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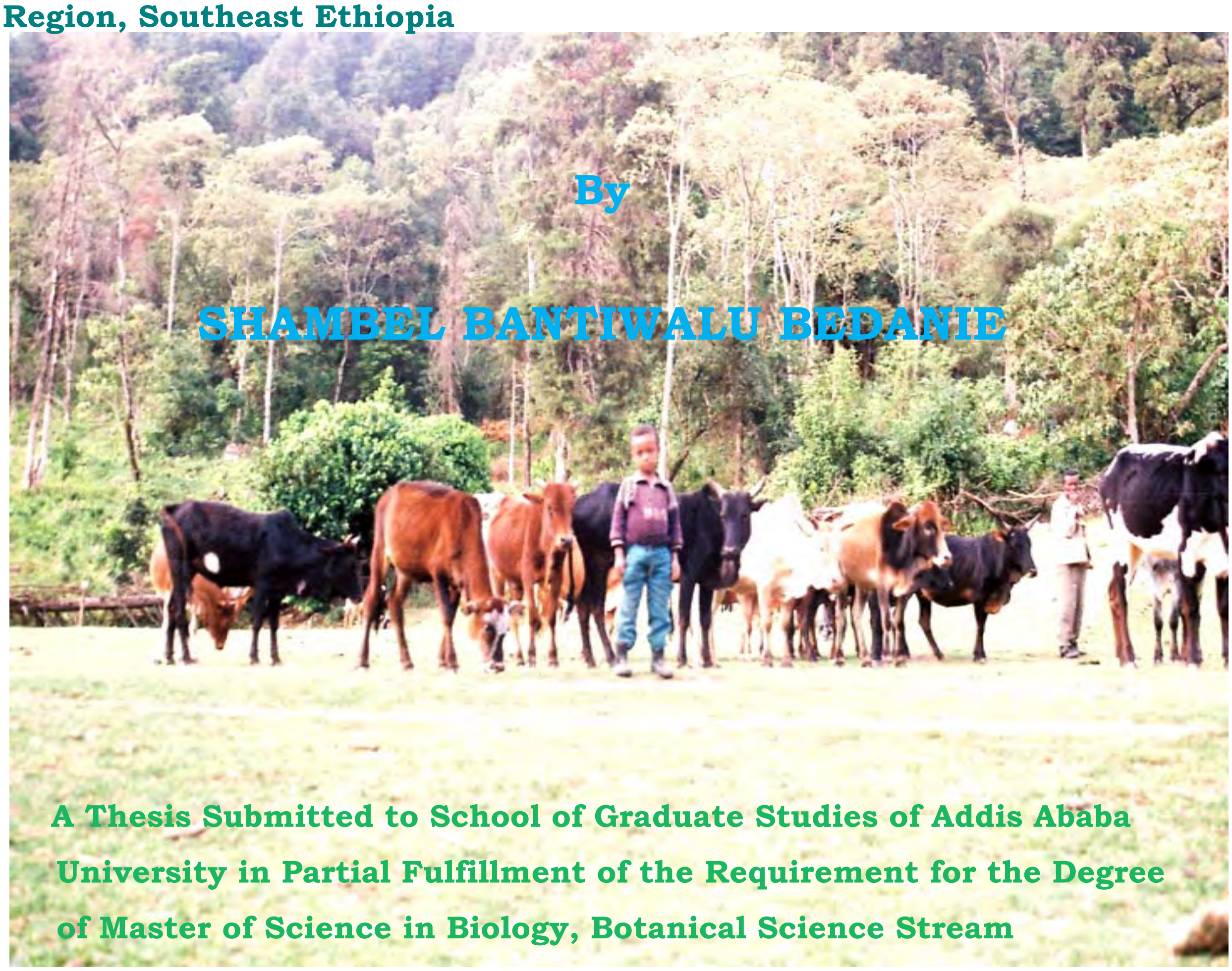
Floristic composition, structure and regeneration status of plant species in Sanka Meda Forest, Guna Distrct, Arsi Zone of Oromia Region, Southeast Ethiopia



By

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ACRONYMS

BSE	BIOLOGICAL SOCIETY OF ETHIOPIA
DBH	DIAMETER AT BREAST HEIGHT
EARO	ETHIOPIAN AGRICULTURAL RESEARCH ORGANIZATION
EFAP	ETHIOPIAN FORESTRY ACTION PROGRAM
EMSA	ETHIOPIAN METEOROLOGICAL SERVICES AGENCY
EWNHS	ETHIOPIAN WILDLIFE AND NATURAL HISTORY SOCIETY
IBC	INSTITUTE OF BIDIVERSITY COSERVATION
ICBP	INTERNATIONAL COUNCIL FOR BIRD PRESERVATION
IVI	IMPORTANT VALUE INDEX
MOA	MINISTRY OF AGRICULTURE
MRPP	MULTI-RESPONSE PERMUTATION PROCEDURE
RED	RELATIVE EUCLIDEAN DISTANCE
RDO	RELATIVE DOMINANCE
RF	RELATIVE FREQUENCY
CSA	CENTRAL STATISTICAL AGENCY
UNDESA	UNITED NATIONS DEPARTMENT OF ECONOMIC AND SOCIAL AFAIRS

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ABSTRACT: *This study was conducted on Sanka Meda Forest in Guna district, Arsi Zone, Oromia National Region in southeast Ethiopia, which is a dry everygreen afromontane type of forest. The objective of the study was to assess floristic composition, vegetation structure, regeneration pattern and to make a phytogeographical comparison of the forest under study with some similar forests in Ethiopia. Systematic sampling method was used to collect vegetation data from seventy 20m x 20m sapling plots for woody species and five 2m x 2m subplots with in each main plot for herbaceous plants. The sampling plots were placed at every 200 m intervals along the nine transect lines laid at 400 m a part. The floristic composition and population structure data for woody species, DBH $\geq$ 7cm and height > 2m, sampling (DBH < 7cm and 1 – 2m height) and all seedlings with a hight < 1m and their regeneration status were recorded in each plot. The vegetation classification was performed using PC – ORD software package. The quantitative species diversity, richness and evenness were computed to describe plant diversity in each community type. Species abundance, cover, and environmental variables (altitude, aspect) were recorded in each sampling plot. A total of 139 vascular plants and a lichen species belonging to 118 genera 63 families were identified. The Asteraceae family had the highest number of species with 21 species and 14 genera followed by Lamiaceae with 10 species and 8 genera. Four plant community types: Croton macrostachyus-Lepidotrichilia volkensii, Maytenus undata, Juniperus procera and Osyris quadripartita-Budleja davidii were recognized. Jaccard's similarity coefficients were below 0.5 for all communities, indicating the prevalance of low similarities among the communities. Thus, all the communities identified are important interms of floristic diversity and sensitive from conservation point of view.Woody species densities for mature individuals were 1060.71 stems ha^{-1}, 416.50 stems ha-^{1} for saplings and 734.64 stems ha^{-1} for seedlings. The basal area of the forest was 34.70m^2 ha^{-1}. The floristic composition species were priorized for conservation using population structure, important value index and rejuvenation as criteria. The population structure and their regeneration behavior in the forest revealed that there is a need for conservation priority for woody plant species with poor regeneration status. The prevailing of strong anthropogenic disturbances in the area implies the need for its immediate conservation action in order to ensure the sustainable utilization of the forest.*

Keywords /Phrases: Afromontane forest, floristic composition, plant community, population structure, phytogeographical comparison, regeneration.

1. Introduction

1.1 Background

Ethiopia is a country with great topographic diversity with high and rugged mountains, flat-topped plateau and deep gorges, incised river valleys and rolling plains. Altitude ranges from the lowest at the depression of Kobat Sink (Afar Depression), which is about 126 m below sea level, to the highest peak at Ras Dejen, 4620 m above sea level (EFAP, 1994). The Great Rift Valley separates the western and southeast highlands and these highlands are bounded on all sides by vast semi-arid lowland areas (Friis, 1992; Tamirat Bekele, 1994). The physical conditions and variations in altitudes have resulted in a great diversity of climate, soil and vegetation cover of the country (Zerhun Woldu 1999; Demel Teketay 2002). These diverse topographic features and climatic conditions of the country have led to the emergence of habitats that are suitable for the evolution and survival of various plant and animal species (EWNHS, 1996). The size of Ethiopian flora is estimated to be over 6,000 species of vascular plants, of which about 10% are considered endemic. Endemism is high on the plateau, mountains, in the Ogaden and Borana and Bale lowlands (Vivero *et al*., 2006; Girma Balcha, 2008).

Conservation of natural vegetation is currently one of the leading agenda for a number of world conservation organizations, authorities and interest groups (UNDESA, 2004). The concern over vegetation conservation generally depends on the anthropogenic activities that lead to the depletion of forest resources (Ramirez-Marcial *et al*., 2001; Reyers, 2004). These authors indicated that the major mechanisms of forest degradation, habitat change and biodiversity loss are: Forest conversion to farmland, exploitation through selective harvest, firewood harvest and charcoal production, seasonally set forest fires, over grazing and hunting of native herbivores. The disturbances created by these activities influence the vegetation dynamics and tree density at the local and regional scales (Hubell *et al*.,1999) and are important in structuring plant communities (Sumina, 1994). They also determine the size class distribution of species (Luoga *et al*., 2004; Canham, 2005). In the face of these problems ecologists and conservation biologists have sought to protect forest vegetation using several different strategies from strict protection in the national parks to suitable management and other integrated conservation and development programs (Borgerhoff and Coppolillo, 2005).

Sustainable forest management has been the main focus of the worldwide forestry sector over the last few decades. It aims to ensure that the goods and services derived from the forest resource meet present day needs without compromising the ability of future generations to satisfy their own requirements. Moreover, sustainable forest Management aims at balancing social, economic and environmental objectives. However, only about 6% of the total forest area in developing countries is managed properly (FAO, 2001). This is very low when compared with about 89% of the total forest area in developed countries, which is subjected to either a formal or an informal forest management (Girma Amente, 2005).

According to Brewbaker (1984), cited in Sharma (2003), the total forest area of the world in 1900 was nearly 7000 million hectares. By 1975 it was reduced to 2890 million hectares. It is estimated that the major reduction has been in tropics and subtropics (40.2%) due to population explosion in these areas. As reported by Manuel and Molles (2002), the global rate of tropical deforestation from 1978 to 1988 was about 30,000 km^2 per year. Forests and woodland are estimated to occupy 650 million hectares or 22% of the total land area of Africa; which corresponds to about 17% of the global forest cover (FAO, 2001). As it is estimated by FAO (2001), the forest in east African region, accounts for 21% of the total forest area of Africa. However, the annual rate of deforestation in this region has increased from 0.7% during period 1981-1990 (FAO, 1993) to 1% from 1990-2000 (FAO, 2001).

Ethiopia is one of the countries in this region with annual deforestation rate of 8% (World Bank, 2002). Ethiopia has a rapidly growing human population of about 75 million largely dependent on low-productivity and rainfed agriculture and over 70 million livestock population competing for land and forest resources. This created high rate of deforestation and forest degradation as important problems in the country (Alemu Mekonnen and Bluffstone, 2007). Today the forest cover in Ethiopia is less than 3% compared with an average of 20% for sub-Saharan Africa (Tesfaye Hunde, 2007).

Reduction in forest cover has a number of consequences including soil erosion and reduced capacity for watershed protection with possible flooding, reduced capacity for carbon sequestration, and loss of biodiversity. This leads to instability of ecosystems and reduced availability of various forest products and services (Alemu Mekonnen and Bluffstone, 2007). The depletion of the natural vegetation in many parts of the country has also led to the threat and decline in number and distribution of many plant species (Tesfaye Bekele, 2000). According to Ensermu Kelbessa *et al*. (1992), 120 threatened endemic plant species are known from Ethiopia. Thirty five of these species were from the Dry Afromontane forests of the country.

1.2 The Statement of the Problem

The availability of accurate data on forest resources is an essential requirement for forest management and planning within the context of sustainable development (FAO, 2007). Botanical assessments such as floristic composition and structure studies are essential in view of their value in understanding the extent of plant diversity in forest ecosystem (WCMC, 1992). Knowledge of floristic composition and structure of forest resources is also useful in identifying important elements of plant diversity, protecting threatened and economic species, and monitoring the state of refers, among others (Ssegawa and Nkuutu, 2006). The study of floristic composition and structure of tropical forest becomes more imperative in the face of the ever increasing threat to the forest ecosystem studies have shown that composition and structure of forests are influenced by a number of factors (Wittmann and Junk, 2003).

Various attempts have been made to study the forests in different parts of Ethiopia. However, the assessment of vegetation composition and other attributes has not been studied so far on the Sanka Mada Forest though it renders significant ecological services and socio-economic values to the local communities. Though Sanka Meda forest is one of the protected forest areas under Arba-Gugu forests, currently it is under server anthropogenic impacts. Hence, there is a need of sound conservation and sustainable use of this forest. This necessitates perceiving the nature of its plant community, species diversity and its linkage to the local communities. The lack of such basic information is one of the serious problems that hampered the coservation management and rational utilization of the forest resources of the area. Thus, species documentation, community identification and description of this forest are important and this study is initiated to provide primary information about the floristic composition, species diversity and structure of this forest.

1.3 Objectives of the study

1.3.1 General Objective

To study the floristic composition, the structure and regeneration pattern of plant species in the Sanka Meda Forest.

1.3.2 Specific Objectives

1. To document the list of plant species in the study area;
2. To identify plant communities existing in the Forest;
3. To assess the regeneration status of some woody species in Sanka Meda Forest;
4. To compare diversity of different community types to analyze the structure of the Forest;
5. To make phytogeographical comparison of the Forest with other similar Forests in the country;
6. To come up with recommendations that may help in the conservation of the Forest resources of the area.

2. Literature Review

2.1. Vegetation of Ethiopia

Ethiopia is one of the countries in the world endowed with rich biological resources. One of these resources is natural vegetation where floristic and faunistic life forms dynamic ecosystems (Girma Balcha, 2004). As defined by Goldsmith *et, al*. (1986), vegetation is an assemblage of plants growing together in a particular location and characterized either by its component species or by the combination of structural and functional characters that determine the appearance, or physiognomy of vegetation.

Many scholars and professionals have attempted to classify and describe the Ethiopian vegetation. Among these EPA (1997), (Breitenbach (1963), Zerihun Woldu (1999), Friis and Sebsebe Demissew (2001), Sebsebe Demisew *et al.* (2004), Sebsebe Demissew (2009) and others have made a considerable contribution in classification and description of the natural vegetation types mostly based on physiognomic basis as well as in proposing their appropriate conservation measures. According to Sebsebe Demissew and Friis (2009), at present the natural vegetation of Ethiopia is divided into nine major types, some of which are divided into subtypes or form of vegetation mosaics. These are 1. Desert and semi-desert scrubland, 2. Acacia – Commiphora woodland, 3. Moist Evergreen Montane rainforest which can be divided into two natural subtypes (Afro-montane rainforest and Transitional rainforest), 4. Lowland semi-evergreen forest, 5. Combretum-Terminalia Woodland and Savannah, 6. Dry evergreen Montane forest and Grassland complex which is divided into four distrinct subtypes (Undifferentiated Afro-montane forest, Dry single –dominant Afro-montane forest of the eastern escarpments and transition between single dominant Afro-montane forest and East African evergreen and semi-evergeen bushland), 7. Afro-Alpine and sub-afro – alpine vegetation, 8. Riparian and 9. Swamp vegetation and coastal vegetation. As described by IBC (2005). These major vegetation types are considered as natural ecosystems of the country. The vegetation of the present study area falls in the dry evergreen afromontane forest vegetation type in the country (Friis 1992; Tamirat Bekele, 1994; EFAP 1994; Sebsebe Demissew, 2009);

2.1.1 Dry Evergreen Montane Forest

The Ethiopian highlands cover more than 50% of the country's land area with Afromontane vegetation (Tamrat 1993, 1994; Yalden 1983), of which dry afromontane forests form the largest part. Several names have been employed to refer to dry afromontane forests in Ethiopia, e.g. tropical high montane conifer forest (Logan 1946), montane dry evergreen forest (Pichi-Sermolli 1957), highland *Juniperus-Podocarpus* forest (Von Breitenbach 1961), dry montane forest (Coetzee 1978), upland dry evergreen forests (Friis *et al*. 1982; Friis 1986), coniferous forest (Anonymous 1988), undifferentiated forest (Friis 1992) and dry evergreen montane forests (Sebsebe Demisew and Friis 2009). The dry afromontane forests are either *Juniperus-Podocarpus* forests or predominantly *Podocarpus* forests, both with broad-leaved species. They occur in both the Northwest and Southeast Highlands, especially on the plateau of Shewa, Wello, Sidamo, Bale,Arsi and Harerge at altitudes 1500-2700 m. The average annual temperature varies between 14 and 20°C and the annual rainfall between 700 and 1100 mm, with most of the rain recorded in July (Friis 1992).

2.1.2 Trends and rate of deforestation in Ethiopian vegetation

A substantial proportion of the land area in highlands of Ethiopia was once believed to have been covered by vegetations having wider coverage than at present (Friis, 1986; EFAP, 1994). Historical sources indicate that, forests might have covered 35-40% of the total land area of the country. If the savanna woodlands are included, about 66% of the country was believed to have been covered by forests and woodlands. However, the country's high forests and woodlands coverage have been declining both in size and quality. This is due to the increased use of forest lands for farmlands; unwise use and excessive utilization of forest products without considering the ecological and economical consequences (EFAP, 1994; Getachew Eshete, 2002). By the early 1950s high forests were reduced to 16% of the total land areas. It has estimated that by the early 1980s the land area covered by forest had declined to 3.6% and by 1989, it was reduced to about 2.7% (EFAP, 1994; Reusing, 1998). At present, the country's total area under forest is 4.07 million hectares, out of which the high forests took about 2.3% (Tesfaye Hunde, 2007). It has been estimated that the annual deforestation rate is between 150,000 and 200,000 hectares (EFAP, 1994). According to the Reusing (1998), the

Ethiopian forests have seen a tremendous decline since 1973. About 24,543 Km^2(2.14%) of the land area of Ethiopia had been deforested between 1973 and 1990. if the existing rate of deforestation and trend of exploiting the remained scarce forests continuous, there will be little hope of having any forest worth mentioning after a few years (EFAP, 1994; EPA, 1997; Sebsebe Demissew, 1998). Currently, there are 92 forests areas in Ethiopia out of which 56,29,5 and 2 of them are dry evergreen montane forest, moist evergreen montane forest, transitional dry-moist evergreen montane forest, semi-evergreen forest type respectively (EFAP, 1994). Most of the high forests in the highlands of the country are already converted into agricultural lands, except few remnants in south and southwestern parts (Demel Teketay, 1999).

2.1.3 Ecological sevices of forests

Ecosystem services are the outcome from ecosystem functions that benefit human being (*FAO*, 2007). The services provided by forests cover a wide range of ecological, economical, social and cultural considerations and processes. This diversity means that there are no easy management is not a technical or mechanical process but one that must necessarly in crepitate a variety of competing interest groups and views (Bingham *et al*., 1995). There are a number of components to broad range of services that forests provide in addition to their values of basic goods. They contribute more than other ferrestrial biomass to climate relavent cycles and biodiversity related processes (FAO, 2007). According to Daily (1997), The major services provided by forests includes: Regulation of water regimes, modulating climate, maintenance of soil quality, carbon sequetraion, maintenance of biodiversity in themselves and being a habitate for other species air pollution, biological control,cultural, aestatic and amenity services.

2.1.4 Socio-economic services of forests

Forests provide a wide range of products and services catering to a variety of man's socio-economic needs. The economic values of the forest are inherently anthropocentric by nature forests form the basis of a variety of industries including timber, processed wood and paper, rubber, and fruits. They also contain products that are necessary to the viability of rural communities. These products include fuel, foder, game, construction materials, and medicines (FAO, 2005).

In Ethiopia forest resource play a vital role as source of energy. The energy consumption of rural Ethiopia is mainly based on biomass sources for which fuel wood being the highest component. Almost, all rural Ethiopian households entirely depend on biomass fuel to meet their energy requirements for cooking, heating and lighting. Biomass based fuel accounts for 85% and 95% of the total energy and household consumptions respectively. In the share of different biomass based fuels in the total domestic energy, fuel wood and tree residues take 70%, Animal dung 8%, agricultural residues 7% and the rest comes from other sources (EARO, 2000). Fuel wood and tree residue represent the bulk of the domestic energy supply. Fuel woods are derived mainly from various forest vegetations such as high forests, woodlands, bush lands, etc. This extra ordinary dependence on biomass-based fuel persisted in the country for along period of time and is one of the highest in Africa (Mulugeta Limeneh, 2007). The forest resource in Ethiopia also provide non-timber forest products (NTFPs), which cover a wide range of product naturally produced by certain forest species (Anonymous, 2001). According to Demel Teketay (2002), The most important NTFPs in Ethiopia include Gum Arabic, resin, coffee, species, incense, edible plant products (fruit, seeds, oil, fodder, etc), fibers, essential oils, tannin and dyes. Traditional Medicine has an important place in the health care of Ethiopian population. It is estimated that 80% of the people in Ethiopia rely on some form of traditional medicines that are obtained from plants for their primary health care needs.

2.1.4 The threats to Ethiopian vegetation

The Ethiopia vegetations, particularly the forest resources are under severe pressure as a consequence of inhabitants' need for farmlands and grazing lands. There is a severe and increasing fuel wood gap in the country; which leads to depletion of the standing stock and, hence, further degradation of the remaining forest stands (EPA, 1997). The loss of forest resource is severe in the Ethiopian highlands where most of the vast mountain massifs in the heart of the country lie above 1500 m elevation (Deriba Geleti, 2006).

These highlands cover about 44% of Ethiopian land area; accommodate 88% of the total population because of their agricultural potential and low prevalence of diseases. They also contain about 95% cultivated land and more than 67% of the livestock (EFAP, 1993). The location of Ethiopian high forests on the zone of these densely populated highlands and their unique ecology make them endangered and more susceptible to strong deforestation of forests (Shiferaw Dessie and Taye Bekele, 2002). Another threat is the conversion of high forest sites to coffee and tea plantations. Currently a number of investors have filed applications for forestland with the regional authorities. In the process of decision making on the requests in most cases little consideration is given to ecological impacts in general and biodiversity conservation in particular.

According to FAO (1985); Getachew Berhan and Yosef Assefa (2002), the major threats to the conservation of the Ethiopian vegetation are increasingly intensive use of forestlands for agriculture and livestock, need of fuel wood and construction materials, forest fires and human settlement. These major causes of forest destruction are very much interrelated and most are ultimately initiated by the rapid population growth in the country.

2.1.4.1 Forest fires and their effect on vegetation

As with ionizing radiation, fire is both a natural and human enhanced factor in ecological system. Forest fires inflect great damages to both the natural and plantation vegetations. In Ethiopia the forest fires occur during the dry seasons between January and April ranging for three Months (Desta Hamito, 2001). The causes of fires vary between highlands and lowlands of the country. As explained by Kenfe Abebe (1993); Dhaba Wirtu (2001), three types of forest fires are distinguished: ground fire (a forest fire which consumes the organic materials beneath surface litter of forest floor) surface fire (a fire that burns surface litter, other loose debris of the forest floor and small vegetation), and crown fire (a fire that advances from bottom to top of the trees or shrubs more or less independently of the surface fire).

Crown fires are typically very intense, consuming the entire plant community above the ground and often its animal components as well. Combustion of the surface litter, or “O” horizon, and Organic mater in the “A” horizon of the soil not only burns dead leaves and organisms but also seeds and other regenerative structures (e.g., bulbs, tubers). Because of the severity of destruction, such areas present a barren landscape and typically take years to being even modest recovery. In the interim the area is subject to erosion following even mild levels of precipitation, thus removing the nutrients required for life and regeneration (Kaufman *et al*. 1993).

Forest fires have both beneficial and adverse effects. Among the beneficial effects of fire is the combustion of dead litter into ash, resulting in the release of mineral nutrients for recycling. This may be coupled with the increased growth of nitrogen – fixing legumes that often occur after moderate surface water. The major impact of crown or surface fire is disturbance of the ecological community, specially the destruction of the organisms and their intertwined relationships. The crown fire and sever surface fires leave the ground surface subjected to erosion, the severity of which depends on the nature of the soil surface and the amount and intensity of precipitation. For the human eye, the aesthetic pleasure derived from the sight of broad expanses of forest and prairie is fractured and the mind-refreshing experience of a walk in the woods is shattered (Kormondy, 2005). Salisbury (1989) described this situation as: “There is no lens wide enough to picture a forest that has just died, black trees extending to the horizon.” This problem is observed in the Sanka Meda forest during this study (See Plate 1).

Plate 1: Use of fire for clearing the Forest by the local communities for expansion of farmland (Photo by Shambel Bantiwalu, 2009).1

Although fire has a beneficial effect in mobilizing nutrients in ash, there are substantial losses of nutrients as a particulate matter in smoke and, especially for nitrogen, by volatization (Hobbs and Gimingham, 1987). Forest fires volatile nitrogen (N) in proportion to the heat generated and organic matters consumed. Typically, N losses range from 100 to 300 kg/ha, 10-40% of the amount in aboveground Vegetation and surface litter (Waring and Schlesinger, 1985). Losses of nitrogen and sulfur are especially large at higher temperatures, reaching 57% and 36% respectively, at 750^0C; losses of nitrogen and phosphorus were four to five times greater in a fire at 800^0C than in one at 600^0C. Substantial amounts of sodium, potassium, iron, and copper were also volatilized during forest fire (Kormondy, 2005).

The air currents and updrafts during fire carry particles of ash that remove other nutrients from the site. These losses are usually much less significant than N losses. Expressed as a percentage of the amount present in aboveground vegetation and litter fire, the losses often follow the order; N > K > Mg > Ca > P > O% (Clayton, 1976). The main effect of the fire is the bulk release of nutrients at one time to the soil surface instead of the gradual release that normally takes place as a result of decomposition. Because of this rapid release, some of the nutrients leave the habitat through the action of wind or water and added to the adjacent locations or atmosphere without benefiting the plants (Ewusie, 1980).

2.2 Biodiversity and its loss in Ethiopia

Currently there are many definitions of biodiversity and most are vague, which probably reflects the uncertainty of the concept. Some consider it to be synonymous with species richness (Heywood, 1998), others see it as species diversity (Bond and Chase, 2002), whereas many give a much broader definition such as the 'fullvariety of life on Earth' (Takacs, 1996) and others have put extra emphasis on threatened species (Brockerhoff *et al*., 2001). Biodiversity is the total variety of life on earth. It includes all genes, species ande cosystems and the ecological processes of which they are part. (ICBP, 1992). One of the most often referred definitions of biological diversity is the one used in the Convention of Biological Diversity: The Convention on Biological Diversity (2003) uses the following definition: "Biological diversity" means the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems.

The topography and diverse climatic conditions of Ethiopia have led the occurrence of habitats that harbor some unique plant species and animals and their assemblages. As a result, Ethiopia is one of the countries in the world with high level of biodiversity. Owing to the long history of agriculture and the diversity of the environment, it is again one of the 12 Vavilove centers of crop genetic diversity. The overall results of the environmental degradation in Ethiopia, whether at a local level or ecosystem level, leads to desertification and its manifestations which eventually become the overriding cause for loss of biodiversity. These disruptions have meant that much endemic biodiversity has been lost and more is threatened (Zerihun Woldu, 2008). As a result, some parts of the country including the high forests zone are categorized among the 34 biodiversity hot spots of the world (Teshome Soromessa *et al*., 2004). These are the eastern central plateau along with similar habitats in east Africa, designated as the Eastern AFromontane Biodiversity Hotspots and the eastern parts of the country along with similar habitats in the Horn of Africa designated as the Horn Biodiversity Hotspots (Zerihun Woldu, 2008). The present study lies in the eastern central plateau which is included in the list of Eastern Afromontane Biodiversity Hotspots. For an area to be included in the list of the world's biodiversity hotpots, it must contain 0.5% of the global total vascular plants and must have loss 70% or more of its original natural vegetation (Myers, 1990). This makes that the degree of rate of deforestation which leads to the loss of biodiversity being expected to be high in the counry.

2.3 The plant community

Distinguishing plant communities has been at the heart of vegetation science for centuries, with a traditional focus on the distribution, composition and classification of plant communities (Kormondy, 2005). Many ecologists attempted to give the botanical definitions for the plant community. Some of these are: Oosting (1956), Grubb (1987), Kent and Coker (1992), Plant communities are defined as an assemblage of functionally similar species populations that occur together in time and space (Magurran, 1988).

Plant communities are separated from each other based on indicator species in combination with a distinctive floristic composition. The latter is considered as one of the key points about plant communities are that they are collections of species which occur together in some common environment or habitat and that the species making up the community are somehow integrated or interact as a society. There is no fixed size for a community. They can range from very small size to variable expanses of grassland or forest (Reiss and Chapman, 2008).

The plant community structure includes attributes such as the number of species, the relative abundance of species, and the kind of species comprising a community (Manual and Molles, 2002). The overall structure of the plant community will be determined by a combination of several features such as the physical environment, community size, and longevity of species present. The community may be stable or unstable, with high or low primary productivity, and may change seasonally or even daily (Reiss and Chapman, 2008).

2.4 Species Diversity, Richness and Similarity

Floristic description of vegetation community involves the analysis of species diversity, evenness and similarity. Species diversity is one of the most important indices used for evaluating the sustainability of forest communities.Diversity and equitability of species in a given vegetation community is used to interpret the relative variation among and within the community and help to explain the underlying reasons for such a difference (Kent and Coker, 1992). Species diversity is described on the basis of two concepts (factors), the total number of species in the community (species richness) and the relative abundance of species (species evenness) within the sample or community. Species diversity is measured by recording the number of species and their relative abundance. These two components of species diversity may be examined separately or combined into some forms of indices. A commonly applied index for measuring the species diversity is the Shannon diversity index (Kent and Coker, 1992; Manuel and Molles, 2002).

As distinguished by Whittaker (1975), there are three different kinds of species diversity, alpha (α), beta (β) and gamma (γ) diversity. Alpha diversity refers to the number of species within a sample area or community. Beta diversity describes the differences in species composition between two adjacent areas or communities. It is a measure of the rate and extent of changes in species along a gradient from one habitat to another. Thus, beta diversity is between habitat diversity that measures the turnover rates. Beta diversity is low when the overlap between the species composition of the two areas is high and is highest when the area have no species in common at all. Beta diversity is sometimes called habitat diversity because it represents differences in species composition between very different areas or environments and the rapidity of change of those habitats. Gamma diversity describes regional differences in species composition (e.g. the difference in species composition between comparable habitats on two adjacent mountain ranges) and it depends on the alpha and beta diversity (Kent and Coker, 1992; Crawley, 1998; Burley, 2001). Species diversity and species evenness are often calculated using the Shannon diversity index (H'), which naturally varies between 1.5 and 3.5 and rarely, exceeds 4.5 (Kent and Coker, 1992). Shannon diversity index is the most appropriate and the most widely used index for combining species richness and evenness (Krebs, 1999).

2.5 Vegetation Changes in Response to Environmental Factors

Within a community at one time species may be spatially distributed according to the variations of the physical environment (Tylor, *et. al*, 2007). The distribution, abundance and diversity patterns of species can result from the interaction between the biotic and abiotic factors at different spatial and temporal scales (Gemedo Dalle, 2004; Feyera Senbata, 2006). The variations of species abundance in response to environmental factors is termed *environmental gradient* (Kent and Coker, 1992). Natural vegetation may respond to environmental gradients in many different ways (Desalegn Wana and Zerihun Woldu, 2005). The physical environments experienced by plants depend on several factors such as geology, topography, location and climate (Reiss and Chapman, 2008).

The interacting influences of topography (landscape), climate and geology are the primary determinants of plant distribution. Thus, variables such as vegetation structure and productivity vary along environmental gradients (Brown, 2001). The influence of topography is intimately connected with other a biotic factors since it can strongly influence local climate and soil development. The main topographic factor is altitude. Higher altitudes are associated with lower average temperatures and a greater diurnal temperature range, higher precipitation, increased wind speeds, more intense radiation and lower atmospheric pressure all which have an influence on plant life. As a result, vertical zonations are common (Taylor, *et al*., 2004). The temperature and moisture along altitude, the nature of substrates and topographic features such as aspects and their configuration can result in distinct or fuzzy units of vegetation (Zerhun Woldu *et al*., 1989).

According to (Taylor, *et al*., 2004), aspect and slope are other most important topographic factors that have striking effects on the pattern of the natural vegetation. In the northern hemisphere, south-facing slopes receive more sunlight and therefore higher light intensities and temperatures, than valleys bottoms and north-facing slopes. The reverse is true in the southern hemisphere. Steep slopes generally suffer from faster drainage and run-off, and the soils are therefore thinner and drier.

3. Materials and Methods

3.1 Description of the study area

3.1.1 Location

The present study was conducted in Oromia Regional state, Arsi Zone on Sanka Meda forest, 260kms southeast of Addis Ababa and 220kms east of the zonal capital, Asela town in Guna district. The site is the part of southeast highlands which is the extension of Harerge, Arsi and Bale highland massifs (Demel Teketay, 1996). The forest is located been 8^0 22' 09’’ – 8^0 24’54”N latitude and 39^0 57’02”- 39^0 58’ 52”E longitude. It is loated 18 kms east of Aba-Jema town which is the capital of the district and has a total area of 480 hectares (Figure 1). This forest plays a vital role in regulating the watershed of the surrounding areas. It is situated between two perennial rivers Etaro and Dagnam-Yelew Rivers which are tributaries of Awash River and is important water catchment for these rivers. The eastern part of the forest drains into Dagnam-Yelew River, and its western part drains into the Etaro River.

Guna is one of the 26 districts of Arsi zone. It was set up as a new district in 2006 departed from the former two districts, Aseko and Merti and became one of the administrative units of Arsi zone. It is located between 7^0 53'1 7"-$8^0$09'17"N latitude and 39^0 41' 59" - 40^0 01' 01"E longitude in the eastern part of the zone having the total area of 405.1 km^2. It shares a boundary with Chole district in the south and south east, Gololcha district in the east and north east, Aseko district in the north and north east, Merti district in the north and northwest and Sude district in south west direction (AZFEDO, 2009).

The name of this District (Guna) is derived from the name of the tree that the Arsi women use for steaming purpose (Keya). The botanical name of this plant is *Olinia rochetiana* which is taxonomically placed in the family Oliniaceae.The local name of this plant is “Qayya beeraa” in Afaan Oromo and “Guna” or “Tife” in Amharic. The part of the plant used for steaming is mainly its stem. Some of the reasons of steaming with this plant (Qayyaa) are: To increase the attraction of the opposite sex, for its pleasant smelling and for beautifying treatments. Currently, Steamig (being fumigate) by this plant is widely used by Arsi and Bale women and also in some large towns and cities. As a result, the selling of the splinters of this plant is common in local markets and the population of this species is declining in the local Forest.

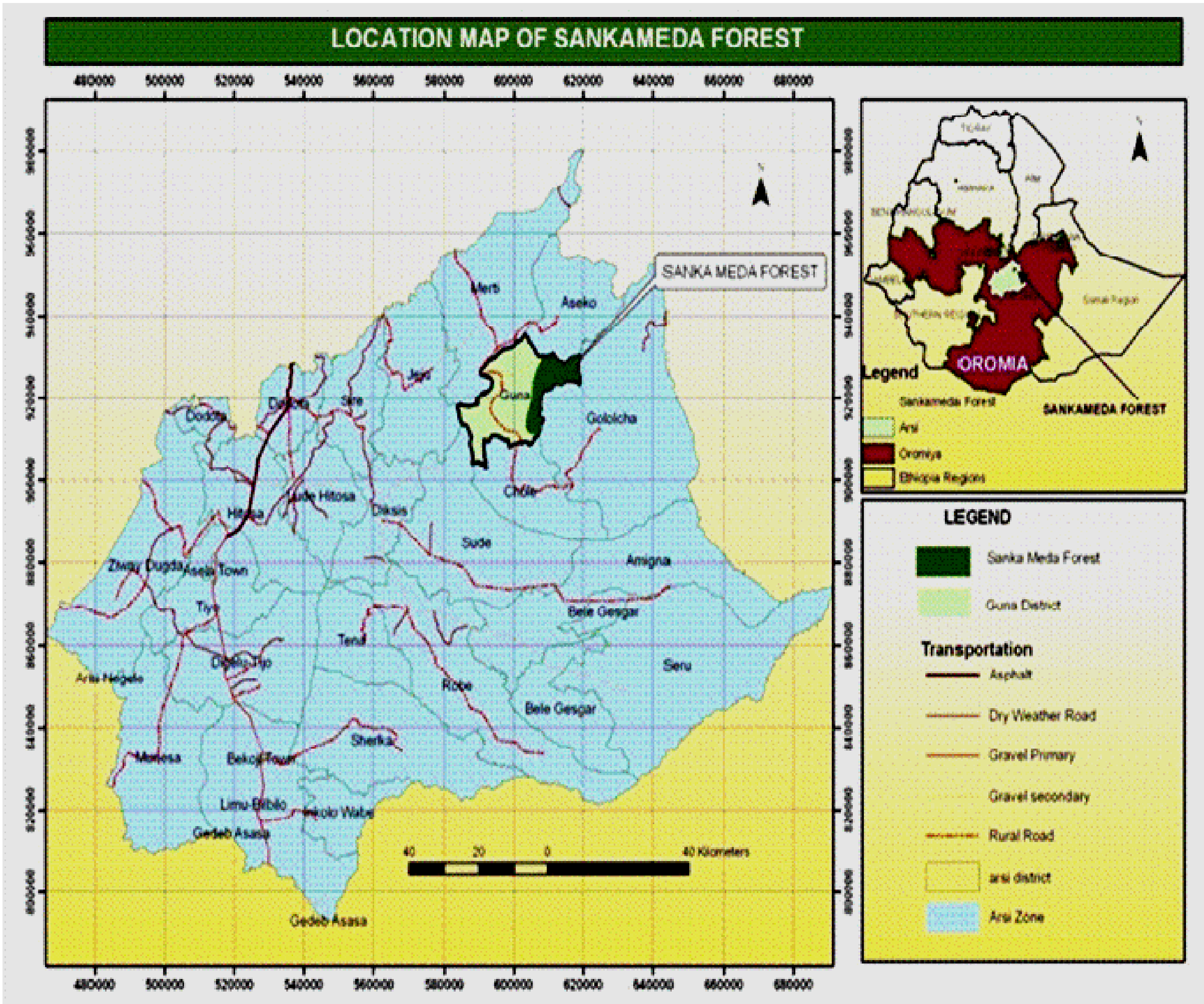


Figure 1: Map of the study site and Saka meda Forest

3.1.2 Geology

The present land form of the district was formed due to tectonic force acting up on the internal part of the earth during Cenozoic era of quaternary period at different epoch. The northern, western, south eastern and most central part of the district is covered by Nazeret series. The southern tip and south western tip of the district is covered by Tarmaber Magazez formation. While it's some central and eastern parts are covered by Alajae formation (AZFEDO, 2009).

3.1.3 Relief and drainage

The relief of Guna district is characterized by undulating high plateau dissected by streams and rivers flowing from these plateau towards the rift valley. Its altitude ranges from approximately 1200 to 3574 meters above sea level. Kamisari (Gugu) maintain is the highest peak (3574m a.s.l.) in this district. The major perennial rivers are Aba-Jema, Kosobankola, Nano, Melkamiya, Etaro, Arba- Kela, Degnam-Yelew, Sorbaye, Dima and Guna rivers. Due to high network formed by river systems, the district has high potential for both traditional and modern irrigation systems (AZFEDO, 2009).

3.1.4 Climate

The rainfall and temperature data for this study were collected form the nearest Meteological station of Aba-Jema about 18km from the Sanka Meda forest. Aba-Jema town is located at 8^0 22' 45"N and 39^0 54' 44"E with altitude of 2760 m a.s.l. Fifteen years data (1992-2006) were taken and calculated from the National Meteorological Services Agency, (NMSA, 2009). Due to its altitudinal location, the district is divided into four agro-climatic zones; Dega, Weina-Dega, Kolla and Wurch. Acording to Hurni (1986), Kolla persists within 500-1500 m.a.s.l., Weina-Gega (1500-2300 m.a.s.l.), Dega (2300-3200 m. a.s.l.) and Wurch (above 3200 m.a.s.l.) belts. Dega covers 84% of the total area of the District, Weina Dega 11%, and Kolla 2% and Wurch 3% (GDRADO, 2009). The mean annual temperature is about 20^0c and the mean minum temperature is 7.3^0c where as the mean maximum temperature is 31.7^0C. The hottest months are from February to June. The maximum temperature is 21.70c recorded in June and the coldest months are from July to December with average minimum temperature of 6.2^{0}c recorded in December. The mean annual rainfall is 1028mm. the rainfall pattern is bimodal, which are short spring rainy season (Belg season) that occurs from the beginning of march to mid-may and long summer rainy season (Meher Season) from end of May to the mid-October. The highest amount of rainfall occurs in July between June and August (Figure 2).

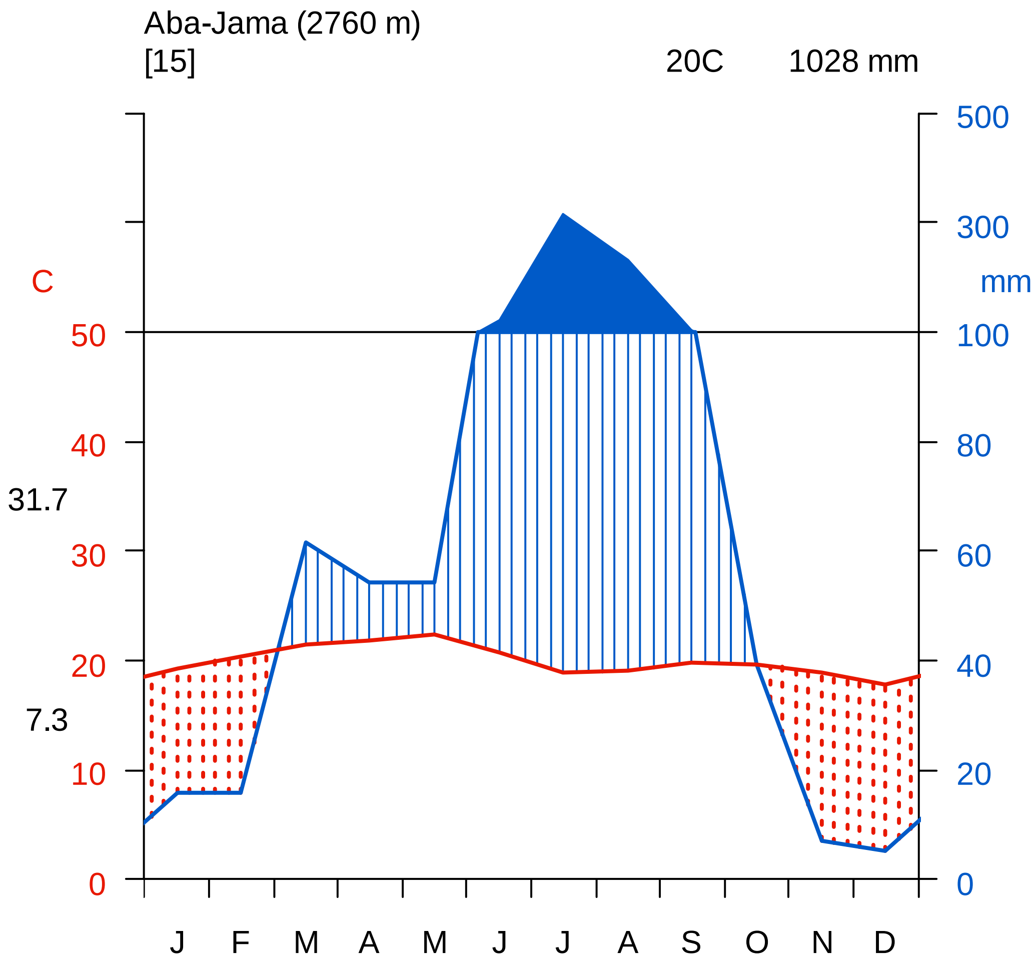


Figure 2: Climatic Diagram for Aba-Jema town (Source: EMSA 1992-2006)

3.1.5 Land use pattern

Land use pattern indicates the classification of land of an area under different type of socio-economic uses. Patterns of land use changes from time to time depending up on socio-economic change. The grazing land, natural forests and fallow lands are declining while the needs for cultivated and residential lands are increasing from time to time.

According to GDARDO (2009), a survey of land in this district shows 70.8% of its land is cultivated, 6.2% pasture, 10.6% forest and the remaining 12.4% is swampy and rocky mountain areas and others (Table 1).

Table 1: Land use characteristics of Guna district.

Component	Area in hectare	Percent
Caltivated land	28,685	70.80
Non-caltiivated land	2,066	5.10
High forest land	4,275	10.60
Woodland and bush land	381	0.90
Rocky mountain area	1,035	2.50
Swampy area	275	0.60
Water body	158	0.40
Settlements	961	2.40
Reserved lands for ivestments	160	0.40
Permanent crops	22	0.10
Pasture land	2,492	6.20
Total	40,510	100.00

Source: GDARDO, 2009.

3.1.6 Soil

The major soil textures are clay (10%) sandy (2%) silt loam (20%), loam soil (40%), swap soil (13%) and clay loam (15%). The fertility status is good. However, the rapid erosion due to high rate of deforestation is one of the major problems of the district (AZFEDO, 2009). As visually observed during the study, the soils in the Sanka Meda forest area are brown in color and with high amount of humus. Sedimentary rock is abundant in the area (Plate 2).

Plate 2: Exposed sedimentary rock on the former road to Asko town at the eastern fringe of The Sanka Meda Forest (Photo by Shambel Bantiwalu 2009)

3.1.7 Population size and distribution

Based on the data obtained from Guna District Agricultural and Rular Development Office (GDARDO, 2009) in the year 2008, the district has a total population of 112,520 of which female population accounted for 47% for rural and 52% for urban areas. From the total population, only about 8% are urban dwellers and about 92% of the populations of the district are living in rural area. The overall sex ratio of the district is 111 males per 100 females (urban 92 males per 100 females and rural 113 males per l00 females). An average family size was 5.1 persons per household. Among the total population of the district, young age (0-14), accounts for 49.42% (rural 50.03% and urban 41.80%) while old age (65+) is of 2.66% (rural 2.56% and urban 4%). On the other hand, the economically active population (age 15-64) account for 47.41%, which is 47.41 for rural and 54.22% for urban (AZFEDO, 2009).

Population density can indicate the relationship between population and resources. The district had the crude density of 278 persons/km^2 in the year 2008, which is greater than the zone average of 132.2 (GOARDO, 2009).

3.1.8 Socio-economic conditions

3.1.8.1 Crop production

Bimodal type of rainfall provides a wide opportunity for the district to produce the crops and use the same land twice a year (during ‘Meher’ and ‘Belg’ seasons). However, Meher is the main growing season in terms of cultivated land and production obtained. The major annual crops grown in the district are cereals, pulses and oil seeds. From cereal crops Barely, Teff, Wheat and Maize are the most widely grown crops in the district. In addition, it is known by production of vegetables like potato, tomato and onion (GDARDO, 2009).

3.1.8.2 Livestock rearing and poultry

Cattle, goats, sheep, horses, mules, donkeys and camels are the major type of livestock rearing in the district. From the total livestock found in the district cattle, goats and sheep account for about 51.61%, 5.19% and 30.57% respectively in the year 2007, indicating cattle occupied the highest share of the livestock found in the district (GDARDO, 2009). Poultry production is another source of family income and food in the district. In 2007 and 2008, there were 65,725 and 90,775 poultry populations in Guna district respectively (Table 2). The prevalence of disease and traditional method of rearing are the major causes for decreasing the quantity and quality of poultry production in the district (GDARDO, 2009).

Table 2: The number of Livestock and Poultry Population

No	Type of input	2007	%	2008	%
1	Cattle	57,362	51.62	66,021	59.41
	Sheep	333,974	30.57	70,685	63.60
	Goats	5,771	5.20	5,880	5.29
	Donkeys	3,379	3.04	4,799	4.32
	Horses	8,941	8.05	11,285	10.15
	Mules	1707	1.54	2,260	2.03
	Livestock (Total)	111,134	100.00	160,930	100.00
2	Poultry	65,725	100.00	90,775	100.00

Source: GDARDO, 2009.

3.1.8.3 Bee-keeping activity

Bee-keeping is another source income generating and food for farmer family. Rapid deforestation rate of vegetation, use of herbicides and insecticide are the main problems in bee farming. However, there were 80 modern hives and 3200 traditional been hives in the year 2008 in the district (GDARDO, 2009).

3.1.8.4 Vegetation of the area

The vegetation of the study area is dry evergreen montage forests with important tree species such as *Junipers procera*, *Podocarpus falcatus*, *Prunus africana*, *Teclea nobilis*, *Cordia africana*, *Olea europaea* subsp. *cuspidata*, *Croton* macrostachyus, *Bersama abyssinica*, *Olea hochstetteri*, *Paveta abyssinica*, *Olinia rochetiana* and *Allophyluus abyssinicus*. Forest patches are observed in Guna District on the way to Aba-Jema town in Angada and Rae-Arba forests and on the road to the Dima town from Aba-Jema in Guna-genetie, Sanka Meda and Sheno forests (Plates 3 & 4). There are also woodlands, bushs, afro-alphine, sub afro-alpine and grasslands which are the major vegetation type in the District but are not included in the present study. Some of the forests in the district are protected by the government. These forests are the part of the protected Arba-Gugu forests. According to the report of AZFEDO (2009), the total area of the Arba-Gugu forest is about 44,355 hectares. Some of the protected

Arba-Gugu forest areas in the Guna District are Sanka Meda, Angada, Ra'e-Arba, Guna-Genetie, Gembeso (Sorbe-Etaro), and Darishe forests.

Plate 3: Northsouth view of part of Sanka Meda Forest (Photo by Shambel Bantiwalu 2009)

Plate 4: Westeast view of part of Sanka Meda Forest where *Podocapus falcatus* is the dominant Species (Photo by Shambel Bantiwalu 2009)

3.1.8.5 Wildlife

The Sanka Meda forest harbours various wild animals including mammals, birds, reptiles, amphibians and insects like wild honey bees. Monkeys, apes, Columbus monkeys, Bush-buck, leopard, Hyena, antelopes and porcupine are some of the mammals. There is also a large numbers of bird species as observed during the study. However, these wild animals are under severe threat due to human interferences and high rate of deforestation of the forest. According to the local inhabitants, the major threats to wildlife are illegal hunting and mass killing of the monkey populations and apes by the local farmers using poisons to keep their crops from attack by these wild animals.

3.2 Methods

3.2.1 Floristic and structural data collection

A reconnaissance survey was carried out from October 2-9, 2009, in order to have an overview of plant assemblages in the site and to determine the sampling and data collection methods and to get a good estimate of the vegetation. It is important to know the size of the vegetation as well as the number of plots to be laid out per hectare before data collection (Panwar and Bhardwaji, 2005). During the reconnaissance survey, the checklist of plant species was recorded using local names. The vegetation and environmental data collection was made from November to December 2009. A total of 70 sample plots were established systematically in transect lines following the Braun-Blanquet approach (Mueller-Dombois and Ellenberge, 1974; Kent and Coker, 1992; Desalegn Wana and Zerihun Woldu, 2005). The plots were laid at every 200 m interval along 9 transect lines, which are laid at 400 m apart. The data of major vegetation attribus were measured for trees, shrubs and climbers and recoreded using twenty by twenty size plots (20 m x 20 m) which were established along the transect belts. The undergrowths of woody species with the height less than 1m were considered as seedlings, single-stemmed individuals with the height of greater than 2m were considered as trees and those in between the seedling and trees/shrubs (with height of 1-2m) were considered as sapling (Singhal, 1996). The height of seedlings and saplings were measured using the tape – meter and for trees it was measured by percent scale clinometer.Tree height calculation followed the Larsen *et al*. (1987) method. All the plant species encountered in each sample plot were recorded using both botanical and vernacular names. The plant species occurring outside sample plots within 10 m distance were recorded only as 'present', but they were not used in the subsequent vegetation data analysis. In each sample plot, the circumferences of woody species at breast height (about 1.3m) were measured and recorded during sampling in the field and conversion to diameter at breast height (DBH) and basal area were made later.

The measurement was taken for trees and shrubs with the height ≥2 m Circumference ≥ 7c m (DBH = 2.50) and above. For trees and shrubs that are branched around the breast height, the circumference were measured separately and averaged. Within the main plots of 20 m x 20 m, five representative subplots of 2 m x 2 m size (four at the four angles of the main plot and one at the center) were set up (Figure 3) to assess herbs or ground flora (Singhal, 1996). Physiographic variables such as altitude, aspect and 3D-locations were measured and recorded for each sampling plots (Appendex 1). Species composition and cover value (the area of ground within a sampling plot occupied by the above ground parts of each species) Kent and Coker (1992), were recorded for each species to determine the plant community types. The recorded percentage cover abundance values were later converted into a modified 1-9 Braun-Blanquet sales (Van der Maarel, 1979) as shown in the table below.

Table 3: Modified Braun - Blanquet cover scales

Values	**Scales**
1	Rare, generally one individual with less than 5% coved of the total plot area
2	Sporadic, with less than 5% cover of the total plot area
3	Abundant, with les than 5% cover of the total plat area
4	Very abundant, with less than 5% cover of the total plot area
5	5-12% covers of the total plot area
6	12-25% covers of the total plot area
7	25-50% covers of the total plot area
8	50-75 covers of the total plot area
9	75-100% covers of the total plot area

Source: Van der Maarel (1979)

Voucher specimens were collected and pressed for identification of the species in the study area and brought to the National Herbrium (ETH), Addis Ababa University, where they were properly identified to species and subspecies levels. The identification was done using the published volumes of Flora of Ethiopia and Eritrea and by comparing with the authentic specimens in the National Herbarium. The nomenclature of plant species also followed the Flora of Ethiopia and Eritrea. The accuracy of identification was checked and confirmed. The vouchers have been deposited at National Herbarium.

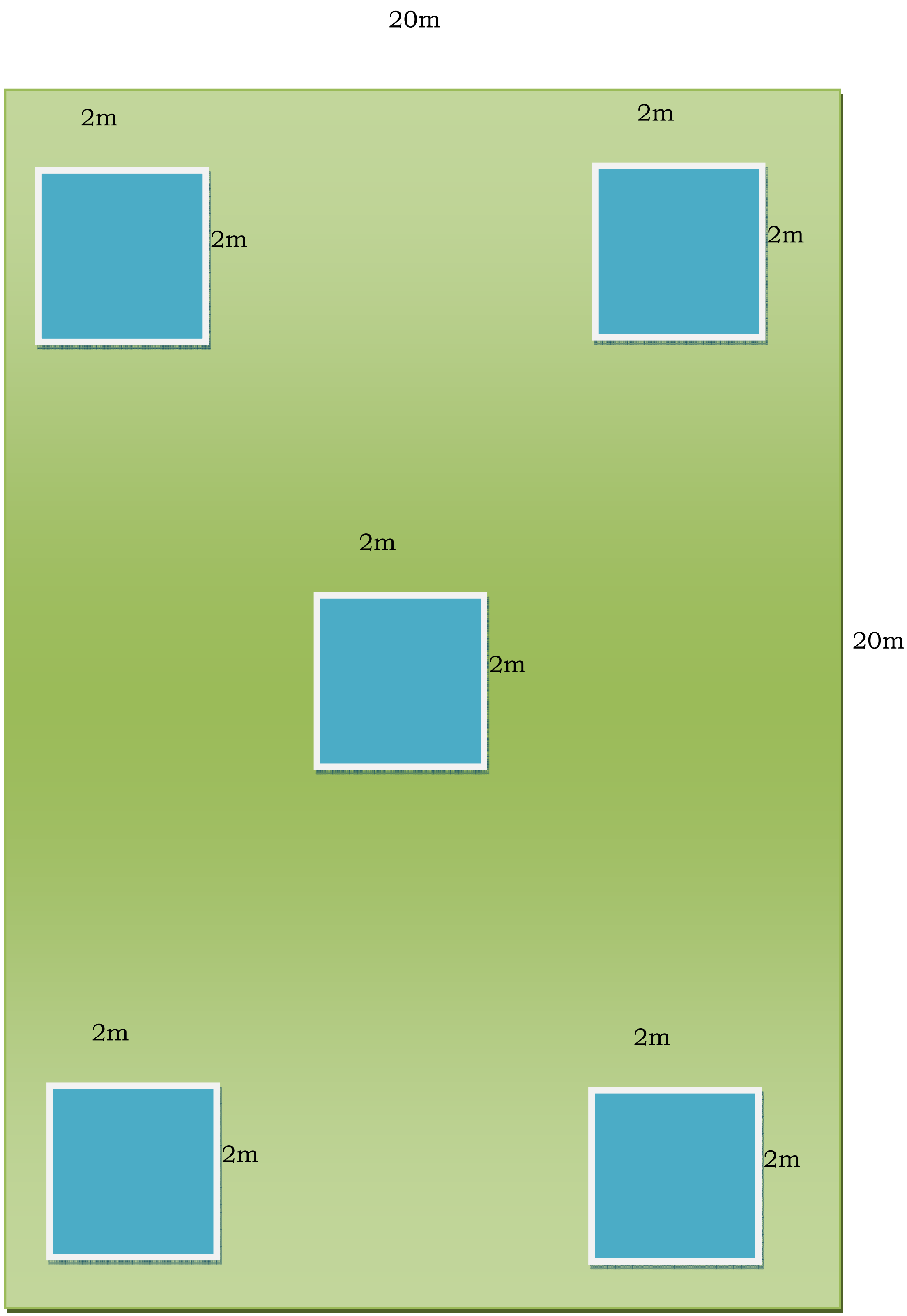


Figure 3: The configuration of stand map of sampling plots

3.2.2 Data analysis

3.2.2.1 Multivariate analysis of vegetation data

Classification by means of cluster analysis is the most common multivariate technique to analyze vegetation data. Consequently, a hierarchical cluster analysis was performed using PC – ORD for windows version 5.0 (Mc Cune and Mefford, 1999; Mc Cune and Grace, 2002) to classify the vegetation into plant community type following (Feyera Senbata *et al*., 2007). The cover abundance data of the species were used for cluster analysis. In the analysis, the relative Eucidean Distance (RED) measures using Euclidean Distance was implemented to eliminate the differences among sample units and the Ward's method was used in order to minimize the total within group mean of squares or residual sum of squares (Mc Cune and Grace, 2002).the identified groups were tested for the hypothesis of no difference between the groups using Multi-response Permutation Procedure (MRPP). Species indicator values were determined using Dufrene and Legendre (1997) method and tested for statistical significance using Monte Carlo technique.

3.2.2.2 Diversity and similarity indices

The quantitative indices of species diversity, richness and evenness were measured using the Shannon-Wiener index (Maguran, 1988) using the formulae:

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

And

$$J = \frac{H'}{H'\max} = \frac{\sum_{i-1}^{S} Pi \ln Pi}{\ln s}$$

Where;

H' = the value of the Shannon-Weiner diversity index

S = number of species in the community

Pi = the proportion of individuals or the abundance of the ith species expressed as a proportion of total cover

ln = log base$_n$ or evenness of the species in the community

J = Equitability (evenness) of species in sampling area or plot

The minimum value of H' is 0, which is the value for a community with a single species, and increases as species richness and evenness increases (Manuel and Molles, 2002). The species evenness that measures the equity of species in a given sample area is represented by 0 and 1, where 0 indicates the abundance of few species and 1 indicates the condition where all species are equally abundant (Whittaker, 1972).

The Jaccard's and Sorensen's similarity indices were used to determine the pattern of species turnover among the communities and to evaluate the similarity between Sanka Meda forest and other similar forests in Ethiopia respectively based on their species, composition. It is determined using the following formulae (Kent and Coker, 1992).

$$S_J = a/a+b+c$$

Where:

"S_J" = Jaccard's similarity coefficient,

a = number of common species to the compared clusters

b = number of species in the first cluster

c = number of species in the second cluster

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

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

3.2.2.3 Structural analysis

The structure of the vegetation was described based on the analysis of species density, DBH, height, basal area, frequency and important value Index (IVI). The regeneration status of the trees, shrubs and lianas was also determined by computing density ratios between seedlings and mature individuals, seedlings and saplings, and sapling and mature individuals. The diameter at breast height (DBH) and tree height were classified into DBH classes and height classes. The percentage frequency distribution of individuals in each class was calculated. The tree or shrub density and basal area, values were computed on hectare basis. These vegetation data were computed and summarized using Microsoft office Excel (2007) spread sheet using the following formulae (Mueller-Dombois and Ellenberg, 1974; Kent and Coker, 1992).

Frequency (F):- Is the chance of finding a species in a particular area in a particular trial samples. It is obtained by using plots and expressed as the number of plots occupied by a given species per total number of plots laid out or, more often as a percentage (Goldsmith *et al*., 1986).

$$F = \frac{Numebr\ of\ \ plots\ in\ which\ a\ species\ occur}{total\ number\ of\ \ plots\ laid\ out\ in\ the\ study\ site} x100$$

According to the law of frequencies (Kent and Coker, 1992), the number of species of a community expressed as percentage frequency (F%) is distributed in the five frequency classes as 0-20, 21-40, 41-60, 61-80, 81-100.

Relative Frequency (RF):- is the frequency of a species/ sum of frequencies of all species x 100.

Density (D):- Is a county of individuals of a species within the sample plot. Counting is usually done in small plots placed several times into vegetation communities under study and the sum of individuals per species is calculated in terms of species density per convenient area unit such as a hectare (Mueller- Dombois and Ellenberg, 1974).

$$D = \frac{Numebr\ of\ \ above\ ground\ stems\ of\ \ a\ species\ countered}{sampled\ area\ in\ hectare\ (ha)}$$

Relative Density (RD):- Is the total number of individuals of a species total number of individuals x 100

Basal Area (BA):- IIs the area outline of a plant near ground surface for trees it is measured through diameter, usually at breast height (DBH), i.e., 1.3m above ground level (Mueller – Dombois and Ellenberg, 1974; Hutchings, 1986). The analysis of species dominance was made using basal area measurements.

$$BA = \pi d^2 / 4$$

Where: BA = Basal Area in m^2 per hectare

d = diameter at breast height in meter.

π = 3.14

In this study the diameter measurement was obtained from circumference $\left(d = c/\pi\right)$.

Relative Dominance (RDO):- Is the total basal area of a species /total basal area of all species x 100; where dominance is the mean basal area per species times number of the species.

Importance Values Index (IVI) was analyzed for woody species. IVI of a species was calculated from the sum of relative dominance (RDO), relative density (RD) and relative frequency (RF) (Kent and Coker, 1992).

IVI = RDO + RD + RF

Based on their IVI values tree species were grouped into classes of conservation priority.

4. Results and Discussion

4.1 Floristic Composition

A total of 139 vascular plant species and a lichen species were identified and documented from the study area. 132 of the specimens were identified to the species level, 6 to the subspecies level and 2 of them to the variety level (appendix 2). The identified species belong to 118 genera and 63 families. Fourteen species were observed outside the sampling plots in the study area within the ranges of ten meters distance. These were *Ficus carica, Ebelia schimperi, Acanthus senni, Urtica semensis, Solanecio gigas, Datura stramonium, Ricinus communis, Alchemilla abyssinica, Lagenaria abyssinica, Pottosporum vividiflorum, Solanum marginatum, Tagetes minuta, Rumex abyssinicus and Ocimum lamiifolium.* The collected species were composed of 26% trees, 2% trees/shrubs, 22% shrubs, 12% lianas, 38% herbs. Among the 38% herbaceous flora, 1.89% are ferns while 9.43% are other epiphytes. Fourteen endemic plant species were recorded from the study area (Appendix 6).The endemic species account about 10% of the total floristic composition of the forest.

The major families were Asteraceae represented by 21 species (15%), Lamiaceae by 10 species (7.1%), Fabaceae by 9 species (6.4%), Aselepiaceae, Rosaceae and Rubiaceae each with 6 species 8.6% (4.3% each), Solanace by 5 species (3.6%), Acanthacerae, Boragnaceae, Celestraceae, Myrsinaceae, Oleaceae, Polygonaceae and Urticaceae are represented by 3 species 15% (2.1% each) of the total floristic composition. The remaining (44.3%) families were represented by one or two species (Appedix 2).

4.2 Plant community classification

Four vegetation community types (clusters) were identified at 12.5% to 25% similarity level from hierachical cluster analysis (Figure 4). The input data matrix has 70 plots and 126 species. The clusters were significantly different ($p < 0.00$) using the Multiple Response Permutation Procedure (MRPP) test. The determination on the number of plant communities was based on the technique of MRPP. The MRPP is used to test whether there is a significance difference between two or more groups of sampling units. The test statistic T value for the identified four communities in Sanka Meda Forest was -26.81 ($P < 0.00$) and the agreement A was 0.11. The test statistic T describes the separation among the groups. The more negative T value indicates the stronger heterogeneity (separation). The agreement, A describes within group hemogeneity and falls between 0 and 1. From the MRPP output, the observed delta value was 14.86 and expected delta value was 16.72. A max = 1 when all the items are identical within groups (delta = 0), when heterogeneity within groups equals expectation by chance A = 0 and A < 0 with more heterogeneity within groups than expected by chance. Delta is the total weighted mean of group distances and expected delta assesses as the average permutations (Mc Cune and J.B. Grace, 2002). The values of A are usually below 0.1 in community ecology (Mc Cune and Mefford, 1999). In this work, a species with a significant indicator value at $p < 0.05$ was considered as an indicator species of the community (Table 5).

Table 4: Communities and the ditribution of samle plots in the communities

Community	No of plots	Plots in the community
I	14	1,2,11,12,14,24,25,26,28,29, 31,50,52,58
II	14	3,22,23,27,41,42,43,44,45, 46,47,49,61,65
III	31	4,6,7,8,9,10,13,15,16,18,20, 30,32,33,35,36,37,38,39,40, 51,54,55,59,62,63,64,66,67, 68,69,
IV	11	5,17,19,21,34,48,53,56,57, 60,70

Table 5: Indicator species for each community and the Monte Carlo test of significance (P*)

Indicator Species	Communities 1	2	3	4	P* Value
Croton macrostachyus	**59**	0	3	0	0.0002
Lepidotrichilia volkensii	**40**	1	7	1	0.001
Masesa lanceolata	**37**	3	23	1	0.009
Stephania abyssinica	**25**	1	1	0	0.0132
Inula cofertiflora	**31**	3	7	0	0.0166
Bersama abyssinica	**30**	3	13	1	0.0332
Plectranthus assurgens	**26**	0	4	11	0.038
Peperomia abyssinica	0	**29**	0	9	0.0052
Calpurnia aurea	0	**36**	5	3	0.0052
Halleria lucida	0	**21**	0	0	0.018
Rytigynia neglecta	31	**35**	15	6	0.0232
Casspourea malosana	1	**25**	8	0	0.0408
Dovyalis abyssinica	11	3	**36**	13	0.009
Juniperus procera	0	0	41	**47**	0.0002
Matenus undata	0	43	0	**52**	0.0002
Osyris quadripartita	0	0	0	**27**	0.0022
Buddleja davidii	0	5	1	**31**	0.0044
Olea europaea subsp.cuspidata	10	2	1	**26**	0.035
Buddleja davidii	0	5	1	**31**	0.0044

The four clusters obtained were named after one or two species that had indicator values. The indicator values were determined by combining the relative abundance and relatie frequencies of each species (Dufrene and Legendre, 1997). The probability values refer to Monte Carlo tests, while the values under each group indicate the closeness of occurrence of a species within a particular group. The bold values reveal significant indicator values ($P < 0.05$) in each group. In all groups, species with high indicator values are those species that were easily observed and repeating themselves in associations. Thus, the identified communities are more or less similar with the natural vegetation assocaition as that one can observe while visiting the forest. The plant community types identified and their attributes are depicted as follow.

4.2.1 *Croton macrostachyus - Lepidotrichilia volkensii* Community type

This community is located between the altitudinal ranges of 2400 and 2720m a.s.l. in the vegetation. It was represented by 14 releves (0.56 ha) and 52 species. The species with indicator values of $\geq$ 15 are considered as common species (Tadesse woredemariam, 2003). Along with the dominant species used in the naming of the community, *Maesa lanceolata*, *Dovyalis abyssinica*, *Bersama abyssinica, Teclea nobilis,* and *Podocarpus falcatus*, were the dominant species in the tree layer of the community. *Inula confertiflora*, *Rytigynia neglecta*, *Rosa abyssinica* and *Solanum anguivi* were important species in the shrub layer. The ground flora was dominanted by *Plectranthus assurgens*, *Achyrospermum schimperi* and *Hypoestes forskaolii*. The common climbers in this community include *Stephania abyssinica*, *Dregea abysinica*, *Ceropogia cufodontis* and *Jusminum abyssinicum*.

4.2.2 *Calpurnia aurea - Peperomia abyssinica* Community type

This community type is situated at altitude between 2487 and 2718 m a.s.l. It comprises 14 releves (0.56 ha) and 21 species belong to the group. *Casspourea mlosana*, *Bersama abyssinica*, *Teclea nobilis*, *Podocarpus falcatus* and *Maytenus obscura* were the dominant species of the tree layer of the community. The shrub layer was dominanted by *Calpurnia aurea*, *Rytigynia neglecta*, and *Myrsine africana*. The herb layer of this community is dominanted by *Hypostes forskaolii* and a fern species (*Pteris cretica*). The occurrence of abundant number of *Peperomia abyssinica* on large P*odocarpus falcatus* trees is a typical characteristic of this group.

4.2.3 *Dovyalis abyssinica* Community type

This community type is found distributed between 2514 and 2748 m a.s.l. The community consist of 31 releves (1.24 ha) and 24 plant species that were associated in the group. *Doyalis abyssinica*, *Bersama abyssinica*, *Teclea nobilis*, *Podocarpus falcatus*, and *Olinia rochetiana* were important tree species in the group. The common species in the shrub layer were *Rytigynia neglecta, Solanum anguivi, Discopodium peninnervum, Canthium oligocarpum*, *Brucea antidysentrica* and *Myrsine africana*. In the ground flora, the dominant herb species were *Achyrospermum schimperi, Cynoglossum aplifolium*, *Kalanchoe petitiana*, and *Pteris cretica*.

4.2.4 *Juniperus procera - Maytenus undata* Community type

This community prevails between the altitudinal ranges from 2536 to 2740 m a.s.l. The community comprises 11 releves (0.44 ha) and 53 plant species in the association. The dominant tree species in this community were *Juniperus procera*, *Maytenus undata*, *Dovyalis abyssinica*, *Olea europaea* subsp. *cuspidata*, *Pavetta abyssinica*, *Millettia ferruginea*, *Podocarpus falcatus* and *Maytenus obscura*. *Buddleja davidii*, *Osyris quadripartita*, *Conyza hypoleuca* and *Myrsine africana* were dominant in the shrub layer of this community. The ground flora (herb layer) of this group was dominated by *Hypostes forskaolii* and *Plectranthus assurgens*. *Premna schimperi*, *Cordia africana*, *Millettia ferruginea*, *Erythrina brucei* and Dracane ellenbeckii were the characteristic tree species in this community. *Dodenea angustifolia*, *Echinops ellenbeckii*, *Epilobium hirusutum* and *Erica arborea* were characteristic shrubs. *Mentha spicata* and *Rumex nervosus* were the characteristic herb species. *Usnea africana* and *Diaphananthe candida* were the common epiphyte species covered the stems of large trees in this community.

The distribution of plant communities is the manifestation of physical gradients like microclimate, soil heterogeneity and elevation, biotic response to physical gradients and historical disturbances (Urban *et al*., 2000). As it has been indicated by Tadesse

Woldemariam (2003), environmental factors such as slope, landscape pattern and altitude also characterize the distribution of plant communities.This environmental foctors might influence the plant community formation of the present study in a similar manner.

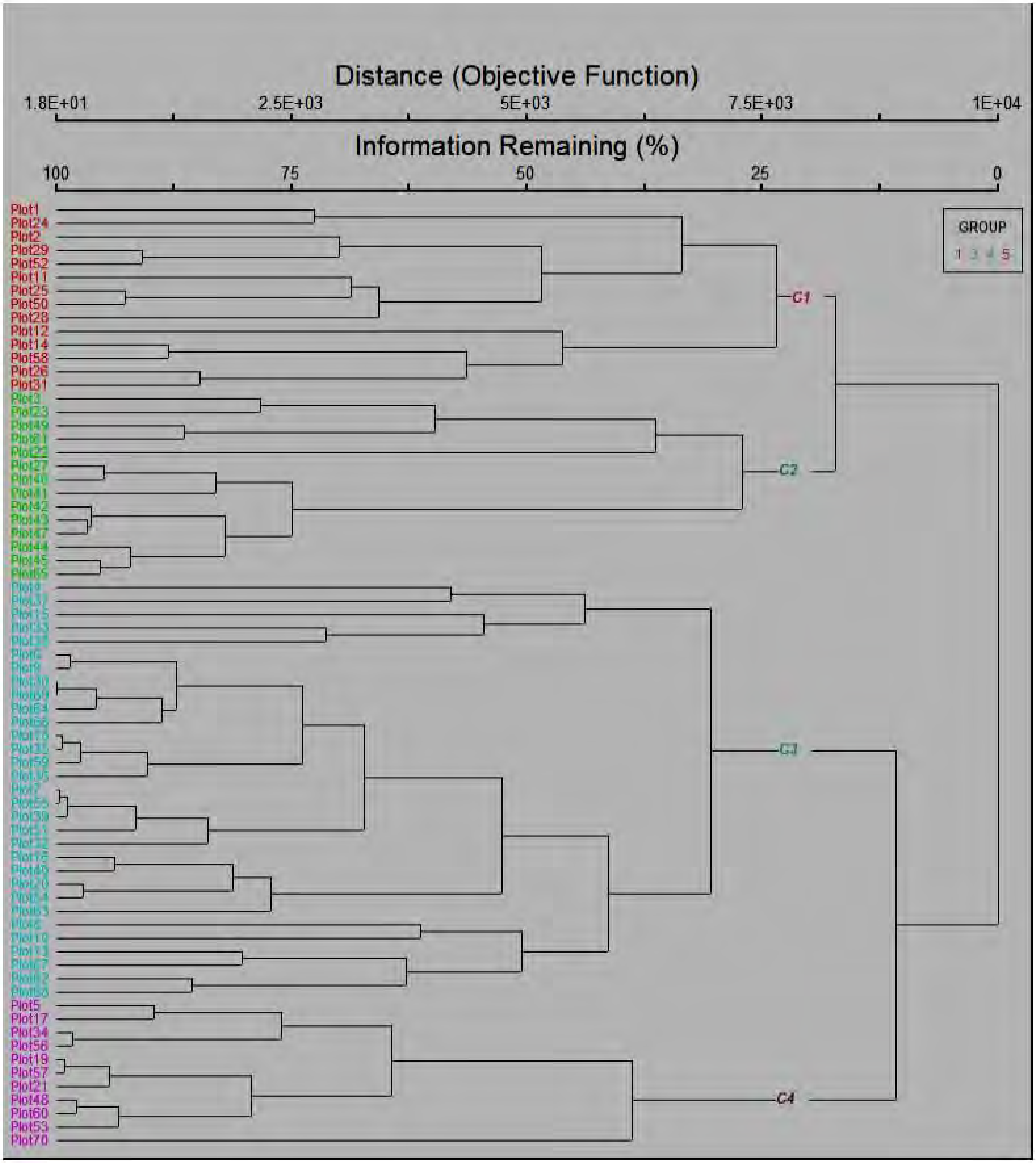


Figure 4: Dendrodram of the vegetation dataobtained from the hierarchical cluster analysis with the level of grouping based on 20% infomation remaining

4.3 Species richness, Diversity and Evenness of the Plant Community Types

A Combination of the number of species and their relative abundance defines species diversity. The values of species diversity depend upon levels of species richness and evenness (Manuel and Molles, 2002). The Shannon – Wiener diversity index (H') was computed for each plant community types. The different values of H' for the communities reflect the difference in their species richness and evenness. The minimum value of H' is 0, which a value for a community with a single species and increases as species rihness and evenness increases. Based on the outcome of the Shannon-Weiner diversity index analysis, community type I had the highest species diversity followed by communities III, IV and II respectively. The highest species richness was obtained for community type III.Community types I and IV took the second rank with similar species richness values and community type II was least in its species richness and diversity but comes second in its species evenness.

Community type III had the least species eveness. Low species evenness can be attributed to excessive environmental disturbances, variable conditions for regeneration and selective exploitation of some species (Alemu Wassie, 2002). Community type I had the highest species diversity and evenness (Table 6). In this community, most representative plots were not susceptible to the disturbances by the local people due to steeped slopes in the area. High species diversity and evenness could be attributed to the presence of optimum environmental factors such as altitude, slope and adequate nutrient and moisture. Reports from other studies indicated that species richness and diversity tends to peak at an intermediate altitudes and decline at the lower and upper elevations (Desalegn Wana and Zerihun Woldu, 2005). The result of the present the study agrees with this regarding species evenness.

Table 6: Shannon-Wiener indices, species richness and evenness of the plant communities

Communities	Altitude (m)	Species richness	Diversity index (H')	H'max	Species evenness (J)
II	2578.21	49	3.155	3.89	0.811
I	2592.86	58	3.408	4.06	0.839
IV	2645.09	58	3.228	4.06	0.795
III	2650.35	68	3.350	4.22	0.794

*Plant communities are arranged in ascending order of altitude.

4.3.1 Similarity among the Plant Communities

The Jaccard's similarity coefficient was used to detect similarities among the plant communities. The distribution of species among the communities showed significant dissimilarity. This was observed from the computed Jaccard's similarity coefficient (Table 7). The overall similarity values in species composition between the communities ranged from 0.16 to 0.21. More similarity coefficient (Sj = 0.21) was observed between community type II and III and less similarity (Sj = 0.16) was observed between community type I and community type IV. Thus, the dissimilarity accounts for 79% for the most similar communities (community II and III) and 84% for those that share least similarities (community I and IV).The relatively higher similarities between community types II and III is probably due to the similar environmental conditions. As it was reported by Desalegn Wana and Zerihun Woldu (2005); Dereje Denu (2007), in addition to altitudinal gradient, other environmental factors such as aspect, slope, soil physical and chemical properties have sound effects on patterns of vegetation in communities. For all communities, the jaccard's similarity coefficient values were below 0.5, indicating the existance of low similarities among the recognized communities which implies that all the communities are important interms of floristic diversity and needs attention from a conservation point of view.

Table 7: Jaccard's similarity coefficieamong the the plant communities

Communities	I	II	III	IV
I		**0.81**	**0.80**	**0.84**
II	0.19		**0.79**	**0.83**
III	0.20	0.21		**0.80**
IV	0.16	0.17	0.20	

*Values in bold refers to Jaccard’s dissimilarty coefficients.

4.4 Vegetation structure

Vegetation structure is the organization in space of individuals that form a vegetation type of plant association. It can be investigated at the level of physiognomic, life form, floristic, biomass and stand vegetation structures which are hierachically integrated. The life form, stratification and coverage are the primary elements which define vegetation structure (Mueller – Dombois and Ellenberg, 1974). In the analysis of vegetation structure, the growth stages of trees as seedlings, saplings and mature trees as the distribution of size classes within a population can be one of the elements of diversity that allows or denies the chance of rapid recovery after disturbances (Harper, 1982). The population structures of trees have a significant implication to their management, sustainable use and conservation (Simon Shibru and Girma Belcha, 2004). The structural patterns that obtained from measured data can be used for checking the variations in population dynamics that may arise from inherent characters or human interventions and their livestocks (Popma *et al*., 1989).

4.4.1. Density

Stand density or tree density, expressed as the number of trees per unit area, is an important forest management parameter. Together with other forest structure parameters like crown closure and crown diameter, it is used by foresters to evaluate regeneration (Quackenbush *et al*., 2000). The total density of mature woody species with DBH > 2.50 cm in Sanka Meda Forest was 1060.71 stems ha^{-1}. This was classified into seven density classes: 1) $\leq$ 1, 2) 1.01 – 5 3) 5.01 – 15 d) 15.01 – 30 5) 30.01-50, 6) 50.1-75 and 7) > 75 stems ha^{-1} were analyzed.The percentage of the numer of species in the density classes (Figure 5a) and density of each woody species ha^{-1} were computed.

Mature woody species (8.16%) which have density distribution ha^{-1} were distributed in the class 7 and these were *Olea hochstetteri* (202.5 ha^{-1}), *Discopodium peninnervum* (190.71 ha^{-1}) *Podocarpus falcatus* (94.64 ha^{-1}) and *Maesa lanceolata* (85.71 ha^{-1}). Those which come next interms of their abundance ha^{-1} (6.12%) were situated in class 6. these were *Maytenus arbutifolia* (65.36 ha^{-1}), *Teclea nobilis* (61.43 ha^{-1}) and *Maytenus obscura* (55.00 ha^{-1}). The 5th class is occupied by a single species *Juniperus procera* (46.79 ha^{-1}) which accounted for 5.4%. The species that were placed in class 4 were including *Dombeyo toridda* (27.86 ha^{-1}), *Brucea antidysenterica* (22.14 ha^{-1}), Buddleja davidii (22.14 ha^{-1}), *Hypericum revolutum* (18.92 ha^{-1}) and *Vernonia auriculifera* (17.5 ha^{-1}). The 3rd and 2nd classes comprised 20.4% and 8.16% of the woody species respectively.

The mature woody species distributed in the class with lowest density (class 1) were *Hagenia abyssinica*, *Prunus africana*, *Acacia abyssinica*, *Olinia prochetiana*, *Halleria lucide, Celtis fricana*, *Erythrina brucei*, *Allophyllus abyssinicus*, *Galiniera saxifrage*, *Mellettia ferruginea*, *Osyris guadripartita*, *Premna schimperi*, *Echops ellenbenckii*, *Ficus sur*, *Pavetta abyssinica*, *Psydrax schimperiana*, *Cassipourea melosana*, *Croton macrostachyus*, and *Senna sptemtrionalis*. The density of saplings (416.50 ha^{-1}) of woody species was also ivestigated (Figure 5b). The species with the highest number of saplings per unit area were placed in the class 6 (6.12%). These were *Olea hochstetteri* (72.32 ha^{-1}), *Discopodium peninnervum* (64.29 ha^{-1}) and *Teclea nobilis* (61.43 ha^{-1}). In class 5,4,3, 2 and 1 the species distribution were 2.04%, 10.20%, 6.12%, 20.41% and 55.10% respectively only a single species (*Halleria* *lucida* 2.04% and 33.80 ha^{-1}) was prevailed in class 5. Species in class 4 were *Maesa lanceolata* (30.61 ha^{-1}), *Maytenus arbutifolia* (23.34 ha^{-1}), *Prunus africana* (19.64 ha^{-1}), *Vernonia auriculifera* (17.50 ha^{-1}) and *Juniperus procera* (16.79 ha^{-1}). The species arranged in class 3 include *Dombeya torrida* (9.95 ha^{-1}) calpurnia aurea (9.00 ha^{-1}). *Brucea antidysenterica* (7.91%) and *Hypericum revolutum* (6.76 ha^{-1}) species that were included in class 2 were *Dracaena afromontata* (5.87 ha^{-1}), *Lepidotrichilia volkensii* (5.48 ha^{-1}), *Bersama abyssinica* (5.23 ha^{-1}) *Rytigynia neglecta* (4.33 ha^{-1}) *Cordia africana* (3.95 ha^{-1}), *Canthium oligocarpum* (3.57 ha^{-1}), *Maytenus undata* (3.19%), *Schefflera abyssinica* (2.50 ha^{-1}) and *Olea europaea* subsp. *cuspidata*(2.17 ha^{-1}). Majority of the species were distributed in class 1. Those species (10-20%) lacking sapling were *Buddleja davidii*, *Urera hypselodendron*, *Dregea abyssinica*, *Rubus steudneri* and *Senna septemtrionalis*. Species (44.89%) bearing very small number ($\leq$1) of sapling ha^{-1} were *Rhus glutinosa*, *Myrsine africana*, *Vernonia amygdalina*, *Psydrax schimperiana*, *Pavetta abyssinica*, *Dovyalis abyssinica*, *Ficus sur*, *Echnops ellenbenckii*, *Premna schimperi*, *Olinia rochetiana*, *Maytenus obscura*, *Hagenia abyssinica*, *Osyris quadripartita*, *Podocarpus falcatus*, *Millettia ferruginea*, *Galiniera saxifraga*, *Erythrina brucei*, *Croton macrostachyus*, *Celtis africana*, *Cassipourea malosana* ,*Allophyllus abyssinicus* and *Acacia abyssinica*.

The seedling density (734.64 ha^{-1}) of the forest was also described for each woody species. The highest seedling density ha^{-1} (Figure 5c) was observed for three species in the density class 7(6.12%), namely: *Discopodium peninnervum* (221.43 ha^{-1}), *Olea hochstetteri* (86.07 ha^{-1}) and *Maesa lanceolata* (80.36 ha^{-1}). The distribution of the seedling density ha^{-1} for these species was $\geq$ 80.36 individuals' ha^{-1} with the maximum 221.43 seedlings ha^{-1} which belongs to *Discopodium penninervum*. The number of species distributed in density 5 and 6 is the least compared with other density classes each with low species. Woody plant species included in density class 5 (4.08%) were *Teclea nobilis* and *Prunus fricana* (each 56.43) ha^{-1}) and those in 5 class (4.08%) *Maytenus arbutifolia* (36.07 ha^{-1}) and *Bersama abyssinica* (31.43 ha^{-1}). The woody plant species included in density class 4(10.20%) were *Halleria lucida* (27.50 ha^{-1}), *Calpurnia aurea* (18.93 ha^{-1}), *Vernonia auriculifera* (17.14 ha^{-1}) *Rytigynia neglecta* (17.14 ha^{-1}), and *Juniperus procera* (16.79 ha^{-1}). Woody plant species distributed in class 3 (8.16%) were *lepidotrichilia volkensii* (15.00 ha^{-1}), *Cordial africana* (12.14 ha^{-1}), *Dombeya torrida* (11.79 ha^{-1}) and *Hypericum revolutum* (6.07 ha^{-1}), and those in class 2(6.12%) were *Senna septemtrionalis* (4.29 ha^{-1}), *Maytenus undata* (2.86 ha^{-1}), and *Pavetta abyssinica* (2.14 ha^{-1}). Most of the woody plant species were prevailed in the lowest density class 1 (55.10%). The specie lacking seedlings ha^{-1} (10.20%) were *Rubus steudneri*, *Dregea abyssinica*, *Urera hypselodendron* and *Buddleja davidii*. Species bearing very small number ($\leq$1) of seedlings ha^{-1} (44.89%) were *Brucea antidysenterica*, *Rhus glutinosa*, *Echnops ellenbenckii*, *Schefflera abyssinica*, *Dovyalis abyssinica*, *Premna schimperi*, *Olinia rochetiana*, *Maytenus obscura*, *Canthium oligocarpum*, *Olea europaea* subsp. *cuspidata*. *Myrsine africana*, *Hagnia abyssinica* and *Osyris quadripartita*.

The distribution patterns of tree species density ha^{-1} were also analyzed, for mature individuals (785.71 ha^{-1}), samplings (337.80 ha^{-1}), and seedlings (507.14 ha^{-1}). The mature tree individuals that contributed more representatives in density class 7 in the forest were *Podocarpus falcatus* (202.50 stems ha^{-1}) and *Juniperus procera* (94.64 stems ha^{-1}). The description and classification of them into specific classes were showed (Figure 5d, e and f). The distribution pattern of the woody species in the density classes is more or less similar. The majority of the species were distributed in the lowest density class ($\leq$ 1 ha^{-1}). The percentage distribution was 42.86% for mature woody species, 55.10% for woody species saplings and 61.22% for woody species seedlings (Figure 5a, b and c). Similar pattern was observed for all tree species. It was 47.5% for mature trees, 52.5% for tree species saplings and 57.5% for tree species seedlings (Figure 5d, e and f). The existence of low number of individuals per unit area in higher density class for majority of species in the forest indicates that they are probably at low status of reproduction or might be under local anthropogenic threats and they are in need of immediate and special attention for conservation priority.

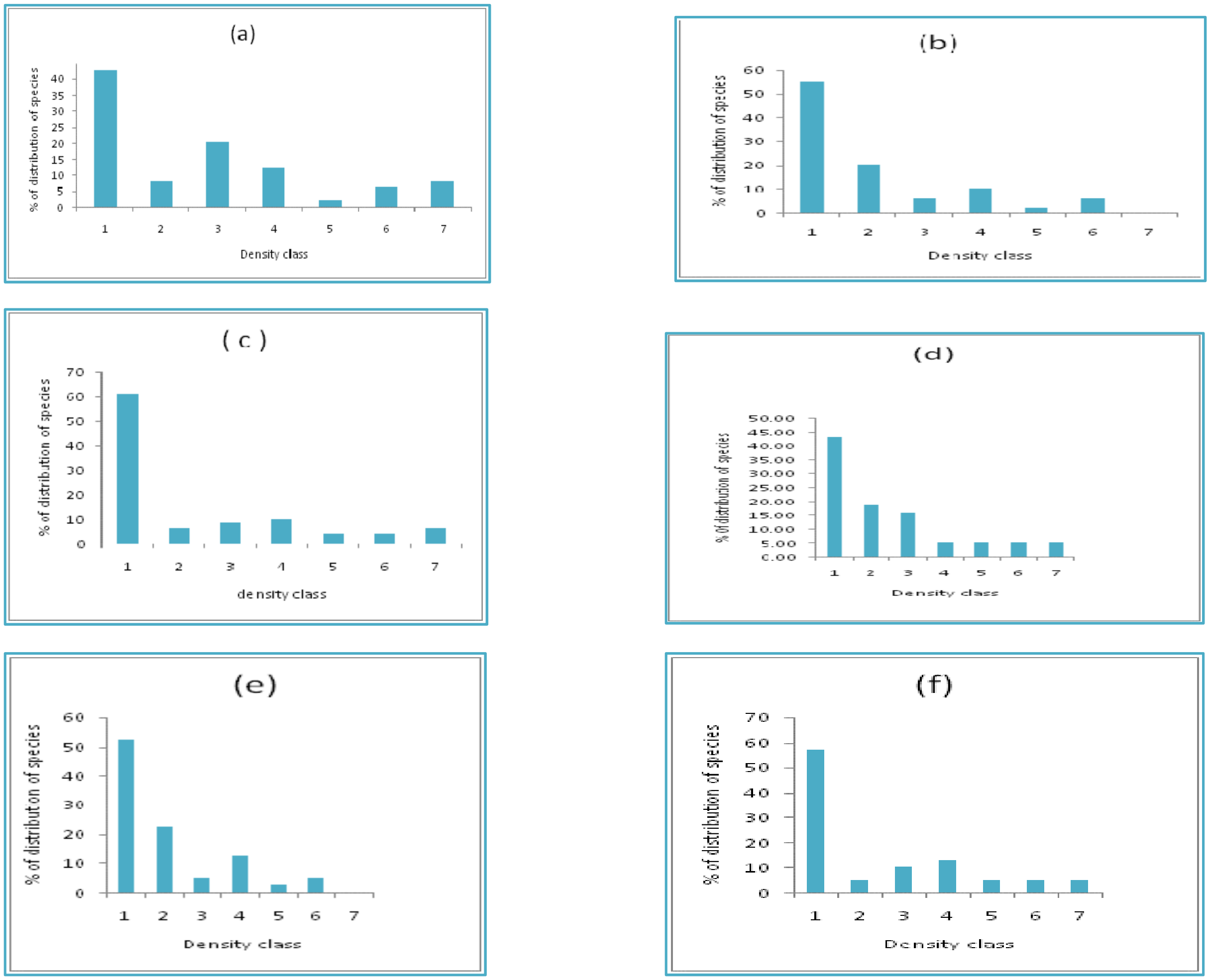


Figure 5: Density of all woody plants and tree species by size In Sanka meda forest, where: (a) density of mature woody species DBH > 2.50 cm, (b) density of saplings DBH ≤ 2.50 cm, (c) density of seedlings DBH <2.50 cm, (d) density of mature trees Dbh >2.50 cm, (e) density of tree seedlings DBH ≤ 2.50 cm, (f) desity of tree saplings DBH ≤ 2.50 cm. Where: 1= ≤ 1, 2 = 1.01-5, 3 = 5.01-15, 4 = 15.01-30, 5 = 30.01-50, 6 = 50.01-75 and 7 = >75 individuals ha^{-1}

The ratio of the density of individuals with DBH > 10cm to those with DBH > 20cm is taken as a measure of the size class distribution (Grubb *et al*., 1963). The density of tree species with DBH $\leq$ 10cm and DBH > 20 cm in Sanka Meda Forest were 55.36 (37.23%), 25.0 (23.37%) and 52.5 (38.98%) stems ha^{-1} respectively. The ratio of tree densities with DBH > 10cm to DBH > 20cm was 0.50. This value was compared with six other dry afromontane forests in Ethiopia (Table 8).

Table 8: Tree density comparison of Sanka Meda with other selected dry afromontane Forests

Forest	**DBH > 10cm(a)**	**Rank**	**DBH>20cm (b)**	**Rank**	**a/b**
Chilmo	638.00	1	250.00	3	2.60
Menagesha –Suba	484.00	3	208.00	6	2.30
Wof-Washa	329.00	5	215.00	5	1.50
Denkoro	526.00	2	285.00	2	1.90
Dindin	437.00	4	219.00	4	1.99
Menagesh Amba Mariam	155.46	7	197.00	7	0.80
Sanka Meda (Present study)	309.29	6	755.71	1	0.41

Sources: Tamirat Bekele (1994); Abate Ayalew *et al*., (2006); Simon Shibru and Girma Balcha (2004) and Abiyou Tilahun (2009).

The proportion of a/b ratio of Sanka Meda Forest is smallest (0.41). This indicates that the predominance of large-sized individuals for some species in the forest. The predominance of large sized individuals in the forest was largery due to the high density of *Juniperus procera* and *Podocarpus falcatus*.

4.4.2. Frequency

Frequency is the number of quadrats in which a given species occurred in the study area. It gives an approximate indication for homogeneity and heterogeneity of vegetation. Lamprecht (1989), indicated that high value in higher frequency and low value in lower frequency classes reveal constant or similar composition and conversely, high percentage of number of species in the lower frequency classes and low percentage of number of species in the higher frequency classes points out a high degree of floristic heterogencity (Simon Shibru and Girma Balcha, 2004). Based on the percentage frequency values, the woody plant species were classified into five frequency classes: 1) 0-20, 2) 21-40, 3) 41-60, 4) 61.80 and 5) 81 – 100 which is expressed in percentage. The frequency and percentage frequency values of each woody species were analyzed. The species that distributed in frequency class 5 were *Podocarpus falcatus* and *Rytigynia neglecta*. These two species have the highest frequency values being 100% for *Podocarpus falcatus* and 82.86% for *Rytigynia neglecta*. In the next higher class 4 (10.42%), species observed were *Maytenus obscura*, *Teclea nobilis, Juniperus procera*, *Bersama abyssinica* and *Dovyalis abyssinica*. The remaining species were distributed in frequency classes 3, 2, and 1 in ascending order containing 4.12%, 14.58% and 66.67% respectively. The present study revealed high percentage of number of species in lower frequency classes and low percentage of number of species in high frequency classes (Figure 6). Thus, the result verifies the existence of high degree of floristic heterogeneity in Sanka Meda Forest.

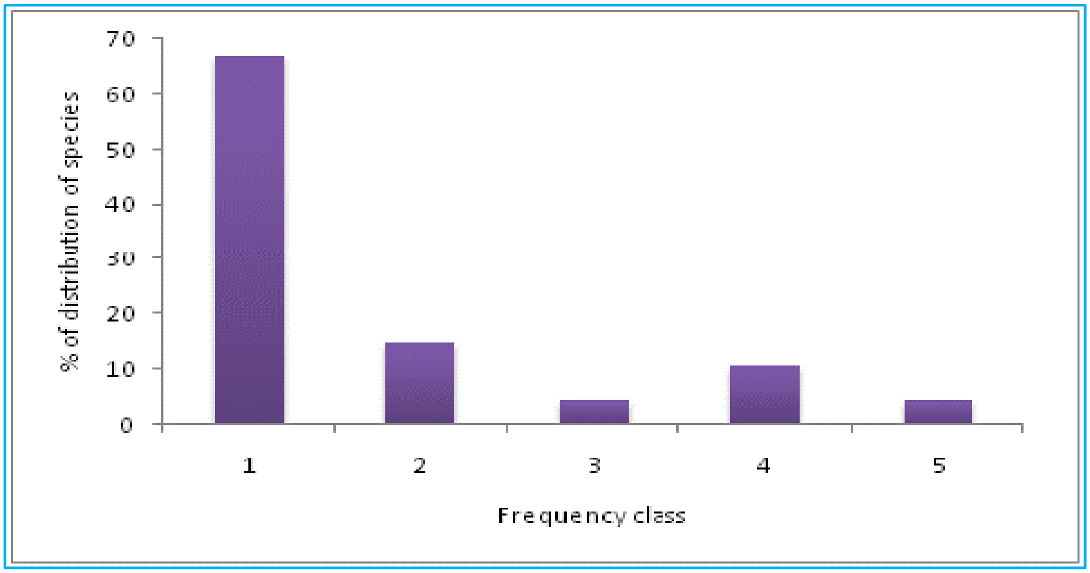


Figure 6: Fequency distribution for woody species in Sanka Meda Forest Where: 1) 0-20, 2) 21-40, 3) 41-60, 4) 61-80 and 5)80-100 frequency clsses.are

4.4.3. Tree height

Tree individuals obtained in the study were classified into eight height classes: I) ≤ 5 m, II. 5.01 – 10 m, III) 10.01 – 15 m, IV) 15.01 – 20 m, V) 20.01 – 25 m, VI) 25.01 – 30 m, VII) 30.01 – 35 m and VIII) > 35 m and these were described (Figure 6). There is higher number of tree individuals in the height class I which accounts 27.13% of the total height classes. The species that contribute to the values in the lowest height class were *Vernonia auriculifera*, *Maytenus obseura*, *Maesa lanceolata*, *Lepidotrichilia volkensii*, *Dovyalis abyssinica*, *Celtis africana*, *Bersama abyssinica*, *Teclea nobilis*, *Premna schimperi*, *Pavetta abyssinica*, *Croton macrostachyus* and *Podocarpus falcatus*. Trees in height class II, (5.01-10 m), III (10.01-15 m), IV (15.01-20 m), V (20.01 – 25 m) and VI (25.01-30 m) together make 54.94% of the total height classes in the forest. From the analysis, tree species that distributed in height classes VII (30.01-35 m) and VIII (>35 m) dominatind the upper canopy of the forest were *Podocarpus falcatus* and *Juniperus procera*. *Podocarpus falcatus* is the emergent tree which grows above all the canopies of trees in the forest. The tree height class distribution values were highest in the lower class followed by decrease in the middle classes (Figure 7) and finally terminate by slight increase in class 7 for *Podocarpus falcatus* and *Juniperus procera*.

Similar results were reported in Chilmo and Menagesha forest of centra plateau of Ethiopia (Tamirat Bekele, 1994), in Denkero forest (Abate, Ayalew *et al*, 2006) and in Menagesha Amba Mariam forest (Abiyou, 2009). The highest tree distribution in the lowest class height implies that the forest has been heavily influenced by the local anthropogenic activities through selective cutting for fuel wood, construction and illegal wood harvest for timber production as it is now in different stages of secondary development. Currently three are some large trees and small to medium-sized individuals. The dominance of small sized individuals is the attribute of good regeneration but low recruitment, which might have been caused by anthropogenic activities.

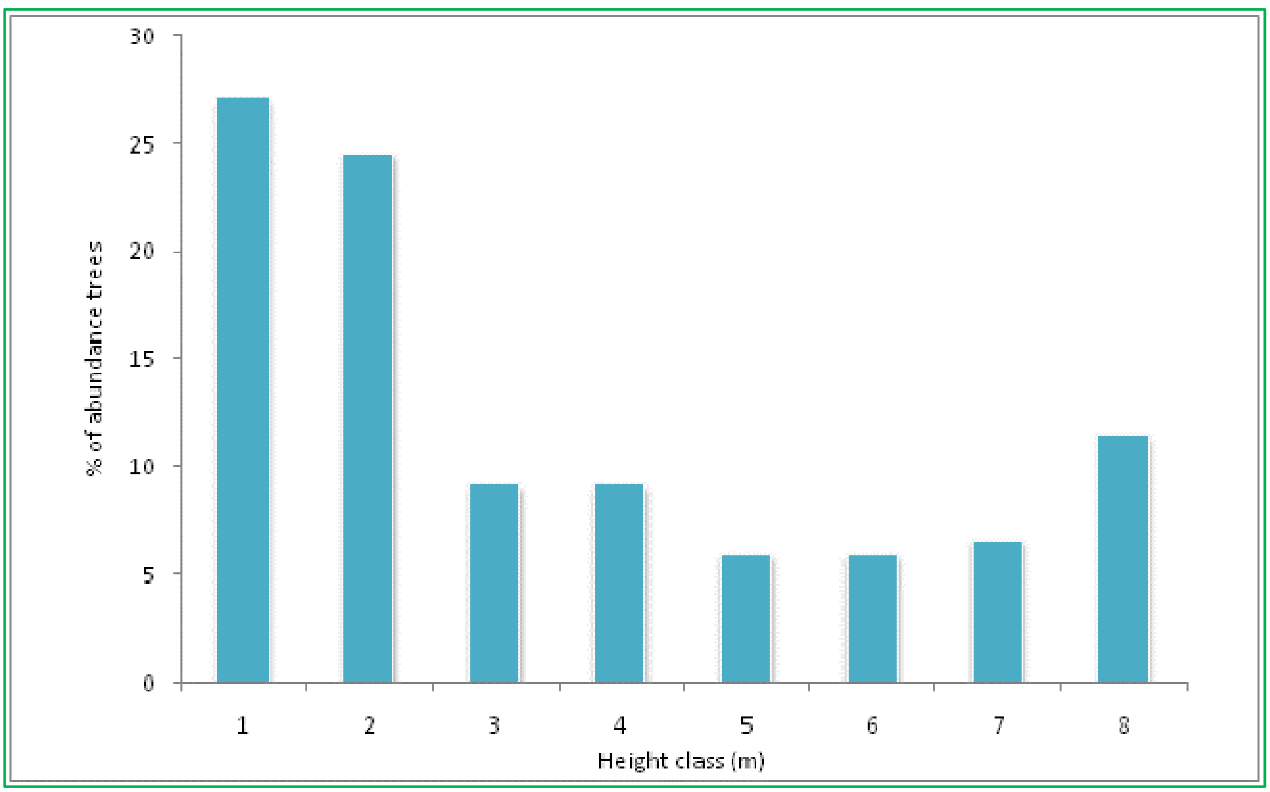


Figure 7: Percentage distribution of trees in height class

4.4.3.1. Vertical Stratification

The vertical structure of trees in Sanka Meda Forest was described following the Lamprecht (1989), classification scheme. For the calculation, the forest stand under study was subdivided into three different vertical height bands (storeys)

1. upper storey (tree height > 2/3 of top height)
2. Middle storey (tree height between 1/3 and 2/3 of top height)
3. Lower storey (tree < 1/3 of top height)

Each tree is classified into one of the tree storeys according to its height. The tallest tree observed in Sanka Meda Forest was *Podocarpus falcatus* with 40 m height. Trees in the lower, middle and upper height bands were those in the height range ≤ 13.3m, 13.3 – 26.67m and > 26.67m respectively. The description was given in Table 9.

Table 9: Density species number and percentage

Story	Density ha^{-1}	%	Species	%
Lower	87.14	56.09	24	42.11
Middle	33.21	21.53	20	35.09
Upper	35.00	22.53	13	22.81

The highest density of stem found in the lower storey and the lowest density is found in the middle storey (Table 9). The most dominant trees in the lower story (< 13.3 m) of the forest are *Maytenus obscura* (20.49%), *Dovyalis abyssinica* (13.93%), *Maesa lanceolata* (13.93%), *Bersama abyssinica* (9.02%), *Lepidotrichila volkensii* (6.56%), *Croton macrostachyus* (6.15%), *Maytenus undata* (4.92%), *Podocarpus falcatus* (4.10%), *Pavetta abyssinica*

(3.64%), *Cassipourea malosana* (2.46%), *Juniperus procera* (2.46%), *Teclea nobilis* (2.46%), *Vernonia auriculifera* (2.46%). The remaining accounts less than 2% each.

The trees in the middle storey of the forest (13.3 – 26.67m), contributed about 21.53% of the tree species in this height class layer. These species include *Podocarpus falcatus* (24.73%), *Olea europaea* subsp. *cuspidata* (15%), *Maytenus undata* (13.98%), *Cassipourea malosana* (8.60%), *Juniperus procera* (8.60%), *Lepidotrichilia volkensii* (5.38%), *Pavetta abyssinica* (4.30%), *Maytenus obscura* (3.23%), *Bersama abyssinica*, (2.15%), *Croton macrostachyus* (2.15%), *maesa lanceolqata* (2.15%) and the remaining contributed less than 2% each.

The upper storey contains emergent tree species (22.53%) of the total individuals in the forest the two dominant emergent tree species in this stand layer are *Podocarpus falcatus* (42.86%) and *Juniperus procera* (34.69%). The other species in the upper storey include *Olea hochstetteri* (4.08%), *Cassipourea malosana* (3.06%), *Bersama abyssinica* (2.04%) *Olea europaea* subsp cuspidate (2.04%), *Olinia rochetiana* (2.04%), *Croton macrostachyus* and the remaing contributed (1.02% each). Only six tree species (24%) found common to all storeys. These were *Podocarpus falcatus, Juniperus procera, Maytenus undata, Bersama abyssinica*, *Cassipourea malosana*, and *Croton macrostachyus*. The species that are common to all tree height profiles were described as species with regular distribution in all layers (Lamprecht, 1989). No species were missed in the lower story, but 80% and 52% were prevailed in the middle and upper tree height profiles respectively. The ratio of individuals to species revealed that species in the lower profile were represented on the average by 4 individuals, were as those in the middle profile were represented by one or two individuals and by two or three individuals in the lower profile (Table 9).

4.4.4. Diameter at Breast Height (DBH)

The distribution of trees in different DBH classes was analyzed. The DBH was classified into seven classes: 1) < 20 cm, b) 20.0140 cm, 3) 40.01 – 60 cm, 4) 60.01 – 80 cm, 5) 80.01 – 100 cm 6) 100.01 – 120 cm and 7) > 120 cm. The majority of the tree individuals are distributed in the first DBH class (DBH < 20 cm) with 279 individual ha^{-1} (64.14%). The distribution of trees in DBH class 2 was 63 individuals ha^{-1} (14.48%) and 26 (5.98%), 15(3.45%), 11(2.53%, 12(2.76%), 29(6.67%) ha^{-1} in DBH classes 3, 4,5,6,7 respectively (Figure 8). The analysis of DBH class distribution revealed more or less similar trends to that of height class distribution (Figure7 & 8). The DBH analysis revealed that more number of individuals was distributed in the lower DBH classes which are followed by a considerable decrease in the middle DBH classes and eventually by slight increase in DBH class 7. This fosters the normal invented J – shape. Similar pattern was observed in Dindin forest (Simon Shibru and Girma Balcha, 2004), and in Menagesha Amba Mariam forest (Abiyou Tilahun, 2009). This pattern indicates that the vegetation has good reproduction but low recruitment which might have been due to selective cutting of large tree individuals.

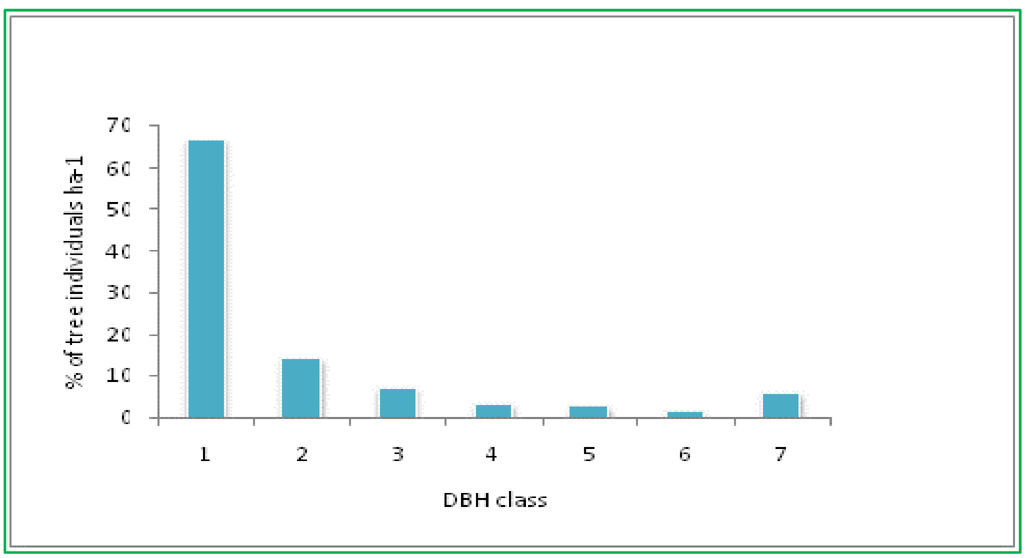


Figure 8: DBH class and percentage of number of individual ha^{-1}

4.4.5. Basal Area

Basal area is the cross-sectional area of all of the stems in a stand at breat height (1.3 m above ground level). This basal area per unit area is used to explain the crowdedness of a stand of forests. A stand of large trees is more stockes than with the same number of trees of smaller diameter (Martin, 1989).

The total basal area of all tree species in Sanka Meda Forest was calculated from DBH data. It was found to be $34.71 m^2 ha^{-1}$ (Table 10). According to Dawins (1959) cited in Lamprecht (1989) the normal basal area of virgin tropical forest in Africa is 23-$37 m^2 ha^{-1}$. Based on this report, the basal area for Sanka Meda Forest is medium. About 67.69% of the total area is distributed in the highest diameter class (Figure 9) which was due to the presence of few, but large sized individuals such as *Juniperus procera*, *Podocarpus falcatus*, *Olea europaea* subsp. *cuspidata* and *Olea hochstetteri*. The contribution of these species to the total basal area was 61.52%, 21.96%, 4.83% and 1.97% respectively. The second highest basal area is distributed in 5th diameter class (80.01 – 100 cm) which may be due to the higher contribution of *Olea europaea* subsp. *cuspidata*, *Schefflera abyssinica*, *Juniperus procera* and *Podocarpus falcatus*. The comparison of the basal area and densities in the diameter classes in Sanka Forest revealed the occurance of more number of individuals in the first two classes (Figure 9). However, the contribution of these individuals to basal area was low. This indicates that species with the highest basal area do not necessarily have the highest density but indicating size differences between species (Tamrat Bekele, 1994; Simon Shibru and Girma Balcha, 2004).

It was reported that BA provides a better measure of the relative importance of the species than simple stem count Cain and Castro (1959), cited in Tamrat Bekele (1994). Species with the largest contribution in basal area can be considered as the most important woody species in the forest. Accordingly, the most important woody species of Sanka Meda Forest were

Juniperus procera, *Podocarpus falcatus*, *Olea europaea* subsp. *cuspidata*, *Olea hochstetteri*, *Cassipourea malosana*, *Maytenus undata*, *Erythrina brucei*, *Schefflera abyssinica*, *Allophyllus abyssinicus*, *Olinia rochetiana*, *Croton mocrostachyus*, *Bersama abyssinica*, *Maytenus obscura*, and *Hagenia abyssinica* and *Lepidotrichilia volkensii*. These were the top 15 dominant tree species in the forest; their BA, density, IVI and frequency values were presented (Appendix 5). As reported by Lamprecht (1989), high density and high frequency coupled with high basal area indicate the overall dominant species of the forest. Hence, *Juniperus procera*, *Podocarpus falcatus*, *Maytenus obscura*, *Teclea nobilis*, *Juniperus procera* and *Bersama abyssinica* were some of the species with such type of distribution in the forest.

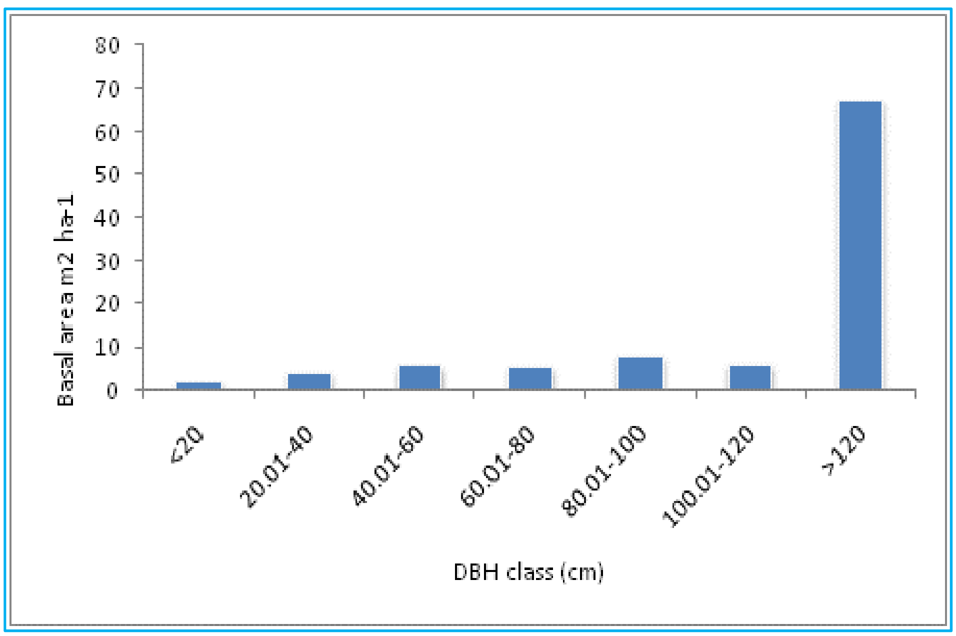


Figure 9: Basl area distribution over DBH classes In Sanka Meda Foest

The basal area of Sanka Meda Forest is compared with the based areas of other six dry afromontane forests in Ethiopia (Table 10).

Table 10: Comparison of the BA of Sanka Meda Forest with BA of other Forests in Ethiopia

Forest	Basal area (m^2/ha)	Source
Wof –Washa	101.80	Tamrat Bekel (1994)
Menagesha Amba Mariam	84.17	ABiyou Tilahun (2009)
Dindin	49.00	Simon SHibru and Girma Balcha (2004)
Denkoro	45.00	Abate Ayalew *et al*., (2006)
Menagesha –Suba	36.10	Tamrat Bekel (1994)
Sanka Meda (present study)	34.71	Shambel Bantiwalu (2010)
Chilimo	30.10	Tamirat Bekele (1994)

From these compared forests, only Chilimo forest has low basal area than Sanka Meda Forest and the rest forests have greater basal areas than the forest under present study. The trees belonging to higher DBH class in Sanka Meda Forest area fewer but contributed considerably to the total basal area. In Wof-Wash forest, the higher DBH classes (>50cm) are better represented and hence they contributed much to the total basal area (Tamrat Bekele, 1994) and this has greater basal area than Sanka Meda Forest. The basal area of a stand is simply the sum of the basal area value of all trees in that stand. The basal area increment response of trees is correlated with climatic and topographic factors (Spiecker *et al*., 1996). The trend of basal area for the compared forests was shown in descending order (Table 10).

4.4.6. Importance Value Index (IVI)

Importance value index indicates the structural importance of a species within a stand of mixed species. It is calculated by summing up the relative percentages of basal area, density and frequency, each weighed equally for each species, relative to the same dimesions for the entire stand (Kathiresan, 2006). According to Curtis and McIntash (1951), IVI gives a more realistic figure of dominance from the structural point of view. As indicated by lamprecht

(1989), it is used for comparison of ecological significance of species in which high IVI value indicates that the species sociological structure in the community is high. Thus, IVI is the most reasonable aspect in the vegetation study. More over, species with the greatest importance value are the most dominant of particular vegetation (Simon Shibru and Girma Balcha, 2004).

The dominant and ecologically most significant tree species in Sanka Meda Forest were *Juniperus procera*, *Podocarpus falcatus*, *Maytenus obscura*, *Teclea nobilis*, *Dovyalis abyssinica*, *Maytenus underta*, *Bersama abyssinica* and *Maesa lanceolata* on the basis their IVI values relative to other species. These tree species and others are described in Table 11. Further more the entire tree species in the forest were grouped into six classes based on their IVI values for conservation priority as follows. 1) >20, 2) 15.01-20, 3) 10.01 – 15, 4) 5.01-10, 5) 1.01-5, 6) <1 IVI values. Percentages of species in the IVI classes were 5.88, 2.94, 8.82, 5.88, 23.53, and 52.94 from class 1-6 respectively (Table 11). Over half (52.94%) was contributed by species prevailed in class 6 of IVI and the rest (47.06%) was shared among species distributed in IVI classes 1-5. The lowest level is attained in class 2 where the representative is only a single species.

Table 11: IVI Classes and number of species in each class in Sanka Meda Forest

IVI class and values	No of species	Percentage	Total IVI
6 (≤1)	18	52.94	6.85
5 (1.01-5)	8	23.53	28.00
4 (5.01-10)	2	5.88	18.32
3 (10.01-15)	3	8.82	34.23
2 (15.01-20)	1	2.94	31.32
1 (>20)	2	5.88	128.82

Table 12: List of species under Each IVI priority classes

Class 6	Class 5	Class 4
Acacia abyssinica *Allophyluss abyssinicus* *Celtis africana* *Cordia africana* *Dracaena afromontana* *Erythrina bruci* *Ficus sur* *Hagenia abyssinica* *Halleria lucida* *Millettia ferruginea* *Olinia rochetiana* *Premna schimperi* *Prunus africana* *Psydrax schimperiana* *Scheffelera abyssinica*	*Cassipourea malosana* *Croton macrosttachyus* *Lepidotrichlia volkensii* *Olea europaea subsp.cuspidata* *Olea hochstetteri* *Pavetta abyssinica* *Vernonia auriculifera*	*Bersama abyssinica* *Maesa lanceolata*
Class 3	Class 2	Class 1
Dovyalis abyssinica *Maytenus undata* *Teclea nobilis*	*Maytenus obscura*	*Juniperus procera* *Podcarpus falcatus*

4.5 Population structure of tree species

Population structure is the distribution of individuals of each species in arbitratily diameter height size classes to provide the overall profile of species under study (Peter, 1996). As it has been pointed out by Steininger (2000), the population structural patterns could be interpreted as an indication of variation in population dynamics that may happen from inherent traits or due to intervention of anthropogenic activities. This had significant implications to their management, sustainable use and conservation (Simon Shibru and Girma Balcha, 2004). The analysis based on relative density distributions by diameter classes carried out for tree species in Sanka Meda Forest showed different patterns from the analysis of some selected tree species in the forest, the existence eight general patterns of population structure were recognized. These were described using representative species in Figure 10a – h.

The first pattern shows high frequency values in the lower DBH classes and progressively decreased and finally frequency is missed from four or more higher DBH class. This pattern is more or less inverted J – shape. According to Feyera Senbeta *et al*. (2007), such distribution pattern is an indication for good biological functions and recruitment capacity for a species. In Sanka Meda Forest, only a few species of trees are in apparent with this type of pattern of population structure. Species with this pattern were *Lepidotrichilia volkensii*, *Barsema abyssinica*, *Halleria lucida*, *Maesa lanceolata*, and *Teclea nobilis.* This distribution pattern was represented by *Maytenus obscura* (Figure 10a).

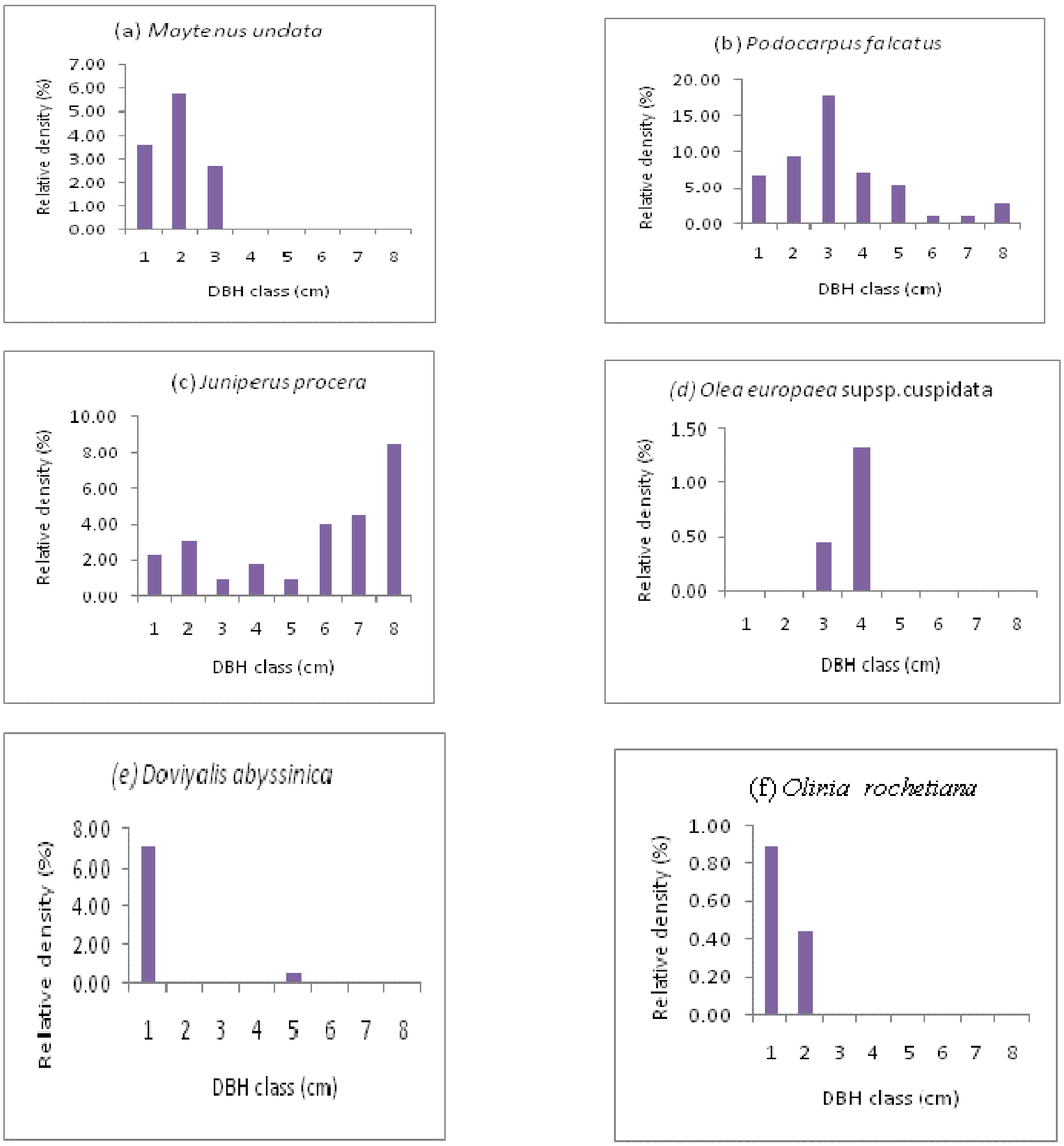
The second pattern was represented by *Podocarpus falcatus* (Figure 10b). In this pattern the lowest DBH classes have lower densities followed by increase in the number of individuals towards the middle classes and then a progressive decrease towards the higher DBH classes. The tree species in this pattern of population structure are *Maytenus undata*, *Cassipourea malosana* and *Croton macrostachyus.* Species with such distribution pattern indicate a poor reproduction and recruitment which may be associated with different factors that inhibit reproduction or the presence of only few seed bearing individuals.

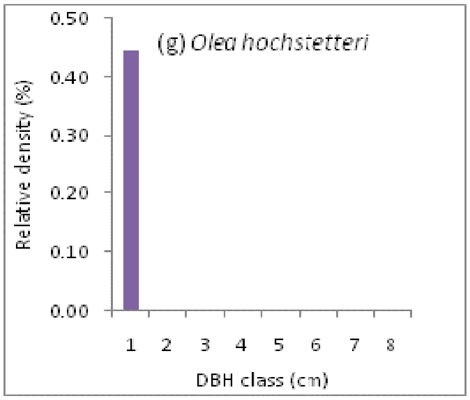
The third pattern was represented by a single species of *Juniperus procera* (Figure 10c). This species has highest frequency in higher DBH classes and low frequency in the middle DBH classes and slightly increased frequency in the lower DBH classes. The species with this type of pattern have large individuals that are with less competent to reproduce and in a weak position of regeneration status (Feyera Senbata *et al*., 2007).

The fourth population structure pattern is represented by *Olea europaea* subsp. *cuspidata* (Figure 10d). In this pattern DBH classes were missed from two lower DBH classes and four or more from higher DBH classes. Another species which exhibited similar population pattern is *Hagenia abyssinica*. Since these species are under high anthropogenic threat in the Sanka Meda Forest, the intensity and type of anthropogenic disturbances might be responsible for such type of trend in population structural pattern. As indicated by Dalling *et al*., (2002), several factors such as surrounding vegetation by means of inter specific interactions, environmental modification, seedling bank, availability of resources, disturbance levels together with stochastic factors like random climatic variability, fluctuations of resources and dispersal limitation may influence the vegetation structure.

The fifth pattern consists of species that occurs in the first DBH class and fifth DBH class but absent in the rest DBH classes (Figure 10e). The only species representing this pattern is *Dovyalis abyssinica*. The six patterns consist of species that occur only in the first and second DBH classes (Figure 10f). This pattern is represented by *Olinia rochetiana* and the other species with this structural pattern are *Maytenus arbutifolia*, *Pavetta abyssinica*, *Venonia amygdalina* and *Vernonia auriculifera*. The seventh population structural pattern consists of species that distributed only in the first DBH class (Figure 10g) and absent in the remaining DBH classes. This pattern is represented by *Olea hochstettrii* the species with pattern of population structure include *Calpournia aurea*, and *Osyris quadripartita*.

The eight population structural pattern consists of a species in the medium DBH classes and absent from the lower and higher DHB classes. This pattern is represented by *Allophyllus abyssinicus* (Figure 10h). The species showing this pattern include *Acacia abyssinica, Celtis africana*, *Ficus sur*, *Erythrina brucei*, *Schefflera abyssinica* and *Premna schimperi*.





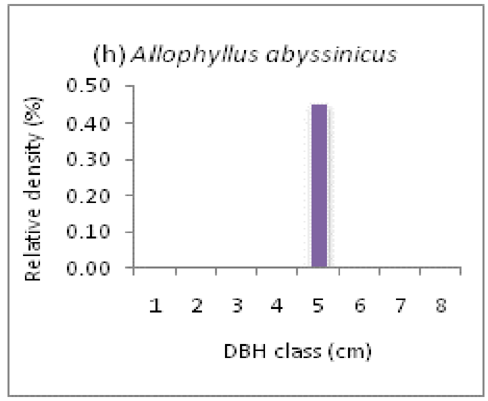


Figure 10: Eight representative patterns of population structure for tree species in Sanka Meda Forest

4.6 Regeneration of woody species is Sanka Meda Forests

Regeneration of any species is confined to a particular range of habitat conditions and the extent of those conditions is a major determinant of its geographic distribution. The population structure of a species in a forest can convey its regeneration behavior. The population structure characterized by the presence of sufficient population of seedlings, saplings and adults, indicates successful regeneration of forest species, and the presence of saplings under the canopies of adult trees also indicates the future composition of a community. Regeneration status of trees can be predicted by the age structure of their populations. Regeneration of a particular species is poor if seedlings and saplings are much less than the mature trees. The study of regeneration of forest trees has important implications for the management of natural forests, and is one of the thrust areas of forestry. Regeneration is the process of silvigeness by which trees and forests survive over time. Research in this field contributes to planning, conservation and decision making in forest resource management programmers (Pokhriyal, *et al*., 2010).

From the analysis of seedlings and saplings data, 45 (32.14%) woody species representing 43 genera and 31 families were recorded for seedlings. As mentioned in section 5.3.1, the total seedling density of the woody species in the forest was 290.93 ha^{-1}.The densities of tree, shrub and liana species seedlings were 200.71 ha^{-1}, 76.79 ha^{-1} and 26.07 ha^{-1} respectively (Figure 11). Similarly, the density of saplings 197.50 ha^{-1} was recorded for 34 (24.29%) woody species representing 31 genera and 23 families. The densities of trees, shrub and liana species saplings were 127.14 ha^{-1}, 59.29 ha^{-1} and 3.2, ha^{-1} respectively. The ratio of seedlings to adult individuals of woody species in the forest was 0.69; the ratio of seedling to saplings was 1.76 and sapling to mature individuals was 0.39. The distribution of mature individuals than seedlings and sapling indicates that the regeneration status of the forest is at low state.

According to Dhaulkhandi *et al*. (2008), the density values of seedlings and saplings are considered as regeneration potential of the species. The presence of good regeneration potential shows stability of the species to the environment. Climatic factors and biotic interferences influence the regeneration of different species in vegetation. Higher seedling density values get reduced to sapling due to biotic disturbances and competition for space and nutrients. The data analysis revealed that the density values for seedlings and saplings of the population structure of the forest are low and deviates from the normal patters of the population. This might be due to high anthropogenic disturbance existing in the forest. This implies a need to develop and implement effective forest management regimes in the area to promote healthy regeneration and the sustainable use of these species.

From the total density of tree species seedlings 41.64% of the total density was contributed by *Bersama abyssinica*, *Croton macrostachyus*, *Dovyalis abyssinica*, *Maytenus obscura*, *Maytenus undeta*, *Halleria lucid*a, *Maesa lanceolata*, *Podocarpus falcatus* and *Teclea nobilis*. About 45% of the total density of tree species sapling was contributed by *Bersama abyssinica*, *Teclea nobilis*, *Maytenus obscura*, *Vernonia auriculifera*, *Podocarpus falcatus*, *Schefflera abyssinica* and *Psydrax schimperiana.* About 37.17% of the total density of shrub species seedlings was coverd by *Inula confertiflora*, *Myrsine africana*, *Brucea antidesenterica*, *Calpurnea aurea*, *Discopodium peninnervum* and *Rytignia neglecta*. 78.49% of the total density of shrub saplings was contributed by *Rytigynia negleca*, *Discopodium peninnervum*, *Rubus steudneri*, *Brucea antidysenterica*, *Conyza hypoleuca*, *Canthium oligocarpum*, *Myrsine africana* and *Calpurnia aurea*.

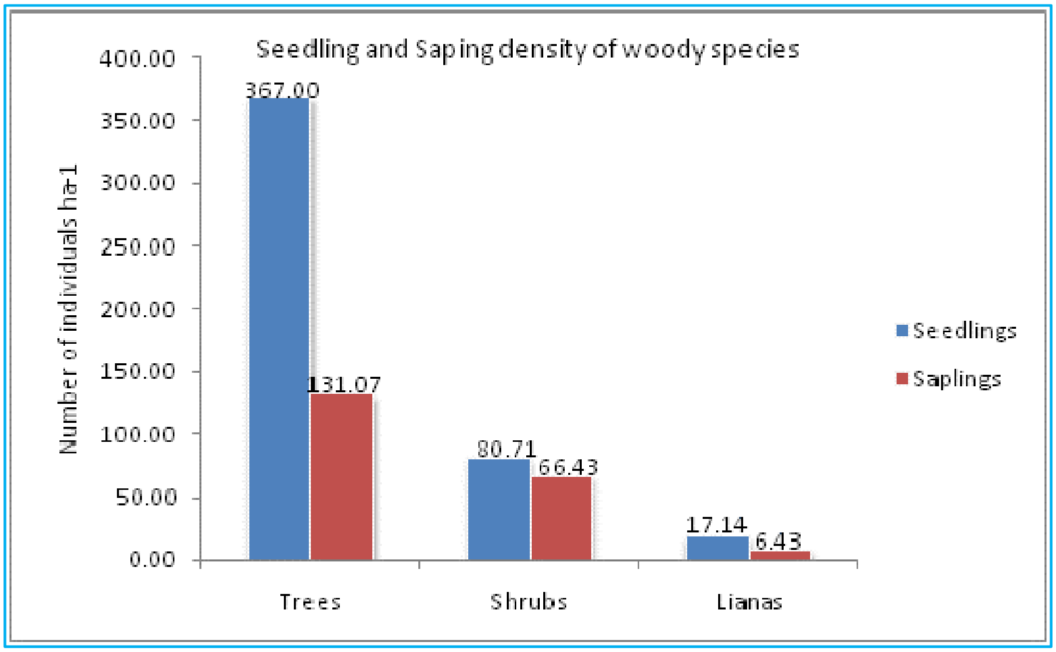


Figure 11: Seedling and sapling distribution of woody species of Sanka Meda Forest

As reported by Uriarte *et al*. (2005), seedling recruitment is a block in the population dynamics of many species of trees. It is one of the important factors in determining the local abundance of adult trees and this call for urgent conservation measures through prioritization. In order to use the regeneration analysis outcomes for priority setting, some selected tree species in the study area were identified in to three regeneration status classes based on the method reported by Simon Shibru and Girma Balcha (2004). Hence, those species that were totally absent in the regeneration are represented by one seedling individual were grouped under class 1; others whose density is between one and ten were categorized under class two and the remaining species were came under class three (Table13).

Table 13: List of tree species under regeneration status classes

Class I	Class II	Class III
Acacia abyssinica	*Apodytes dimidiata*	*Bersama abyssinica*
Allophyllus abyssinicus	*Cordia africana*	*Cassipourea malosana*
Hagenia abyssinica	*Maytenus arbutifolia*	*Juniperus procera*
Celtis africana	*Millettia ferruginea*	*Lepidotrichilia volkensii*
Dracaena afromontana	*Olinia rochetiana*	*Maesa lanceolata*
Ficus sur	*Osyris quadripartita*	*Maytenus undata*
Erica arborea	*Pavetta abyssinica*	*Olea europaea* subsp. *cuspidata*
Galinera saxifraga	*Premna schimperi*	*Teclea nobilis*
Nuxia congesta		*Vernonia amygdalina*

Trees and stands of trees are able to survive and grow under unique combination of environmental conditions (e.g., nourishment, moisture, light and space). Different types of trees or stand require different combinations of these factors depending on their particular adaptations. Healthy, productive stands are those in which these factors are found in appropriate quantities for optimum growth and development for the species mix in question. The manner in which these factors interact at the scale of the seedling will determine the ability of seedlings to germinate, become established, survive and grow (Ward *et al*., 2006).

The environmental factors affecting the seedling features vary at spatial scales, hence, they act on a micro site – depending on the way altering the seedling survivorship probability (Castro *et al*., 2004). The regeneration of existing tree populations in an area can be impeded by a lack of recruitment due to several causes, such as the scarce production and dispersion of seeds, and the high mortality of seedlings. The severity of drought, anthropogenic activities, and the overgrazing by domestic and wild herbivores (Comez *et al*., 2003). Regeneration success and stand dynamics in forest ecosystem are strongly linked to seedling and juvenile performance (Pigott and Pigott, 1993). Thus, identifying critical factors influencing these stages is important for developing sound forest conservation practice.

There are different factors like regeneration structure and species interactions between adults and at lower age are the major treats (Grau, 2000). Although the relative abundance, growth and distribution of seedlings and/or saplings are important in determining species that replace the canopy, abundance of seedlings and /or saplings should not at all considered as an indicator of the definitive establishment of young individuals. The reason is that, the establishment of many indigenous woody species seedlings and/or saplings is not easy to regenerate because of unfavorable microhabitat. A good understanding of natural regeneration of any vegetation community requires information on the presence and absence of persistent soil seed banks or seedling banks, quantity and quality of seed rain, longevity of seeds in the soil, losses of seeds to predation and deterioration, triggers for germination of seeds in the soil and sources of regrowth after disturbances. Tropical forest species regenerate from one or more sources (pathways) i.e., (i) Seed rain: recently dispersed seeds; (ii) Soil seed bank: dormant seeds in the soil; (iii) Seedling bank or advance regeneration: established, suppressed seedlings in the under story; and (iv) Coppice: root or shoot sprouts of damaged individuals (Garwood, 1989). Thus, as the present study did not include the seed ecology, continuous assessment of the natural regeneration and investigation of the status of soil seed bank is required to know seed production and dispersal ecology, pre-and post dispersal seed predation, seed rain, fate of dispersal seeds, seedling establishment and growth, seed dormancy and cues for seed germination as well as the rate and the recruitment processes of seedlings from the soil seed bank in the forest.Analysis of population structures, using frequency distribution of the height and diameter classes of naturally generated woody species, can provide an insight in to their regeneration status (Silverton and Doust, 1993; Brokaw, 1987; Burrows, 1990). Depending up on the frequency distribution of age structures, the prevailing regeneration behavior of all tree species and selected shrubs in the forest were divided into five regeneration patterns. The first category is represented by *Olinia rochetiana* and the other categories are represented and described under *Hagenia abyssinica*, *Podocarpus falcatus*, *Prunus africana* and *Olea europaea*, subsp. *cuspidata*. (Figure 12a – e).

Olinia rochetiana (Figure 12a): This pattern of distribution shows higher number of seedlings and saplings than the mother plants and the number of saplings are better represented than the mature individuals of trees or shrubs. The pattern has many individuals at seedling stage and decreasing number of individual successively at saplings and adult stages and exhibited typical inverted J-shape curves. The plant species included in this regeneration category are *Burcea antidysenterica*, *Inula* c*onfertiflora* and *Vernonia auriculifera*. The inverted J-shape pattern signifies that these species have good regeneration potential.

Hagenia abyssinica (Figure 12b). This pattern consists of few mature individuals seedlings and saplings individuals which substitute the mother plant. Species with such type of pattern are poor in their reproduction and recruitment potential because there are no juveniles, which tend to become a mother plant. This might be due to anthropogenic by disturbances such as selective cutting of trees of *Hagenia abyssinica* for its quality timber and harvest of its floral parts for medicinal use. An other species in this pattern is *Celtis africana*. The result implies that these species need conservation priority.

Podocarpus falcatus (Figure 12c): The pattern of distribution in this category shows maximum number of mature mother plant than saplings and lower number of seedlings .It exhibits a J-shape regeneration curve with higher recruitment than regeneration. The species exhibiting this type of regeneration curve are *Maesa lanceolata*, *Juniperus procera* and *Pavetta abyssinica.* The pattern indicates that the juvenile performances of these species are under strong influences factors. These might be anthrogenic disturbances or environmental factors that alter the seedling survival ship.

Prunus africana (Figure 12d): The distribution pattern of regeneration was represented by Gassian type of distribution (Tagesse Warano, 2005). The species with this type of pattern are *Bersama abyssinica*, *Conyza hypoleuca*, *Discopodium peninnervum*, *Eplobium hirsutum*, *Premna shimperi*, *Psydrax schimperiana*, *Rytigynia neglecta*, *Rubus steudneri*, *Schefflera abyssinica* and *Teclea nobilis.* This pattern of distribution has high number of saplings than seedlings and mother plant. The present study also followed similar distribution with high number of individuals in sapling stage and the two extremes remain with lower number of individuals.

Olea europaea subsp. *cuspidata* (Figure 12e): This regeneration pattern represents the species with only seedlings and mature individuals. There is a gap between the floristic composition of matured stands and the regeneration. This might suggest that the saplings are influenced by disturbances or the by the environmental factors. Species with this pattern of regeneration behavior include *Cordia africana*, *Canthium oligocarpum*, *Calpurnia aurea*, *Croton marostachyus*, *Dovyalis abyssinica*, *Lepidotrichilia volkensii*, *Maytenus obscura*, *Maytenus arbutifolia*, *Maytenus undata*, *Myrsine Africana*, *Cassipouria malosana, Apodytes dimidiata*, *Asparagus africanus*, *Dregea abyssinica*, *Halleria lucida*, *Leonotis schimperi*, *Milletia ferruginea*, *Osyris quadripartita*, *Stephania abyssinica*, *Schefflera abyssinica* and *Urera hypselodendron.*

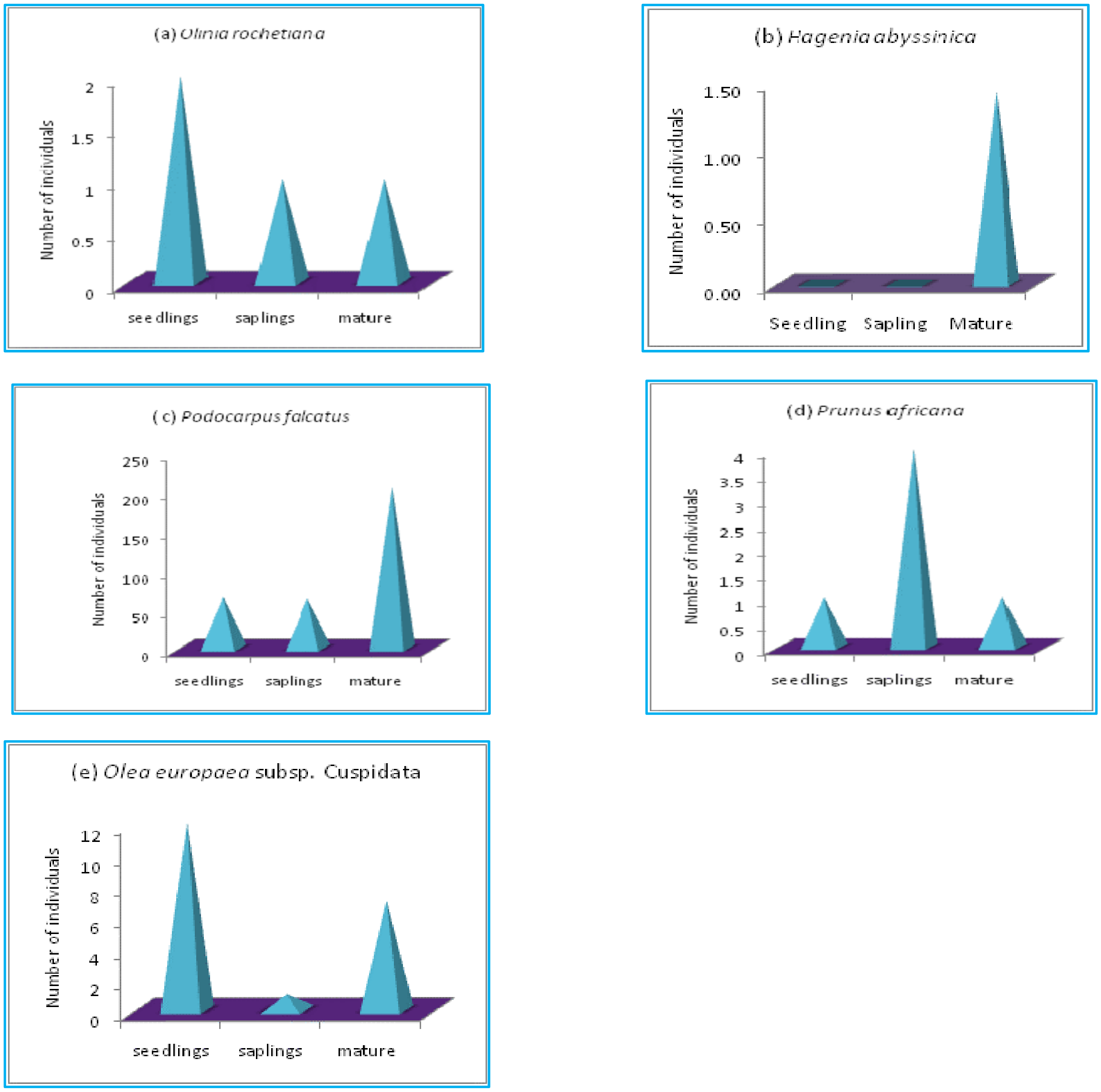


Figure 12: The regeneration pattern in Sanka Meda Forest represented by selected species

4.6 Phytogeographical comparison

A major objective of floristic analysis is to identify floristic patterns among the distributions of taxa. A traditional approach of identifying distribution affinities among the taxa of a flora involves the recognition of floristic elements (phytogeographical elements) based up on the native worldwide distributional ranges of the taxa. Although floristic elements may be defined in different ways and the assessment of taxa to floristic elements may be more confident for some taxa than others and the floristic element approach has been used widely, geographical position, represented by latitude and longitude, of a flora plays a more important role in determining the composition of floristic elements than climate. This may be in part because floristic elements are defined by their geographical, rather than ecological distributions (Qian, *et al*., 2006).

The direct comparison of the species diversity of one forest with other forests is not feasible due to variations in size, survey methods used, and objective of the study among forests. (Tadesse, Woldemariam, 2003). However, the overall species richness of the forest can give more or less a general impression of their diversity and phytogeographical similarity. In this regard Sanka Meda Forest is compared with six dry evergreen afromontane forests in the country to see the distribution pattern of woody species in the study area and to know the relative similarity in its woody species composition (Table 14). These are Biteyu, Dindi, Menagesha Suba, Menagesha Amba Mariam and Denkoro dry everygreen afromontane forests. Biteyu is located at the edge of western escarpment of Gurage Mountain in Southern shewa 17km northwest of Butajira town. Its altitude ranges from 2590 – 2890 m a. s. l. (Mekonnen Biru, 2003). Dindin forest is situated in southeastern Ethiopia between 08^{0} 37'-08^{0} 39' N and 40^{0}11' – 40^{0}16' E and its elevation is from 21500-3000 m a.s.1. (Simon Shibru and Girma Balcha, 2004); the Menagesha Suba forest is arelatively well protected forest located about 30km southwest of Addis Ababa between 80^{0} 56' – 9^{0} 00' N and 38^{0} 32' - 38^{0} 34' E. Its altitude ranges from 2440 – 3400 m a.s.l. (Abate Zawdie, 2007). Menagesha Amba Mariam forest is located about 28 km west of Addis Ababa between 9001’ – 09^{0} 00' N and 38^{0}35' - 38^{0}34' E. Its altitude ranges from 2574 – 2948 m a.5.1. (Abiyou Tilahun, 2009). The Denkoro forest is located in south wello between 10^{0} 35'-11^{0} 15' N and 38^{0}35' – 38^{0}36' E. It elevates from 1500 – 3500 m a.s.1. (Abate Ayalew *et al*., 2006). Munessa Shashemene forest is located 230 km south of Addis Ababa at 7^{0}31' N and 38^{0}37' E. Its altitude extends from 2100 – 2700 m a.s.1. (Getachew Tesfaye 2007).

In the analysis of the data from the seven forests, Sorensen's (1948) similarity index was used with the formula, Ss = $2a / (2a + b + c)$

Where, Ss = Soresen's similarity coefficient;

a = number woody species common to Sanka Meda Forest and other forests in comparison;

b = Number of woody species found only in Sanka Meda Forest;

c = Number of woody species found only in the forest in comparison with Sanka Meda forest.

Table 14: Phytogeographical comparison between Sanka Meda and Other Forests

Forest	**Altitudinal range**	**No of species**	**a**	**b**	**c**	**Ss**
Sanka Meda	2400-2748	139				
Biteyu	2590-2890	83	32	55	48	0.380
Menagesha Suba	2440-3400	82	30	57	30	0.041
Menagesha Amba Mariam	2574-2948	219	38	47	41	0.460
Dindin	2150-3000	81	48	37	34	0.580
Munessa – Shashemene	2100-2700	61	28	59	34	0.380
Denkoro	1500-3500	174	38	45	23	0.530

Sorensen's similarity index which is dependent on the number of common species shared by the forests being compared indicated that Sanka Meda and Dindin forests show the highest similarity (58%). This was followed by Denkoro and Menagesha Amba Mariam with similarity of 53% and 46% respectively. The Sanka Meda and Menagesha Suba forests had the lowest similarity of 4.1%. The probable explanation for high similarity between Sanka Meda and Dindin forests is that both forests are located close to each other on the Hararge – Arsi – Bale high landmass of the same altitudinal range as well as geological formation and topography. The narrow corridors of grasslands and woodlands which separate the two forests are another indicative that the two forests were separated form each other through time by the effect of anthropogenic activities.

The distribution range of a species is controlled by environmental factors for which the organism has the narrowest range of adaptability or control. Other important factors controlling species distribution a part from changes in the environmental conditions include evolutionary changes that greatly influence the potential range of species (Mwasumbia *et al.*, 2000). This explains high dissimilarity between species confined to Sank Meda and Menagesha Suba forests and the two forests differ in their woody species probably due to different levels of precipitation as well as the nature of the soils.

5. Conservation status of the Sanka Meda Forest

Sanka Meda forest is poorly protected. Agriculture is the main threat, coupled with exploitation of trees for fuelwood and timber. The large timber trees are being logged out for the the last 40 years by the local Etaro Sawmill that has been constructed in in 1971 on the western border of this forest. The expanding rural population in the area which utilizes this forest for construction material, fuel and charcoal, threatened the forest. Traditionally, the forest was used for gathering honey, as one of the major activities of the local people is livestock production; it also provides grazing area to the local communities (Plate 5). Because of its location on landscape of beautiful scenery at the northern escarpment of the Kamsarie (Gugu) mountain which is about 3574m above sea level, this forest can be ideal place for naturalists and mountaineers and area of great pleasure for tourists, if the necessary infrastructures are fulfilled.

Plate 5: Cattle grazing at the place called "Sanka Meda" in the forest (Photo by Shambel Bantiwalu 2009)

Etaro Sawmill is an elaborative and only operating Sawmill in this area. It is located 14 km east of Aba-Jema town at the western edge of Sanka Meda forest. It was built by the two Italian citizens and it is the 4th Sawmill but now the only operating Sawmill in the area. Currently, this Sawmill has splitting, smoothing, cutting, designing and maintenance sections. It uses two vertical, two horizontal and one frame saws with a capacity of producing over 12m^{3} timbers per day (Plates 6 & 7).

Plate 6: View of Etaro sawmill and timber produced on its back side (Photo by Shambel Bantiwalu, 2009)

Plate 7: View of Etaro sawmill and timber produced on its front side (Photo by Shambel Bantiwalu, 2009)

Although it had started production with 200 workers, now it has 110 workers out of which 40 of them are permanent employees, 30 of them are employed on the basis of contract and 40 of them are daily workers that are used in the forest for cutting and rolling to the mill. From the year 1971 – 2007, the saw mill was totally dependent on the natural vegetation of Sanka Meda for its production of the timber. However, since 2008 until the time of the present study, it has shifted its source to the plantation which was planted during the Derge rigime.Mainly it uses *Podocarpus falcatus*, *Juniperus procera* and *Hagenia abyssinica* from natural vegetation; *Pinus patula* and *Cupressus lucitanica* from the plantation site for timber production.Currently, the conservation status of the Sanka Meda is at a very low status. Forest conservation has never been the concern of the local communities as the local people view a forest as a source of fuel wood, and something which prevents cultivation. At present, the largest proportion of this forest has been burned and cleared for cultivation. Great areas of the drier slopes in north and south west are burned each year and erosion is severe (Plate 8).

Plate 8: Expansion of the farmland in the southwestern part of the forest (Photo by Shambel Bantiwalu, 2009)

As metioned earlier, the local inhabitants use the forest as a primary source of fuel and grazing area. They chiefly use *Olea europaea* subsp.*cuspidata* as a fuel wood, *Juniprus procera* for construction purposes, *Podocarpus falcatus* for timber production through traditional way of logging, *Allophyllus abyssincus* and *Acacia abyssinica* for making charcoal and *Teclea nobilis* for making farming implements and sticks ('Dulla' or 'Ulee'). As it has been observed during this study, the men cut a tree of *Olea europaea* subsp.*cuspidata* down and the women and girls hack it in to splinters and carry a load home each day (Plate 11). Another and perhaps most destructive habit of local communities is their cutting of slabs bark from *Juniperus procera* and *Podocarpus falcatus*. This bark is used for making traditional beehives and for making (closing) the roofs of their houses and they always choose a smooth trunked large trees for this purpose (Plates 9 & 10).

Plate 9: One of the local houses whose roof is made of the bark of *Juniperus procera* (Photo by Shambel Bantiwalu, 2009).

Plate 10: *Juniperus procera* in the forest suffering from bark harvest by the local inhabitants (Photo by Shambel Bantiwalu, 2009).

Plate 11: Girls hacking Olea europaea into splinters for firewood harvest (Photo by Shambel Babtiwalu, 2009)

It seems that most of the local people spend their time in the forest hacking trees and the presence of scattered and dying forest tree species around the Sanka Meda Forest indicates the work they have done and the magnitude of deforestation rate in the area (Plares 11-15).

Plate 12: Land degradation and soil erosion along the roadvthat crosses the the forest (Photo by Shambel Bantiwalu, 2009)

Plate 13: A big tree of Juniperus procera which became victim of local fire (Photo by Shambel Bantiwalu, 2009).

Plate 14: Podocarpatus falcatus logged by local wood loggers in the middle of the forest (Photo by Shambel Bantiwalu, 2009).

Plate 15: Stump of Podocarpatus falcatus cut by local wood loggers (Photo by Shambel Bantiwalu, 2009).

6. Conclusion and Recommendations

6.1. Conclusion

The floristic composition, structure and regeneration of plant species is Sanka Meda Forest has been studied. The results of the study indicated that the forest had high species diversity i.e., 139 species of vascular plants and a lichen species belonging to and 118 genera and 63 families were recognized. Asteraceae was found to be the most dominant family followed by Laminaceae and Solanaceae. The vegetation was grouped in to four different plant community types. The plant communities produced match with the natural physiognomic associations that an observer can recognize in the field. Species diversity and richness varied among the community types and also along the altitudinal gradient. The variation in species composition, and diversity among plant communities could be attributed to different factors, such as altitude, soil property, slope, anthropogenic activities, of which altitude play a major role. The species richness variation among communities confirms this fact. Based on the structural description of DBH and Height classes' distribution in the Sanka Meda forest, More or less similar trends have been revealed in both parameters. The density of tree species in the forest decreases with increasing DBH and Height classes, which implied the predominance of smallsized individuals in the lower classes than in the higher classes indicating good recruitment of the forest and rare occurrence of large individuals. This shows that the forest is in the secondary state of development. The analysis of frequency classes for woody species revealed higher percentage of species number of individuals in the lower frequency classes which is the evidence for the floristic heterogeneity of the Forest.The study site harbors a significant number of endemic plant species (10%).The presence of endemic species and economically useful indigenous trees indicates the uniqueness and potentiality of the area which needs immediate conservation actions. Even though the Sanka Meda forest has been protected, The Government protection seems nominal, there is no sustainable management plan in place and no enforcement of the rules. Thus, currently The Forest is experiencing high rate of destruction because of the frequent (daily) visits of the people from near by villages for their daily requirement of fuel, fodder, wood for construction and other forest products. This has resulted in the depletion of the forest, there by causing damage to both plant and animal diversity of the area.

6.2 Recommendations

Depending up on the informations obtained from the study the following points were made as recommendations:

⇒ The Present study can contribute towards the understanding of plant species diversity and regeneration, which has considerable importance in its conservation. However, this study is very preliminary and it is recommended that subsequent ecological studies are vital concering species composition, diversity, and distribution of possible plant communities with repect to other environmental factors such as soil properties which will provide additional data on floristic composition and diversity changes, which will be useful in forest management and conservation efforts.

⇒ Raising awareness of local communities on the value of forest resources and ecological consequences of deforestation and device mechanisms by which human impacts can be minimized through discussion and consultation with the local communities.

⇒ The present study was limited to floristic composition and structure of woody plants thus, further studies on soil seed bank, seed physiology, and land use management system in the area are recommended.

⇒ Detailed ethnobotanical studies are also required to explore the wealth of indigenous knowledge on the diverse of plants and their implications in conservation

⇒ Increasing education activities on forest fire and its impact strengthen public awareness of forest fire and its management. I.e. local communities should be the main managers of forest fires.

⇒ Educating and encouraging the local communities to practice the use of alternative materials such as crop residues for making the roof of their houses instead of tree barks.

⇒ The government and its institutions should play their respective roles and responsiblies in strengthening the very low existing efferts as well as in correcting the gaps and in creating integrated mechanisms at national, regional and local levels for implementing and enforcing the rules of conservation and sustainable use of forest resources.

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8. Appendices

Appendix 1: Releve characterisics of Sanka Meda Forest

Transect	Releve No.	Aspect	Species richness	3D Location		Altitude (m)	Locality
1	1	EW	16	$8^0$24’54”N	$39^0$57’58”E	2400	Dagnam-Yelew
	2	EW	16	$8^0$24’54”N	$39^0$57’52”E	2670	Dagnam-Yelew
	3	NS	18	$8^0$24’53”N	$39^0$57’38”E	2586	Dagnam-Yelew
	4	NS	17	$8^0$24’54”N	$39^0$57’28”E	2682	Etero
2	5	WE	17	$8^0$24’40”N	$39^0$57’26”E	2592	Etero
	6	WE	11	$8^0$24’41”N	$39^0$57’36”E	2684	Etero
	7	WE	16	$8^0$24’40”N	$39^0$57’43”E	2687	Etero
	8	EW	22	$8^0$24’40”N	$39^0$57’43”E	2685	Dagnam-Yelew
	9	NS	15	$8^0$24’41”N	$39^0$57’52”E	2612	Dagnam-Yelew
	10	EW	19	$8^0$24’42”N	$39^0$57’54”E	2604	Dagnam-Yelew
	11	EW	17	$8^0$24’42”N	$39^0$57’56”E	2564	Dagnam-Yelew
	12	EW	15	$8^0$24’41”N	$39^0$57’58”E	2520	Dagnam-Yelew
3	13	EW	16	$8^0$24’30”N	$39^0$57’59”E	2514	Dagnam-Yelew
	14	EW	15	$8^0$24’32”N	$39^0$57’56”E	2630	Dagnam-Yelew
	15	EW	21	$8^0$24’31”N	$39^0$57’53”E	2626	Dagnam-Yelew
	16	NS	16	$8^0$24’31”N	$39^0$57’48”E	2599	Etero
	17	WE	20	$8^0$24’31”N	$39^0$57’42”E	2600	Etero
	18	WE	16	$8^0$24’32”N	$39^0$57’38”E	2620	Etero
	19	WE	12	$8^0$24’32”N	$39^0$57’35”E	2670	Etero
	20	WE	15	$8^0$24’31”N	$39^0$57’30”E	2684	Etero
4	21	WE	13	$8^0$24’22”N	$39^0$57’26”E	2678	Etero
	22	NW	22	$8^0$24’22”N	$39^0$57’29”E	2658	Etero
	23	NW	14	$8^0$24’22”N	$39^0$57’33”E	2630	Dagnam-Yelew
	24	NW	13	$8^0$24’21”N	$39^0$57’37”E	2560	Dagnam-Yelew
	25	NW	12	$8^0$24’22”N	$39^0$57’42”E	2676	Dagnam-Yelew
	26	EW	16	$8^0$24’21”N	$39^0$57’51”E	2506	Dagnam-Yelew

Transect	Releve No.	Aspect	Species richness	3D Location		Altitude (m)	Locality
5	27	EW	10	$8^0$24’00”N	$39^0$57’54”E	2550	Dagnam-Yelew
	28	NS	17	$8^0$24’00”N	$39^0$57’46”E	2560	Dagnam-Yelew
	29	Plain	20	$8^0$24’00”N	$39^0$57’40”E	2622	Sanka Meda
	30	Plain	11	$8^0$24’01”N	$39^0$57’01”E	2638	Sanka Meda
	31	Plain	16	$8^0$24’01”N	$39^0$57’29”E	2640	Sanka Meda
	32	NS	15	$8^0$24’00”N	$39^0$57’20”E	2660	Etero
	33	NS	18	$8^0$24’01”N	$39^0$57’14”E	2605	Etero
6	34	WE	11	$8^0$23’06”N	$39^0$57’48”E	2720	Etero
	35	WE	11	$8^0$23’06”N	$39^0$57’24”E	2718	Etero
	36	Plain	14	$8^0$23’07”N	$39^0$57’32”E	2710	Sanka Meda
	37	Plain	17	$8^0$23’07”N	$39^0$57’36”E	2748	Sanka Meda
	38	Plain	24	$8^0$23’07”N	$39^0$57’40”E	2660	Sanka Meda
	39	Plain	16	$8^0$23’06”N	$39^0$57’47”E	2665	Sanka Meda
	40	Plain	9	$8^0$23’06”N	$39^0$57’50”E	2640	Sanka Meda
	41	EW	12	$8^0$23’06”N	$39^0$57’52”E	2618	Dagnam-Yelew
	42	EW	8	$8^0$23’07”N	$39^0$57’55”E	2578	Dagnam-Yelew
	43	EW	10	$8^0$23’07”N	$39^0$57’57”E	2550	Dagnam-Yelew
	44	EW	8	$8^0$23’06”N	$39^0$57’58”E	2546	Dagnam-Yelew
	45	EW	11	$8^0$23’06”N	$39^0$58’01”E	2488	Dagnam-Yelew
7	46	SW	15	$8^0$23’38”N	$39^0$58’38”E	2487	Dagnam-Yelew
	47	SW	16	$8^0$23’37”N	$39^0$57’42”E	2500	Dagnam-Yelew
	48	SW	12	$8^0$23’37”N	$39^0$57’42”E	2536	Dagnam-Yelew
	49	WE	17	$8^0$23’37”N	$39^0$57’37”E	2562	Etero
	50	WE	14	$8^0$23’38”N	$39^0$57’34”E	2574	Etero
	51	WE	15	$8^0$23’37”N	$39^0$57’29”E	2600	Etero
	52	SN	14	$8^0$23’37”N	$39^0$57’22”E	2658	Etero
	53	SN	11	$8^0$23’37”N	$39^0$57’17”E	2694	Etero
	54	WE	10	$8^0$23’37”N	$39^0$57’13”E	2702	Etero
	55	WE	14	$8^0$23’38”N	$39^0$57’10”E	2708	Etero
	56	WE	11	$8^0$23’37”N	$39^0$57’06”E	2620	Etero

Transect	Releve No.	Aspect	Species richness	3D Location		Altitude (m)	Locality
8	57	SN	16	$8^0$23'28"N	$39^0$57'12"E	2604	Etero
	58	SN	17	$8^0$23'27"N	$39^0$57'20"E	2720	Etero
	59	SN	14	$8^0$23'27"N	$39^0$57'32"E	2614	Etero
	60	SN	9	$8^0$23'27"N	$39^0$57'40"E	2740	Sanka Meda
	61	WE	13	$8^0$23'28"N	$39^0$57'50"E	2718	Sanka Meda
	62	WE	16	$8^0$23'27"N	$39^0$58'00"E	2684	Dagnam-Yelew
	63	WE	15	$8^0$23'27"N	$39^0$58'10"E	2678	Dagnam-Yelew
	64	WE	17	$8^0$23'27"N	$39^0$58'22"E	2610	Dagnam-Yelew
9	65	SN	13	$8^0$22'09"N	$39^0$58'00"E	2624	Dagnam-Yelew
	66	SN	13	$8^0$22'09"N	$39^0$57'46"E	2548	Dagnam-Yelew
	67	SN	12	$8^0$22'09"N	$39^0$57'23"E	2624	Sanka Meda
	68	SN	10	$8^0$22'09"N	$39^0$57'14"E	2710	Sanka Meda
	69	WE	11	$8^0$22'10"N	$39^0$57'08"E	2716	Etero
	70	WE	24	$8^0$22'09"N	$39^0$57'02"E	2642	Etero

Appendix 2: List of plant species collected in Sanka Meda Forset, Southeast of Ethiopia

T = Tree, Sh = Shrub, T/sh = Tree/shrub, C = Climber, E = Epiphyte, G = Graminoid, H = Herb,

S.No.	Botonical Name	Family	Habit	Local Name	V.No
1	*Acacia abyssiniea* Hochst. ex Benth.	Fabaceae	T	Laaftoo	28
2	*Acanthus sennii* Chiov.	Acanthaceae	Sh	Qoree shakakee	1066
3	*Achranthes aspera* L.	Amaranthaceae	H	Darguu	23
4	*Achyrospermum schimperi* (Hochest.ex Brig.) Perkins	Laminaceae	H	Urgo loonnii	09
5	*Alchemilla abyssinica* Fresen.	Rosaceae	H	Yemdr kosso	1099
6	*Alchemilla kuwuensis* Engl.	Rosaceae	H		360
7	Allophyllus abyssinicus (Hochest.) Radlk.	Sapindaceae	T	Embus	402
8	*Apodytes dimidiata* E.Mey.ex Arn.	Icacinaceae	T	Muka fardaa	376
9	*Arisaema schimperanum* Schott	Araceae	H	Boqoloo	343

S.No.	Botonical Name	Family	Habit	Local Name	V.No
				warabessa	
10	*Asparagus africanus* Lam.	Asparagaceae	Sh	Sariitii	15
11	*Bersama abyssinica* Fresen.	Melianthaceae	T	Lolchiisaa	11
12	*Bidens prestinaria* (Sch.Bip.)Cufod.	Asteraceae	H	Habaaboo Mosqalaa	520
13	*Bothriocline schimperi* Oliv. &Hiern ex Benth.	Asteraceae	H		163
14	*Brassica nigra* (L.) Koch	Brassicaceae	H	Yemdr feto	1050
15	*Brucea antidysenterica* J.F.Mill.	Simaroubiaceae	Sh	Abaaloo	10
16	*Buddleja davidii* Franch.	Loganiaceae	Sh	Adaadii	76
17	*Calpounia aurea* (Ait.) Benth.subsp. *aurea*	Fabaceae	Sh	Ceekataa	137
18	*Canthium oligocarpum* Hiern	Rubiaceae	Sh	Mixoo	121
19	*Cardamine trichocarpa* A.Rich.	Brassicaceae	H	Feexoo	1072
20	*Carissa edulis* Wahl.	Apocynaceae	Sh	Agamsa	663
21	*Cassipourea malosana* (Baker) Alston	Rhizophoraceae	T	Worer	374
22	*Celtis africana* Burm.f.	Ulmaceae	T	cayyii	670
23	*Ceropegia cufodontis* Choiv.	Asclepiadaceae	C		454
24	*Clematis longicauda* Steud.ex A.Rich.	Ranunculaceae	C	HIdda osolee	1043
25	*Clematis simensis* Fresen.	Ranunculaceae	C	Hidda galee	145
26	*Colutea abyssinica* Kunth & Bouche	Fabaceae	H	Misiiraahant uu taa	1021
27	*Conyza hypoleuca* A.Rich	Asteraceae	Sh	Nechilo	68
28	*Cordia africana* Lam.	Boraginaceae	T	Waddessa	1027
29	*Crotalaria guatiniana* A.Rich.	Fabaceae	H		358
30	*Croton macrostachyus* Huchst.ex Del.	Ephorbiaceae	T	Bakkanniisa	07
31	*Cynoglossum amplifolium* Hochst.ex A. in DC. Var. amplifolium	Boreginaceae	H	Qorcha michii	264
32	*Cynoglosum geometricum* (Bak. & Wright) Edwards	Boraginaceae	H	Maxxanee	526
33	*Cyperus fischerianus A.Rich.*	Cyperaceae	G	Qunii	257
34	*Cyphostemma adenocaule* (Steud. ex.	Vitaceae	C	Hidda xorsoo	1040

S.No.	Botonical Name	Family	Habit	Local Name	V.No
	A.Rich.)				
35	*Datura stramonium* L.	Solanaceae	H	Manjii	1085
36	*Diaphananthe candida* Cribb	Orchidaceae	E	Teketsila	299
37	*Diaphananthe schimperiana* (A.Rich.) Summerh.	Orchidaceae	E	Teketsila	50
38	*Digitaria abyssinica (Hochst.ex A.Rich.)Stapf.*	Poaceae	G	Merga gogorii	47
39	*Discopodium peninnervum* Huchst.	Solanaceae	Sh	Ameraroo	06
40	*Dodonea angustifolea* L.f.	Sapindaceae	Sh	Xedechaa	1023
41	*Dombeya torrida* (J.F.Gmel.) P.Bamps	Sterculiaceae	T	Dannissa	535
42	*Dovyalis abyssinica* (A.Rich.) Warb.	Flacourtaceae	T	Koshomii	21
43	*Dracaena afromontata* Mildbr.	Dracaenaceae	T	Mirqoo	356
44	*Dregea abyssinica* (Hochst.) K.Schum.	Asclepiadaceae	C	Hidda warabessa	252
45	*Ebelia schimperi* Vatke	Myrsinaceae	C	Anquu	1093
46	*Echinops ellenbeckii* O.Hoffm.	Asteraceae	Sh	Sokoruu	1029
47	*Echinops giganteus* A.Rich.	Asteraceae	H	Koshoshila	874
48	*Epilobium hirsutum* L.	Onagraceae	Sh		1030
49	*Erica arborea* L.	Ericaceae	Sh	Shaatoo	1037
50	*Erythrina brucei* Schweinf.	Fabaceae	T	Waleena	1031
51	*Ficus carica* L.	Moraceae	T	Etsebeles	1081
52	*Ficus sur* Forssk.	Moraceae	T	Harbuu	525
53	*Galiniera saxifraga* (Hochest.) Bridson	Rubiaceae	T		418
54	*Galinsoga parviflora* Cav.	Asteraceae	H	Aramamo	524
55	*Galium aparinoides* Forssk.	Rubiaceae	H	Maxxannee	502
56	*Hagenia abyssinica* (Brace) J.F. Gmel	Rosaceae	T	Heexoo	448
57	*Halleria lucida* L.	Scrophularaceae	T		378
58	*Haplocarpha schimperi* (Sch.Bip.) Beauv.	Asteraceae	H	Getin	357
59	*Helichrysum foetidum* (L.) Moench.	Asteraceae	H	Adeelaa	130
60	*Helichrysum schimperi* (Sch.Bip.ex A.Rich.) Moeser	Asteraceae		Baalchii	132

S.No.	Botonical Name	Family	Habit	Local Name	V.No
61	*Helinus mystacinus* (Ait.) E. Mey.ex Steud.	Rhamnaceae	C	Hidda xarii	1012
62	*Hypericum revolutum* Vahl	Hypericaceae	Sh	Garambaa	359
63	*Hypoestes forskaolii* (Vahl) R.Br.	Acanthaceae	H	Dhiga dhabduu	14
64	*Indigofera roseo-coerlea* Bak.f.	Fabaceae	H		456
65	*Inula confertiflora* A.Rich.	Asteraceae	Sh	Wionagift	102
66	*Isoglossa punctata* (Vahl) Brummitt & Wood	Acanthaceae	H		283
67	*Juniperus procera* Hochst.ex Endle.	Cupressaceae	T	Hindheesa	02
68	*Jusminum abyssinicum* Hochst. ex DC.	Oleaceae	C	Hidda Ichilbee	453
69	*Kalanchoe petitiana* A.Rich.	Crassulaceae	H	Bosoqqee	30
70	*Lagenaria abyssinica* (Hook.f.) C. Jeffrey	Cucurbitaceae	C	Buqqee sexana	1112
71	*Laportea alatipes* Hook.f.	Uriticaceae	H	Dobbii	503
72	*Leonotis oecymifolia* (Burm.f.) Iwarsson	Lamiaceae	Sh	Bokoluu	1026
73	*Lepidotrichilia Volkensii* (Giürke) Leroy	Melliaceae	T	Ashu	25
74	*Lobelia giberroa* Hemsl.	Lobeliaceae	Sh	Seedaree	864
75	*Maesa lanceolata* Forssk.	Myrsinaceae	T	Abbayyii	04
76	*Malva verticillata* L.	Malvaceae	H	Liittii	947
77	*Maytenus arbutifolia* (A.Rich)Wilezek	Celestraceae	T	Kombolcha	20
78	*Maytenus obscura* (A.Rich.)Cuf.	Celestraceae	T	Kombolcha	0008
79	*Maytenus undata* (Thunb.) Blackelock	Celestraceae	T	Kokolfaa	18
80	*Mentha spicata* L.	Lamiaceae	H	Nana	1028
81	*Millettia ferruginea* (Hochst.) Bak. subsp.*drassana* (Cuf.) Gillett	Fabaceae	T	Birbiiraa	1024
82	*Myrsine Africana* L.	Myrsinaceae	Sh	qechemaa	39
83	*Neckera remota* Bruch & Schimp.ex Möll. Hal.	Neckeraceae	E		727
84	*Nuxia congesta* R.Br. ex Fresen.	Loganiaceae	T	Qaweessa	152
85	*Ocimum hamiifolium* Hochst. ex Benth.	Lamiaceae	sh	Demakessie	1091

S.No.	Botonical Name	Family	Habit	Local Name	V.No
86	*Olea europaea* subsp.*cuspidata* (Wall.ex G.Don) C.f.	Oleaceae	T	Ejerrsa	03
87	*Olea hochstetteri* Bak.	Oleaceae	T	Ejersa dhalaa	12
88	*Olinia rochetiana* A.Juss.	Oliniaceae	T	Qayya beeraa	55
89	*Osyris quadripartita* Decn.	Santalaceae	Sh	Waatoo	79
90	*Pavetta abyssinica* Fresen.var abyssinica	Rubiaceae	T	Mukaa dalechaa	41
91	*Peperomia abyssinica* Miq.	Piperaceae	E	Teketsila	45
92	*Periploca linearifolia* Quart.Dill. & A.Rich.	Asclepiadaceae	C	Hidda dimaa	462
93	*Phagnalon abyssinicum* Sch. Bip.ex A.Rich.	Asteraceae	H		520
94	*Physalis peruviana* L.	Solanaceae	H	Shamara'ee	476
95	*Phytolacca dodecandra* L.'Hėrit.	Phytolaccaceae	C	Andooddee	488
96	*Pittosporum viridiflorum* Sims	Pittosporaceae	T/sh	Soolee	1148
97	*Plantago lanceolata* L.	Plantaginaceae	H	Qorxobii	1192
98	*Plectranthus assurgens* (Baker) J.K.morton	Lamiaceae	H	Balagowaa	13
99	*Plectranthus punctatus* L. 'Hėrit subsp. *punctata*	Lamiaceae	H		24
100	*Podocarpus falcatus* (Thunb.) R.B.ex Mirb.	Podocarpaceae	T	Birbirsa	01
101	*Premna schimperi* Engl.	Verbanaceae	T	Urgeessaa	1025
102	*Prunus africana* (Hook.f.) Kalkm.	Rosaceae	T	Hoomii	126
103	*Psydrax schimperiana* (A.Rich.)	Rubiaceae	T	Sagad	1022
104	*Pteris cretica* L.	Pteridaceae	H	Anujjira gabadhuu	151
105	*Rhus glutinosa A.rich.*	Anacardiaceae	T	xaxessa	1104
106	*Ricinus communis* L.	Euphorbiaceae	Sh	Qobboo	185
107	*Rosa abyssinica* Lindely	Rosaceae	Sh	Goraa	361
108	*Rubus steudneri* Schweing.	Rosaceae	Sh	Enjorii	247
109	*Rumex abyssinicus* Jacq.	Polygonaceae	H	Embuacho	377
110	*Rumex nepalensis* Spreng.	Polygoneace	H	Shaabbee	352
111	*Rumex nervosus* Vahl	Polygonaceae	H	Dhangaggoo	05
112	*Rytigynia neglecta* (Hiern) Robyns	Rubiaceae	Sh	Mete-guree	269

S.No.	Botonical Name	Family	Habit	Local Name	V.No
113	*Salvia nilotica* Jacq.	Lamiaceae	H	Hulegeb	606
114	*Satureja paradoxa* (Vatke) Engl.	Lamiaceae	H		133
115	*Satureja punctata* (Benth.) Briq. subsp. *satureja*	Laminaceae	H		375
116	*Schefflera abyssinica* (Hochst. ex A.Rich.) Radlk.	Araliaceae	T	Gatamee	198
117	*Secamone parvifolia* (Oliv.) Bullock	Asclepiadaceae	C	Hidda guraacha	27
118	*Senecio layeratus* Forssk.	Astreaceae	H		285
119	*Senna septemtrionalis* (Viv.) Irwin & Barneby	Fabaceae	Sh	Qorchabofaa	44
120	*Smilax aceps* Will.	Smilaceae	C	Hidda galee	131
121	*Solancecio angulatus* (vahl)C.Jefferey	Asteraceae	H		1070
122	*Solanecio gigas* (Vatke) C.Jefferey	Asteraceae	Sh	Shokoko gomen	16
123	*Solanum anguivi* Lam.	Solanaceae	H	Hiddi saree	1100
124	*Solanum marginatum* L.f.	Solanaceae	Sh	Hiddii	1042
125	*Sonchus asper* L.	Asteraceae	H	Qoree haree	195
126	*Stephania abyssinica* (Dillon & A.Rich.) Walp.	Menispermaceae	C	Hidda kalaala	1032
127	*Tagetes minuta* L.	Asteaceae	Sh	Gime	26
128	*Teclea nobilis* Del.	Rutaceae	T/sh	Hadheessaa	1059
129	*Thynmus shimperi* Ronniger subsp. *schimperi*	Lamiaceae	H	Xosignii	182
130	*Toddalia asiatica* (L.) Lam.	Rutaceae	C	Harangamaa	43
131	*Urera hypselodendron* (A.Rich.) Wedd.	Urticaceae	C	Jonfok Hereg	1062
132	*Uritaca simensis* Steud.	Urticaceae	H	Dobii	832
133	*Usnea africana*	Usnaceae	E	Arii-Mukaa	946
134	*Verbascum sinaiticum* Benth.	Scrophulariaceae	Sh	Kutiinaa	519
135	*Vernonia amygdalina* Del.	Asteraceae	T/sh	Ebicha	179
136	*Vernonia auriculifera* Hiern	Asteraceae	T	Reejjii	529

S.No.	Botonical Name	Family	Habit	Local Name	V.No
137	*Vernonia hochstetteri* Sch.Bip. ex Walp.	Asteraceae	Sh		250
138	*Vernonia urticifolia A.Rich.*	Asteraceae	Sh		251
139	*Vernonia leopoldi* (Sch.Bip.ex Walp.) Vatke	Asteraceae	Sh		1000
140	*Vigna vexillata* (L) A.Rich	Fabaceae	C	Hidda qamalee	800

Appendix 3: Plant Families with their genera and species distribution in the study area

No	Family	Genera	%	Species	%
1	Acanthaceae	3	2.5	3	2.1
2	Amaranthaceae	1	0.8	1	0.7
3	Anacardiaceae	1	0.8	1	0.7
4	Apocynaceae	1	0.8	1	0.7
5	Araceae	1	0.8	1	0.7
6	Araliaceae	1	0.8	1	0.7
7	Asclepiadaceae	4	3	4	2.8
8	Asparagaceae	1	0.8	1	0.7
9	Asteraceae	14	11.8	21	15
10	Boraginaceae	2	1.6	3	2.1
11	Brassicaceae	2	1.6	2	1.4
12	Celestraceae	1	0.8	3	2.1
13	Crassulaceae	1	0.8	1	0.7
14	Cucurbitaceae	1	0.8	1	0.7
15	Cupressaceae	1	0.8	1	0.7
16	Cyperaceae	1	0.8	1	0.7
17	Draceae	1	0.8	1	0.7
18	Ephorbiaceae	2	1.6	2	1.4
19	Ericaceae	1	0.8	1	0.7

No	Family	Genera	%	Species	%
20	Fabaceae	9	7.6	9	6.4
21	Flacourtaceae	1	0.8	1	0.7
22	Hypericaceae	1	0.8	1	0.7
23	Icacinaceae	1	0.8	1	0.7
24	Lamiaceae	8	6.6	10	7.1
25	Lobeliaceae	1	0.8	1	0.7
26	Loganiaceae	2	1.6	2	1.4
27	Malvaceae	1	0.8	1	0.7
28	Meliaceae	1	0.8	1	0.7
29	Meliantaceae	1	0.8	1	0.7
30	Menspermaceae	1	0.8	1	0.7
31	Moraceae	1	0.8	23	1.4
32	Myrsinaceae	3	2.5	3	2.1
33	Neckeraceae	1	0.8	1	0.7
34	Oleaceae	3	2.5	3	2.1
35	Olineaceae	1	0.8	1	0.7
36	Onagraceae	1	0.8	1	0.7
37	Orchidaceae	1	0.8	2	1.4
38	Phytolaceae	1	0.8	1	0.7
39	Piperaceae	1	0.8	1	0.7
40	Pittosporaceae	1	0.8	1	0.7
41	Plantaginaceae	1	0.8	1	0.7
42	Poaceae	1	0.8	1	0.7
43	Podocarpaceae	1	0.8	1	0.7
44	Polygonaceae	1	0.8	3	2.1
45	Pteridaceae	1	0.8	1	1.7
46	Ranuncluaceae	1	0.8	2	1.4
47	Rhaminaceae	1	0.8	1	0.7

No	Family	Genera	%	Species	%
48	Rhizxophoraceae	1	0.8	1	0.7
49	Rosaceae	6	5.0	6	4.2
50	Rubiaceae	6	5.0	6	4.2
51	Rutaceae	2	1.6	2	1.4
52	Santalaceae	1	0.8	1	0.7
53	Sapindaceae	2	1.6	2	1.4
54	Scrophularaceae	2	1.6	2	1.4
55	Simaroubiaceae	1	0.8	1	0.7
56	Smilaceae	1	0.8	1	0.7
57	Solanaceae	5	4.0	5	4.0
58	Sterculiaceae	1	0.8	1	0.7
59	Ulmaceae	1	0.8	1	0.7
60	Ureticaceae	3	2.5	3	2.1
61	Usnaceae	1	0.8	1	0.7
62	Verbenaceae	1	0.8	1	0.7
63	Vitaceae	1	0.8	1	0.7

Appendix 4: Indicator values (% of perfection) of each species for each group and Monte Carlo test (Prbability values) of significace observed for each species. Bold values under each group are indicators.

Botanical name	**Communities**				
Community I	**1**	**2**	**3**	**4**	**P* value**
Croton macrostachyus	**59**	0	3	0	0.0002
Lepidotrichilia volkensii	**40**	1	7	1	0.001
Masesa lanceolata	**37**	3	23	1	0.009
Dovyalis abyssinica	11	3	36	13	0.009
Stephania abyssinica	**25**	1	1	0	0.0132
Inula cofertiflora	**31**	3	7	0	0.0166
Rytigynia neglecta	31	35	15	6	0.0232
Bersama abyssinica	**30**	3	13	1	0.0332

Olea europaea subsp.cuspidata	10	2	1	26	0.035
Plectranthus assurgens	**26**	0	4	11	0.038
Casspourea malosana	1	25	8	0	0.0408
Achyrospermum schimperi	29	5	20	1	0.0626
Cynoglossum amplifolium	1	0	18	6	0.0914
Rosa abyssinica	14	0	0	0	0.0948
Teclea nobilis	27	30	12	4	0.0952
Conyza hypoleuca	1	0	3	16	0.1118
Olea hochstetteri	6	13	0	0	0.1204
Pavetta abyssinica	4	2	2	18	0.1332
Kalanchoe pettitiana	1	5	6	19	0.1916
Podocarpus falcatus	25	27	24	23	0.196
Solunum anguivi	24	10	11	9	0.1962
Vernonia auriculifera	14	4	6	0	0.2737
Discopodium peninnervum	18	2	19	3	0.3661
Maytenus obscura	12	27	18	25	0.3767
Solunam angulatus	8	0	1	3	0.4241
Dregea abyssinica	9	4	13	0	0.4353
Canthium oligocarpum	5	0	9	1	0.4665
Brucea antidysenterica	14	1	10	4	0.4679
Toddalia asitica	7	0	0	0	0.5453
Lobelia giberroa	7	0	0	0	0.5489
Galium aparinoids	7	0	0	0	0.5545
Laportia alatipes	7	0	0	0	0.5545
Physalis peruviana	7	0	0	0	0.5559
Plectranthus punctatus	7	0	0	0	0.5577
Acacia abyssinica	7	0	0	0	0.5577
Allophyllus abyssinicus	7	0	0	0	0.5655
Vernonia uricifolia	7	0	0	0	0.5673
Jusminum abyssinicum	7	0	0	0	0.5673
Ceropegia cufodontis	7	0	0	0	0.5673
Indigofera rseo-coerlea	7	0	0	0	0.5673
Hagenia abyssinica	7	0	0	0	0.5673
Secamone parvifolia	7	0	0	0	0.5691
Pteris cretica	8	6	12	3	0.6515
Olinia rochetina	1	0	6	3	0.6603
Haplocarpha schimperi	2	5	0	0	0.6787
Vernonia amygdalina	3	5	1	0	0.7125
Asparagus africanus	6	0	4	6	0.8456
Hypoestes forskaolii	24	26	25	23	0.9008
Rubus steudneri	1	3	3	0	0.908

Perpiloca linearifolia	5	0	1	0	0.9126
Prunus africana	5	0	1	0	0.9156
Achyranthus aspera	5	0	1	1	0.9206
Achyrospermum schimperi	4	4	2	0	1
Community II					
Matenus undata	0	43	0	52	0.0002
Lepidotrichilia volkensii	40	1	7	1	0.001
Buddleja davidii	0	5	1	31	0.0044
Peperomia abyssinica	0	**29**	0	9	0.0052
Calpurnia aurea	0	**36**	5	3	0.0052
Masesa lanceolata	37	3	23	1	0.009
Dovyalis abyssinica	11	3	36	13	0.009
Stephania abyssinica	25	1	1	0	0.0132
Inula cofertiflora	31	3	7	0	0.0166
Halleria lucida	0	**21**	0	0	0.018
Rytigynia neglecta	31	**35**	15	6	0.0232
Bersama abyssinica	30	3	13	1	0.0332
Olea europaea subsp.cuspidata	10	2	1	26	0.035
Casspourea malosana	1	**25**	8	0	0.0408
Achyrospermum schimperi	29	5	20	1	0.0626
Teclea nobilis	27	30	12	4	0.0952
Olea hochstetteri	6	13	0	0	0.1204
Pavetta abyssinica	4	2	2	18	0.1332
Kalanchoe pettitiana	1	5	6	19	0.1916
Podocarpus falcatus	25	27	24	23	0.196
Solunum anguivi	24	10	11	9	0.1962
Psydrax schiperiana	0	1	0	8	0.2302
Vernonia auriculifera	14	4	6	0	0.2737
Smilaxanceps	0	10	2	0	0.2789
Discopodium peninnervum	18	2	19	3	0.3661
Maytenus obscura	12	27	18	25	0.3767
Dregea abyssinica	9	4	13	0	0.4353
Brucea antidysenterica	14	1	10	4	0.4679
Urera hypselodendron	0	8	5	0	0.4859
Digitaria abyssinica	0	7	0	0	0.5459
Diphananthe schimperina	0	7	0	0	0.5459
Myrsine africana	0	12	6	12	0.5495
Apodytes dimdita	0	7	0	0	0.5529
Rumex nepalensis	0	7	0	0	0.5529
Scheffleria abyssinica	0	7	0	0	0.5529
Crotalaria quatiniana	0	7	0	0	0.5529

Hypericum revolutum	0	7	0	0	0.5529
Carissa edulis	0	7	0	0	0.5577
Celtis africana	0	7	0	0	0.5603
Pteris cretica	8	6	12	3	0.6515
Haplocarpha schimperi	2	5	0	0	0.6787
Vernonia amygdalina	3	5	1	0	0.7125
Hypoestes forskaolii	24	26	25	23	0.9008
Rubus steudneri	1	3	3	0	0.908
Achyrospermum schimperi	4	4	2	0	1
Community III					
Juniperus procera	0	0	41	47	0.0002
Croton macrostachyus	59	0	3	0	0.0002
Lepidotrichilia volkensii	40	1	7	1	0.001
Buddleja davidii	0	5	1	31	0.0044
Calpurnia aurea	0	36	5	3	0.0052
Masesa lanceolata	37	3	23	1	0.009
Dovyalis abyssinica	11	3	**36**	13	0.009
Stephania abyssinica	25	1	1	0	0.0132
Inula cofertiflora	31	3	7	0	0.0166
Rytigynia neglecta	31	35	15	6	0.0232
Bersama abyssinica	30	3	13	1	0.0332
Olea europaea subsp.cuspidata	10	2	1	26	0.035
Plectranthus assurgens	26	0	4	11	0.038
Casspourea malosana	1	25	8	0	0.0408
Achyrospermum schimperi	29	5	20	1	0.0626
Cynoglossum amplifolium	1	0	18	6	0.0914
Teclea nobilis	27	30	12	4	0.0952
Conyza hypoleuca	1	0	3	16	0.1118
Pavetta abyssinica	4	2	2	18	0.1332
Kalanchoe pettitiana	1	5	6	19	0.1916
Podocarpus falcatus	25	27	24	23	0.196
Solunum anguivi	24	10	11	9	0.1962
Vernonia auriculifera	14	4	6	0	0.2737
Smilaxanceps	0	10	2	0	0.2789
Galinsoga parviflora	0	0	6	0	0.3579
Discopodium peninnervum	18	2	19	3	0.3661
Maytenus obscura	12	27	18	25	0.3767
Solunam angulatus	8	0	1	3	0.4241
Satureja punctat	0	0	6	0	0.4333
Dregea abyssinica	9	4	13	0	0.4353
Sonchus asper	0	0	6	0	0.4355

Canthium oligocarpum	5	0	9	1	0.4665
Brucea antidysenterica	14	1	10	4	0.4679
Urera hypselodendron	0	8	5	0	0.4859
Myrsine africana	0	12	6	12	0.5495
Pteris cretica	8	6	12	3	0.6515
Olinia rochetina	1	0	6	3	0.6603
Matenus arbutifolia	0	0	5	3	0.7025
Vernonia amygdalina	3	5	1	0	0.7125
Asparagus africanus	6	0	4	6	0.8456
Hypoestes forskaolii	24	26	25	23	0.9008
Rubus steudneri	1	3	3	0	0.908
Perpiloca linearifolia	5	0	1	0	0.9126
Prunus africana	5	0	1	0	0.9156
Achyranthus aspera	5	0	1	1	0.9206
Helichrysum foetidum	0	0	3	0	1
Helichrysum schimperi	0	0	3	0	1
Clematis semensis	0	0	3	0	1
Rhus glutinosa	0	0	3	0	1
Bothriocline schimperi	0	0	3	0	1
vernonia leopordi	0	0	3	0	1
Senna septemtronalis	0	0	3	0	1
Achyrospermum schimperi	4	4	2	0	1
Phytolacca dodecandira	0	0	3	0	1
Dombeya torrida	0	0	3	0	1
Echinops gigateus	0	0	3	0	1
Verbascum sinaiticum	0	0	3	0	1
vernonia hochstetteri	0	0	3	0	1
Bidens prestinaria	0	0	3	0	1
Ficus sur	0	0	3	0	1
Satureja paradoxa	0	0	3	0	1
Helinus mystacinus	0	0	3	0	1
Cyphostema adenocaule	0	0	3	0	1
Vigna vexillata	0	0	3	0	1
Community IV					
Juniperus procera	0	0	41	**47**	0.0002
Matenus undata	0	43	0	**52**	0.0002
Lepidotrichilia volkensii	40	1	7	1	0.001
Osyris quadripartita	0	0	0	**27**	0.0022
Buddleja davidii	0	5	1	**31**	0.0044
Peperomia abyssinica	0	29	0	9	0.0052
Calpurnia aurea	0	36	5	3	0.0052

Masesa lanceolata	37	3	23	1	0.009
Dovyalis abyssinica	11	3	36	13	0.009
Rytigynia neglecta	31	35	15	6	0.0232
Bersama abyssinica	30	3	13	1	0.0332
Olea europaea subsp.cuspidata	10	2	1	**26**	0.035
Plectranthus assurgens	26	0	4	11	0.038
Achyrospermum schimperi	29	5	20	1	0.0626
Cynoglossum amplifolium	1	0	18	6	0.0914
Teclea nobilis	27	30	12	4	0.0952
Conyza hypoleuca	1	0	3	16	0.1118
Pavetta abyssinica	4	2	2	18	0.1332
Diphananthe Candida	0	0	0	9	0.1466
Cardamine trichocarpa	0	0	0	9	0.1466
Senecio layeratus	0	0	0	9	0.1548
Colutea abyssinica	0	0	0	9	0.1548
Ddonea angustifolea	0	0	0	9	0.1548
Millettia ferruginea	0	0	0	9	0.1548
Premna schimperi	0	0	0	9	0.1548
Leonotis oecymifolia	0	0	0	9	0.1548
Cordia africana	0	0	0	9	0.1548
Mentha spicata	0	0	0	9	0.1548
Echinops ellenbeckii	0	0	0	9	0.1548
Epilobiumhirsutum	0	0	0	9	0.1548
Erythrina brucei	0	0	0	9	0.1548
Erica arborea	0	0	0	9	0.1548
Clematis longcauda	0	0	0	9	0.1554
Usnea africana	0	0	0	9	0.1614
Dracaene ellenbeckiana	0	0	0	8	0.1618
Rumex nervoses	0	0	0	9	0.1624
Neckera remota	0	0	0	9	0.1638
Cyperus fischerianus	0	0	0	9	0.1662
Kalanchoe pettitiana	1	5	6	19	0.1916
Podocarpus falcatus	25	27	24	23	0.196
Solunum anguivi	24	10	11	9	0.1962
Psydrax schiperiana	0	1	0	8	0.2302
Discopodium peninnervum	18	2	19	3	0.3661
Maytenus obscura	12	27	18	25	0.3767
Solunam angulatus	8	0	1	3	0.4241
Canthium oligocarpum	5	0	9	1	0.4665
Brucea antidysenterica	14	1	10	4	0.4679
Myrsine africana	0	12	6	12	0.5495

Pteris cretica	8	6	12	3	0.6515
Olinia rochetina	1	0	6	3	0.6603
Matenus arbutifolia	0	0	5	3	0.7025
Asparagus africanus	6	0	4	6	0.8456
Hypoestes forskaolii	24	26	25	23	0.9008
Achyranthus aspera	5	0	1	1	0.9206
Tagetes minuta	0	4	0	4	1

Appendix 5: IVI, rank, and consevation priority class of tree species

No	species	RD	RDO	RF	IVI	Rank	P.class
1	*Juniperus procera*	5.34	61.15	6.80	73.29	1	1
2	*Podocarpus falcatus*	14.09	31.08	10.36	55.53	2	1
3	*Maytenus obscura*	9.27	0.92	7.40	17.59	3	2
4	*Teclea nobilis*	6.60	0.18	6.95	13.73	4	3
5	*Dovyalias abyssinica*	3.93	0.15	6.36	10.44	5	3
6	*Maytenus undata*	4.58	1.34	4.14	10.06	6	3
7	*Bersama abyssinica*	2.49	0.12	6.66	9.27	7	4
8	*Maesa lanceolata*	3.68	0.19	5.18	9.05	8	4
9	*Lepidotrichia volkensii*	1.54	0.14	3.25	4.94	9	5
10	*Olea europaea* subsp.*cuspidata*	0.60	1.76	2.51	4.87	10	5
11	*Vernonia auriculifera*	2.59	0.01	1.78	4.38	11	5
12	*Cassipourea malosana*	0.86	0.61	2.81	4.27	12	5
13	*Croton Macrostachyus*	1.21	0.13	2.81	4.15	13	5
14	*Pavetta abyssinica*	0.29	0.16	1.92	2.37	14	5
15	*Maytenus arbutifolia*	0.86	0.02	0.74	1.62	15	5
16	*Olea hochstetteri*	0.12	0.54	0.74	1.40	16	5
17	*Olinia rochetiana*	0.12	0.11	0.74	0.96	17	6
18	*Erythrina brucei*	0.05	0.65	0.15	0.85	18	6
19	*Halleria lucida*	0.18	0.04	0.59	0.82	19	6
20	*Vernonia amygdalina*	0.21	0.01	0.44	0.66	20	6
21	*Psydrax schimperiana*	0.23	0.05	0.30	0.58	21	6
22	*Schefflera abssinica*	0.14	0.15	0.15	0.44	22	6
23	*Hagenia abyssinica*	0.01	0.06	0.30	0.37	23	6
24	*Prunus africana*	0.05	0.01	0.30	0.36	24	6
25	*Allophyllus abyssinicus*	0.01	0.10	0.15	0.26	25	6

26	*Premna schimperi*	0.10	0.00	0.15	0.25	26	6
27	*Cordia africana*	0.04	0.02	0.15	0.21	27	6
28	*Dracaena afromontata*	0.05	0.00	0.15	0.20	28	6
29	*Dombeya torrida*	0.01	0.03	0.15	0.19	29	6
30	*Galiniera saxifraga*	0.03	0.01	0.15	0.19	30	6
31	*Milletti ferruginea*	0.01	0.02	0.15	0.18	31	6
32	*Ficus sur*	0.01	0.01	0.15	0.17	32	6
33	*Acacia abyssinica*	0.01	0.01	0.15	0.17	33	6
34	*Celtis africana*	0.01	0.00	0.15	0.16	34	6

Appendix 6: List of endemic species with their IUCN categries from the study area

Botanical name	**Family**	**Habit**	**IUCN Category**
Acanthus sennii Chiov.	Acanthaceae	Shrub	NT
Diaphananthe candida Cribb.	Orchidaceae	Epiphyte	VU
Echinops Ellenbeckii O.Hoffm.	Asteraceae	Shrub	EN
Erthrina brucei Schweinf.	Fabaceae	Trees	LC
Inula Confortiflora A.Rich.	Asteraceae	Shrub	NT
Kalanchoe petitiana A. Rich.	Crassulaceae	Herb	LC
Millettia ferruginea (Hochest.) Bak.	Fabacee	Tree	LC
Rhus glutinosa A. Rich.	Anacardiaceae	Shrub	VU
Satureja Paradoxa (Vatke) Engl.	Lamiaceae	Herb	NT
Solanecio gigas (Vatke) (Jefferey)	Asteraceae	Shrub	LC
Solanum marginatum L.f.	Solanaceae	Shrub	LC
Thymus schimperi Lonniger subsp. schimperi	Lamiaceae	Herb	LC
Urtica seminsis Steud.	Urticaceae	Herb	LC
Vernonia leopoldi (Sch. Bip. ex Walp.)	Asteraceae	Shrub	LC