4 °C. Awash Melka Kunture has a mean annual temperature of 25.3 °C (Figure 2).

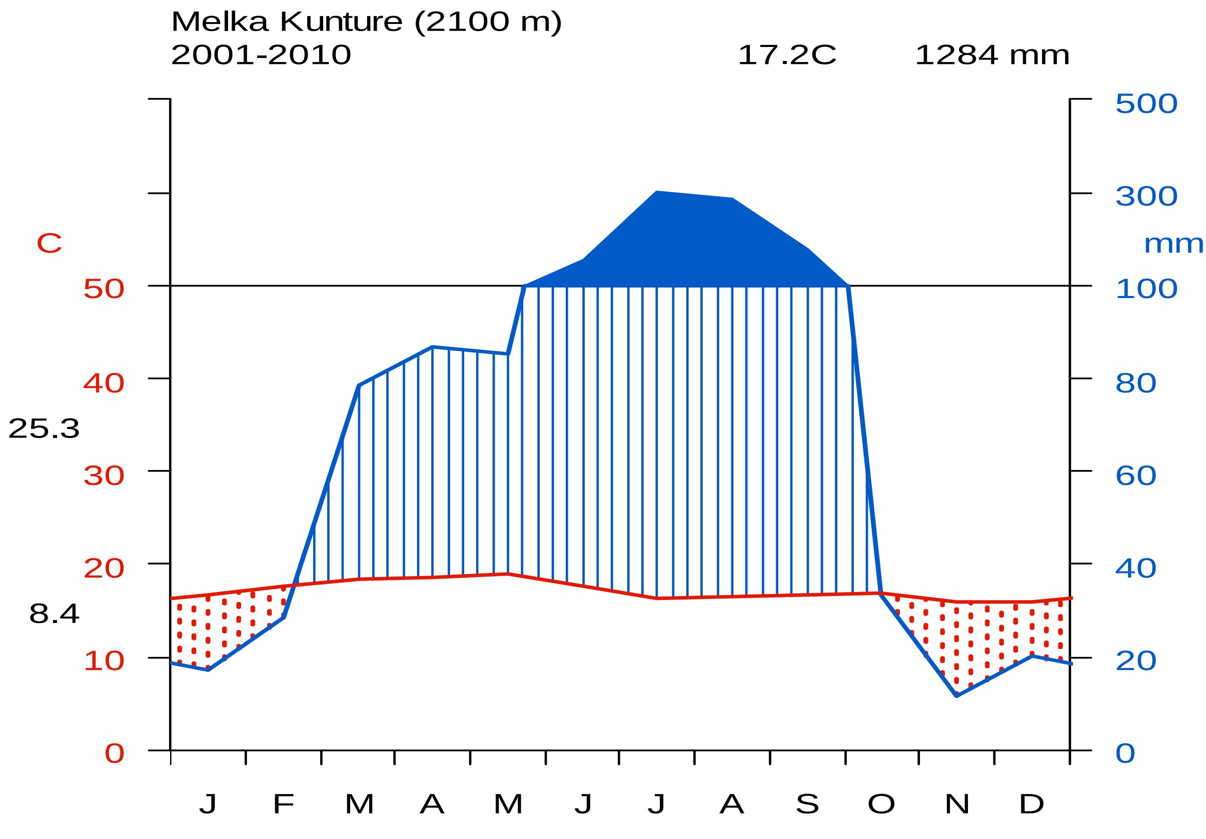

Figure 2: Climadiagram of Awash Melka Kunture Prehistorical Archaeological Site

Data Source: Ethiopian National Meteorological Station Agency (from 2001 to 2010).

3.1.8. Vegetation

The study area is characterized by ever green and deciduous trees (Plate 1) like *Acacia abyssinica*, *Acacia seyal*, *Acacia albida*, *Croton macrostachyus* and *Vernonia amygdalina*. Among the shrubs *Rosa abyssinica*, *Rhamnus staddo*, *Pterolobium stellatum*, *Ocimum lamiifolium* are the most common species in the area (personal observation).

Plate 1: Vegetation of Awash Melka Kunture Prehistoric Archaeological Site (partly)

3.2. Methods

3.2.1. Reconnaissance survey

A preliminary survey was made in August, 2011 in and around the Awash Melka Kunture Prehistoric Archaeological Site in order to obtain vegetation patterns of the study area and determine representative sampling sites. In addition to that, plants that were in their reproductive stage were collected in order to facilitate the vegetation data collection process. During the visit working staff and security guards of the site were met and a brief explanation about the purpose of the study was given. The data collection was conducted from September to November, 2011.

3.2.2. Sample design

Systematic sampling design was used for this study to collect vegetation data following Muller-Dombois and Ellenberg (1974) and Mitiku Tikssa *et al.* (2009).Ten line transects were laid at every 20 m distance perpendicular to the Awash River. The first line transect was laid systematically 200 m from the main road fence. Sixty main plots having an equal size of 10 m x 10 m (100 m^2) were laid out to collect the data on woody species. Within the main plot 1 m x 1 m sub-plots were laid, four at the corners and one in the middle, for herbaceous data collection (Figure 3). The distance between the main plots was 20 m along each of the line transects. The latitude, longitude and altitude were taken from the centre of each main plot and measured using GPS.

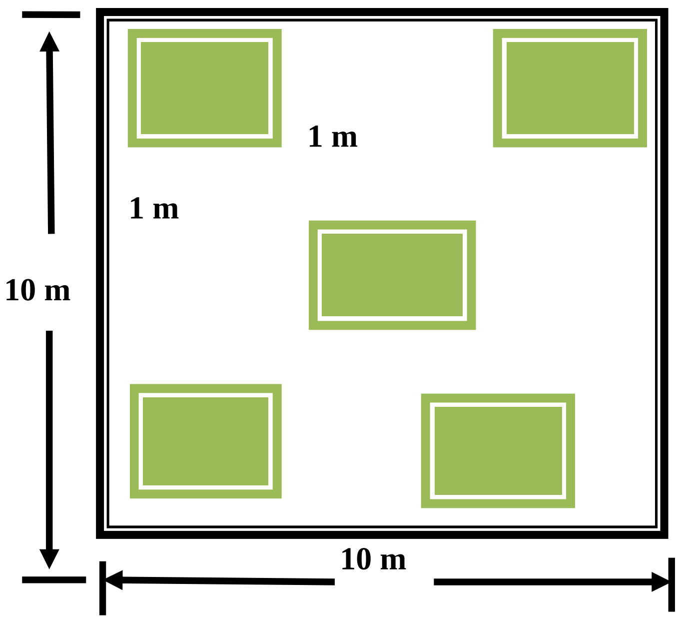

Figure 3: Sampling plot design of the study area (AMKPAS)

A cover-abundance value of all woody plants was estimated following the Braun-Blanquet scale and then transferred to OTV as modified by van der Maarel (1979). In each plot, the diameter and height of all woody tree species was recorded. Diameter was measured for all individual trees having a DBH greater than 2.5 cm using a diameter tape. If the tree branched at breast height or below, the diameter was measured separately for the branches and averaged. Trees with DBH less than 2.5 cm were enumerated but not measured for DBH. Height was measured for any individual tree and shrub using a calibrated stick. In places where topographic features made it difficult to measure the height of trees and shrubs, it was estimated visually. The presence-absence and cover abundance data, defined here as the proportion of area in a quadrat covered by a given species, was recorded and gathered from each quadrat. Later, it was converted to cover abundance values using the modified 1-9 Braun-Blanquet scale (van der Maarel, 1979) which means: 1: Rare, generally one individual; 2: Occasional, with less than 5% cover of the total area; 3: Abundant, with less than 5% cover of the total area; 4: Very abundant, with less than 5% cover of the total area; 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; and 9: 75-100% cover of the total area.

Seedling and sapling density and regeneration of the tree species were recorded. In each of these quadrats, the numbers of all seedlings that were less than 1 m high were recorded. Individuals that had attained 1 m and above but with a DBH less than 2.5 cm, were considered as saplings and counted.

3.2.3. Floristic data collection

All plant species including herbs, shrubs, lianas and trees in each quadrat were recorded. Additional plant species occurring outside the quadrat, but inside the study area were also documented but only as “present”, they were not used in the cluster and ordination data analysis. The local names of the species were recorded and included in the list of taxa. During the study, physiographic variables such as altitude, longitude, and latitude were measured for each quadrat using GPS. The plant specimens were assigned by tentative field identifications and then brought to the National Herbarium (ETH) of Addis Ababa University, Ethiopia for further identification where voucher specimens are deposited. Taxonomic identification was made following the Flora of Ethiopia and Eritrea and Honeybee Flora of Ethiopia, by consulting experts, and by using authenticated herbarium specimens.

3.3. Data Analysis

3.3.1. Vegetation data analysis

Hierarchical cluster analysis is one of the most commonly used multivariate techniques to analyze community ecological data. It helps to group a set of observations (vegetation samples) together, based on their attributes or floristic similarities (Kent and Coker 1992). For this study, agglomerative hierarchical classification using similarity ratio cluster analysis was performed using R for windows version 2.11.1 (Venables *et al*., 2010) to classify the vegetation into plant community types based on abundance data of the species in each quadrat.

3.3.1. Measurement of species diversity and similarity indices

Biological diversity can be calculated in various ways. In this study, the Shannon-Wiener diversity index, species richness and Shannon's evenness were computed to describe species diversity of the plant community types (Kent and Coker, 1992). The Shannon-Wiener diversity index was calculated as follows:-

$H' = -\sum_{i=1}^{s} pi \ln pi$, Where,

H′ = Shannon diversity index,

S = the number of species,

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

ln = $logbase_n$

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

J = Evenness,

H′ = Shannon-Wiener diversity index and

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

Following Kent and Coker (1992), Sorensen's similarity index was used to determine the pattern of species turnover between the communities. It was being described as follows:-

$$S_s = \frac{2a}{(2a+b+c)}$$

- **S_s=** Sorensen's similarity coefficient;
- **a** = Number of species common to both samples;
- **b** = Number of species in sample 1 only;
- **c** = Number of species in sample 2 only

3.3.2. Structural data analysis

The structure of the vegetation in this study was described using the frequency of distribution of DBHs, plant height and IVI. Tree density and basal area values were computed on a per-hectare basis. Species Importance Value Indices (SIVI) were computed for dominant woody species based on their relative density (RD), relative dominance (RDO) and relative frequency (RF) to determine dominance following (Kent and Coker, 1992; Lemessa Kumsa, 2010). The different formulas that are important in conducting structural analyses are described below:-

SIVI = Relative Density (abundance) + Relative Frequency + Relative Dominance (basal area), where:

- Relative Density of a species (RD) = $\frac{\text{Number of individuals of a species}}{\text{Number of individuals of the sample}} \times 100$
- Relative Frequency of a species (RF) = $\frac{\text{Number of sample plots containing a species}}{\text{Sample units for all species of the sample}} \times 100$
- Relative Dominance of a species (RDO) = $\frac{\text{Basal area of a species}}{\text{Total basal area of the sample}} \times 100$

Basal Area (BA) was calculated using DBH as follows:-

- Basal Area (BA) = $\pi d^2/4$, where, $\pi = 3.14$; d = DBH (cm)

4. RESULTS AND DISCUSION

4.1. Floristic composition of the study area

A total of 139 plant species in 114 genera and 45 families were identified from the study area (Appendix 1). Out of the total species Poaceae contributed 24 (14.27%); Fabaceae 23 (16.55%) species, Asteraceae 16 (11.51%) species while Lamiaceae contributed nine (6.47%) species, Rubiacea five (3.60%) species, Acanthaceae four (2.88%) specie whilst Apiaceae, Asclepiadaceae, Cyperaceae, Malvaceae, Ranunculaceae, Scrophulariaceae and Solanaceae each had three species (each contributing 2.16%). The family Commelinaceae, Cucurbitaceae, Rhamnuaceae, Verbanaceae and Vitaceae each had two species (each contributing 1.44%) and the remaining 27 families had one species each (totalling 19.44%) (Appendix 2). This dominance of Poaceae was reported from similar vegetation study of (Getaneh Belachew, 2006). Whereas, the studies (Teshome Soromessa *et al*., 2004; Anteneh Belayneh, 2006; Negusse Tadesse, 2006; Getachew Tena *et al*., 2008) showed the dominance of Fabaceae and Asteraceae. This may imply that the variation of different places in their ecological settings attributed to the variation of the dominating families.

The four species-rich families contributed (Poaceae, Fabaceae, Asteraceae and Lamiaceae) 51.80% of the total plant species, and the remaining 41 families contributed 48.20% of the total plant species. Among the total species 92 (66.19%) are herbs, 18 (12.95%) are shrubs, 11 (7.91%) are climbers, ten (6.47%) are shrubs/trees, seven (5.76%) are trees and one (0.72%) is liana (Figure 4).

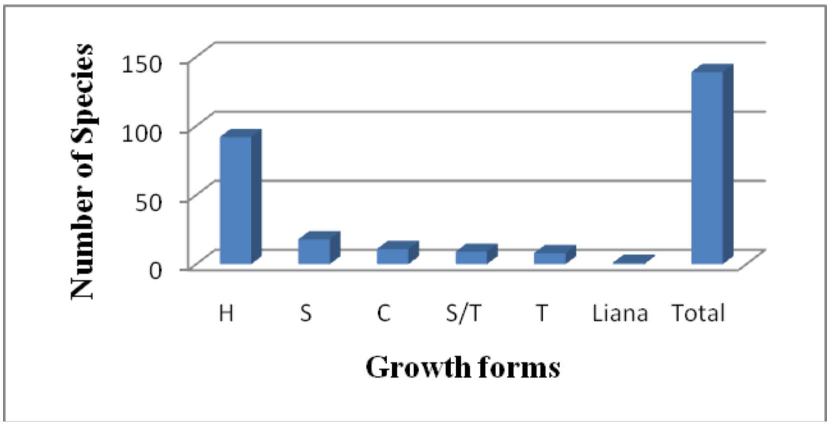

Figure 4: The growth forms of the species in Awash Melka Kunture Prehistoric Archaeological Site

4.1.1. Endemic Plants in Awash Melka Kunture Archaeological Site

Six endemic plant species and one subspecies were revealed in the study area. Five species and one subspecies of these species are herbs and one species is a shrub. These species are distributed into six families and seven genera (Table 2). This showed that Awash Melka Kunture is not only a home of archaeological excavations but it is also a place where one can find a range of plant species including endemics.

Table 2: Lists of endemic plants with their families and growth forms

No.	Scientific Name	Family	Habit
1	*Argyrolobium schimperianum* Hochst. ex A. Rich.	Fabaceae	Herb
2	*Astragalus atropilosulus* subsp. *atropilosulus* (Hochst.) Bunge	Fabaceae	Herb
3	*Bidens macroptera* (Sch. Bip. ex Chiov.) Mesfin	Asteraceae	Herb
4	*Gomphocarpus purpurascens* A. Rich.	Asclepiadaceae	Herb
5	*Kniphofia foliosa* Hochst.	Asphodelaceae	Herb
6	*Lippia adoënsis* Hochst. ex Walp.	Verbenaceae	Shrub
7	*Thunbergia ruspolii* Lindau	Acanthaceae	Herb

4.2. Plant Communities in Awash Melka Kunture

From the 139 plant species 91 species were used for vegetation classification. The results from cluster analysis as imputed in the R-2.11.1 statistical data analysis output showed five different communities (clusters) for Awash Melka Kunture Prehistoric Archaeological Site (See Figure 5). The communities were described based on their synoptic cover values. The following plant communities were named based on the two dominant woody species which have the highest mean cover/abundance that appears within the cluster.

4.2.1. *Ocimum lamiifolium - Pavetta abyssinica* Community Type I

This community type is the most species rich of the communities found in the study area. This might be because the community is found near to the Awash River and has no interference from anthropogenic factors. The community is distributed within the altitudinal range 2001 to 2035 m a.s.l. This community contains 13 plots and 64 species which are situated along Awash River and around the middle of the area. The shrub indicator species of this community include *Carissa spinarum, Ocimum lamiifolium, Capparis sepiaria, Ocimum urticifolium, Premna schimperi, Rhus natalensis, and Vernonia biafrae*. The only dominant tree species in this community is *Acacia albida*. The most common herb indicator species in the community are *Hyparrhenia rufa, Bidens macroptera*, *Digitaria abyssinica*, and *Bidens camporum*.

4.2.2. *Grewia ferrugenea – Acacia abyssinica* Community Type II

It is the second richest community type in the study area. It consists of 17 plots and 61 species between the altitudinal range of 2003 and 2022 m a.s.l. This community is only represented by one tree species which is *Acacia abyssinica.* The shrub indicator species of the community are *Grewia ferrugnea, Croton macrostachyus, Rosa abyssinica* and *Vernonia amygdalina*. The common climbers in this community are *Glycine wightii* and *Zehneria* *scabra*. The herb layer comprises *Achyrantes aspera* and *Hypoestes triflora*. This community type is threatened by the expansion of farm lands by the surrounding inhabitants and grazing of cattle (Plate 2).

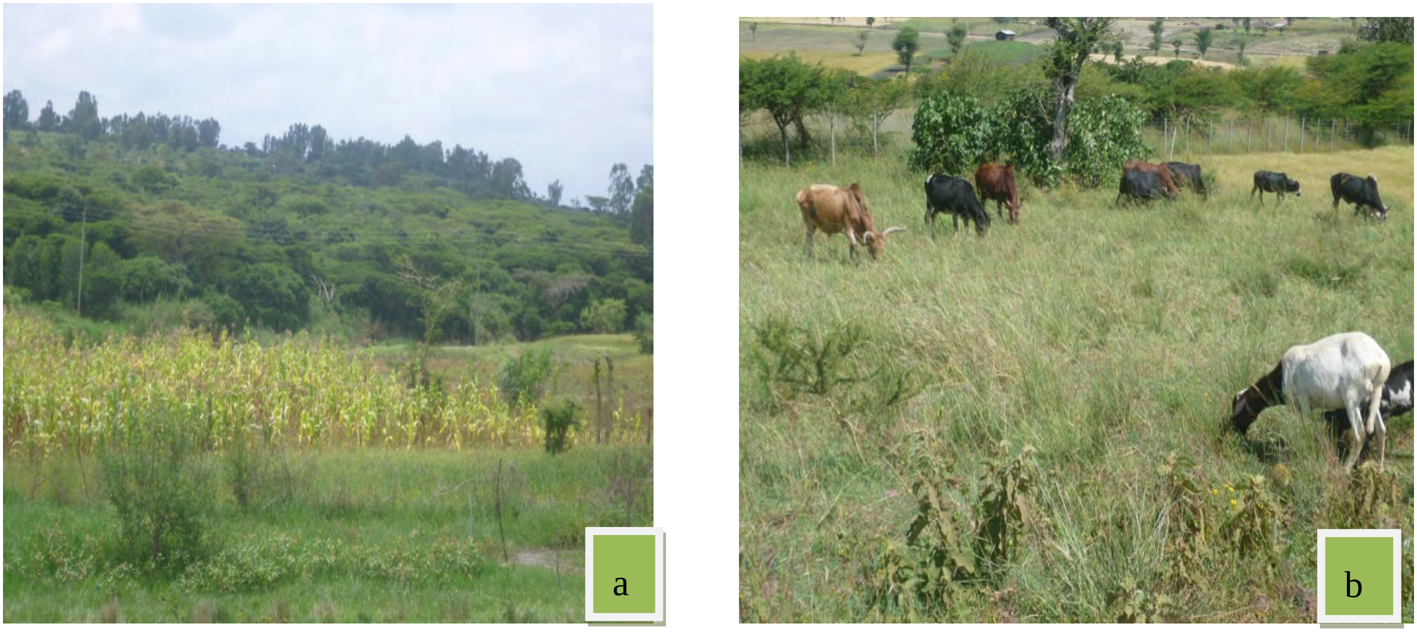

Plate 2: Farmlands (a) and grazing activities (b) near the study area

4.2.3. *Acacia seyal - Jasminum grandiflorum* Community Type III

This community comprises of nine plots and 43 species distributed between the altitudinal range 2000 to 2027 m a.s.l. This community is found along the lower fence towards the Dairy and Flower Farm Company (Plate 3). The community is mostly dominated by grass species. The tree indicator of this community is *Acacia seyal* and the shrub indicators include *Jasminum grandiflorum*, *Premna schimperi* and *Pterocephalus frutescens*.

Most of the herb layer indicators in the community are grasses. These are *Pennisetum sphacelatum*, *Aristida adoensis and Arthraxon prionodes*. Additionally, *Conyza abyssinica*, *Helictotrichon elongatum*, *Peucedanum harmsianum*, *Plantago lanceolata* and *Polygala sphenoptera* are found.

Plate 3: The Dairy and Flower Farm Company

4.4.4. *Carissa spinarum - Acacia persiciflora* Community Type IV

This community comprises of 12 plots and 43 species distributed within the altitudinal range from 2005 to 2030 m a.s.l. The tree indicator species in this community are *Acacia persiciflora*, *Acacia sieberiana,* and *Acacia etbaica*. Shrub dominant species are found such as *Carissa spinarum*, *Calpurnia aurea* and *Pterolobium stellatum*. The herb layer of this community is dominated by *Crassocephalum sarcobasis*, *Sporobolus pyramidalis*, *Hygrophila schulii* and *Cynodon aethiopicus*.

4.2.5. *Acacia lahai - Euclea racemosa* Community Type V

This community type is the least species rich of the community types in the area. This is attributed to the presence of herbaceous plants and the clearance of some of the woody species for walking paths. This community consists of nine plots and 42 species within the altitudinal range of 2003 to 2026 m a.s.l. The tree and shrub indicator species in this community are *Acacia lahai* and *Euclea racemosa*, respectively.

Pennisetum thunbergii, *Hyperthelia dissoluta*, *Bothriochloa isculpta*, *Sehima nervosum* and *Bidens pilosa* are the dominant herb species in this community.

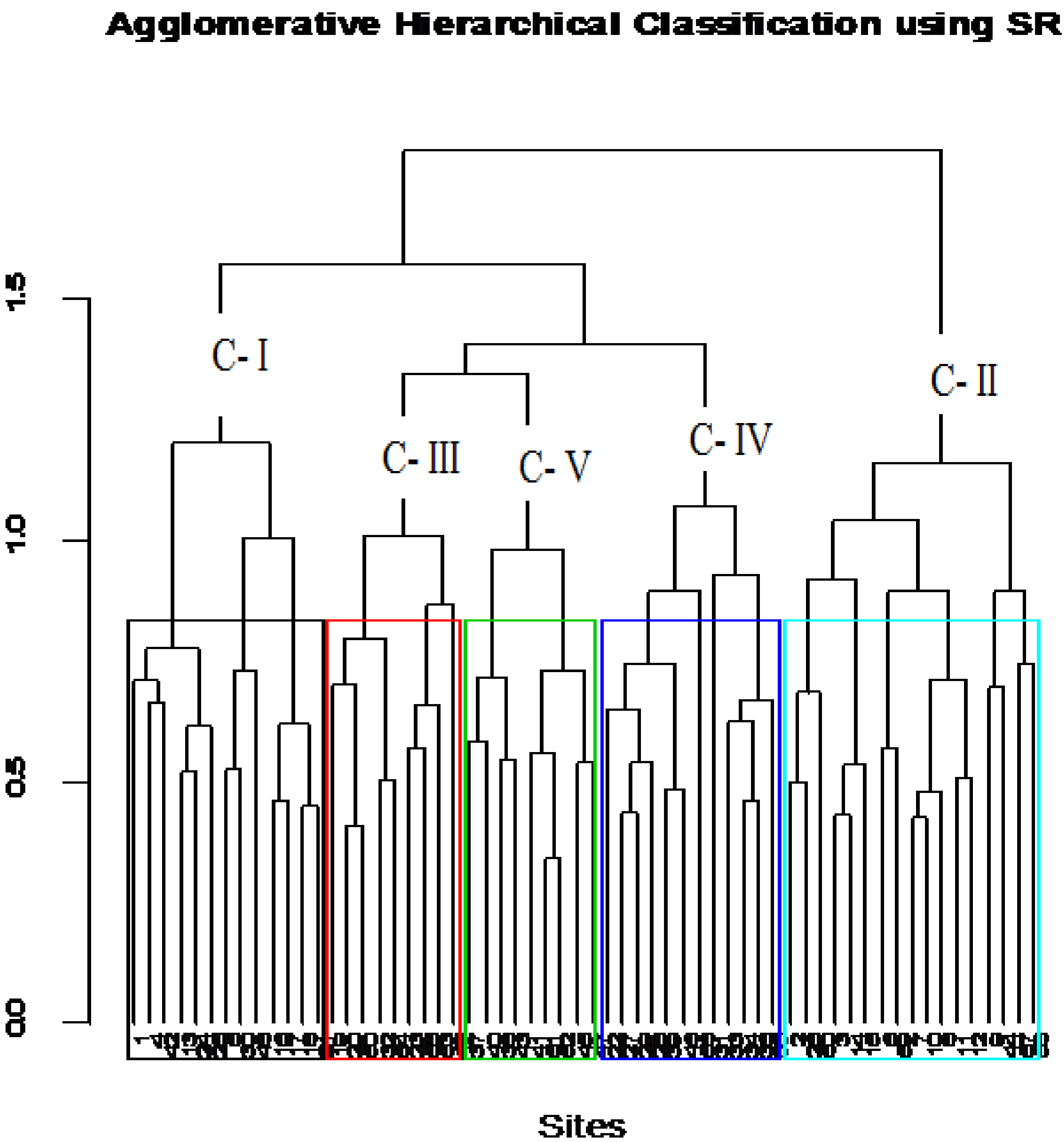

Figure 5: Dendrogram of the clusters (community types) of Awash Melka Kunture Prehistoric Archaeological Site

The communities contain the following plots,

- C- I: 1, 4, 5, 13, 16, 17, 18, 21, 24, 25, 30, 42, 48
- C- II: 2, 26, 60, 33, 14, 15, 6, 59, 7, 10, 8, 11, 12, 9, 44, 57, 58
- C- III: 19, 20, 50, 32, 54, 23, 55, 53, 49
- C- IV: 22, 27, 29, 28, 39, 46, 56, 31, 33, 34, 35, 36,
- C- V: 37, 40, 38, 43, 41, 51, 52, 45, 47

Table 3: Synoptic table of the communities (figures in bold relate to the indicator species for each representative community)

Name of the species	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Hyparrhenia rufa	**6.38**	2.71	4.22	5.42	4.33
Bidens macroptera	**3.77**	3.06	1.44	3.00	0.89
Ocimum lamiifolium	**2.85**	2.06	1.00	1.58	2.00
Digitaria abyssinica	**2.31**	0.65	0.00	1.17	1.44
Pavetta abyssinica	**2.00**	1.76	0.00	0.25	0.56
Rhus natalensis	**1.77**	1.18	0.56	1.50	0.33
Vernonia biafrae	**1.23**	0.76	1.22	0.25	0.56
Acacia albida	**0.85**	0.00	0.00	0.00	0.33
Bidens camporum	**0.54**	0.00	0.33	0.25	0.00
Grewia ferrugenea	2.00	**3.06**	0.56	2.00	1.11
Achyrantes aspera	1.46	**2.88**	0.00	0.83	0.00
Acacia abyssinica	1.38	**1.94**	0.67	1.08	0.67
Rosa abyssinica	0.00	**1.47**	1.11	0.42	0.89
Croton macrostachyus	0.38	**1.06**	0.44	0.75	0.33

Table 3 Cont'd …

Name of the species	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Glycine wightii	0.38	**0.59**	0.00	0.00	0.00
Vernonia amygdalina	0.00	**0.53**	0.00	0.50	0.00
Hypoestes triflora	0.00	**0.47**	0.00	0.00	0.00
Zehneria scabra	0.15	**0.41**	0.00	0.00	0.00
Acacia seyal	4.23	3.29	**5.33**	2.92	4.00
Pennisetum sphacelatum	1.46	1.88	**3.33**	3.08	3.11
Arthraxon prionodes	0.00	0.18	**0.56**	0.50	0.00
Polygala sphenoptera	0.08	0.18	**0.44**	0.00	0.11
Plantago lanceolata	0.08	0.00	**0.11**	0.00	0.00
Peucedanum harmsianum	0.08	0.00	**0.11**	0.00	0.00
Carissa spinarum	3.85	1.82	2.00	**4.17**	3.00
Acacia persiciflora	0.77	2.53	1.56	**3.33**	2.89
Pterolobium stellatum	0.54	0.94	0.00	**2.08**	0.67
Dregea shimperi	1.62	0.41	0.00	**1.75**	0.00
Heteropogon contortus	0.62	1.06	1.22	1**.50**	1.33
Acacia etbaica	1.15	0.18	0.67	**1.42**	0.56
Kniphofia foliosa	0.69	0.59	0.67	**1.08**	0.00
Sporobolus pyramidalis	0.38	0.06	0.00	**0.92**	0.44
Acacia sieberiana	0.00	0.00	0.56	**0.83**	0.33
Hygrophila schulii	0.00	0.00	0.00	**0.50**	0.00

Table 3: Cont'd…

Name of the species	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Calpurnia aurea	0.00	0.29	0.00	**0.50**	0.00
Cynodon aethiopicus	0.00	0.59	0.00	**0.42**	0.00
Pennisetum thunbergii	2.46	1.47	4.00	3.42	**5.22**
Hyperthelia dissolute	1.62	1.82	3.00	1.50	**3.22**
Acacia lahai	1.31	1.18	0.56	1.67	**2.56**
Sehima nervosum	0.77	0.59	0.56	0.33	**2.44**
Bothriochloa isculpta	0.92	0.71	0.89	1.00	**2.33**
Bidens pilosa	0.77	1.53	0.11	0.92	**1.89**
Euclea racemosa	0.38	0.00	0.00	0.00	**1.11**
Crassocephalum sarcobasis	0.69	0.29	0.33	0.33	**0.89**
Delphinium dasycaulon	0.31	0.29	0.11	0.33	**0.78**

4.5.6. Species richness, diversity and evenness of the plant communities

From the five community types, community type 1 has the highest species richness (64 species), diversity, and species evenness. Community type 2 is the second least in species evenness. Community type 5 has the lowest in species richness but has the highest species evenness, similar to that of community 1. The smallest species richness in community 5 may be because the community is dominated by grasses and some of the area has been cleared for walking paths. Community 3 has the least evenness and diversity (Table 4). All the communities have broadly similar evenness values; this might be attributed to the relatively small variation in altitudinal ranges between the communities.

Table 4: Species Richness, Diversity and Evenness of the communities based on their descending order of richness

Community Types	Richness	Diversity (H)	Shannon Evenness
1	64	3.68	0.89
2	61	3.49	0.85
4	46	3.37	0.88
3	43	3.15	0.84
5	42	3.34	0.89

4.5.7. Similarity between the community types

The Sorensen's similarity coefficient of the five communities shows that, community 1 and 5 have the highest similarity (71%) followed by community 1 and 4 and community 4 and 5 which have equal similarity ratios of 69%. A relatively low similarity ratio is observed between the communities 2 and 5, 3 and 4, and 2 and 3. The lowest similarity ratio is observed between the community 3 and 5 which is 57% (Table 5). Overall the communities have showed relatively nearest similarity amongst each other. This might be due to that many of the species distributed throughout the communities and due to the altitudinal proximity.

Table 5: The Sorensen's similarity of the communities

Community types	1	2	3	4	5
1	--	0.67	0.70	0.69	0.71
2		--	0.60	0.68	0.64
3			--	0.61	0.57
4				--	0.69
5					--

4.3. Species Importance Value (SIV)

The SIV of the tree species is given in the Table 6. Tree species with the highest SIV (*Acacia seyal*, *Acacia persiciflora*, and *Acacia abyssinica*) contributed 53.89% SIV. These species are found in the family Fabaceae. *Acacia seyal* has the highest SIV of 101.20 or 33.73% followed by *Acacia persiciflora* (38.94 or 12.98%) *and Acacia abyssinica* (21.53 or 7.18%). The lowest SIV was recorded by *Croton macrostachyus* and *Dodonaea angustifolia*.

Table 6: Species Importance Value index of the selected three species of Awash Melka Kunture Prehistoric Archaeological Site

No.	Name of the Species	RD (%)	RF (%)	RDO (%)	SIV	IVI (%)
1	*Acacia abyssinica*	8.09	13.25	0.19	21.53	7.18
2	*Acacia albida*	2.21	2.41	0.18	4.80	1.60
3	*Acacia etbaica*	4.41	4.82	0.05	9.28	3.09
4	*Acacia lahai*	5.15	4.82	0.06	10.02	3.34
5	*Acacia persiciflora*	20.59	18.07	0.28	38.94	12.98
6	*Acacia seyal*	53.68	46.99	0.53	101.20	33.73
7	*Croton macrostachyus*	2.94	4.82	0.02	7.78	2.59
8	*Dodonaea angustifolia*	2.94	4.82	0.01	7.77	2.59
	Total	**100**	**100**	**100**	**300**	**100**

Note: RD = Relative density, RF = Relative frequency, SIV = Species important value and IVI = Important value index

4.4. Vegetation Structure of Awash Melka Kunture

4.4.1. Diameter at breast height (DBH)

The general pattern of the DBH class distribution of the tree species was calculated based on the sampled area. A total of 136 individuals (85 individuals/ha) were counted with DBH class > 2.5 cm within sampled plots. The total DBH density between 12.6 – 22.6 cm is 18.75 (22.06%) individuals/ha, those with DBH density between 22.7 – 32.7 cm is 2.5 (2.94%) individuals/ha and those with DBH density between 32.8 – 42.8 cm is 0.625 (0.74%) individuals/ha. It shows an inverted J-shape; with many small stems compared with large ones (Figure 5). This pattern shows a good reproduction and regeneration potential of the area. An inverted J-shape is observed in natural undisturbed montane forest, which has mainly small sized stem density compared with the larger ones (Nebel *et al*., 2001). Similar results were observed by Abate Ayelew *et al*. (2006); Feyera Senbeta and Demel Teketay (2001), Feyera Senbeta (2006), Haile Yinger *et al*. (2008), Fekadu Gurmessa (2010), Feyera Abdena (2010) and Lemmesa Kumsa (2010).

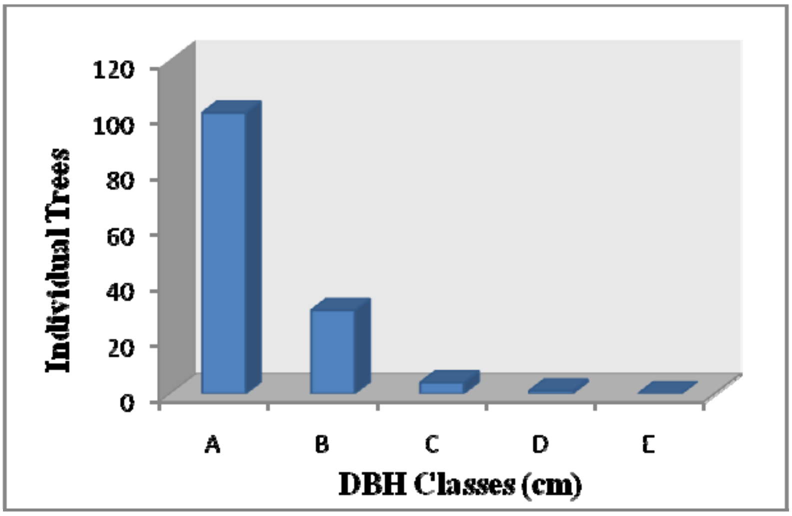

Figure 6: Stem class density distribution of Awash Melka Kunture Archaeological Site

4.4.2 Height

The woody species in the study area are categorised into three height classes: 2.5 m -5 m, 5.01 m – 7.01 m and > 7.02 m (Figure 6). Most of the species (97.80%) are found in class A and the remaining 2.20% are found in class B.

As height increases from one class to the other the density of individuals falls dramatically. This clearly reveals the dominance of small sized individuals and the presence of high regeneration but lower recruitment and absence of matured individuals. It might be due to the presence of competition among the species and the area was disturbed by anthropogenic factors some decades ago. Fekadu Gurmessa (2010) also stated that the density decreasing with increasing height could be attributed to a high rate of regeneration but irregular recruitment potential. The study by Feyera Senbeta and Demel Teketay (2003) revealed that the dominance of small trees and shrubs in the forest suggests that the bigger tree species are selectively removed or exploited. However, selective removal and cutting is absent in this study site.

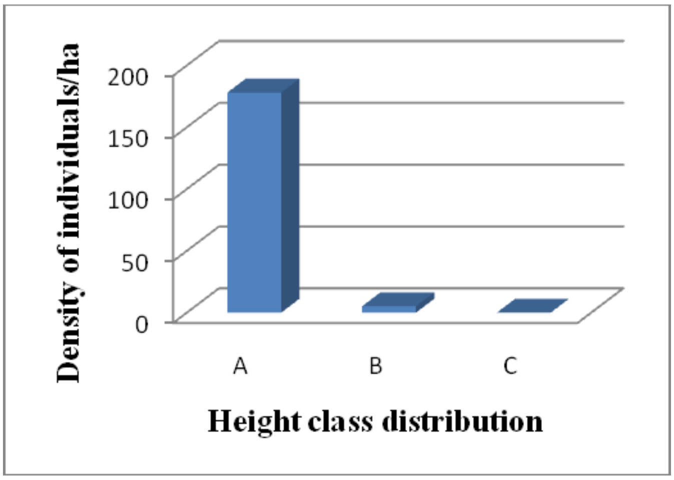

Figure 7: Height class distribution of woody species in Awash Melka Kunture Prehistoric Archaeological Site

Legend: A = 2.5 – 5 m, B = 5.01 – 7.01 m and C= >7.02 m

4.4.3. Population structure

The patterns of diameter class distribution indicate the general trends of population dynamics and recruitment processes for a given species. Analysis of eight tree species in the study site revealed two general patterns (Figure 7). The first pattern was positively skewed or an inverted J- shape, which has a high number of species in the lower DBH classes and the number of individuals in the species showed a gradual reduction at the highest DBH classes. This pattern was exhibited by the species *Acacia seyal*, *Acacia persiciflora*, *Acacia etbica, Acacia lahai*, *Croton macrostachyus* and *Dodonaea angustifolia*., The species *Croton macrostachyus and Dodonaea angustifolia* failed only in the first lower DBH class. Thus these species are under recruitment.

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

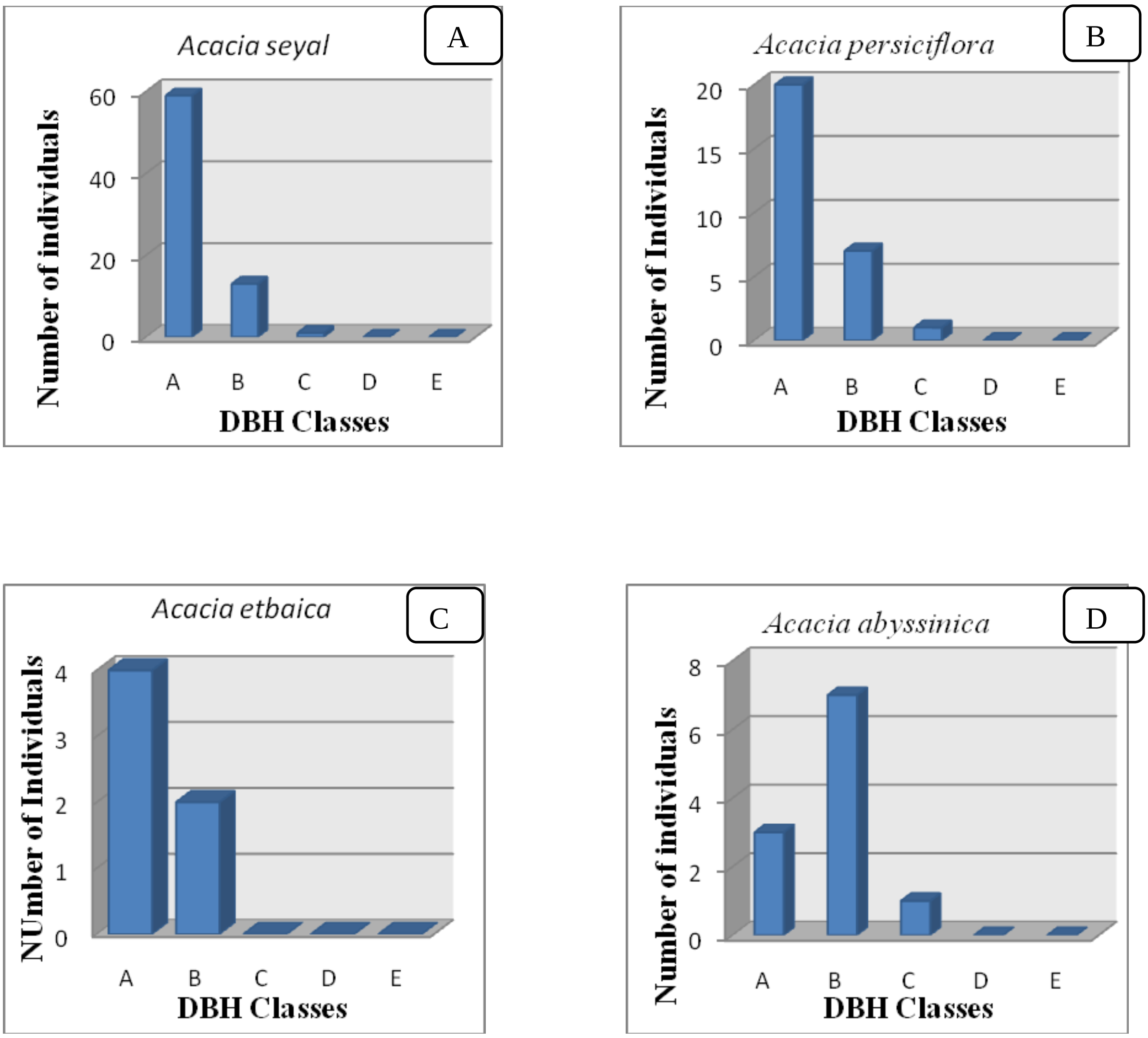

Figure 8: Population structure of some selected tree species

Legend: DBH Class; A= 2.5-12.5 cm; B= 12.6-22.6 cm; C= 22.7-32.7 cm; D= 32.8-42.8 cm; and E= 42.9-52.9 cm

4.5. Regeneration Status

A description of the regeneration status of a particular area, in this case the protected area of Awash Melka Kunture Prehistoric Archaeological Site, helps to determine and monitor future conservation and management options. Accordingly, the regeneration status of the woody species at Awash Melka Kunture Prehistoric Site was determined. From nine representative woody species, a total of 183.9 seedlings/ha, 154.58 saplings/ha and 54.38 mature individuals/ha were recorded (Table 7). The ratio of seedlings and saplings to mature individuals was 3.68:1 and3.10:1respectively. This result shows the presence of more seedlings than saplings and mature individuals. The numbers of saplings are even more than the number of mature individual plants which shows that the archaeological site is under regeneration. In this study different species have different densities of seedlings and saplings. The highest density of seedlings and saplings was found in the species *Dodonaea angustifolia*, *Acacia seyal* and *Acacia etbaica*. The species *Acacia sieberiana*, *Acacia albida*, *Acacia abyssinica* and *Croton macrostachyus* showed the lowest seedling and sapling densities.

Table 7: List of selected tree species used to determine the regeneration status

No.	Name of the species	No. Seedling	No. Sampling	Abundance	Total
1	*Acacia abyssinica*	1	3	7	11
2	*Acacia seyal*	78	104	73	255
3	*Acacia persiciflora*	17	25	21	63
4	*Acacia albida*	3	1	4	8
5	*Dodonaea angustifolia*	395	253	28	676
6	*Croton macrostachyus*	8	2	4	14
7	*Acacia etbaica*	2	6	5	13
8	*Acacia sieberiana*	3	1	2	6
9	*Acacia etbica*	30	57	15	102
	Total	537	452	159	1148
	/ha	183.65	154.58	54.38	392.62

4.6. Conclusion and Recommendations

4.6.1. Conclusion

Awash Melka Kunture Prehistoric Archaeological Site (AMKPAS) is one of the unique areas in Ethiopia which has relatively high species diversity together with archaeological artefacts. Its flora comprises 139 species in 114 genera and 45 families. Poaceae has the highest number of species followed by Fabaceae and Asteraceae. Of the total species, identified from the study area, seven were found to be endemic to the Flora of Ethiopia.

The vegetation was grouped into five community types each of which had varying degrees of species richness, diversity and evenness. Plant community type 1 has the highest species richness (64 species), diversity, and species evenness while the least evenness and diversity was observed for community type four. The variation among communities could be due to different factors (anthropogenic, altitude, soil moisture factors, etc) of which anthropogenic are anticipated the greatest.

The DBH analysis for woody species revealed variations in the population structure. The density of woody species decreases with increasing DBH, indicating the predominance of small-sized individuals in the area. This implies that the archaeological site is in a good state of recruitment. Analysis of population structure of most common tree species of the study area revealed different patterns of population structure, indicating relatively a medium variation among species population dynamics within the study site. Accordingly, two population patterns have been observed; inverted J-shaped and bell shaped. Analysis of regeneration of some selected woody species revealed that tree species such as *Acacia etbaica*, *A. albida* and *Acacia abyssinica* are with lowest seedling and sampling stage in the study site.

4.6.2. Recommendations

Awash Melka Kunture Prehistoric Archaeological Site (AMKPAS) provides important economic and social value to the rural communities living around the area, by its attraction to tourists. To minimize the present human influence on this unique area and for the future management of the area in a sustainable manner, the following recommendations are made:

- Participatory management programmes should be introduced and implemented so that the local communities assume responsibility for the management and conservation of the area and become beneficiaries of the economic payback derived from this activity.
- Raising public awareness on the use of Archaeological site resources and the vegetation within it, through extension programmes.
- Further investigation is needed on the patterns of functioning ecosystem; the soil, the seed banks, the establishment of seedlings and the role of gap dynamics for the species.
- To promote the sustainable use of the area, ethnobotanical studies and exploration of indigenous knowledge on the diverse uses of the plants should be undertaken.

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APPENDICES

Appendix 1: List of plant species collected from Awash Melka Kunture Prehistoric Archaeological Site (T= Tree, H= Herb, S= Shrub, S/T= Shrub or Tree, C= Climber and L= Liana)

No	Scientific Name	Family	Habit	Local Name (Afan Oromo	Coll No.
1	*Acacia abyssinica* Hochst. ex Benth.	Fabaceae	T		MF & MM 180
2	*Acacia albida* Del.	Fabaceae	T	Garbii	MF & MM 203
3	*Acacia brevispica* Harms	Fabaceae	T		MF & MM 172
4	*Acacia etbaica* Schweinf.	Fabaceae	T	Dodoti	MF & MM 177
5	*Acacia persiciflora* Pax	Fabaceae	T	Bate	MF & MM 122
6	*Acacia seyal* Del.	Fabaceae	T	Wachu	MF & MM 232
7	*Acacia sieberiana* DC.	Fabaceae	T	Lafto Guracha	MF & MM 234
8	*Achyranthes aspera* L.	Amaranthaceae	H		MF & MM 113
9	*Agrocharis melanantha* Hochst.	Apiaceae	H		MF & MM 183

Cont …

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
10	*Aloe macrocarpa* Tod.	Aloaceae	H	Alge	MF & MM 139
11	*Anagallis serpens* Hochst. ex DC.	Pripulaceae	H		MF & MM 139
12	*Anarrhinum forskaohlii* (Gmel.) Cufod.	Rhamnuaceae	S/T	Kedida	MF & MM 152
13	*Argyrolobium schimperianum* Hochst. ex A. Rich.	Fabaceae	H		MF & MM 143
14	*Aristida adoensis* Hochst.	Poaceae	H		MF & MM 117
15	*Arthraxon prionodes* (Steud.) Dandy 7, 310	Poaceae	H		MF & MM 145
16	*Asparagus flagellaris* (Kunth) Baker	Asparagaceae	S		
17	*Astragalus atropilosulus* (Hochst.) Bunge	Fabaceae	H		MF & MM 237
18	*Bidens camporum* (Hutch.) Mesfin	Asteraceae	H	Ababo Maqala	MF & MM 124
19	*Bidens macroptera* (Sch. Bip. ex Chiov.) Mesfin	Asteraceae	H	Ababo Maqala	MF & MM 127

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
20	*Bidens pilosa* L.	Asteraceae	H	Metene	MF & MM 112
21	*Bothriochloa isculpta* (Hochst. ex A. Rich.) A. Camus	Poaceae	H		MF & MM 119
22	*Brachiaria eruciformis* (J.E.Smith) Griseb.	Poaceae	H	Machera	MF & MM 242
23	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	S/T	Cheka/Digta	MF & MM 134
24	*Capparis sepiaria* L.	Capparidaceae	S	Arangama	MF & MM 201
25	*Cayratia gracilis* (Guill. & Perr.) Suesseng.	Vitaceae	C		MF & MM 181
26	*Ceropegia affinis* Vatke	Asclepiadaceae	H		MF & MM 194
27	*Chamaecrista mimosoides* (L.) Greene	Fabaceae	H		MF & MM 220
28	*Clematis hirsuta* Perr. & Guill.	Ranunculaceae	C		MF & MM 239
29	*Clematis simensis* Fresen.	Ranunculaceae	C	Hida Fiti	MF & MM 229

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
30	*Clerodendrum myricoides* (Hochst.) Vatke	Lamiaceae	S		MF & MM 84
31	*Commelina africana* L.	Commelinaceae	H		MF & MM 87
32	*Conyza abyssinica* Sch. B.P. ex A. Rich.	Asteraceae	H		MF & MM 121
33	*Conyza schimperi* Sch. Bip. ex A. Rich.	Asteraceae	H		MF & MM 185
34	*Conyza sumatrensis* (Retz.) E.H. Walker	Asteraceae	H		MF & MM 217
35	*Crassocephalum rubens* (Juss. ex Jacq.) S. Moore	Asteraceae	H		MF & MM 132
36	*Crotalaria pycnostachya* Benth.	Fabaceae	H		MF & MM 218
37	*Croton macrostachyus* Hochst. ex Del.	Euphorbiaceae	S/T	Bekenisa	MF & MM 214
38	*Cucumis ficifolius* A. Rich.	Cucurbitaceae	H	Holoto	MF & MM 238
39	*Cyanotis barbata* D. Don.	Commelinaceae	H		MF & MM 47
40	*Cycnium tubulosum* (L.f.) Engl.	Scrophulariaceae	H		MF & MM 212

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
41	*Cynodon aethiopicus* Clayton & Harlan	Poaceae	H	Ketisa/Serdo	MF & MM 228
42	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	H		MF & MM 66
43	*Cyperus longus* L.	Cyperaceae	H		MF & MM 25
44	*Cyphostemma niveum* (Hochst. ex Schweinf.) Descoings	Vitaceae	C	Gorersa	MF & MM 123
45	*Delphinium dasycaulon* Fresen.	Ranunculaceae	H		MF & MM 136
46	*Dicrocephala chrysanthemifolia* (Bl.) DC.	Asteraceae	H		MF & MM 216
47	*Digitaria abyssinica* (Hochst. ex A. Rich.) Stapf	Poaceae	H	Wereta	MF & MM 246
48	*Dregea shimperi* (Decne.) Bullock	Asclepiadaceae	Liana	Hida Felana	MF & MM 147
49	*Dyschoriste radicans* Nees	Acanthaceae	H		MF & MM 223
50	*Echinops hispidus* Fresen.	Asteraceae	H	Sokoru	MF & MM 186

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
51	*Eleusine floccifolia* (Forssk.) Spreng.	Poaceae	H	Chekorsa	MF & MM 231
52	*Eragrostis pilosa* (L.) P. Beauv.	Poaceae	H		MF & MM 116
53	*Euclea racemosa* Murr.	Ebenaceae	S/T	Miesa	MF & MM 224
54	*Ficus carica* L.	Moraceae	S/T	Logo	MF & MM 227
55	*Fimbristylis bisumbellata* (Forssk.) Bub.	Cyperaceae	H		MF & MM 163
56	*Fuerstia africana* T. C. E. Fr.	Lamiaceae	S		MF & MM 189
57	*Galinsoga quadriradiata* Ruiz & Pavon	Asteraceae	H	Aba Debo	MF & MM 170
58	*Galium spurium* L.	Rubiaceae	H	Metene	MF & MM 148
59	*Geranium aculeolatum* Oliv.	Geraniaceae	H		MF & MM 230
60	*Glycine wightii* (Wight & Arn.) Verde.	Fabaceae	C		MF & MM 146
61	*Gomphocarpus purpurascens* A. Rich.	Asclepiadaceae	H		MF & MM 188

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
62	*Grewia ferruginea* Hochst. ex A. Rich.	Tiliaceae	S	Tekonu	MF & MM 114
63	*Guizotia schimperi* Sch. Bip. ex Walp.	Asteraceae	H	Hada Adi	MF & MM 190
64	*Harpachne schimperi* Hochst. ex A. Rich.	Poaceae	H		MF & MM 78
65	*Helichrysum schimperi* (Sch. Bip. ex A. Rich.) Moeser	Asteraceae	H		MF & MM 222
66	*Helictotrichon elongatum* (Hochst. A. Rich) C. E. Hubb.	Poaceae	H		MF & MM 157
67	*Heteromorpha arborescens* (Spreng.) Cham. & Schlecht.	Apiaceae	S	Riga Kalu	MF & MM 192
68	*Heteropogon contortus* (L.) Roem. & Schult.	Poaceae	H		MF & MM 140
69	*Hygrophila schulii* (Hamilt.) M.R. & S. M. Almeida	Acanthaceae	H		MF & MM 235
70	*Hyparrhenia anthistirioides*	Poaceae	H		MF & MM 198
71	*Hyparrhenia hirta* (L.) Stapt. /Themeda truandra	Poaceae	H		MF & MM 141
72	*Hyparrhenia rufa* (Nees) Stapf	Poaceae	H	Go'aa	MF & MM 156

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
73	*Hyperthelia dissoluta* (Steud.) Clayton	Poaceae	H	Kecha	MF & MM 120
74	*Hypoestes triflora* (Forssk.) Roem. & Schutt.	Acanthaceae	H		MF & MM 115
75	*Indigofera ambelacensis* Schweinf.	Fabaceae	H		MF & MM 219
76	*Indigofera spicata* Forssk.	Fabaceae	S		MF & MM 130
77	*Ipomoea indica* (Burm.f.) Merrill	Convoluvlaceae	C		MF & MM 208
78	*Jasminum grandiflorum* L.	Oleaceae	C	Kemete	MF & MM 125
79	*Kalanchoe laciniata* (L.) DC.	Crassulaceae	H		MF & MM 179
80	*Kniphofia foliosa* Hochst.	Asphodelaceae	H		MF & MM 169
81	*Kohautia coccinea* Royle	Rubiaceae	H		MF & MM 244
82	*Lantana trifolia* L.	Verbanaceae	S		MF & MM 173
83	*Leucas martinicensis* (Jacq.) R.Br.	Lamiaceae	H		MF & MM 166

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
84	*Linum strictum* L.	Linaceae	H		MF & MM 210
85	*Lippia adoënsis* Hochst. ex Walp.	Verbenaceae	S	Kusaye	MF & MM 135
86	*Malva verticillata* L.	Malvaceae	H		MF & MM 226
87	*Ocimum lamiifolium* Hochst. ex Benth.	Lamiaceae	S	Bokollu	MF & MM 153
88	*Ocimum urticifolium* Roth	Lamiaceae	S	Nech Bekollu	MF & MM 155
89	*Opuntia ficus-indica* (L.) Miller	Cactaceae	S	Beles	MF & MM 208
90	*Osyris quadripartita Decn.*	Santalaceae	T		MF & MM 17
91	*Otostegia tomentosa* subsp. *ambigiens* (Chiov.) Sebald	Lamiaceae	S		MF & MM 191
92	*Oxalis radicosa* A. Rich.	Oxalidaceae	H		MF & MM 204
93	*Panicum subalbidum* Kunth	Poaceae	H		MF & MM 199
94	*Parietaria debilis* G. Forst.	Urticaceae	H		MF & MM 205

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
95	*Pavetta abyssinica* Fresen.	Rubiaceae	S/T	Yewotet Memcha Erba Aneni	MF & MM 164
96	*Pennisetum sphacelatum* (Nees) Th. Dur. & Schinz	Poaceae	H	Migra	MF & MM 129
97	*Pennisetum thunbergii* Kunth /Setaria incrassate	Poaceae	H	Migra Sere	MF & MM 161
98	*Pennisetum villosum* Fresen.	Poaceae	H		MF & MM 236
99	*Peucedanum harmsianum* Wolff	Apiaceae	H		MF & MM 168
100	*Physalis peruviana* L.	Solanaceae	H		MF & MM 202
101	*Plantago lanceolata* L.	Plantaginaceae	H	Kurisa	MF & MM 200
102	*Polygala sphenoptera* Fresen.	Polygalaceae	H		MF & MM 118
103	*Premna schimperi* Engl.	Lamiaceae	S/T	Urgesa	MF & MM 138
104	*Pseudognaphalium luteo-album* (L.) Hilliard & Burtt	Asteraceae	H		MF & MM 142

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
105	*Pterocephalus frutescens* Hochst. ex A. Rich	Dipsacaceae	S		MF & MM 175
106	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	S	Arengema (Kontr)	MF & MM 197
107	*Rhamnus staddo* A. Rich.	Rhamnaceae	S/T		MF & MM 152
108	*Rhus natalensis* Krauss	Anacardiaceae	S	Debobecha/Tatesa	MF & MM 154
109	*Rhynchosia minima* (L.) DC.	Fabaceae	C		MF & MM 158
110	*Rosa abyssinica* Lindley	Rosaceae	S	Gora	MF & MM 221
111	*Rubia cordifolia* L.	Rubiaceae	H		MF & MM 16
112	*Rumex abyssinicus* Jacq.	Polygonaceae	H	Mokmoko	MF & MM 211
113	*Salvia nilotica* Juss. ex Jacq.	Lamiaceae	H	Shokoksa	MF & MM 131
114	*Satureja abyssinica* subsp. *abyssinica* (Benth.) Briq.	Lamiaceae	H		MF & MM 144
115	*Scleria melanotricha* Hochst. ex A. Rich.	Cyperaceae	H		MF & MM 64

Cont ….

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
116	*Scorpiurus muricatus* L.	Fabaceae	H		MF & MM 100
117	*Sehima nervosum* (Rottler) Stapf.	Poaceae	H		MF & MM 171
118	*Setaria pumila* (Poir.) Roem. & Schult.	Poaceae	H	Migra Sere	MF & MM 213
119	*Sida rhombifolia* L.	Malvaceae	H		MF & MM 225
120	*Sida schimperiana* Hochst. ex A. Rich.	Malvaceae	S	Gufte	MF & MM 206
121	*Snowdenia polystachya* (Fresen.) Pilg.	Poaceae	H	Muja	MF & MM 233
122	*Solanum americanum* Mill.	Solanaceae	H	Sama	MF & MM 215
123	*Solanum incunum* L.	Solanaceae	H		MF & MM
124	*Sopubia ramosa* (Hochst.) Hochst.	Scrophulariaceae	H		MF & MM 126
125	*Spermacoce sphaerostigma* (A. Rich.) Vatke	Rubiaceae	H		MF & MM 182
126	*Sporobolus agrostoides* Chiov.	Poaceae	H		MF & MM 150

Cont …

No.	Scientific Name	Family	Habit	Local Name (Afan Oromo)	Coll No.
127	*Sporobolus pyramidalis* P. Beauv.	Poaceae	H	Murigi	MF & MM 195
128	*Striga hermonthica* (Del.) Benth.	Scrophulariaceae	H		MF & MM 176
129	*Swertia abyssinica* Hochst.	Gentianaceae	H		MF & MM 34
130	*Tagetes minuta* L.	Asteraceae	H		MF & MM 167
131	*Teramnus labialis* (L.f.) Spreng.	Fabaceae	C		MF & MM 187
132	*Thunbergia ruspolii* Lindau	Acanthaceae	H	Billiq	MF & MM 137
133	*Trifolium semiplosum* Fresen.	Fabaceae	H		MF & MM 209
134	*Trifolium steudneri* Schweinf.	Fabaceae	H		MF & MM 240
135	*Vernonia amygdalina* Del.	Asteraceae	S/T	Girawa	MF & MM
136	*Vernonia biafrae* Oliv. & Hiern	Asteraceae	C		MF & MM 162
137	*Vicia sativa* L.	Fabaceae	H		MF & MM 207
138	*Vigna membranaceae* A. Rich.	Fabaceae	H		MF & MM 243
139	*Zehneria scabra* (Linn.f.) Sond.	Cucurbitaceae	C		MF & MM 128

Appendix 2: List of families and genera

No.	Name of family	Number of genera	Number of species
1	Acanthaceae	4	4
2	Aloaceae	1	1
3	Amaranthaceae	1	1
4	Anacardiaceae	1	1
5	Apiaceae	3	3
6	Asclepiadaceae	3	3
7	Asparagaceae	1	1
8	Asphodelaceae	1	1
9	Asteraceae	11	16
10	Boraginaceae	1	1
11	Cactaceae	1	1
12	Capparidaceae	1	1
13	Commelinaceae	2	2
14	Convoluvlaceae	1	1
15	Crassulaceae	1	1
16	Cucurbitaceae	2	2
17	Cyperaceae	2	3
18	Dipsacaceae	1	1
19	Ebenaceae	1	1
20	Euphorbiaceae	1	1
21	Fabaceae	15	23
22	Gentianaceae	1	1

Cont ….

23	Geraniaceae	1	1
24	Lamiaceae	8	9
25	Linaceae	1	1
26	Malvaceae	2	3
27	Moraceae	1	1
28	Oleaceae	1	1
29	Oxalidaceae	1	1
30	Plantaginaceae	1	1
31	Poaceae	19	24
32	Polygalaceae	1	1
33	Polygonaceae	1	1
34	Pripulaceae	1	1
35	Ranunculaceae	2	3
36	Rhamnuaceae	2	2
37	Rosaceae	1	1
38	Rubiaceae	5	5
39	Santalaceae	1	1
40	Scrophulariaceae	3	3
41	Solanaceae	2	3
42	Tiliaceae	1	1

Cont….

43	Urticaceae	1	1
44	Verbenaceae	2	2
45	Vitaceae	2	2
Total number		**114**	**139**

Appendix 3: Sample plots and their geographical positions

T	Plot number	Altitude	UTM
1	1	2018 m	0456040:0962137
1	2	2006 m	0456023:0962104
1	3	2011 m	0456011:0962078
1	4	2015 m	0455997:0962049
1	5	2019 m	0455982:0962020
1	6	2016 m	0455979:0962008
1	7	2013 m	0455971:0961965
2	8	2017 m	0455965:0961932
2	9	2019 m	0455953:0961909
2	10	2022 m	0455942:0961878
2	11	2015 m	0455918:0961878
2	12	2021 m	0455920:0961911
2	13	2017 m	0455925:0961942
2	14	2015 m	0455936:0961974
2	15	2015 m	0455949:0962006
2	16	2020 m	0455954:0962035
3	17	2011 m	0455957:0962063
3	18	2010 m	0455954:0962099

3	19	2011 m	0455934:0962096
3	20	2011 m	0455934:0962096
3	21	2022 m	0455916:0962052
3	22	2018 m	0455902:0962013
3	23	2013 m	0455898:0961991
4	24	2014 m	0455887:0961959
4	25	2016 m	0455887:0961923
4	26	2018 m	0455882:0961889
4	27	2027 m	0455818:0961837
4	28	2021 m	0455844:0961839
4	29	2023 m	0455843:0961891
5	30	2035 m	0455860:0961938
5	31	2019 m	0455793:0961964
5	32	2017 m	0455780:0961930
5	33	2010 m	0455778:0961899
5	34	2014 m	0455769:0961804
5	35	2024 m	0455780:0961035
6	36	2020 m	0455776:0961808

T	Plot number	Altitude	UTM
6	37	2004 m	0455706:0962175
6	38	2010 m	0455699:0962141
6	39	2013 m	0455695:0962103
6	40	2009 m	0455607:0962117
7	41	2009 m	0455676:0962150
7	42	2009 m	0455691:0962178
7	43	2013 m	0455674:0962202
7	44	2014 m	0455658:0962185
7	45	2015 m	0455652:0962153
8	46	2005 m	0455621:0962153
8	47	2003 m	0455618:0962180
8	48	2001 m	0455630:0962213
8	49	2013 m	0455641:0962234
8	50	2000 m	0455613:0962247
9	51	2026 m	0455591:0962229
9	52	2001 m	0455596:0962197
9	53	2027 m	0455087:0962072
9	54	2003 m	0455678:0962094

T	Q	Alt	UTM
10	55	2018 m	0455371:0962015
10	56	2030 m	0455678:0961980
10	57	2003 m	0456117:0962104
10	58	2003 m	0456117:0962104
10	59	2019 m	0456143:0962036
10	60	2022 m	0456109:0962019