PLANT SPECIES COMPOSITION, DIVERSITY AND SOCIO-ECONOMIC BENEFITS OF HOMEGARDEN AGROFORESTRY SYSTEM IN LEMO DISTRICT, HADDIYA ZONE OF SNNPRS, ETHIOPIA

MSc. THESIS

By

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JIMMA, ETHIOPIA

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In Partial Fulfillment of the Requirements for the Degree of Master of Science in Natural Resource Management (Forest and Nature Conservation)

By

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DEDICATION

This thesis is dedicated to my late sister Kebenesh Lemaiyke and my family for committed care for achievement in my life.

STATEMENT OF THE AUTHOR

I declare that this thesis, submitted in partial fulfillment of the requirements for M.Sc. degree in Forest and Nature Conservation at Jimma University, is my own original work and has not been submitted to any institution anywhere for the award of any academic degree or diploma. This thesis can be deposited in the university library to be made available to readers under the rules of the university library. All sources of materials used for this thesis had been duly acknowledged.

Name_____

Signature_____

Place _____

Date of submission_____

BIOGRAPHICAL SKETCH

Mintamir Lemaiyke was born in 1990 in Hosanna Town, Haddiya Zone, SNNPRS, Ethiopia. She attended her grade school at Hail Bubamo, Junior Secondary School at Yikatit 25/67 High School and Preparatory School at Wochamo Comprehensive High School. She attended her undergraduate program at Hawassa University, Wondo Genet College of Forestry and Natural Resources and received BSc in NRM (in the stream of Farm Forestry) in July 2010. Right after her graduation, she worked for Anna Lemo district, Hadiya Zone, SNNPRS as forestry expert. She joined Jimma University College of Agriculture and Veterinary Medicine to pursue her M.Sc. in Natural Resource Management specialization Forest and Nature Conservation.

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LIST OF ABBREVIATIONS AND ACRONYMS

CSA	Central Statistics Agency
DBH	Diameter at Breast Height
ETB	Ethiopian Birr
HG	Homegarden
IVI	Important Value Index
KI	Key Informant
LWARDO	Lemo District Agriculture and Rural Development Office
NRM	Natural Resource Management
SNNPRS	South Nations Nationalities and Peoples Regional State

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ABSTRACT

Homegarden agroforestry is believed to be more diverse both in nature and socioeconomic benefits. The landholding size decreases as population density increases. The demand for wide range of goods and services of households are provided through planting a dozen of plant species in homegarden agroforestry. The objective of the study was to investigate plant Species composition, diversity and socioeconomic benefits of homegarden agroforestry in Lemo District, SNNPRS, Ethiopia. Multistage sampling techniques were employed to conduct the study. A total of 135 homegardens (83 from mid altitude and 52 from highland) were randomly selected for the study. Complete inventory of homegardens was conducted to assess every plant species in the homegarden. Socioeconomic data were collected through household interview. A total of 80 plant species representing 45 families were recorded in the homegarden in the study area. In comparison more plant species and richness were recorded in homegarden found in mid altitude. Seventy seven plant species were recorded in homegardens found in mid altitude compared to 57 plant species in the homegarden found in the highland. The difference was statistically significant (P=0.026). However, the growth habits of plants species (trees and herbs) found in homegardens were not statistically significant difference (p>0.05) except shrubs. The socioeconomic benefit results show that13 major plants use categories were identified in both altitudes. The mean annual income from the homegarden was 3,103.60Birr in mid altitude and 1,974.67 Birr in the highland. The difference was statistically significant (p<0.05). Homegarden agroforestry is one form of land use practice in the study area. Although the nature of homegardens in mid altitude and highland is more or less similar, there is a difference in terms of the socioeconomic benefits of the homegarden. Attention should be given to the existing homegarden agroforestry practices to promote homegarden agroforestry to enhance biodiversity conservation and improve its socioeconomic benefits.

Key Words: Homegarden, species diversity, socioeconomic benefits, highland, mid altitude, species richness.

INTRODUCTION

1.1 Background Information

Homegarden refers to a definite boundary surrounding a homestead (Kehlenbeck, 2007). In the homegarden, a diverse mixture of perennial and annual plant species are arranged either in a vertical or horizontal arrangement mainly for subsistence production. As a system homegarden is one of the most complex and diverse systems found across the regions (Abdoellah *et al*., 2006). Literatures have shown that homegardens especially in tropical regions are known for their structural complexity and species diversity. Due to positive ecological and socioeconomic features (Kumar and Nair, 2006) homegarden has received considerable attention as a sustainable land use system (Abebe, 2005; Méndez *et al.*, 2001). Currently, homegarden agroforestry has been promoted as on farm conservation strategies (Hammer *et al*., 2003). According to Kippie (2002) the system is stable even in a very dense population of up to 500 persons per square kilometer. The diversity of plants in the homegarden provides multiple benefits to the households (Olajide-Taiwo *et al*., 2010).

In Ethiopia, homegarden agroforestry system has been widely practiced and most of the systems are characterized by dominant native perennial crops like enset and coffee (Abebe, 2005). These crops are often grown in association with fruits and vegetables, roots, tubers, and pulses (Abebe *et al*., 2010). The composition and arrangement of plant species and the size of homegardens vary from place to place (Asfaw, 2002). Due to efficient nutrient cycling, soil moisture retention and soil structure maintenance homegarden agroforestry is among low input agricultural production systems. According to Abebe (2006) the importance of homegarden is two to three times higher than that of the cereal-based systems found in Ethiopia.

Homegarden is a source of food year-round (Eibl *et al*., 2000) which is important for household food security. Since there is diverse mixture of plant species in the homegarden, at least there is one harvestable crop throughout the year. These allow the owner of homegardens to rely on the homegardens to enhance household food security against the risk (Jose and Shanmugaratham, 1993). Homegarden plays a key role in improving the livelihoods

of the households. The benefit of home garden goes to the nutritional security especially for resource poor rural household (Olajide-Taiwo *et al*., 2010).

Several studies have been undertaken to study homegarden in Southern part of Ethiopia. For example, Asfaw and Woldu (1997) in Wolayta and Gurage zones, Wassihun *et al*. (2003) around Arbaminch homegarden, Abebe (2005) in Sidama zone, Seta *et al*. (2013)Wolayta zone and Melese and Daniel (2015) Gedeo zone. Plant species composition and diversity of homegardens in space and time vary depending on a combination of agroecological and socioeconomic condition. Moreover, the characteristics of the homegarden are influenced by the culture and the experience of community (Castiñeiras *et al*., 2002).

Homegarden agroforestry is common in Lemo district of Hadiya Zone, SNNPRS. The tradition is practiced for ages. The area is one of highly populated areas in Ethiopia. The population density of the area is about 426 persons/km^2 (LWARDO, 2009). Due to high population density, the landholding size decreases over a period of time. Nevertheless, demand for food increases gradually. Many non-government organizations have been engaged in integrated crop production and poverty reduction programs, mainly focusing on participatory poverty reduction and rural capacity building and safety net projects in the District. Lemo District Agriculture Rural Development Office is also working on poverty reduction through sustainable land management approach. One of the solutions to meet diverse needs of the people with fixed amount of land is promotion of homegarden agroforestry. However, this practice has not been studied in relation to plant species composition, diversity and socio economic benefits of homegarden agroforestry practices in the District. Scientific information about homegardens in the Districts is insufficient to promote homegarden agroforestry as land management approach. The present study is to identify the plant species diversity, composition and socioeconomic benefits of the homegardens of the study area. Therefore, the aim of this study way to provide information on plant species composition, diversity and socioeconomic benefit of the homegardens agroforestry. Also the result of the study is relieved the with information for the farmers better management of homegarden in a sustainable way, for development agents (use the

recommendations as a tool to improve their extension delivery) and researchers (provide baseline information for conducting further research).

1.2 Objectives of the Study

1.2.1 General Objective

- To investigate plant species composition, diversity and socioeconomic benefits of Homegarden Agroforestry in Lemo district, Haddiya zone, SNNPRS.

1.2.2 Specific Objectives

- To identify and compare plant species composition and diversity at mid altitude and highland; and
- To assess and compare socio-economic benefits of homegardens Agroforestry at mid altitude and highland.

1.2.3 Research Questions

- Is there difference between mid altitude and highland plant species composition and diversity of plant species?
- Is there difference between mid altitude and highland of socio-economic benefits of homegardens agroforestry?

2. LITERATURE REVIEW

2.1. Homegarden Agroforestry

Agroforestry refers to land use system in which trees or shrubs are grown in association with agricultural crops and /or pastures. There is ecological and economic interaction between the trees and other components of agroforestry (Alao and Shuaibu, 2013). Agroforestry can take different forms such as alley cropping, improved fallow, homegardens, contour vegetation strips, planting on terraces, living fences, shelterbelts (Nair, 1990). In homegarden, multipurpose trees and shrubs are deliberately managed in association with annual and perennial agricultural crops. Most of the time homegarden agroforestry is intended primarily for household consumption (Gautam *et al*., 2004).

There are two types of homegardens based on their contribution to the welfare of households. The first ones is the one that confined within the compound around the house. This type of homegarden is small-scale in size and it provides supplementary food production systems around houses (Marten and Abdoellah, 1988). Most of homegardens from Latin America belong to this category (Mendez *et al*., 2001).To some extent; this homegarden is also common in most parts of tropical regions. The second one is the one that extends to farm fields around the house. This type of homegarden forms the principal means of livelihood for farming households. Most of the homegardens in the highlands of Eastern Africa belong to this category (Rugalema *et al*., 1994).

Ethiopia is one of the tropical countries where homegarden agroforestry is the common practice (Abebe, 2005). In some area cereal-crop based farming systems, staple food crops such as tef (*Eragrostis tef* (Zucc.) Trotter), barley (*Hordeum vulgare* L.), wheat (*Triticum sativum* L.) and Sorghum (*Sorghum bicolor* L.) are grown in outer farm fields, while supplementary vegetables, fruits and spices are grown in homegardens. In another areas perennial-crop based farming systems, staple food crops (enset, coffee and maize) as well as other cash and food crops are grown in the homegardens (Asfaw, 2001; Abebe, 2005). For instance, Huang et al. (2002) identified three categories of functional groups in homegarden agroforestry systems, i.e. ecological, conservational and livelihood functional groups, but

classified groups differ on ecological and socioeconomic sustainability respectively. It is an integrated system which comprises different things in its small area that produces a variety of foods and agricultural products including staple crops, vegetables, fruits and medicinal plants (Polegri and Negri, 2010). The biophysical aspects of homegardens such as soil conservation effects and potential for carbon sequestrations are the main ecological benefits human beings provide from this practice in addition to their nutritional and economic benefits (Mohan, 2004).

2.2 Species Composition, Species Richness and Diversity

Homegardens often contain a high degree of biodiversity (Eyzaguirre and Linares, 2004) and different species or varieties that are found in the surrounding macro-system, it maintained over long periods to be conserved *in situ* (Rao and Hodgkin, 2002). Plant composition of homegardens area has floristic richness and plant species from diverse genera and families (Newton, 2007). Measures of species diversity play a center role in ecology and conservation biology (Magurran, 2004) since species diversity are an important parameter of a plant community, one of the major criteria for nature conservation and connected to ecosystem dynamics and environmental quality (Kalema, 2010). The high diversity of species in homegarden have a wide socioeconomic and agroecological roles (Unofia *et al.*, 2012).

In Ethiopia, different researches have been conducted on species composition and diversity in homegardens. For example, Abebe (2005) reported that 78 crop species with an average of 16 per homegardens were recorded from Sidama Zone, Southern Ethiopia. In Gedeo homegarden (Melese and Daniel, 2015) reported that 75 plant species in 48 families. In Wolayta homegardens a total of 159 plant species with 131 genera and 55 families were recorded (Seta *et al*., 2013). The result shows a total of 120 tree and shrub species were recorded in the agroforestry homegardens of Sidama, Southern Ethiopia (Abebe, 2013). In Jabithenan homegarden, North-Western Ethiopia, a total of 69 plant species belonging to 40 families and different function groups were recorded, with families Euphorbiaceae, Myrtaceae, Mimosoideae and Rutaceae the most dominated families (Mekonnen *et al*., 2014). A total of 135 plant species belonging to 110 genera and 58 families, were recorded from Sabata homegardens (Hailu and Asfaw, 2011). Additionally another report from the Holeta

homegarden also show that 112 plant species were belonging to 93 genera and 43 families were identified and documented (Mekonnen, 2011). Haileselasie and Hiwot (2012) reported that 40 plant species in homegarden in the Hintalo Wejerat of Tigray, Northern Ethiopia.

The functional point of view in Sidama homegarden a total of ten functional groups of crops were recognized, each represented by 3–15 species, the most species were fruits 23.5 percent of all species, followed by root and tubers 16.1 percent and vegetables 14.4 percent. Other function a groups included stimulant crops 10.0 percent, cereals 8.8 percent, pulses 8.1 percent, spices and condiments 4.5 percent, oil crops 3.2 percent, medicinal and fragrance crops 2.9 percent and the rest group 8.6 percent (Abebe et *al.,* 2010). Different plant species ranging from fruits, vegetables, spices, food and cash crops, plant species with ten different uses were identified in Gedeo homegarden (Melese and Daniel, 2016). *Enset ventricosum* plant species with the highest relative frequencies for being culturally popular as food source (Hailu and Asfaw, 2011). In Holeta homegarden of the recorded plant species, 25 percent were used as sources of food, 13 percent as medicine and 10 percent as household tools (Mekonen *et al.,* 2015).In Gedeo homegarden plant species, 40 percent were food crops, 17.3 percent were crops used for income, 13.3 percent were medicinal, 17.3 percent were plants used as live fence, 20 percent were used for building and fuel, 10.6 percent were used for home materials, 4 percent were used as spices, 5.3 percent were stimulants, 10.6 percent were used as ornamentals and 20 percent plant species were used for shading (Melese and Daniel, 2016).

With respect to the growth forms of plants, the herb, tree and shrub plant species account 44 percent, 32percent and 20percent respectively (Melese and Daniel, 2016). In Hararghe Eastern Ethiopia a large number of species utilized by the people used for medicinal purpose (49%) were from herbs, 36% from trees and 5% belong to the category of shrubs (kandari *et al.,* 2015). In Sebeta-Awas district of the Oromia Region of Ethiopia homegardens of the total plant species, 39.8 percent were herbs, 30.1% were trees, 23.0% shrubs and 7.1% climbers. The origin of the plant species are found 58% exotic and 48%are indigenous species (Mekonen *et al.,* 2015). Homegardens of Holeta town have different multipurpose trees, shrubs, herbs, and climbers habits. It includes 29.46 percent annual and 70.54 percent

perennial crops (Amberber, 2011). The average number of crop species per farm was 16 with values ranging from 7 to 26 (Abebe, 2005). Mean homegarden species richness were significantly less in highland area (Schadegan *et al.,* 2013).

2.3 Socioeconomic Benefit of Homegarden

Homegardens of the tropical countries were found to be food-producing subsistence farming systems. The high diversity and complexity in the structure of homegardens fulfill a range of social, economic and ecological functions. The technique of management and high diversity of homegardens reflect the wisdom of traditional culture and ecological knowledge that have evolved over the years (Das and Das, 2005). Homegardens have mostly been considered in their role as sustainable production systems contributing to food security, nutrition and income generation especially in developing countries (Bailey *et al.* ,2009). It contributes to household food security and nutrition by providing direct access to diverse foods that can be harvested, prepared and fed to family members, often on a daily basis (Adekunle, 2013). Community has most adapt and access land resources and important components to ensuring food security (Buchmann, 2009). Food security status 88.8% of the household found food from homegarden and the variety of annual and perennial crops and vegetables grown in these gardens provide fresh products throughout the year in southwester Ethiopia (Kebebew *et al., 2011*). It holds high potential to provide 3 to 44% calories and 4 to 32% protein intake (Kitalyi *et al*., 2013). Providing direct access to food and important nutrients from homegarden helping to prevent diseases and mortality (Mitchell and Hanstad, 2004). Diversified planting and harvesting time of food crops and fruits trees are the key elements for homegardens contributions to household food and nutrition security. Households in much of the tropics depend for their livelihoods on the variety and continued production of food and other products. In such systems, maintenance of agro biodiversity and ensuring food security are important for the well-being of the population.

Homegarden is helpful to cope up with the shortage and failures of staple field crops (Mekonen, 2011). Unlike the seasonal harvests of staple foods from outlying fields, homegarden harvests are continuous that facilitates harvest of the required product when needed for consumption. This reduces post-harvest losses that can be high 70% poor storage

facilities (Albrecht and Kandji, 2003). The production of homegarden sufficient for 10 months to feed their family. Some of the cultivated crops in the homegarden like Enset ventriconsu, cabbage and pulses were critical in July and August in filling shortage of food (Kebebew *et al*., 2011). The enset-coffee agroforestry homegardens of Southern Ethiopia that are dominated by two native perennial crops, Coffee (*Coffea arabica* L.) and Enset (*Enset ventricosum* Welw.Cheesman), are examples of such agricultural systems (Abebe, 2013). Both together cover more than 60% of the cropland. Enset (*Ensete ventricosum* (Welw.) Cheesman) is a multipurpose crop and a staple food for about 15 million people in the region (Tsegaye and Struik, 2001). Food sources ranging from minor grains and pulses, root and tuber crops and fruits and vegetables to non-timber forest products have the potential to make a substantial contribution to food and nutrition (Ebert, 2014). Moreover, homegarden provides a diverse and stable supply of socioeconomic products and benefits to the families that maintain them. Homegarden crops represent a source of food and basis for nutritional quality in rural households than other practices.

Homegardens can contribute to household income in several ways the sale of products produced on homegardens significantly improves the family's financial status (Hoogerbrugge and Fresco, 1993). According to Zebene (2003) reported that in Gedeo and Sidama, homegardens are aimed primarily at meeting household food needs and supplementary cash needs. The household may sell products produced in the homegarden, including fruits, vegetables and other valuable materials such as bamboo and wood for construction or fuel (Marsh, 1998). The homegarden production actually between 9% and 51% of production is sold (Hoogerbrugge and Fresco, 1993). In the studied sample, 42.1% of households sold homegarden produce at the local market (Vasey, 1985). Crops produced on homegardens in southeastern Nigeria accounted for over 60% of family cash income (Okigbo, 1990**).** In Bangladesh, 54 percent of households reported selling homegarden products (Talukder *et al.,* 2010). Pandey *et al.* (2006) who reported that compared with the rice fields of Java, the homegarden has a greater diversity of production and usually produces a higher net income; in West Java, fish production in homegarden ponds is common, with an income of 2 to 2.5 times that of rice fields in the same area. Homegardens were mainly dominated by fruit trees, which provide subsistence and cash to household (Kebabew and Urgessa, 2011). More

than45% of the household income contributed by homegardening in Batticaloa District (Krishnal *et al*., 2012).The most important income source are homegarden products, which mentioned by 70% of the sample. Income from homegarden product averaged 34.5% of total income for all the families (Méndez *et al*., 2001).Motiur *et al*. (2005) who reported that an average of 15.9% and 11.8% of the South-West and North-Eastern Bangladesh households' income derived from homegardens respectively

A total of 59.38% of homegarden owners obtained cash incomes from their homegarden in addition to subsistence uses in Holeta homegarden (Mekonnen, 2011). Out of this, 64.29% of the income was from vegetables, tuber and root plants. The average annual income derived from 769.18 Birr /year/homegarden and varies from 72.81 Birr to 1456.1Birr (Mekonnen, 2011). In generally the homegardens crop diversity are potentially to provide a wide range of resources, such as nutritious foods, marketable products, firewood, fodder, herbs, spices and medicinal plants (Mekonnen, 2015). Therefore, homegardens agroforestry significantly improved the household financial and food statuses of the communities (Bishaw and Abdelkadir, 2003). Twenty-five and seventeen percent of Mbeya rural community's income and food requirement per year contributed by homegardens respectively. However, agroforestry homegardens products sold varied highly from one household to another (Trinh *et al.,* 2003; Tynsong and Tiwari, 2010) homegardens contributed much to the community's livelihoods. Therefore, agroforestry homegardens remain the main occupation for income generation and food supply to rural communities as reported by Mendez *et al*. (2001); Maroyi *et al.,* 2009; Guuroh *et al*., 2011). Krishnal (2012) reported that homegardens reduced the cost of labor as most of activities in homegardens operated by family labor.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

The study was conducted in Lemo district, Haddiya Zone, SNNPRS, Ethiopia. The district is located about 230 km south of Addis Ababa and about 175km from Hawassa, the capital city of the Region. Geographically, it is located between $7^{o}22'$ and $7^{O}45'$ latitude and $37^{o}40'$ and $38^{o}00'$ longitude. Lemo district is bordered in the east by Ana Lemo, in the west by Misha; in the North by Misha and Silte zone and in the south by Anegacha district (LWARDO, 2009).

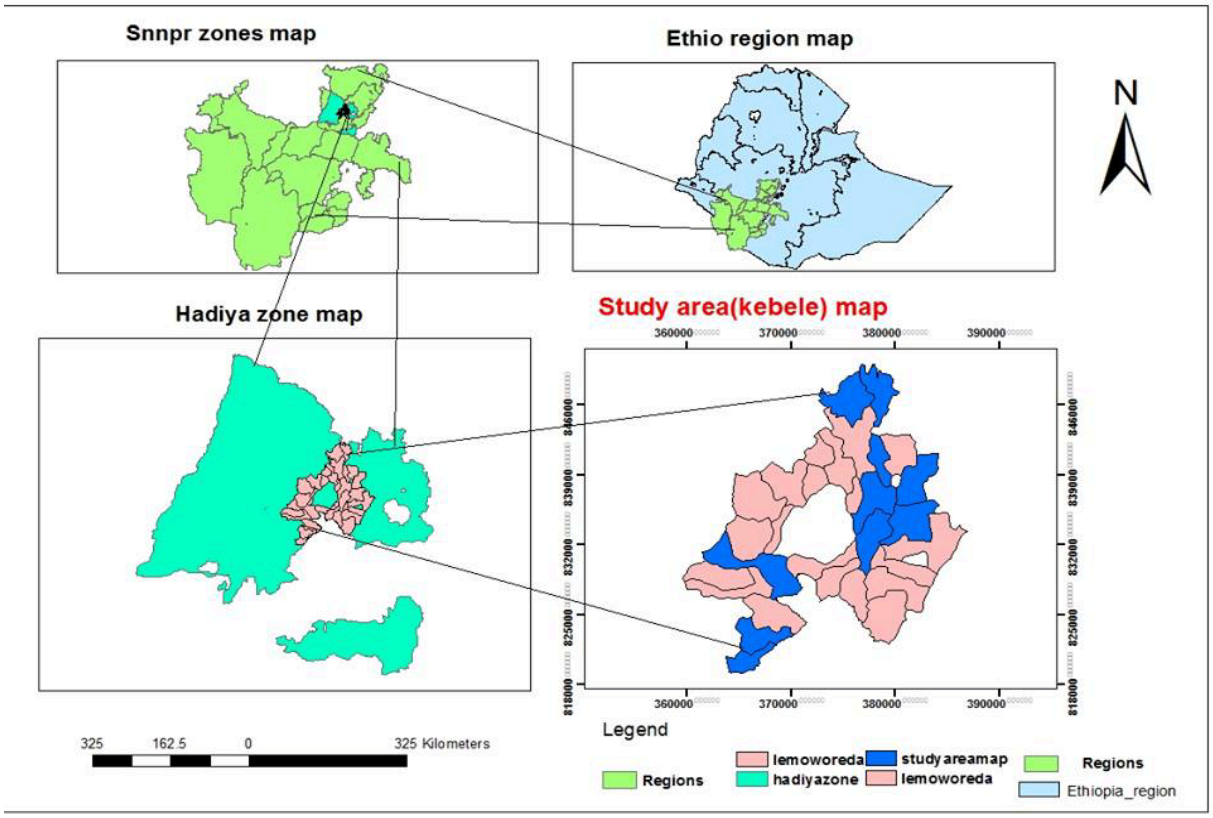

Figure 1. Map of Ethiopia showing Regions and the study area

The topography of the study area is characterized as 54.3% flat, 5.4% hilly and 40% undulating. The district's land mass lies between 1900 - 2700 meters above sea level (m.a.s.l) (LWARDO, 2009).

Agro ecologically, the district is categorized into mid altitude and highland. Mid altitude accounts on the largest portion of the district which is about 91%. The highland account for only 9% of the total area of the district. The mean annual minimum and maximum temperatures of the study area is $13C^{o}$ and $23C^{o}$ respectively. The mean annual rainfall varies between 900-1400 mm. The longest rainy season is start from June to end of September and the area receives short rain in January to April (Berihanu, 2010).

Lemo district has a total population of 134,966 of whom 66,791 are males and 68,175 are females (CSA, 2014). The population density of the area is about 426 persons/km^2 (LWARDO, 2009). The five largest ethnic groups are Hadiya (62.13%), Silte (30.3%), Amhara (3.05%), Kambaata (2.67%), and Sebat Bet Gurage (0.45%); all other ethnic groups made up 3.4% of the population. Hadiya is spoken as a first language by 57.81%, 31.35% Silte, and 6.63% spoke Amharic and 3.36% spoke Kambaata; the remaining 0.85% spoke all other primary languages reported. The religion of the population Muslim accounts for 58.52%, protestant account for 22.09% Ethiopian Orthodox Christianity accounts for 18.36% and the rest are Catholic (CSA, 2014).

Agriculture is the dominant economic activity in the district. The livelihood of the people in the district depends mainly on mixed agriculture (crop-livestock production). The main annual crops are wheat, teff, potatoes, barley, maize, beans, peas, sorghum, cabbage, carrots and onions. The main perennial and widely used for income-generated crops in the district are enset, coffee, chat, sugarcane, avocadoes, casmir and timber trees**.** Enset is the main perennial crop in Lemo district, a source of food all year round (LWARDO, 2009).

The total land area coverage of the district is 34973 ha. Currently, forestland of the district is 1,559 ha of the total land area such as natural forest (519) ha, community forest is (240) ha and private forest land is (800) ha. The common tree in the area include, *Croton macrostachyus, Ficus sur, Cordia africana, Hagenia abyssinica, Podocarpus falcatus, Millettia ferruginea, Prunus africana, Juniperus procera, Erythrina abyssinica, Eucalyptus* and *Gravillea robusta* which are grown as boundaries, live fences and woodlots (LWARDO, 2009).

3.2 Methods

3.2.1 Study site selection and sampling techniques

Lemo district was selected purposively due to the presence of high potential of traditional homegarden agroforestry practices. A multistage sampling technique was employed to select the homegarden for the study. First, the district was divided into mid altitude (1900-2300) and highland (2300-2700) (Bekele, 2007). The sample of the kebeles employed expected prevalence or proportion of the total kebele to be included in sample i.e. 10%. From the total 33 kebeles in the Lemo district, 10 kebele (5 each) were again randomly selected. Once the kebeles were identified, the sample size was determined using the formula as has been used by Daniel, (1999) and a total of 135 households were calculated and proportionally allocated to kebeles in the mid altitude and highland (Table 1). The households were selected based on simple random sampling technique.

$$n = \frac{Z^2 p(1-p)}{d^2} \rightarrow n' = \frac{NZ^2P(1-P)}{d^2(N-1) + Z^2P(1-P)}$$

Where:-

n = sample size,

n'= sample size with finite population correlation

N = Population size,

Z = Z statistic for a level of confidence for 95% at 1.96

P = expected prevalence or proportion of population to be included in sample i.e. 10%) and

d = degree of accuracy desired (0.05)

Table 1**:** Total households and sample size of the households

Name of Kebeles	Total HHs	Sample size	Altitude
Highland			
Shermo Dacho	630	13	1500-2700
Ana Belasa	485	10	2334-2536
2nd Omoshera	493	11	2300-2750
Dijo Demala	607	12	2500-2700
1nd Omoshera	245	6	2358-2571
Total		**52**	
Mid altitude			
Debub Belessa	431	9	2200-2300
Lisana Sena	797	17	2000-2200
Tachignaw Amecho	690	15	1900-2300
Ambicho Gode	1076	23	1900-2300
Jiwe	873	19	1900-2300
Total		**83**	
Grand Total	**6326**	**135**	**1900-2700**

3.2.2 Methods of data collection

3.2.2.1 Types and sources of data

Information was collected on plants species and socioeconomic benefits of the homegarden agroforestry. Both primary and secondary sources were used for the study. The primary data involve plant inventory, household survey and field visual observation and secondary data involve information obtained from literatures, district and kebeles offices.

3.2.2.2. Plant Inventory

A complete enumeration of 135 homegardens (83 from mid altitude and 52 from highland) were carried out. The homegarden was used as a plot as a result the area of the homegarden was recorded. Each plant species in the homegarden were identified and recorded. Moreover complete inventory of woody species were carried out in the homegarden. Diameter at Breast

height (1.3 m DBH) and number of individuals of woody species with DBH≥ 5 cm were also measured and counted. Local names of plant species and uses were also recorded by asking the owners' of the homegarden. Measuring tape was used for measuring the diameter. The collected specimens were dried and pressed for further identification and reconfirmation at Biology Department of Wochamo University. Scientific nomenclature of plant species was carried out using plant identification manuals like Useful trees and shrubs of Ethiopia (Bekele, 2007) and Flora of Ethiopia and Eritrea (Hedberg *et al*., 2004; Hedberg *et al*., 2006). Finally, the specimens were deposited in the Wochamo University of Biology Department for providing final checking by taxonomic experts and for documentation.

3.2.2.3 Socioeconomic data collection

Socioeconomic benefits of homegardens were collected from the owner of the homegarden selected for plant inventory through interview. Structured and semi-structured questionnaire were prepared to collect data. The questionnaire has two parts (Appendix 2). The first part is about background information of the respondents including wealth status, family size, total landholding, educational status, sex, homegarden size and age of homegarden. The second part has detail question about socioeconomic benefits of homegarden. Thus, information about purpose of homegarden or plant use category, multipurpose woody species uses in the homegarden, seasonal availability of plants in the homegarden, actual income of household from marketable homegarden product considering the price of the products at the time of assessment. The questions presented directly to each sample respondents by the interviewer and administered on a face-to-face interview bases. The sample households living in the kebele was categorized into three wealth classes rich, medium and poor according to the set of criteria (Table 2). Wealth ranking used for identified wealth status of the household influenced the plants species composition of homegardens. The purpose of wealth ranking in the study was to investigate how HHs in different social classes influenced the plants species of homegardens.

Table 2: Criteria for wealth ranking in Lemo District

	Social class		
Criteria of wealth category	**Rich**	**Medium**	**poor**
Land hold size	More than 2-2 ha	2 -1ha	<1 ha
Oxen	More than 2	2-1	1<
Enset and other perennial crop	More than 0.5ha	0.5-0.25ha	<0.25ha
Cow and other large ruminants	More than 5-5	4-3	2-1
Small ruminants goat and sheep	More than 6	5-3	2-1

Source: Lemo District Agriculture and Rural Development Office

3.2.3. Data analysis

3.2.3.1. Plant species analysis

Complete inventory of homegarden was conducted to assess every plant species in the homegardens, which used in the analysis of plant species area curve, frequency, relative frequency. Species richness is simply the number of plant species present in the homegarden.

Species area curve was drawn the total numbers of homegarden were checked by drawing the species area curve. The species accumulation curve is concerned with accumulation rates of new species over the sampled area and depends on species identity. The AccuCurve is a Microsoft Excel 2007 based program calculating various accumulation curves for a set of samples containing more species (Drozd and Novotny, 2010).

Frequency

Frequency was used for all plant species describing the distribution of a species through a homegardens. Absolute frequency, which is the number of homegarden in which the species recorded and relative frequency of a species, computed as the ratio of the absolute frequency of the species to the sum total of the frequency of all species. It is determined by using the following formula.

F = Number of homegardens in which a species occurs x 100

Total number of sampled homegardens

Relative Frequency

Relative frequent is the distribution of one species in a sample relative to the distribution of all species.

Relative frequency = Frequency of a species in the homegarden x 100

Total frequency of all species in the sampled homegardens

Frequency and relative frequency were calculated for all identified plants from 83 (mid altitude) and 52 (highland) representative homegardens.

3.2.3.2. Woody Species Analysis

Diameter at Breast Height (DBH)

Diameter at Breast Height (DBH) measurement is taken at about 1.3 m above the ground using measuring tape**.** The circumference is converted into diameter by solving for DBH in the question:

$C = \pi * DBH$

Where: C= Circumference of the tree,

$\pi = 3.14$

DBH= Diameter at Breast Height of tree.

Therefore, $DBH = C/\pi$..... (FFA Forestry, 2010).

Shannon-Weiner Index H'

Shannon-Wiener diversity index and Shannon's evenness were computed to describe species diversity of the woody in the homegardens. Shannon - Wiener diversity index is the most popular measure of woody species diversity (Kent and Coker, 1992). Shannon-Wiener diversity index was calculated as follows.

$$\mathbf{H'} = -\sum_{i=1}^{s} Pi \ln pi \text{.....1}$$

Where H' = Shannon-Wiener Diversity Index

s = number of species

Pi = the proportion of individuals or abundance of the ***ith*** species expressed as Proportion of the total abundance

ln = natural logarithm of *pi* Values of the Shannon diversity index (H') usually lies between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5 (Kent and Coker, 1992).

Evenness Index

Evenness index (E) was calculated as follows to estimate the homogeneous distribution of woody species in homegarden.

Where: H' = Shannon-Wiener Diversity Index;

H max=lnS $E=\frac{H^1}{H_{max}}=\frac{H^1}{ln_S}=\frac{\sum_{i-1}^{s} pilnpi}{lnS}$ with H max=ln S

E = Evenness;

Hmax = lnS;

S = total number of species in the sample.

Importance Value Index

The importance value index (IVI) is a composite index based on the relative measures of woody species frequency, abundance and dominance (Jose *et al.*, 1994) and signifies the relative importance of an individual tree species occurring in the homegardens. IVI was calculated using the formula:

Where RA is the relative abundance; RD is relative dominance and RF is relative frequency

Relative Abundance = $\frac{\text{Number of individual species} * 100}{\text{Total number of individuals}}$

Relative dominance is the total basal area of a species/total basal area of all species *100

Basal area it express in meter square per hectare. Basal area is used to calculate the dominance of species.

$BA=Л (D/2)^2= (DBH/2) *3.14$..... (Suratman, 2012)

Where: BA - Basal area (meter square)

D - Diameter at Breast Height (cm)

Л= 3.14

Relative Dominance = Dominance of a species * 100

Total dominance of all species

Relative Frequency = Frequency of a species *100

Frequency of all species

IVI = RA + RD + RF

3.2.3.3. Socioeconomic data analysis

Data were analyzed and summarized using percentages and descriptive statistics, independent t-test used for comparing income of households and species richness, person correlation used for analyzing correlation of landholding size, size of homegarden, age of homegarden, family size, wealth status with species richness and multiple response used for analyzing multipurpose woody species uses. The results were analyzed and synthesized using Statistical Package for Social Sciences (SPSS) Software Version 20 and Microsoft Office Excel 2007.

4. RESULTS AND DISCUSSION

4.1. Plants Species Composition and Diversity

4.1.1 Species area curves

In this study, the species area curves showed that the raise for the two altitude homegarden were flattened before the total number of samples considered were exhausted (Figure 2) showing that sufficient number of samples were considered to determine species diversity of each system. From the 45th and 28th sample homegarden, the species area curve starts to flatten at mid altitude and highland respectively. The leveling out of the species area curve is used to determine whether adequate samples were taken. The species area curve is a cumulative curve that relates the occurrence of species with the area sampled. When the curves grow up and flattened at the end, this indicates that the number of plots taken is sufficient (Gotelli and Colwell, 2001).

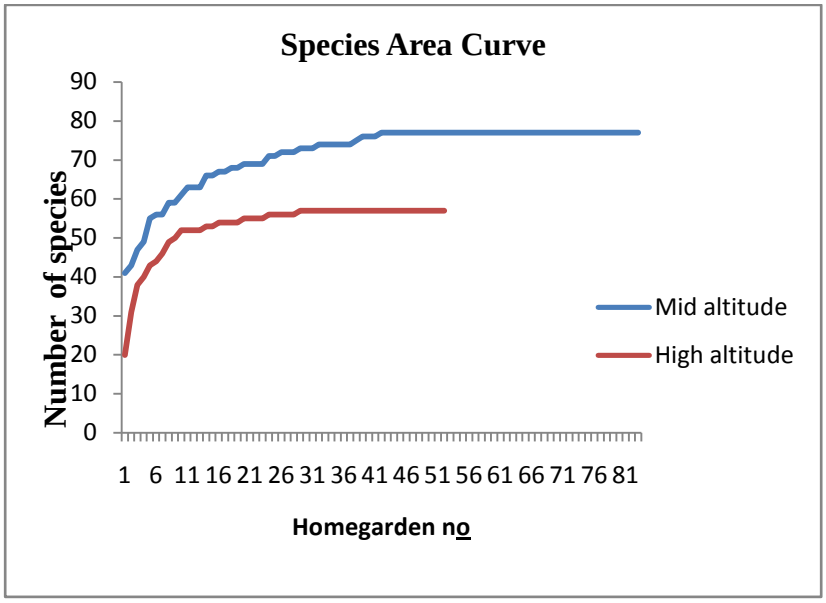

Figure 2.Cumulative species area curve of mid altitude and highland in Lemo district

4.1.2. Species composition

Plant species composition result showed that, more plant species were recorded under the mid altitude than Highland. Seventy seven plant species were recorded in homegardens found in mid altitude as compared to 57 plant species in the homegardens found in highland (Appendixes 4 & 5). The highest number of families recorded in a homegarden was 41 and 36 in the highland (Appendixes 4 & 5). The commonly represented families were Poaceae which contains (17.1%) and (13.9%) in mid altitude and highland respectively followed by Rosaceae 14.63% and 11.11%, Lamiaceae which contains 12.20% and 11.11% in mid altitude and highland respectively, followed by other families. This result is similar with Wondimu *et al*. (2007) who reported that the Poaceae is the largest family around 'Dheeraa' homegarden, Arsi, Ethiopia. Alfred (2013) reported that the Poaceae were dominating large portion of family found in the homegardens of Zimbabwe.

Growth habits of the plant species result showed that herbs were the highest growth habits with 61.7%, followed by trees with 32% whereas shrubs 6.3% were the lowest growth habits in mid altitude and herbs were the highest growth habit with57.3%, followed by trees with 29.4% whereas shrubs 13.3% were the lowest growth habit in the highland (Table 3). Growth habit of tree and herb showed no significant difference $p>0.05$ between mid altitude and highland. Shrub showed a significant difference $p<0.05$ between mid altitude and highland. The result of the study revealed that the two major plant growth habits (*i.e*., herbs and trees) accounted for the highest proportion of growth habits at both altitudes. Growth habit result showed that herbs > trees> shrubs in both altitudes. Because in the study area the farmer grow the majority of plant species food production are the herbaceous in all homegardens and tree were the main essential of homegardens products. This is in line with kandari *et al. (*2015) in Hararghe Eastern Ethiopia who reported 49 percent herbs, 36 percent trees and 5 percent shrubs. Mekonen *et al.* (2015) reported that from the total species, 39.8 % were herbs, 30.1% were trees, and 23.0% were shrubs as recorded in Sebeta-Awas district of the Oromia Region of Ethiopia.

Plant species composition of the homegarden consists of both native and exotic species. The result showed in mid altitude and highland homegardens 80 plant species were recorded

(Appendix 3). This result is supported by Abebe (2005, 2013) who reported that 78 crop species were recorded from Sidama homegardens, Southern Ethiopia. In Gedeo homegarden, Melese and Daniel (2015) reported 75 plant species in 48 families. Other results observed by Seta *et al*. (2012) reported 159 plant species in 55 families which were recorded in Wolayta homegardens, Southern Ethiopia.

Table 3:Habit growth of plant species of both altitudes

Habit growth	**(%)of Mid**	**(%)of Highland**	**P value**
Herb	61.7	57.3	0.921
Shrub	6.3	13.3	0.002
Tree	32	29.4	0.164

4.1.3. Species richness and diversity

The result showed that more species richness per homegarden was recorded under the mid altitude than the highland. Statically, the result showed that plant richness was significantly different (P value =0.026) between mid altitude and highland. The average species per homegarden was 20.4 and 17.7 in mid altitude and highland respectively (Table 4). Plant species richness varied across altitudinal variation. Abebe (2013) reported that altitude and slope of the farms affected heterogeneity of crop species. In the low altitude sites where temperatures are suitable, the number of crops increased because of their good adaptability to the climatic conditions. However, this was also associated with road access, because most of the low altitude sites also had better access to the roads that facilitate marketing. Soemarwoto and Conway (1991) also reported a decrease in plant species diversity of homegardens with increasing altitude. Hodel *et al*. (1999) reported that species richness decreased with increase elevation due to decreased mean temperature.

Table 4**:** Species composition and richness

Species Composition	**Highland**	**Mid altitude**	**p-value**
Total number of species	57	77	
Max no of species / HG	36	41	
Min no of species / HG	9	10	
Average of species /HG	17.7	20.4	0.026

4.1.4. Frequency of plant species

The result showed that *Ensete ventricosum* was the most frequently recorded species in both altitudes (Tables 5 & 6). There is because *Ensete ventricosum* is a multi benefit crop in the study area and culturally popularly used as food source such as kocho, bula, hamicho and also used for medicine, fiber, fodder and other uses. Wassihun (2003) reported that E. ventricosum has high frequency of occurrence as useful plants in daniio gade (home-gardens) in Southern Ethiopia, supporting the present finding. Abebe (2005) also reported that *Ensete ventricosum* has key position as a dominant species in Southern homegardens. Amberber *et al*. (2014) reported that *Ensete ventricosum* (93.75%) was the most frequent species in Holeta homegardens.

Enset has 100% frequency occurrence in highland than mid altitude (96.4%), and with increasing altitude of farms the frequency of enset increased. The frequency occurrence of each species across the study site is presented in Tables 5 & 6. Because highlanders grow more enset landraces, they use to feed different enset products or the products of enset-cereal mix as food. This result is similar with Maryo *et al*. (2014) who reported that the highest number of enset landraces were recorded at altitudes above 2500 m. a. s. l. and *Dega* agro climatic areas cultivated large number of enset landraces than other areas. *Persea american* a second frequented plant species in mid altitude. Due to farmer grow fruit plant in their homegarden such as avocado, Kazimir, Banana and other fruits and they focus on cash crops production. In this study *Croton macrostachyus* frequented ranked second in frequency occurrences in highland because the farmers belief that it is important in increasing soil fertility, conserving soil moisture, shade for crop in the homegardens and used for fuel wood.

In general, *Ensete ventricosum, Brassica carinata, Zea may, Solanum tuberosum, Persea american, Coffea arabica, Croton macrostachyus* were recorded top of frequency of on farm occurrence in both altitude. These results are also supported by Abebe (2005) who reported that *Coffea arabica,* Enset, *Zea may* and *Brassica* species were found at the top of frequency of crop species for Sidama homegardens in south Ethiopia.

Table 5:Frequency of plant species recorded in mid altitude homegardens

Scientific name	**N=83**	**Frequency (%)**	**RF (%)**
Ensete ventricosum	80	96.4	4.73
Persea americana	78	94.0	4.62
Cordia africana	74	89.2	4.38
Brassica carinata	72	86.7	4.26
Zea mays	65	78.3	3.85
Coffea arabica	62	74.7	3.67
Solanum tuberosum	59	71.1	3.49
Catha edulis	57	68.7	3.37
Capsicum annuum	56	67.5	3.31
Ruta chalepensis	52	62.7	3.08
Croton macrostachyus	50	60.2	2.96
Ocimum basilicum	45	54.2	2.66
Beta vulgaris	44	53.0	2.60
Cupressus lusitanica	44	53.0	2.60
Daucus carota	43	51.8	2.54
Erythrian brucei	43	51.8	2.54

Table 6: Frequency of plant species recorded in highland

Scientific name	Frequency N=52	Frequency (%)	RF (%)
Ensete ventricosum	52	100	5.84
Croton macrostachyus	45	86.5	5.05
Brassica carinata	45	86.5	5.05
Solanum tuberosum	39	75	4.38
Capsicum annuum	37	71.2	4.15
Cupressus lusitanica	36	69.2	4.04
Zea mays	33	63.5	3.70
Erythrina brucei	33	63.5	3.70
Ruta chalepensis	30	57.7	3.37
Ocimum basinthium	28	53.8	3.14
Eucalyptus globulus	26	50	2.92
Arundo donax	26	50	2.92

4.2. Woody Species Compositions

The result showed that more woody species were recorded under the mid altitude than highland. Thirty six plant species were recorded in homegardens found in mid altitude as compared to 23 plant species in the homegardens found in the highland (Table 7). The species belong to 23 and 17 families in the mid altitude and highland respectively (Appendixes 8). Due to mid altitude grow more fruit tree plant such as Avocado, Kazimir, Apple and other fruits in their homegardens for income generation and they focus on cash crops production. This finding is similar with (Castiñeiras *et al*., 2002;Shrestha *et al*., 2002) who reported that along the elevation gradient, structural complexity of homegardens decreases due to changes of crop species composition and less fruit tree species were cultivated in homegardens of higher elevations. The family Rosaceae was 26% and 23%, which was the dominant family of the woody species recorded in mid altitude and highland respectively, followed by Myrtaceae with 17.4% and 11.8%, which was second the commonly observed family among woody species. Woody species have various socioeconomic and ecological roles. Woody Species

composition result showed that in mid altitude and highland, 39 plant species were recorded (Appendix 6). Bajigo and Tadesse (2015) who reported that 32 woody species belonging to 19 families were recorded in Wolayitta Zone homegardens. Negash *et al*. (2012) also reported that 58 woody species in 30 families were recorded in southeastern Rift Valley Ethiopia. Abebe (2013) also reported that 120 tree and shrub species were recorded in the homegardens of Sidama, Southern Ethiopia.

In this study, many indigenous species exist, in mid altitude dominated species such as *Cordia africana, Croton macrostachyus, Erythrina brucei, Juniperus procera, Prunus africana, Olea europaea, Millettia ferruginea, Hagenia abyssinica*. In highland dominated species are *Croton macrostachyus, Erythrina brucei, Olea europaea, Juniperus procera, Prunus africana, Vernonia amygdalina, Cordia africana, Teclea nobilis and Ekebergia capensis* (Appendix 8). The farmers are belief the importance of indigenous species in soil conservation and soil fertility improvement. The indigenous plant species used for shade service (for humans and livestock), ability to increase soil fertility, fodder provision, wood for construction, firewood and timber production are the main services provided by farmers in the study area to incorporate them in their homegardens. In the front yards, native timber species such as *Podocarpus falcatus* and *Olea europaea* are kept scattered in wide spacing so that they provide shade to humans and animals. Boundaries of the front yards, which are often boundaries of the homegarden, are planted with live fences of *Cupressus lusitanica, Juniperus procera* and *Prunus africana*.

In this study of the total woody species *Erythrina brucei* and *Millettia ferruginea* are endemic trees species were recorded in both altitude shows (Appendix 8). The existence of these species in traditional homegarden agroforestry practices showing that it has given the advantage of conserving these species.

Table 7: Woody Species Compositions and Origin of Plants

woody species	Mid altitude	Highland
Total woody species	36	23
Families	23	17
Indigenous woody	44.44	69.57
Exotic woody	55.56	30.43

4.2.1. Woody Species Richness and Diversity

The result shows more woody species richness per homegarden was recorded under the mid altitude than in the highland. Woody species richness found to be high in the mid altitude. The result shows that woody plant richness were significantly different (P value<0.05) between mid altitude and high-altitude (Table 8). The present finding is also similar with the work done by Bajigo and Tadesse (2015) who reported that the middle elevation was highest in woody species richness. The woody Shannon diversity index result shows that 2.79 and 2.32 of the mid altitude and highland respectively and the Evenness value was 0.38 and 0.33 mid altitude and highland respectively (Table 8). Woody Shannon diversity index was not significant difference p>0.05 between mid altitude and the highland. In this study the Shannon diversity index for woody species is H'=2.79 in mid altitude and H'=2.32 in the highland, which is higher than previous study of the trees and shrubs diversity index (H´=1.41) in Sidama homegardens(Abebe, 2013) and the Shannon diversity index for Woody (H´=2.02) in Gununo Watershed, Wolayitta Zone (Bajigo and Tadesse, 2015).

Table 8: Diversity index both site

	Study sites		
Index	**Mid altitude**	**Highland**	**P value**
Species richness/HG	8.72	6.61	0.003
Shannon	2.79	2.32	0.090
Evenness	0.38	0.33	

4.2.2. Importance Value Index (IVI)

To assess the importance of each species, the IVI was estimated for the woody species recorded in the homegardens in both altitudes. The IVI result among the shows that woody species in the mid altitude, *Cordia africana* is the most important species that rank first, due to its good quality timber, improves soil properties in the homegarden and fast growth. Yakob *et al*. (2014) reported that *Cordia africana* is the most important species as a result the socioeconomic and ecological benefits of the tree has made it popular among farmers. *Persea americana* ranked second, due to the majority of the household were cultivating *Persea Americana* and *Casimiroa edulis* in the homegarden for food and income generating purpose. Suitable to in the mid altitude the dominancy of fruit and timber trees high due to farmers' chosen the species for income generation and timber production and *Croton macrostachyu* ranked third following the other woody species (Table 9).

IVI analysis of woody species in the highland result shows that *Croton macrostachyus* is the most important species, which ranked first followed by *Cupressus lusitanica* and *Erythrina brucei* (Table 9). In the highland farmers belief that *Croton macrostachyus* and *Erythrina brucei* planting in the homegarden for enhancement of soil fertility and fuel wood and *Cupressus lusitanica* used for live fence and house construction. In the front yards, native timber species such as *Podocarpus falcatus* and *Olea europaea* are scattered in wide spacing so that they provide shade to humans and animals. Boundaries of the front yards, which are often boundaries of the homegarden, are planted with live fences of *Cupressus lusitanica*, *Juniperusprocera* and *Prunus africana*.

Table 9: Mid altitude and Highland IVI

Species	Mid altitude IVI	Species	Highland IVI
Cordia africana	34.67	*Croton macrostachyus*	43.5
Persea american	32.36	*Cupressus lusitanica*	40.3
Croton macrostachyus	24.81	*Erythrina brucei*	29.3
Cupressus lusitanica	23.67	*Eucalyptus globulus*	26
Erythrina brucei	20.94	*Persea american*	15.9
Eucalyptus globulus	11.25	*Olea europaea subsp*	13.9
Prunus africana	10.45	*Prunus africana*	12.2
Juniperusprocera	10.41	*Cordia africana*	11.6
Casimiroa edulis	10.02	*Podocarpus falcatus*	11.3
Podocarpus falcatus	9.87	*Juniperusprocera*	10.7

4.3. Socio Economic Benefits

4.3.1. Households and homegarden characteristics

In this study homegarden characteristics show that average landholding size of the households were 1.61 ha and 1.50 ha in mid altitude and highland areas respectively. The mean size of homegarden was 0.29 ha and 0.28 ha in mid altitude and highland respectively and the average age of homegarden was 30.7 and 34.2 years old in mid altitude and highland respectively. In this study, 89.2% and 92.3% were male headed whereas the remaining 10.8% and 7.7% were female headed in mid altitude and highland respectively (Table 10).

Table 10**:** Homegarden characteristic

Homegarden Characteristics	Mid altitude	Highland
Average landholding size(ha)	1.61	1.50
Average homegarden size (ha)	0.28	0.29
Average age of homegarden(no)	30.7	34.2
Average species richness (no)	20.4	17.7
Average family size (no)	7.9	6.9

4.3.2. Wealth status of the households

The wealth status of the household was medium 54.22% and 53.2%, the poor 24.10% and 25%, the remaining 21.15% and 21.69% are rich with better living condition in mid altitude and the highland respectively (Table 11). In the mid altitude, the average species richness ranged from 29.94 to 13.05 specie. It showed a declining trend from rich to poor wealth class. In the highland, the average species richness ranged from 24.27 to 12.31ha. It showed a declining trend from rich to poor wealth class. LSD analysis showed significant difference between the rich and poor wealth classes (Table 11). In this study, rich farmers had significantly higher number of species than poor farmers (Figure 3 A). This is because a poor tends to focus on few selected species to satisfy immediate needs. This is in line with research in homegardens of Aris Negele, Ethiopia by Tolera *et al*. (2008) that reported poor farmers experience income constrain to focus on few selected species which generate money to satisfy their immediate needs.

Table 11: Wealth Status of the Households in both sites

	Mid altitude			**Highland**			**P value**
ı status	(%) Wealth status	Species richness (no)	Average HG area(ha)	(%)Wealth status	Average Species Richness(no	Average HG area(ha)	
Rich	21.69	29.94	0.4971	21.15	24.27	0.5	0.000
Medium	54.22	19.91	0.28	53.2	17.64	0.29	0.000
Poor	25	13.05	0.098	24.10	12.31	0.10	0.000

*. Significant at the 0.05 level.

The result showed in the mid altitude the average area of homegardens ranged from 0.49 to 0.098 ha. In the highland, the average area of homegardens ranged from 0.5 to 0.10 ha. It showed a declining trend from rich to poor wealth class. LSD analysis showed significant difference between the rich and poor wealth classes (Table 11). Rich farmers had significantly larger homegarden size than poor farmers (Figure 3, B). Larger farms had more plant species. This is because smallholder farmers concentrate on fewer species of greater utility and allocate more of their land to food crops, while large holders can have enough money to include different types of plant species. This finding is supported by Kumar *et al*. (2004) who

reported that the pattern showed increased plant species richness with increased landholding of homegarden systems.

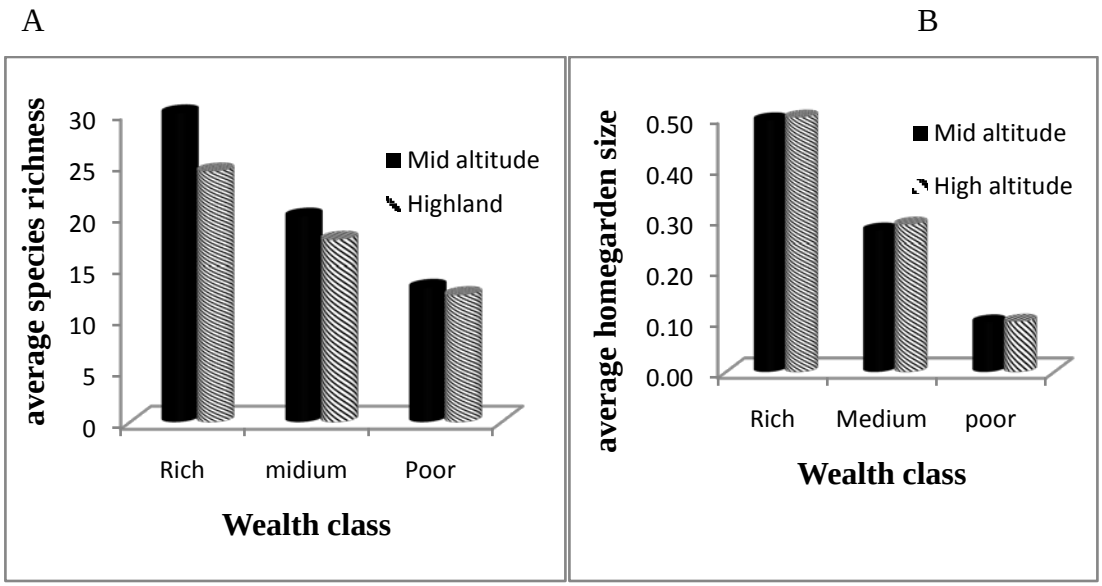

Figure 3.Average species richness and average area of homegarden in both altitudes

4.3.3. Correlation of species richness and diversity

Species richness and diversity were among households mainly due to socioeconomic and ecological conditions. In mid, altitude correlation result showed that wealth status had a strong significant positive correlation with species richness (r=832, P=0.000) (Table 12). Due to higher crop diversity found in homegardens of rich households, which related to larger garden sizes, larger landholdings are suitable for staple crop production, social contacts used for gathering planting material and they have enough money buy the seedling. This study is supported by Shrestha *et al*. (2004) who reported that there is a positive influence of household's wealth status concerning crop diversity at farm level. Total land holding size had a strong significant positive correlation with species richness (r =.891, P=0.000). Abebe (2013) reported increasing species richness with increasing land-holding size in Sidama homegarden systems. Larger farms had more plants and plant species. This is because smallholder farmers concentrate on fewer species of greater utility and allocate more of their land to food crops, while large holders can have enough money to include different types of

plant species. Homegarden size had a strong significant positive correlation with species richness (r = .946, P=0.000). Other finding result showed that homegarden size has positive correlation with species richness in Indonesia (Abdoellah *et al*., 2002) and India (Das and Das, 2005). Age of Homegarden significant positive correlation with species richness (r=.421 p=.000). Family size significant positive correlation with species richness (r=.691,p=.000). Due to household characteristics in the area, populous households enjoyed more labor inputs and times devoted to homegardening, the majority of activities in homegardens operated by family labor and had more needs, so there had more diverse plant species in the homegardens. Krishnal (2012) reported that homegardens reduced the cost of labor as most of the activities in homegardens were operated by family labor. This present finding supported by Schadegan *et al*. (2013) reported that the size of households had a significant positive correlation with homegarden species richness (r = 0.189, sig = 0.004). Correlation of wealth status, landholding size, homegarden size, age of homegarden and family size with species richness in mid altitude are summarized in Table 12.

Table12: Correlation of Species richness in mid altitude

Pearson Correlation	**Species richness**	**p-value**
Wealth status	.832**	.000
Total landholding size	.891**	.000
Homegarden size	.946**	.000
Age of Homegarden	.421**	.000
Family size	.691**	.000

**. Correlation is significant at the 0.01 level (1-tailed)

Similarly, in the highland, correlation test showed that wealth status showed there is no significant difference between wealth class and wealth status has positive correlation with species richness (r=.014,p=.461) Table 13. Total land holding size had a strong significant positive correlation with species richness (r = .786, P=0.000). Homegarden size had a strong significant positive correlation with species richness(r=.826, p=.000). The present finding is also similar with the work done by Quiroz *et al*. (2004) who found that the homegarden size is positively correlation with species richness. In small homegardens, particularly tree species

richness decreases, resulting in a poor vertical vegetation structure and decrease of perennial crops in small gardens (Peyre *et al.,* 2006). Additionally, Sunwar *et al*. (2006) showed that homegarden size has positive correlation with species richness in India. Age of homegarden has significant positive correlation with species richness (r=.608, p=.000) (Table 13). Family size has significant positive correlation with species richness(r=.762, p=.000). Correlation of wealth status, landholding size, homegarden size, age of homegarden and family size with species richness in highland are summarized (Table 13).

Table 13: Correlation of Species Richness in Highland

Pearson Correlation	**Species richness**	**p-value**
Wealth status	.014	.461
Landholding size	.786**	.000
Homegarden size	.826**	.000
Age of homegarden	.608**	.000
Family size	.762**	.000
**. Correlation is significant at the 0.01 level (1-tailed).		

4.3.4. Income from marketable homegarden product

The result shows that the mean annual income of household was 3103.60 Birr per homegarden in mid altitude which is higher than1974.67 Birr per homegarden in the highland. Result shows that annual income per household has significant difference p value = 0.02 between mid altitude and highland Table 14. Abebe (2013) reported that in the low altitude sites where temperatures are suitable, the crops are increased because of their good adaptability to the climatic conditions and associated with road access, because most of the mid altitude sites also had better access to the roads that facilitate marketing.

In this study, the income of household in each homegarden varies from a minimum 150 to a maximum 14060 Birr /y/HG/site. The present finding is similar with the work done by Mekonnen (2011) who reported the annual income of the household varied from 72.81 to 1456.1 Birr /y/HG/in Holeta homegardens. Abdoellah *et al. (*2006) also reported that the

income derived from the homegardens had significantly positive correlation with the size of homegardens and species richness in Indonesian village. Mendez *et al.* (2001) reported that farmers who have large homegarden size were getting more income because of having large homegarden size they produce more crops. The most important income source was homegarden product, which was maintained by 70% of the sample (Méndez *et al.,* 2001). Homegarden systems provide an additional food supply and cash income for the people (Das and Das, 2005).

Table 14: Income from marketable homegarden product

Homegarden	**Mean**	**N**	**SE.**	**Min**	**Max**	**P value**
Highland	1974.67	52	221.245	150	7370	0.02
Mid altitude	3103.6	83	351.58	157	14060	
Total	2668.75	135	236.5	150	14060	

The result showed that household income from marketable homegarden products ETB/year/ of the study area. The result shows that, the contribution of homegarden for their livelihood cash crop mean annual income is higher in mid altitude with 1722.91 ETB than highland with 706.42 ETB. Statically, cash crop significant difference between mid altitude and highland $p<0.05$shows (Table 15). This is due to mid altitude can grow more potential of fruit and cash crop like coffee, chat, avocado and Casmir higher than highland but in the highland cash crop fruits is apple dominated. Stable crop mean annual income of household is 454.33 ETB per homegarden in mid altitude which is lower than 454.33 ETB per homegarden in highland. Result showed that annual income per household has significant difference $p <0.05$ between mid altitude and the highland. This is due to the fact the highland farmer grow potential of stable crop such as Enset and Maize higher than the mid altitude. Enset can be sold in the local market and urban market specially the time of cultural day (*Meskel*) the finding of the true cross and (*Gena*) Charismas Enset product costly sale. The mean annual income from vegetable crop of the household is 972.19 ETB per homegarden in mid altitude higher than 383.87 ETB per homegarden in highland. Result showed that annual income per household has significant difference ($p <0.05$) between mid altitude and the highland. Because mid altitude farmers grow high potential vegetable crops in their homegarden for income

generation such as *Daucus carota*, *Brassica oleracea*, *Beta vulagaris*, *Lycopersicon esculentum*, *Solanum tuberosum* and *Brassica carinata* these species farmer adapted to sale urban market (Hosanna) for their livelihood. In the highland *Capsicum annum*, *Solanum tuberosum* and *Brassica carinata* are dominated rural market vegetable crops. The mean annual income from spices per household was no significantly difference ($p > 0.05$) between mid altitude and the highland. The mean annual income from bamboo of the household was170 ETB per homegarden in mid altitude which is lower than 391ETB per homegarden in highland. The result showed that the annual income per household was significant different $p < 0.05$ between mid altitude and the highland. Highlander grows potential of bamboo higher than mid altitude shows. Due to these variations, reflect ecological adaptations of the species to particular sites. This result supported by (Kelbessa *et al.,* 2000) reported that bamboo potentially grows in the southern, southwestern and northwestern parts of the country in highland ranging from 2200 – 4000 m a. s. l higher than other ecology altitude.

Table 15: Household income from marketable homegarden products (ETB/year/HH 1014)

Products	**Homegardens**	**Mean income/HH**	**Std. Deviation**	**P value**
Cash crop	Highland	706.42	891.72	0.001
	Mid altitude	1722.91	2141.46	
Stable crop	Highland	454.33	425.04	0.000
	Mid altitude	165.48	211.68	
Vegetable	Highland	383.87	415.87	0.000
	Mid altitude	972.19	997.10	
Spices	Highland	282.59	333.69	0.189
	Mid altitude	178.49	308.21	
Bamboo	Highland	391	301.96	0.030
	Mid altitude	170	189.46	

4.3.4.1 Correlation of species richness with income of household from homegarden

Diversity and species richness varied among households mainly due to local socioeconomic and physical conditions. Farmers benefit from homegardens in several ways. Homegarden act as reserve bank of food and cash for farmers. Even though, income from homegardens was different with the size of the homegardens, larger farms had more individual plants and plant species. The correlation result showed that annual income of household from homegarden marketable products had a strong significant positive correlation with species richness (r=0. 872, p=0.000) in mid altitude and highland (r=.791, p=. 000) Table 16. This is because smallholder farmers concentrate on fewer species of greater utility and allocate more of their homegarden to food crops, while large homegarden can have enough money to include different types of plant species. Farmers who have large homegarden size were getting more income because of having large homegarden size they produce more crops. This finding similar with Abdoellah (2006) who reported the income derived from the homegardens had significantly positive correlation with species richness. This study is supported by Schadegan *et. al* (2013) who also reported that significant positive correlation between homegarden species richness and household income from homegardening (r= 0.414, p *value* =0.000), confirming the role of diversification to improve economic and nutritional conditions of rural communities.

Table 16: Correlation of species richness and income of household from homegarden

	Pearson Correlation	**Species richness**
Income of mid altitude	Pearson Correlation	.872**
	Sig. (1-tailed)	.000
Income of highland	Pearson Correlation	.791**
	Sig. (1-tailed)	.000

* * Correlation is significant at the 0.01 level (1-tailed)

4.3.5. Purpose of homegarden

Purpose of homegarden result showed that 13 major plant use category were identified in both altitude from total plant species such as 31% were used for food , 14.29% were crops used for income generate, 11.69% were used for spices, 9.09% were plants used as live fence in mid altitudes. In highland 28% were used for food 10% were used for income 10%were used for fuel wood, 10% were used for medicine 8% were used for spice, 8% were used for house constriction and 6% were used for fodder (Table 17). These results agree with maroyi (2013) who found eight different plant use categories which were identified in Zvishavane homegarden, Zimbabwe. In Gedeo homegarden, Melese and Daniel (2015) have recorded 10 major plant use categories and 10 functional groups of crops were recognized in Sidama homegarden (Abebe, 2005; 2010).

Table 17**:** Purpose of homegarden

Purpose of Homegarden Mid altitude	**Percent**	**Purpose of Homegarden Highland**	**percent**
Food	31	Food	28
Income	14.29	Income	10
Spice	11.69	Fuel wood	10
Live fence	9.09	medicine	10
Medicine	7.79	Spice	8
House construction	7.79	House construction	8
Fuel wood	6.49	Fodder	6
Stimulant	5.19	Timber	4
Ornamentals	3.90	Shading	3
Timber	3.90	Ornamentals	3
Fodder	3.90	Live fence	3
Shading	2.60	Fencing	3
Fencing	2.60	Stimulant	2

4.3.6. Seasonal availability of plants in homegarden

The time/ season and frequency of harvesting vary from plant to plant depending on the availability of plants and parts. It varied from place to place due to ecological and climatic conditions. Food producing plants are cultivated in the study area, available in different seasons. The study result indicate that there were at least two obtainable products from homegarden throughout the year. Homegarden insure continuous production and utilization throughout the year. Homegardens products are more available during the main rainy season between June and October when prices for grains become high (Fig 4). In addition, *Solanum tuberosum*, *Ensete ventricosum* and *Zea may* was highly served the community as transitory food during stock depletion and new harvest is not ready especially for resource poor households. These seasonal very important in filling the shortage of food at household level. Similarly, in homegarden in Sebeta-Hawas District, products are more available during the main rainy season between June and September (Tefera, 2010).

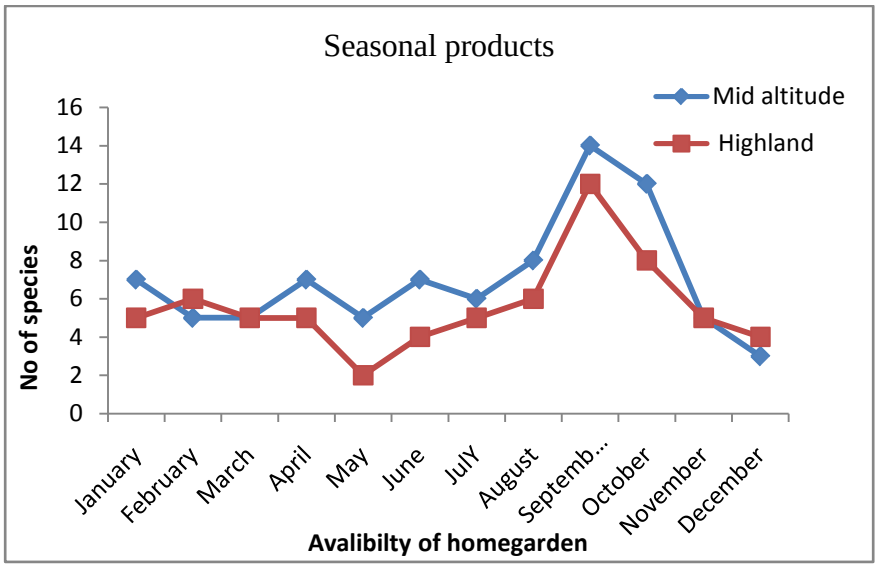

Figure 4.Seasonal homegarden products

5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion

Taking into account plant species composition, diversity and socioeconomic benefits homegarden is an important land use approaches in study area. However, there variation mainly in terms of its role both ecological and socioeconomic conditions. Tradition of homegarden agroforestry there is common in the homegardens of the study area but differences occur in composition of the species which the variation is mainly credited to differences in altitude, homegarden size and wealth status of the farmer. The altitudinal difference (1900–2700 m a.s.l.) is large enough to demonstrate variation in the composition of plant species. The result shows more species richness per homegarden was recorded under the mid altitude than the highland. Homegardens of the two areas are irreplaceable production units since they provide almost everything the household requires for subsistence. Nevertheless, their role must not to be judged only in terms of satisfying family needs. As diversity measures used in this study indicated, homegardens are major provider to plant diversity supported by managed landscapes of the two altitudes. The floristic composition showed that the homegardens are rich (80 species) in plant diversity. The results of this study indicated that homegardens had high species diversity and a rich floristic composition that is worthy of *in situ* conservation of plant biodiversity, income source vegetables and other species. More cultivate and protect a mixture of herbs, trees and shrubs depending on the. This study showed that the average household size of the study area is about seven, this is high population compared to Ethiopian average household size which is 4.7 (CSA, 2014). Therefore, homegarden is one of the solutions to support a very dense population to reducing food insecurity. Homegardens provide significant contributions for the households in the study area. The composition of plant species varied between mid altitude and the highland: mid altitude had shown higher complexity in species richness and species diversity. Attention should be given to the existing homegarden agroforestry practices and the practices must be promoted to highland to enhance biodiversity conservation and socioeconomic benefits in the homegarden agroforestry.

5.2 Recommendations

- ✓ Promotion of homegarden as sustainable land use must take in to account the agroecology and social factors
- ✓ Since homegarden is an important land use, attention should be given to it to promote conservation and improve livelihoods
- ✓ Policy makers should consider the sustainability of homegarden agro biodiversity with respect to the life patterns and knowledge of the local people
- ✓ Further studies should be done on the significance of homegarden from REDD+ point of views

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7. APPENDIX

Appendix 1.Plant species inventory Format

Homegarden owner's name----------Agroecology----------Kebeles----------

Home garden size---------- (ha)

Age of homegarden----------

Altitudinal range----------m.a.s.l

	species name		Scientific name	DBH (cm)	Height	Plant growth habit	Use of plant	Arrangement (Horizontal/vertical)
No of spp	local name	Amharic name						

Appendix 2 . Questionnaire survey formant

1. Household Information

Homegarden owner's name----------Agroecology----------Kebeles----------

Main occupation_____

Total land holding size----------(ha)

Home garden size---------- (ha)

Age of homegarden----------

No	Household Characteristics	Category / Code				
		1	2	3	4	5
2.1	Sex	Male☐	Female ☐			
2.2	Age					
2.3	Religion	Orthodox☐	Muslim ☐	Protestant ☐	other☐	
2.4	Marital status	Single	Married	Widowed	Divorced	
2.5	Educational status	Cannot read/write ☐	Read/Write☐	primary 1st cycle (1- 4)☐	primary 2nd cycle (5-8)☐	Secondary 1st cycle & above (9-10 & above)☐
2.6	Family/ household size					
2.7	Wealth categories					

2. Socioeconomic benefits of homegardens

2.1 Why do you practice your homegarden or what is the purpose of your homegarden?

2.2. List the benefits you obtain from your homegarden?

2.3 Are you able to sustain your family with the products from your homegarden ?

1. Yes 2. No

2.4 If the answer 2.2 above is no, how important is your homegarden relative to other land uses?

2.5 List major crops and products you obtain from your homegarden throughout the year

Season	Products	Purpose (consumption, sale or both)
January		
February		
March		
April		
May		
June		
July		
August		
September		
October		
November		
December		

2.6 which species do you use multipurpose ? why?

No	Tree/shrub Species	Exotic or Indigenous	Reason

2.6. Components of homegarden for income generation and source of food?

Components	Source of food/cash	Benefit of species	Unit	Unit/ price	Total Income generate	Total consumption

2.7. Please classify the product you obtain from your homegarden (Primary importance, secondary importance, tertiary importance)

. _____

Keys:
Primary: Products that are essential to your livelihood
Secondary: Products that are very important but not absolutely essential
Tertiary : Products that serve a purpose but are not essential

2.8 Please rate your homegarden as a source of (food, cash, others_____

Appendix 3. Botanical name of plant species in both altitude

no	**Scientific name**	Family name	Amharic name	Origin of plant	Habit growth
1	*Acacia abyssinica* Hochst.	Fabaceae	Girar	Indigenous	Tree
2	*Aframomum corrorima* (Braun) Jansen	Zingiberaceae	Korerima	Endemic	Herb
3	*Ajuga integrifolia* Buch.-Ham. ex D. Don	Lamiaceae	Anamura	Indigenous	Herb
4	*Allium cepa* L.	Alliaceae	K/Shinkurt	Exotic	Herb
5	*Allium sativum* L.	Alliaceae	N/shinkurt	Exotic	Herb
6	*Annona reticulata* L..	Annonaceae	Gishta	Exotic	Tree
7	*Artemisia absinthium* L.	Asteraceae	Arity	Exotic	Herb
8	*Arundinaria alpina* K. Schum.	Poaceae	Kerkha	Indigenous	Herb
9	*Arundo donax* .	Poaceae	Shenbiko	Indigenous	Herb
10	*Beta vulagaris* var. esculenta L.	Chenopodiaceae	Qey sir	Exotic	Herb
11	*Beta vulgaris* subsp.vulparis	Amaranthaceae	Koseta	Exotic	Herb
12	*Brassica carinata* A. Br.	Brassicaceae	Gomen	Indigenous	Herb
13	Brassica oleracea var. capitata L.	Brassicaceae	T/gomen	Indigenous	Herb
14	*Caesalpinia decapetala* (Roth) Alston	Fabaceae	Digita	Indigenous	Shrub
15	*Canavalia africana* Dunn.	Fabaceae	Adenguare	Indigenous	Herb
16	*Capsicum annuum* L.	Solanaceae	Kariea	Exotic	Herb
17	*Carica papaya* L.	Caricaceae	Papay	Exotic	Tree
18	*Casimiroa edulis* La Llave	Rutaceae	Kazimir	Exotic	Tree
19	*Casuarina cunninghamiana* Miq.	Casuarinaceae	Shewishewi	Exotic	Tree
20	*Catha edulis* (Vahl) Forssk.ex Endl.	Celastraceae	Chat	Indigenous	Shrub
21	*Chloris gayana Kunth*	Paniceae	Rodes	Indigenous	Herb
22	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	Lomi	Exotic	Shrub
23	*Citrus medica* L.	Rutaceae	Tiringo	Exotic	Shrub
24	*Citrus sinensis* (L.)Osb.	Rutaceae	Buritukan	Exotic	Shrub
25	Coffea arabica L.	Rubiaceae	Buna	Indigenous	Shrub
26	*Colocasia esculenta* (L.) Schott	Araceae	Godere	Exotic	Herb

27	*Cordia africana* Lam.	Boraginaceae	Wanza	Indigenous	Tree
28	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	Indigenous	Tree
29	*Cucurbita pepo* L.	Cucurbitaceae	Duba	Exotic	Herb
30	*Cupressus lusitanica*	Cupressaceae	Yef.Tid.	Exotic	Tree
31	*Cymbopogon citratus* (DC.)Stapf.	Poaceae	Tej-sar	Exotic	Herb
32	*Daucus carota* L.	Apiaceae	Carrot	Exotic	Herb
33	*Dovyalis caffra (Hook.f.Harv.)Hook.f.*	Flacourtiaceae	Koshim	Exotic	Shrub
34	*Ekebergia capensis* Sparrm.	Meliaceae	Lol	Indigenous	Tree
35	*Ensete ventricosum* (Welw.)	Musaceae	Enset	Indigenous	Herb
36	*Erythrina brucei* Schweinf.	Fabaceae	korch	Endemic	Tree
37	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Key Barzaf	Exotic	Tree
38	*Eucalyptus globulus* Labill.	Myrtaceae	N/ Barzaf	Exotic	Tree
39	*Ficus sur*	Moraceae	Shola	Indigenous	Tree
40	*Grevillea robusta R.Br.*	Proteaceae	Giraviliya	Exotic	Tree
41	*Hagenia abyssinica* (Bruce) J.F. Gmelin	Rosaceae	Kosso	Indigenous	Tree
42	*Juniperus procera* Hochst.	Cupressaceae	Yabsha Tsid	Indigenous	Tree
43	*Justicia schimperiana* (Hochst. ex Nees) T.	Acanthaceae	Sensel	Indigenous	Shrub
44	*Lactuca sativa L.*	Asteraceae	Selata	Exotic	Herb
45	*Lippia adoensis* Hochst.ex Walp.	Verbenaceae	Koseret	Indigenous	Herb
46	*Lycopersicon esculentum* Mill.	Solanaceae	Timatim	Exotic	Herb
47	*Malus sylvestris* Miller.	Rosaceae	Apple	Exotic	Tree
48	*Mangifera indica* L.	Anacardiaceae	Mango	Exotic	Tree
49	*Melia azedarach* L.	Meliaceae	Nime	Exotic	Tree
50	*Millettia ferruginea* (Hochst.)Bak.	Fabaceae	Birbira	Endemic	Tree
51	*Musa x paradisica.L*	Musaceae	Muze	Exotic	Herb
52	*Nicotiana tabacum L.*	Solanaceae	Tambaho	Exotic	Herb
53	*Ocimum basilicum* var.	Lamiaceae	Besobela	Exotic	Herb
54	*Ocimum lamiifolium* Hochst.ex. Benth.	Lamiaceae	Damakesse	Indigenous	Herb
55	*Olea europaea* L. subsp. cuspidata	Oleaceae	Weyra	Indigenous	Tree
56	*Opuntia cylindrica* (Lam). D.C.	Cactaceae	kulekoale	Exotic	Shrub
57	*Pennisetum purpureum Schumach*	Poaceae	Zihone sar	Indigenous	Herb
58	*Persea americana* Mill.	Lauraceae	avocado	Exotic	Tree
59	*Podocarpus falcatus* (Thunb.)Mirb.	Podocarpaceae	Zigba	Indigenous	Tree
60	*Prunus africana* (Hook.f.)Kalkm.	Rosaceae	Tikur enchit	Indigenous	Tree
61	*Prunus persica* L.	Rosaceae	Kok	Exotic	Tree
62	*Prunus x doemstica* L.	Rosaceae	Prim	Exotic	Tree
63	*Psidium guajava* L.	Myrtaceae	Zeitun	Exotic	Tree
64	*Pycnostachys abyssinica* Fresen.	Lamiaceae	Tontona	Endemic	Shrub
65	*Rhamnus prinoides* L‟ Herit.	Rhamnaceae	Gesho	Indigenous	Shrub

66	*Ricinus communis* L.	Euphorbiaceae	Gullo	Indigenous	Shrub
67	*Rosmarinus officinalis* L.	Lamiaceae	siga mitibesha	Exotic	Herb
68	*Rumex abyssinicus* Jacq.	Polygonaceae	Meqmeqo	Indigenous	Herb
69	*Ruta chalepensis L.*	Rutaceae	Tendam	Exotic	Herb
70	*Rytigynia neglecta (Hiern) Robyns*	Rubiaceae	Abera	Indigenous	Tree
71	*Saccharum officinarum* L.	Poaceae	Shenkorageda	Exotic	Herb
72	*Sesbania sesban (L.)Merr.*	Fabaceae	Sesbaniya	Indigenous	Shrub
73	*Solanum tuberosum* L.	Solanaceae	Dinchi	Exotic	Herb
74	*Sorghum bicolor* L.	Poaceae	Mashilla	Indigenous	Herb
75	*Spathodea campanulata (S. nilotica)*	Bignoniaceae	ykibrit hinchit	Exotic	Tree
76	*Syzygium guineense* (Wild.) DC.	Myrtaceae	Dokma	Indigenous	Shrub
77	*Teclea nobilis* Del.	Rutaceae	Taa	Indigenous	Shrub
78	*Vernonia amygdalina* Del.	Asteraceae	Grawa	Indigenous	Shrub
79	*Zea mays* L.	Poaceae	Bokolo	Exotic	Herb
80	*Zingiber officinale* Rosc.	Zingiberaceae	Zingibel	Exotic	Herb

Appendix 4.Botanical name of plant species in mid altitude

No	**Scientific name**	Family name	Amharic name	Origin of plant	growth Habit
1	*Acacia abyssinica* Hochst.	Fabaceae	Girar	Indigenous	Tree
2	*Aframomum corrorima* (Braun) Jansen	Zingiberaceae	Korerima	Endemic	Herb
3	*Ajuga integrifolia* Buch.-Ham. Ex D. Don	Lamiaceae	Anamura	Indigenous	Herb
4	*Allium cepa* L.	Alliaceae	K/Shinkurt	Exotic	Herb
5	*Allium sativum* L.	Alliaceae	N/shinkurt	Exotic	Herb
6	*Annona reticulata* L..	Annonaceae	Gishta	Exotic	Tree
7	*Artemisia absinthium* L.	Asteraceae	Arity	Exotic	Herb
8	*Arundinaria alpina* K. Schum.	Poaceae	Kerkha	Indigenous	Herb
9	*Arundo donax L.*	Poaceae	Shenbiko	Exotic	Herb
10	*Beta vulagaris* var. esculenta L.	Chenopodiaceae	Qey sir	Exotic	Herb
11	*Beta vulgaris* subsp.vulparis	Amaranthaceae	Koseta	Exotic	Herb
12	*Brassica carinata* A. Br.	Brassicaceae	Gomen	Indigenous	Herb
13	Brassica oleracea var. capitata L.	Brassicaceae	T/gomen	Indigenous	Herb
14	*Caesalpinia decapetala* (Roth) Alston	Fabaceae	Digita	Indigenous	Shrub
15	*Canavalia africana* Dunn.	Fabaceae	Adenguare	Indigenous	Herb
16	*Capsicum annum* L.	Solanaceae	Kariea	Exotic	Herb
17	*Carica papaya* L.	Caricaceae	Papay	Exotic	Tree
18	*Casimiroa edulis* La Llave	Rutaceae	Kazimir	Exotic	Tree
19	*Casuarina cunninghamiana* Miq.	Casuarinaceae	Shewishewi	Exotic	Tree

20	*Catha edulis* (Vahl) Forssk.ex Endl.	Celastraceae	Chat	Indigenous	Shrub
21	*Chloris gayana Kunth*	Paniceae	Rodes	Exotic	Herb
22	*Citrus aurantiifolia* (Christm.) Swingle	Rutaceae	Lomi	Exotic	Shrub
23	*Citrus medica* L.	Rutaceae	Tiringo	Exotic	Shrub
24	*Citrus sinensis* (L.)Osb.	Rutaceae	Buritukan	Exotic	Shrub
25	Coffea arabica L.	Rubiaceae	Buna	Indigenous	Shrub
26	*Colocasia esculenta* (L.) Schott	Araceae	Godere	Exotic	Herb
27	*Cordia africana* Lam.	Boraginaceae	Wanza	Indigenous	Tree
28	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	Indigenous	Tree
29	*Cucurbita pepo* L.	Cucurbitaceae	Duba	Exotic	Herb
30	*Cupressus lusitanica*	Cupressaceae	Yef.Tid.	Exotic	Tree
31	*Cymbopogon citratus* (DC.)Stapf.	Poaceae	Tej-sar	Exotic	Herb
32	*Daucus carota* L.	Apiaceae	Carrot	Exotic	Herb
33	*Dovyalis caffra (Hook.f.Harv.)Hook.f.*	Flacourtiaceae	Koshim	Exotic	Shrub
34	*Ensete ventricosum* (Welw.)	Musaceae	Enset	Indigenous	Herb
35	*Erythrina brucei* Schweinf.	Fabaceae	korch	Endemic	Tree
36	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Key Barzaf	Exotic	Tree
37	*Eucalyptus globulus* Labill.	Myrtaceae	N/ Barzaf	Exotic	Tree
38	*Ficus sur*	Moraceae	Shola	Indigenous	Tree
39	*Grevillea robusta R.Br.*	Proteaceae	Giraviliya	Indigenous	Tree
40	*Hagenia abyssinica* (Bruce) J.F. Gmelin	Rosaceae	Kosso	Indigenous	Tree
41	*Juniperus procera* Hochst.	Cupressaceae	Yabsha Tsid	Indigenous	Tree
42	*Justicia schimperiana* (Hochst. ex Nees)	Acanthaceae	Sensel	Indigenous	Shrub
43	*Lactuca sativa L.*	Asteraceae	Selata	Exotic	Herb
44	*Lippia adoensis* Hochst.ex Walp.	Verbenaceae	Koseret	Endemic	Herb
45	*Lycopersicon esculentum* Mill.	Solanaceae	Timatim	Exotic	Herb
46	*Malus sylvestris* Miller.	Rosaceae	Apple	Exotic	Tree
47	*Mangifera indica* L.	Anacardiaceae	Mango	Exotic	Tree
48	*Melia azedarach* L.	Meliaceae	Nime	Exotic	Tree
49	*Millettia ferruginea* (Hochst.)Bak.	Fabaceae	Birbira	Endemic	Tree
50	*Musa acuminata* Colla	Musaceae	Muze	Indigenous	Herb
51	*Nicotiana tabacum L.*	Solanaceae	Tambaho	Indigenous	Herb
52	*Ocimum basilicum* var.	Lamiaceae	Besobela	Indigenous	Herb
53	*Ocimum lamiifolium* Hochst.ex. Benth.	Lamiaceae	Damakesse	Indigenous	Herb
54	*Olea europaea* L. subsp. cuspidata	Oleaceae	Weyra	Indigenous	Tree
55	*Opuntia cylindrica* (Lam). D.C.	Cactaceae	kulekoale	Exotic	Shrub
56	*Pennisetum purpureum Schumach*	Poaceae	Zihone sar	Exotic	Herb
57	*Persea americana* Mill.	Lauraceae	avocado	Exotic	Tree
58	*Podocarpus falcatus* (Thunb.)Mirb.	Podocarpaceae	Zigba	Indigenous	Tree

59	*Prunus africana* (Hook.f.)Kalkm.	Rosaceae	Tikur enchit	Indigenous	Tree
60	*Prunus persica* L.	Rosaceae	Kok	Indigenous	Tree
61	*Prunus x doemstica* L.	Rosaceae	Prim	Exotic	Tree
62	*Psidium guajava* L.	Myrtaceae	Zeitun	Exotic	Tree
63	*Pycnostachys abyssinica* Fresen.	Lamiaceae	Tontona	Endemic	Shrub
64	*Rhamnus prinoides* L‟ Herit.	Rhamnaceae	Gesho	Indigenous	Shrub
65	*Ricinus communis* L.	Euphorbiaceae	Gullo	Indigenous	Shrub
66	*Rosmarinus officinalis* L.	Lamiaceae	siga mitibesha	Exotic	Herb
67	*Rumex abyssinicus* Jacq.	Polygonaceae	Meqmeqo	Indigenous	Herb
68	*Ruta chalepensis L.*	Rutaceae	Tendam	Indigenous	Herb
69	*Saccharum officinarum* L.	Poaceae	Shenkorageda	Exotic	Herb
70	*Sesbania sesban (L.)Merr.*	Fabaceae	Sesbaniya	Indigenous	Shrub
71	*Solanum tuberosum* L.	Solanaceae	Dinchi	Exotic	Herb
72	*Sorghum bicolor* L.	Poaceae	Mashilla	Indigenous	Herb
73	*Spathodea campanulata (S. nilotica)*	Bignoniaceae	ykibrit hinchit	Exotic	Tree
74	*Syzygium guineense* (Wild.) DC.	Myrtaceae	Dokma	Indigenous	Shrub
75	*Vernonia amygdalina* Del.	Asteraceae	Grawa	Indigenous	Shrub
76	*Zea mays* L.	Poaceae	Bokolo	Exotic	Herb
77	*Zingiber officinale* Rosc.	Zingiberaceae	Zingibel	Exotic	Herb

Appendix 5.Botanical name of plant species in highland

No	**Scientific name**	Family name	Amharic name	Origin of plant	Habit growth
1	*Aframomum corrorima* (Braun) Jansen	Zingiberaceae	Korerima	Indigenous	Herb
2	*Ajuga integrifolia* Buch.-Ham. Ex D. Don	Lamiaceae	Anamura	Indigenous	Herb
3	*Allium cepa* L.	Alliaceae	K/Shinkurt	Exotic	Herb
4	*Allium sativum* L.	Alliaceae	N/shinkurt	Exotic	Herb
5	*Artemisia absinthium* L.	Asteraceae	Arity	Indigenous	Herb
6	*Arundinaria alpina* K. Schum.	Poaceae	Kerkha	Indigenous	Herb
7	*Arundo donax L.*	Poaceae	Shenbiko	Indigenous	Herb
8	*Beta vulagaris* var. esculenta L.	Chenopodiacea e	Qey sir	Exotic	Herb
9	*Beta vulgaris* subsp.vulparis	Amaranthaceae	Koseta	Exotic	Herb
10	*Brassica carinata* A. Br.	Brassicaceae	Gomen	Indigenous	Herb
11	Brassica oleracea var. capitata L.	Brassicaceae	T/gomen	Indigenous	Herb
12	*Capsicum annum* L.	Solanaceae	Kariea	Exotic	Herb
13	*Catha edulis* (Vahl) Forssk.ex Endl.	Celastraceae	Chat	Indigenous	Shrub
14	*Chloris gayana Kunth*	Paniceae	Rodes	Exotic	Herb
15	Coffea arabica L.	Rubiaceae	Buna	Indigenous	Shrub

16	*Colocasia esculenta* (L.) Schott	Araceae	Godere	Exotic	Herb
17	*Cordia africana* Lam.	Boraginaceae	Wanza	Indigenous	Tree
18	*Croton macrostachyus* Del.	Euphorbiaceae	Bisana	Indigenous	Tree
19	*Cucurbita pepo* L.	Cucurbitaceae	Duba	Exotic	Herb
20	*Cupressus lusitanica*	Cupressaceae	Yef.Tid.	Exotic	Tree
21	*Cymbopogon citratus* (DC.)Stapf.	Poaceae	Tej-sar	Exotic	Herb
22	*Daucus carota* L.	Apiaceae	Carrot	Exotic	Herb
23	*Ekebergia capensis* Sparrm.	Meliaceae	Lol	Indigenous	Tree
24	*Ensete ventricosum* (Welw.)	Musaceae	Enset	Indigenous	Herb
25	*Erythrina brucei* Schweinf.	Fabaceae	korch	Endemic	Tree
26	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Key Barzaf	Exotic	Tree
27	*Eucalyptus globulus* Labill.	Myrtaceae	N/ Barzaf	Exotic	Tree
28	*Ficus sur*	Moraceae	Shola	Indigenous	Tree
29	*Grevillea robusta R.Br.*	Proteaceae	Giraviliya	Indigenous	Tree
30	*Hagenia abyssinica* (Bruce) J.F. Gmelin	Rosaceae	Kosso	Indigenous	Tree
31	*Juniperus procera* Hochst.	Cupressaceae	Yabsha Tsid	Indigenous	Tree
32	*Lactuca sativa L.*	Asteraceae	Selata	Exotic	Herb
33	*Lippia adoensis* Hochst.ex Walp.	Verbenaceae	Koseret	Endemic	Herb
34	*Lycopersicon esculentum* Mill.	Solanaceae	Timatim	Exotic	Herb
35	*Malus sylvestris* Miller.	Rosaceae	Apple	Exotic	Tree
36	*Musa acuminata* Colla	Musaceae	Muze	Indigenous	Herb
37	*Nicotiana tabacum L.*	Solanaceae	Tambaho	Indigenous	Herb
38	*Ocimum basilicum* var.	Lamiaceae	Besobela	Indigenous	Herb
39	*Ocimum lamiifolium* Hochst.ex. Benth.	Lamiaceae	Damakesse	Indigenous	Herb
40	*Olea europaea* L. subsp. cuspidata	Oleaceae	Weyra	Indigenous	Tree
41	*Pennisetum purpureum Schumach*	Poaceae	Zihone sar	Exotic	Herb
42	*Persea americana* Mill.	Lauraceae	avocado	Exotic	Tree
43	*Podocarpus falcatus* (Thunb.)Mirb.	Podocarpaceae	Zigba	Indigenous	Tree
44	*Prunus africana* (Hook.f.)Kalkm.	Rosaceae	Tikur enchit	Indigenous	Tree
45	*Prunus persica* L.	Rosaceae	Kok	Indigenous	Tree
46	*Rhamnus prinoides* L‟ Herit.	Rhamnaceae	Gesho	Indigenous	Shrub
47	*Ricinus communis* L.	Euphorbiaceae	Gullo	Indigenous	Shrub
48	*Rosmarinus officinalis* L.	Lamiaceae	siga mitibesha	Exotic	Herb
49	*Ruta chalepensis L.*	Rutaceae	Tendam	Indigenous	Herb
50	*Rytigynia neglecta (Hiern) Robyns*	Rubiaceae	Abera	Indigenous	Tree
51	*Saccharum officinarum* L.	Poaceae	Shenkoraged a	Exotic	Herb
52	*Sesbania sesban (L.)Merr.*	Fabaceae	Sesbaniya	Indigenous	Shrub
53	*Solanum tuberosum* L.	Solanaceae	Dinchi	Exotic	Herb

54	*Teclea nobilis* Del.	Rutaceae	Taa	Indigenous	Shrub
55	Terminalia	Combretaceae	Aballo'o	Indigenous	Tree
56	*Vernonia amygdalina* Del.	Asteraceae	Grawa	Indigenous	Shrub
57	*Zea mays* L.	Poaceae	Bokolo	Exotic	Herb

Appendix 6. Relative Frequency of plant species in mid altitude

Scientific name	**Frequency**	**Frequency %**	**RF**
Ensete ventricosum (Welw.) Cheesman	80	96.4	4.73
Persea american Mill.	78	94.0	4.62
Cordia africana L.	74	89.2	4.38
Brassica carinata	72	86.7	4.26
Zea mays L.	65	78.3	3.85
Coffea arabica L.	62	74.7	3.67
Solanum tuberosum L.	59	71.1	3.49
Catha edulis(Vahl.) Forssk.ex Endl.	57	68.7	3.37
Capsicum annuum L.	56	67.5	3.31
Ruta chalepensis L.	52	62.7	3.08
Croton macrostachyus	50	60.2	2.96
Ocimum basilicum L.	45	54.2	2.66
Beta vulgaris L.	44	53.0	2.60
Cupressus lusitanica	44	53.0	2.60
Daucus carota L.	43	51.8	2.54
Erythrina brucei	43	51.8	2.54
Saccharum officinarum L.	36	43.4	2.13
Casimiroa edulis La. Llave.	35	42.2	2.07
Lycopersicon esculentum Mill.	35	42.2	2.07
Cucurbita pepo L.	34	41.0	2.01
Musa X paradisiaca L.	32	38.6	1.89
Brassica oleracea L. var. capitata	32	38.6	1.89
Olea europaea subsp.	27	32.5	1.60

Ocimum lamiifolium Hochst ex Benth	26	31.3	1.54
Rosmarinus officinalis L.	24	28.9	1.42
Nicotiana tabacum L.	23	27.7	1.36
Arundo donax L.	22	26.5	1.30
Juniperus procera Hochst,ex.Endl	21	25.3	1.24
Arundinaria	20	24.1	1.18
Lippia adonensis Hochst.Ex Walp.	20	24.1	1.18
Prunus africana L.	20	24.1	1.18
Allium sativum L.	19	22.9	1.12
Allium cepa L.	19	22.9	1.12
Beta vulgaris subsp.vulparis	18	21.7	1.07
Eucalyptus globulus Labil	17	20.5	1.01
Rhamnus prinoides L" Herit.	16	19.3	0.95
Podocarpus falcatus	16	19.3	0.95
Mangifera indica L.	15	18.1	0.89
Malus sylvestris Miller	14	16.9	0.83
Sesbania sesban (L.)Merr.	14	16.9	0.83
Ajuga integrifolia Buch, Ham	13	15.7	0.77
Colocasia esculenta (L.)Schoot.	13	15.7	0.77
Acacia abyssinica Hochst.ex Benth	11	13.3	0.65
Lactuca sativa L.	11	13.3	0.65
Citrus aurantifolia (Christm.) Swingle	10	12.0	0.59
Citrus sinesis L. Osb.	9	10.8	0.53
Chloris gayana Kunth	9	10.8	0.53
Cymbopogon citratus (DC.)Stapf.	9	10.8	0.53
Artemisia absinthium L.	8	9.6	0.47
Millettia ferruginea	8	9.6	0.47
Annona reticulate L	8	9.6	0.47
Vernonia amygdalina Del.	8	9.6	0.47
Sorghum bicolor (L.) Moench	8	9.6	0.47
Pennisetum purpureum Schumach	8	9.6	0.47

Ficus sur Forssk.	7	8.4	0.41
Psidium guajava L.	7	8.4	0.41
Canavalia africana L.	6	7.2	0.36
Ricinus communis L.	6	7.2	0.36
Prunus x domestica L.	6	7.2	0.36
Prunus persica (L.) Batch	5	6.0	0.30
Afromomum korarima (Braun) Jansen	5	6.0	0.30
Casuarina cunninghamiana	5	6.0	0.30
Zingiber officinalis L.	5	6.0	0.30
Grevillea robusta R.Br.	3	3.6	0.18
Dovyalis caffra (Hook.f.Harv.)Hook.f.	3	3.6	0.18
Opuntia cylindrica (Lam.) DC.	3	3.6	0.18
Spathodea campanulata (S. nilotica)	3	3.6	0.18
Rumex abyssinicus Jacq	2	2.4	0.12
Eucalyptus camaldulensis Dehnh.	2	2.4	0.12
Carica papaya L.	2	2.4	0.12
Justicia scnimperiana	2	2.4	0.12
Caesalpinia decapetala	1	1.2	0.06
Syzygium guineense	1	1.2	0.06
Hagenia abyssinica (Bruce) J. F. Gmel.	1	1.2	0.06
Melia azedarach L.	1	1.2	0.06
Citrus medica L.	1	1.2	0.06
Pycnostachys abyssinica fresen	1	1.2	0.06

Appendix 7. **Relative Frequency of plant species in Highland**

Scientific name	Frequency	Frequency %	RF
Ensete ventricosum (Welw.) Cheesman	52	100	5.84
Croton macrostachyus	45	86.54	5.05
Brassica carinata	45	86.54	5.05
Solanum tuberosum	39	75	4.38
Capsicum annuum	37	71.15	4.15
Cupressus lusitanica	36	69.23	4.04
Zea mays	33	63.46	3.70
Erythrina brucei	33	63.46	3.70
Ruta chalepensis	30	57.69	3.37
Ocimum basilicum	28	53.85	3.14
Eucalyptus globulus	26	50	2.92
Arundo donax	26	50	2.92
Persea american	24	46.15	2.69
Ocimum lamiifolium Hochst ex Benth	24	46.15	2.69
Lippia adonensis Hochst.Ex Walp.	22	42.31	2.47
Arundinaria	20	38.46	2.24
Allium sativum L.	20	38.46	2.24
Cucurbita pepo L.	19	36.54	2.13
Saccharum officinarum L.	19	36.54	2.13
Coffea arabica L.	18	34.62	2.02
Rosmarinus officinalis L.	18	34.62	2.02
Olea europaea subsp. caspidata	18	34.62	2.02
Juniperus procera	16	30.77	1.80
Artemisia absinthium	15	28.85	1.68
Prunus africana	14	26.92	1.57
Colocasia esculenta Schoot.	12	23.08	1.35
Vernonia amygdalina	12	23.08	1.35
Allium cepa	12	23.08	1.35

Nicotiana tabacum	11	21.15	1.23
Podocarpus falcatus	11	21.15	1.23
Malus sylvestris	10	19.23	1.12
Catha edulis	10	19.23	1.12
Musa X paradisiaca	10	19.23	1.12
Beta vulgaris	10	19.23	1.12
Cordia africana	10	19.23	1.12
Rytigynia neglecta	9	17.31	1.01
Cymbopogon citratus	9	17.31	1.01
Rhamnus prinoides	8	15.38	0.90
Teclea nobilis	8	15.38	0.90
Daucus carota	7	13.46	0.79
Ekebergia capensis	7	13.46	0.79
Lycopersicon esculentum	7	13.46	0.79
Pennisetum purpureum	7	13.46	0.79
Hagenia abyssinica	6	11.54	0.67
Lactuca sativa	6	11.54	0.67
Brassica oleracea . var. capitata	6	11.54	0.67
Chloris gayana	5	9.62	0.56
Ficus sur Forssk.	5	9.62	0.56
Beta vulgaris subsp.vulparis	4	7.69	0.45
Grevillea robusta	3	5.77	0.34
Terminalia	2	3.85	0.22
Ajuga integrifolia Buch, Ham	2	3.85	0.22
Ricinus communis	1	1.92	0.11
Eucalyptus camaldulensis Dehnh.	1	1.92	0.11
Prunus persica	1	1.92	0.11
Afromomum korarima	1	1.92	0.11
Sesbania sesban	1	1.92	0.11

Appendix 8. **Botanical name of woody species in both altitude.**

No	**Scientific name**	Family name	Origin of plant
1	Acacia abyssinica subsp. abyssinica	Mimosoideae	indigenous
2	Annona reticulata L	Annonaceae	exotic
3	Caesalpinia decapetala	Caesalpinioideae	exotic
4	*Carica papaya L.*	Caricaceae	exotic
5	*Casimiroa edulis* La. Llave.	Rutaceae	exotic
6	*Casuarina cunninghamiana*	Casuarinaceae	exotic
7	*Citrus medica*	Rosaceae	exotic
8	*Citrus sinesis* L. Osb.	Rutaceae	exotic
9	*Cordia africana*	Boraginaceae	indigenous
10	*Croton macrostachyus*	Euphorbiaceae	indigenous
11	*Cupressus lusitanica*	Cupressaceae	exotic
12	*Ekebergia capensis* Sparm.	Somboo	indigenous
13	*Erythrina brucei*	Papilionoideae	endemic
14	*Eucalyptus camaldulensis*	Myrtaceae	exotic
15	*Eucalyptus globulus Labil*	Myrtaceae	exotic
16	*Ficus sur F.capens*	Moraceae	indigenous
17	*Grevillea robusta R.Br.*	Proteaceae	exotic
18	*Hagenia abyssinica*	Rosaceae	indigenous
19	*Juniperus procera Hochst,ex.Endl*	Cupressaceae	indigenous
20	*Malus sylvestris Miller*	Rosaceae	exotic
21	*Mangifera indica L.*	Anacardiaceae.	exotic
22	*Melia azedarach L.*	Meliaceae	exotic
23	*Millettia ferruginea,*	Papilionoideae	indigenous
24	*Olea europaea subsp caspidata*	Oleacea	indigenous
25	Opuntia cylindrica (Lam.) DC.	Euphorbiaceae	exotic
26	*Persea american Mill.*	Lauraceae	exotic
27	*Podocarpus falcatus*	Podocarpaceae	indigenous

28	*Prunus africanus*	Rosaceae	indigenous
29	*Prunus persica (L.) Batch*	Rosaceae	exotic
30	*Prunus x domestica L.*	Rosaceae	exotic
31	*Psidium guajava L.*	Myrtaceae	exotic
32	*Rhamnus prinoides L. herit*	Rhamnaceae	indigenous
33	*Ricinus communis L.*	Euphorbiaceae	indigenous
34	*Rytigynia neglecta* (Hiern) Robyns	Rubiaceae	indigenous
35	*Sesbania sesban (L.)Merr.*	Fabaceae	indigenous
36	*Spathodea campanulata (S. nilotica)*	Bignoniaceae	exotic
37	Syzygium guineense	Myrtaceae	indigenous
38	*Teclea nobilis Del.*	Rutaceae	indigenous
39	*Vernonia amygdalina*	Asteraceae	indigenous

Appendix 9.**Important value index of woody species in mid altitude.**

Scientific name	Rel.Freq	Rel.Abundance	Rel.Dom	IVI
Cordia africana L.	13.43	17.47	3.85	34.75
Persea american Mill.	14.16	15.27	3.00	32.43
Corton macrostachyus L.	9.07	10.89	4.92	24.88
Cupressus lusitanica Hill.	7.99	13.08	2.66	23.73
Erythrina brucei	7.80	7.95	5.26	21.01
Eucalyptus globulus Labil	3.09	4.04	4.17	11.30
Prunus africanus	3.63	2.74	4.12	10.49
Juniperus procera Hochst,ex.Endl	3.81	3.22	3.42	10.45
Casimiroa edulis La. Llave.	4.72	3.22	2.11	10.04
Podocarpus falcatus	2.90	1.92	5.09	9.92
Olea europaea var.africana	3.27	2.67	3.71	9.65
Millettia ferruginea,	1.45	1.30	5.17	7.92
Ficus sur F.capens	1.27	0.68	5.33	7.28
Malus sylvestris Miller	2.54	2.26	2.38	7.18

Acacia abyssinica subsp. abyssinica	2.00	1.51	3.35	6.85
Opuntia cylindrica (Lam.) DC.	0.54	0.21	5.64	6.39
Mangifera indica L.	2.72	1.85	1.78	6.35
Spathodea campanulata (S. nilotica)	0.54	0.41	5.19	6.15
Casuarina cunninghamiana	0.91	0.89	3.62	5.41
Grevillea robusta R.Br.	0.54	0.55	3.08	4.18
Rhamnus prinoides L. herit	2.54	1.10	0.52	4.16
Citrus medica L.	0.18	0.07	3.85	4.10
Vernonia amygdalina	1.45	1.37	1.12	3.94
Melia azedarach L.	0.18	0.21	3.06	3.45
Prunus persica (L.) Batch	0.91	0.89	1.59	3.39
Psidium guajava L.	1.27	0.82	0.99	3.08
Citrus sinesis L. Osb.	1.63	0.82	0.53	2.99
Annona reticulate L	1.45	0.82	0.71	2.99
Eucalyptus camaldulensis Dehn.	0.36	0.14	2.23	2.73
Ricinus communis L.	1.09	0.41	0.72	2.22
Caesalpinia decapetala	0.18	0.07	1.92	2.17
Prunus x domestica L.	0.36	0.48	1.23	2.07
Carica papaya L.	0.36	0.21	1.33	1.90
Hagenia abyssinica	0.18	0.07	1.50	1.75
Sesbania sesban (L.)Merr.	0.91	0.34	0.37	1.62
Syzygium guineense	0.18	0.07	0.48	0.73
	100.00	100.00	100.00	

Appendix 10.Important value index of woody species in Highland.

Scientific name	Rel.Freq	Rel.Abundance	Rel.Dom	IVI
Corton macrostachyus L.	14.71	23.24	5.67	43.62
Cupressus lusitanica Hill.	11.76	23.94	3.39	39.09
Erythrina brucei	10.78	11.37	7.34	29.50
Eucalyptus globulus Labil	8.50	12.86	5.06	26.42
Persea american Mill.	7.84	4.15	4.04	16.04
Olea europaea var.africana	5.88	3.66	4.40	13.94
Prunus africanus	4.58	2.08	5.60	12.25
Cordia africana L.	3.27	1.48	6.94	11.69
Podocarpus falcatus	3.59	1.78	6.31	11.69
Juniperus procera Hochst,ex.Endl	5.23	2.08	3.42	10.72
*Ekebergia capensis*Sparm.	2.29	1.58	6.14	10.01
Rytigynia neglecta (Hiern) Robyns	2.94	2.08	4.94	9.96
Ficus sur F.capens	1.63	0.69	7.60	9.93
Eucalyptus camaldulensis Dehn.	0.33	0.30	7.61	8.23
Vernonia amygdalina	3.92	1.98	1.94	7.84
Teclea nobilis Del.	2.61	1.98	3.01	7.60
Hagenia abyssinica	1.96	0.69	3.95	6.60
Grevillea robusta R.Br.	0.98	0.89	4.63	6.50
Malus sylvestris Miller	3.27	1.78	1.00	6.05
Rhamnus prinoides L. herit	2.61	0.89	0.85	4.35
Terminalia	0.65	0.20	3.38	4.23
Prunus persica (L.) Batch	0.33	0.20	1.91	2.44
Ricinus communis L.	0.33	0.10	0.85	1.27
	100.00	100.00	100.00	300.00