ASSESSMENT OF WOODY SPECIES IN AGROFORESTRY SYSTEMS AROUND JIMMA TOWN, SOUTHWEST ETHIOPIA

MSc THESIS

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ASSESSMENT OF WOODY SPECIES IN AGROFORESTRY SYSTEMS AROUND JIMMA TOWN, SOUTHWEST ETHIOPIA

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A Thesis

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MSc THESIS APPROVAL SHEET

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DEDICATION

I dedicate the thesis to my wife, Meskerem Alemayehu and my son, Yonatan Buchura, for all their contribution.

STATEMENT OF AUTHOR

First, I declare that this thesis is my own work and that all sources of materials used for writing it have been duly acknowledged. This thesis has been submitted to Jimma University, College of Agriculture and Veterinary Medicine in partial fulfillment of the requirements for the Degree of Master of Science and is deposited at the library of the University to be made available to borrowers under the rules and regulations of the library. I declare that I have not submitted this thesis to any other institution anywhere for the award of any academic degree, diploma, or certificate.

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BIOGRAPHICAL SKETCH

The Author, Buchura Negesse Wari, was born in East Shewa Zone, Gimbichu District on November 12, 1982. He attended elementary education at Dirre Dogomsisa school from 1992-1996 and Cheffe Donsa Junior elementary school from1997 - 1998, Secondary education at Bishoftu Ada'a Model secondary high school from 1998 - 2000, Diploma at Alage Agricultural TVET college from 2000 - 2004 and he attended his BSc program in Jimma University College of Agriculture and Veterinary Medicine. He graduated with Bachelor of Science in Natural Resource Management in 2009. Then, he was employed by Oromia Agricultural Office in Boset District Agricultural and Rural Development Office, East Shewa Zone. He served as agriculture extension supervisor, soil and water conservation Expert and Naural Resource Management process owner after received BSc until he joined Jimma University, College of Agriculture and Veterinary Medicine October 2014 to pursue MSc program in field of Natural Resource Management (Watershed Management).

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ABBREVIATIONS

ANOVA	Analysis of Variance
BOFED	Bureau of Finance and Economic Development
BOPED	Bureau of Planning and Economic Development
CSA	Central Statistics Agency
DBH	Diameter at Breast Height
GPS	Global Positioning System
ha	Hectare
IVI	Importance Value Index
Km	Kilometer
LSD	Least Significance Difference
LUT	Land Use Type
m	Meter
PA	Peasant Association
SPSS	Statistical Package for Social Science
WSF	World's State Forests

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ABSTRACT

Woody species are the major components of traditional agroforestry system. Agroforestry species varies with the types of agroforestry practices in different parts of Ethiopia. This study was conducted to assess woody species across land uses in three different sites around Jimma town, Southwest Ethiopia. A total of 100 plots were laid out (20 plots of homegardens, 24 plots of crop fields, 19 plots of coffee farms, 20 plot of pasture lands and 17 plots of woodlots) with sample plot size of 25m x *25m for homegarden, coffee farm and grazing land, 40m*x *40m for crop field and 10m* x*10m for woodlots and calculated per hectare. The result showed that a total of 60 woody species belonging to 34 families and 54 genera were identified from three sites. Fabaceae was the most dominant family with 11 (18.3%) species followed by Euphorbiaceae family with 7 (11.7%) species. Out of identified species, 53.3% were trees, 45% shrubs and 1.67% climber. Species diversity, richness, evenness and density were statistically not significantly different ($P > 0.05$) within sites, slope and elevation classes, whereas highly significant different ($P < 0.05$) between land uses system. Grazing lands were more diversified than homegardens, coffee farm, crop field and woodlots in the overall study sites. A density of woody species in woodlots (9495 stems/ha) was higher than coffee farm (2485 stems/ha), homegarden (2112 stems/ha), grazing land (1192.3 stems/ha) and crop field (532 stems/ha) in the study area. Therefore, density and frequency of individual woody species were identified various in different land use type, slope and elevation classes. The higher percentage of woody species was frequently observed at the lower frequency classes in all land use system. Generally, agroforestry systems are conserving several woody species diversity in its system and woody species* w*ere varies among land use types in the study area. More basic and applied researches should be encouraged and done to support the plan and management of agroforestry system.*

Keywords: Agroforestry system, woody species, homegardens, crop field, grazing land, coffee farm, Jimma

1. INTRODUCTION

1.1 Background

Agroforestry is an ancient practice of cultivating trees with crops and livestock (Nair, 1993; WSF, 2005; McNeely and Schroth, 2006) and is deliberate use of tree in agricultural landscape (Kumar and Nair, 2006). It is an integrated land use approach that characterized by deliberate maintenance of trees and other woody perennials in fields and pastures (Zaman *et al.,* 2010). It can also be described as a multispecies systems which consist of field crop species, pasture species, trees, or combinations of these (Malezieux *et al* ., 2009).

Agroforestry systems come in a wide variety of shapes and forms throughout Africa (Foresta *et al.*, 2013) and other developing countries (Nair, 1993). Improved fallows, rotational woodlots, contour hedgerows, enclosure, boundary planting, homegardens and farm forestryare some agroforestry systems and technologies practiced in Eastern Africa (Chirwa *et al.*, 2015). Agroforestry practices can be relevant for different agro-ecological zones and many systems with a range of different compositions which can fulfill essentially the same functions for livelihoods and landscapes (Mbow *et al.,* 2013).

Practically, various agroforestry practices including various forms of tree planting and indigenous practices exist (Nyaga *et al.,* 2015) and trees are planted on farms in different niches (Nair, 1993). Several types of traditional agroforestry practices exist in different parts of Ethiopia.These practices are found on crop lands, homegardens, farm boundary, fencing, grazing lands and degraded lands (Tesfaye, 2005; Abreha and Gebrekidan, 2014).

Agroforestry encompasses a very large and diverse set of practices ranging from croplands to complex forest production (Ogunwusi, 2013). It has been known in its diversity, ecosystem balance, sustainability, household food security and rural development (Tesfaye *et al*., 2010). Variety of woody species in agricultural systems supplies products and ecological services (Tesfaye *et al*., 2010; Mesele *et al.,* 2012; Girmay *et al*., 2015). Homegarden agroforestry practices can provide good socio-economical and agro-ecological service (Kumer and Nair, 2004; Badege *et al.,* 2013; Ewuketu, 2014).

Woody species diversity influenced by various environmental factors. Diverse physiographic features have contributed to the formation of diverse ecosystems characterized by great species diversity (Nair, 1993) and physical factors influence farm level woody species diversity (Tesfaye, 2005). Any changes in any component of the whole system will have effects on the other components because agroforestry system is diversified and integrated (Acharya and Kafle, 2009; Zerihun and Kaba, 2011). The compositions of crops are influenced by altitude of farms (Tesfaye, 2013) and related with a slope (Mamo *et al*., 2013). The interactions of nature within and between species can influence its coexistence gain by changing its environment, either directly or indirectly (Reyes, 2008).

In Ethiopia, inventory and documentation of agroforestry practices are very few and has been concentrated in the southern parts of Ethiopia (Tesfaye *et al*., 2010; Mathewos *et al.,* 2013; Badege *et al*., 2013). Even though few agroforestry empirical researches were conducted in the southwestern, it is inadequate from biophysical point of view to understand dynamic nature of agroforestry in phase of population growth. Information on system is scattered and unbalanced as well as active evaluation approaches were not well developed and documented. Even existing information varies within sites and agroforestry system which needs development of management approaches and scientific knowledge to identify species and enable proper use of plant composition in the system.

Therefore, assessing the existing woody species in theagroforestry system is necessary to fill this gap. Scientific information and clear understanding of agroforestry system component is considered to be essential for planning and sustainable management of the systems. This demand-driven scientific research will address identified gaps with regard to plant species composition in agroforestry system around Jimma town, Southwestern Ethiopia.

1.2 Objective

1.2.1 General objective

- To investigate existing woody species in Agroforestry system around Jimma town, Southwest Ethiopia

1.2.2 Specific objectives

- To identify, record and document agroforestry systems component currently being practiced in the study area
- To identify woody species used for agroforestry systems in the study area.
- To identify woody species composition and diversity of the agroforestry in the area

1.3 Reseach Questions

This research will respond the folloing questions

i) What agroforestry systems are currently being practiced in the area?
ii) What is the woody species diversity and structure of the agroforestry? and
iii) What are woody species used for agroforestry systems in the area?

2. LITERATURE REVIEW

2.1 Definition and Concept of Agroforestry

Agroforestry is the set of land-use practices involving the deliberate combination of trees, agricultural crops and/or animals on the same land management unit in some form of spatial arrangement or temporal sequence (Lundgren and Raintree, 1982; Xu *et al.*, 2011). Agroforestry systems can be classified on the type of components involved namely, silvopastoral systems (production of livestock and woody plant species), agrosilvicultural systems (woody plant species and crops) and agrosilvopastoral systems (production of livestock, woody plant species and crops) (Nair, 1993).

Agroforstry is a development of the interface between agriculture and forestry. Trees and shrubs, crops, pasture, and livestock together with the environmental factors of climate, soil and landform are the main components (Young, 1989). This componens can be arranged in many different ways (Nair, 1993) and determined in local physical environment, ecological characteristics, socioeconomic and cultural factors (Kumar and Nair, 2004).

A large number of tree species with different qualities can be used in agroforestry systems (Lwakuba *et al.*, 2003). Different systems are often categorized on the basis of structure (temporal or spatial arrangement), function (Windbreak, soil fertility and soil conservation), socioeconomics (management and commercial objective) and ecology (environmental conditions and ecological sustainability) (Nair, 1993).

It requires relatively little land as trees can be planted around the homestead and on field boundaries (Franzel and Wambugu, 2007). Agroforestry used as a strategy to overcome the lack of success in past tree planting through providing opportunities for both food and tree production on the same unit of land (Badege and Abdu, 2003; Tahir, 2008). It has been known in its potentials as a land management alternative for maintaining the soil fertility and productivity (Reyes, 2008). Trees are used for shelter belt, fodder, cash income and soil fertility (Abreha and Gebrekidan, 2014) and also known for ecological sustainability and diversifies livelihood of local community (Kumar and Nair, 2006).

2.2 Agroforestry Practices

Agroforestry practice is a distinctive arrangement of components in space and time (Alao and Shuaibu, 2013). Main agroforestry practices include improved fallows, taungya (growing annual agricultural crops during the establishment of a forestry plantation), homegardens, alley cropping, growing multipurpose trees and shrubs on farmland, boundary planting, farm woodlots, orchards or tree gardens, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture and apiculture with trees (Nair, 1993). Traditional agroforestry practices are found on crop lands, homegardens, farm boundary, fencing, grazing lands and degraded lands (Abreha and Gebrekidan, 2014). It includes trees and shrubs in silvopastoral lands, trees on farmlands and homesteads (Kindu, 2001).

2.2.1 Homegarden Agroforestry

It is commonly defined as land use system involving deliberate management of multipurpose trees and shrubs intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop, and animal unit is being intensively managed by family labour (Kumar and Nair, 2006).

Homegarden agroforestry systems are practiced in different parts of Ethiopia (Fentahun and Hager, 2010; Abreha and Gebrekidan, 2014; Tefera *et al*., 2015). It is characterized as backyards, front-yards, side-yards and enclosing yards in central, eastern, western and southern Ethiopia (Zemede and Ayele, 1995).

Homegardens are often described as generic land-use systems with high species diversity (Tesfaye *et al.,* 2010). Distribution of species in the homegarden creates a forest like multi-storey structure (Krishnal and Weerahewa, 2014) and is an assemblage of almost multipurpose tree, shrub and herb with some climbers in the boarder (Albuquerque *et al.,* 2005). It is very complex systems with very sophisticated structure and a large number of components (Fernandes and Nair, 1986; Bajigo and Tadesse, 2015).

Fruit trees were the predominant horticultural crop in the homegardens. The five most common fruit trees were *Citrus aurantifolia*, *Psidium guajava*, *Mangifera indica*, *Phoenix dactylifera* and *Citrus paradise* (Gebauer, 2005**)**. Mostly Plant species found in homegarden are *Persea americana , Cordia africana, Coffea arabica, Mangifera indica, Millettia ferruginea, Catha edulis, Ficus vasta, Psidium guajava* (Abreha and Gebrekidan, 2014), *Cordia africana, Coffea arabica, Mangifera indica, Persea americana* (Ewuketu *et al.,* 2014). *Coffea arabica, Rhamnus prinoides, Mangifera indica, Citrus aurantifolia, Citrus sinensis and Psidium guajava* are common fruit trees components of homegarden agroforestry (Aklilu *et al.,* 2013). Zerihun *et al.* (2011) also reported that *Persea americana, Coffea arabica, Catha edulis, Ensete ventricosum* and *Musa* species *are the most cultivated in the homegarden.*

2.2.2 Crop land Agroforestry

Presence of several agroforestry elements in the agricultural landscape may greatly enhance tree cover and structural heterogeneity and resources to the remaining forest remnants, thereby contributing to biodiversity maintenance (Schroth *et al.,* 2004). In farmland trees are mainly grown naturally, large in size and very scattered and trees are highly endangered as compared to other niches (Abreha and Gebrekidan, 2014).

When agricultural crops are planted near leguminous trees such as *Acacia albida* observed crop yields have been higher (Kumar and Nair, 2006; Adegeye *et al.,* 2011). The choice of trees and crops for inclusion in proposed taungya plantations considers the various intra and inter-specific interactions (Adegeye *et al.,* 2011). Because same tree species affect other plants through competing shade, nutrient, water and other factors (Abyot *et al.,* 2013).

The patterns of tree stocks and tree cover that emerge on farm lands are quite different from those found in natural forests. The tree species found in their farm land is through retention of naturally regenerated indigenous tree species and plantation activities. The major trees found on-farm lands and which were deliberately left by the farmers were *Croton macrostachys*, *Acacia abyssinica* and *Cordia africana* (Aklilu *et al., 2013)* and *Milletia ferruginea* is commonly grown trees (Abyot *et al*., 2013).

2.2.3 Coffee Agroforestry

There is high density of trees, small trees and shrubs in forest coffee system in southeastern and southwestern parts of the country (Feyera, 2006). A native tree species in traditional tree-crop and Enset-coffee agroforestry systems is higher in the eastern and southern parts of Ethiopia (Tesfaye, 2005; Zebene and Agren, 2007).

Farmers in southern Ethiopia retain *Cordia africana* and *Millettia ferruginea* in enset-coffee based agroforestry (Tesfaye, 2005; Zebene and Agren 2007; Mesele, 2013). Coffee is common agroforestry systems in southern part of Ethiopia and cultivated under the shade of remnant native trees such as *Albizia gummifera*, *Acacia abyssinica*, *Millettia ferruginea*, *Ficus sur*, *Ficus vasta* and *Cordia africana* (Mesele, 2013). The planting of *E. ventricosum* and *C. arabica* requires the existence of native shade trees, and further intensified the farming system to form multistrata agroforests (Mesele and Negussie, 2008). The major trees commonly used as shade trees in garden coffee include *Acacia abyssinica, A. sieberiana, Albizia gummifera, Bersama abyssinica, Celtis africana, Cordia africana, Croton macrostachyus, Ekebergia capensis, Entada abyssinica, Erythrina abyssinica, E. burana, Faidherbia albida, Ficus sur, F. sycomorus, F. vasta, Milletia ferruginea, Pygeum africanum, Olea capensis and Syzygium guineense* (Workafes and Kassu 2000). In fruit-coffee-agroforety system, fruit trees took up space, together with trees and shrubs. *M. ferruginea and Cordia africana* were the most dominant native tree species and *Diospyros abyssinica, Vepris dainellii* and *Dracaena steudneri* were the least dominant in coffee agroforestry system (Mesele *et al.,* 2012).

2.2.4 Grazing land Agroforestry

A large number of woody species occurs in the traditional bush fallow system and scattered trees on grazing land systems of the derived guinea savanna ecosystem (Oke and Jamala, 2013). Silvopastoral systems comprised of pasture forage crops between rows of trees is one of many promising agroforestry land-use systems. The successful use of these forages in agroforestry systems will require more complete understanding of plant response to the actual microenvironments encountered (Lin *et al.,* 1999).

The trees species identified in grazing land are very large in size and are very scattered (Abreha and Gebrekidan, 2014). *Cordia africana, Acacia abyssinica, Ficus ovate* and *Sesbania sesban* play an interactive role in animal production by providing shade, fodder and other services. The fodder trees serves as live fence around grazing units and farmyards, and Sometimes fruits and pods are consumed (Aklilu *et al.*, 2013).

2.2.5 Woodlots Agroforestry

Eucalyptus species are introduced into Ethiopia from Australia in 1894-1895 (Pohjonen and Pukkala, 1990). As FAO report shows about 42,300 hectares of plantations at the early 1970s in Ethiopia. Tola *et al.* (2014) and FAO (2011) reported that woodlots of exotic tree species such as Eucalyptus expanding because of increasing demand for various wood products.

The expansion of commodity production of non-traditional cash crops, mainly Khat (*Catha edulis*) and Eucalyptus species, has gradually resulted in a homogenization of the structure and composition (Tesfaye, 2005; Kumar and Nair, 2004; Mersha, 2013). According to Bajigo and Tadesse (2015) variation in structure and composition of woody species among agroforestry practices is characterized in the complex nature of homegarden whereas simple structure in woodlots due its single species composition. *Eucalyptus* is mainly cultivated as a single species but some smallholders mix with fruit trees and forest trees (FAO, 2011).

Distribution of woody species is less diversity in woodlot than parkland and Homegarden due to single species dominance i.e. Eucalyptus tree (Young, 1989; Nair, 1993).

2.3 Biophysical Factors Affecting Woody Species in Agroforestry System

Agroforestry system structure varies from place to place according to the local physical environment, ecological characteristics, socioeconomic and cultural factors (Kumar and Nair 2004). Altitude variation can determine species abundance and density Tesfaye (2005) and Species richness is favorably influenced by altitude (Fantahun, 2008). Elevation, slope and aspect significantly correlated negatively with species richness, whereas only elevation and slope related significantly (Mamo *et al*., 2013). Other scholars report disagree with this idea

which there is no significant variation in woody density, hedging and canopy cover among altitude zone (Mideksa *et al.,* 2015). Lozada *et al.* (2006) also stated that there is no consistent pattern of diversity reduction and species richness did not vary significantly among land-use types, either for observed or estimated values.

Diameter and height class distribution of the population structure of the North West Ethiopia reflected an interrupted reversed J-shape (L-shape). It shows that the highest frequency distribution recorded in the lower diameter and height classes which imply gradual decrease towards the higher classes (Abyot *et al.,* 2014; Temesgen *et al.,* 2015). This implies that human interference and management activities can determine the structure and composition of species. Mohammed *et al.* (2015) also stated that structures of coffee populations different along the management gradient.

2.4 Species Richness, Evenness and Diversity

Species richness, abundance and diversity of farm land tree species are different among different land use practices (Lalisa and Herbert, 2010; Bikila and Zebene, 2016). Numbers of scholars reported difference number/ species richness of woody species invarious study area and land use type. A total of 55 woody species in the traditional agroforestry practices of the Southeastern Ethiopia (Abiot and Gonfa, 2015) and 40 woody species in homegarden agroforestry, crop land, grazing land and natural forest of Tigray region, Ethiopia (Etefa and Raj, 2013).

Homegardens are characterized by a higher number of woody plant species than most other land use types (Belay *et al.,* 2014). Motuma *et al.* (2008) identified that 64 woody species in homegardens of Arsi Negelle district, South-Central of Ethiopia and 15 species in Dello Mena, South-East Ethiopia (Bikila and Zebene, 2016).A total of120 trees and shrubs species are grown with multiple perennial and annual crops in homegardens of south western of Ethiopia (Tesfaye, 2005).A total of 37 tree species are identified in Bangladesh (Zaman *et al.,* 2010), 26 woody species in Central Sudan (Gebauer, 2005), 44 woody species in North-Western Ethiopia (Ewuketu *et al*., 2014) and 28 woody species in Abreha we Atsebeha (Etefa and Raj, 2013).

In crop field a total of 32 woody species are identified in Arsi Negelle district, South-Central Ethiopia (Motuma *et al.,* 2008), 15 woody species in Abreha we Atsebeha (Etefa and Raj, 2013) and 49 tree species were in Southwestern Ethiopia (Tola *et al.*, 2014).In grazing land a total of 45 woody species in Bale Zone Southeast Ethiopia (Mideksa *et al.*, 2015), 29 woody species in South Omo Zone of Southern Ethiopia (Terefe *et al.,* 2010) and 18 woody species in Abreha we Atsebeha (Etefa and Raj, 2013). A total of 30 plant species are identified in the adjacent communal grazing lands in Northern Ethiopia (Wolde and Mastewal, 2013).

In *Eucalyptus camaldulensis* plantation woodlot 37 species in South Western Ethiopia (Shiferaw and Pavlis, 2012) and a total of 39 tree species are identified in Northeastern Zimbabwe (Tyynelä, 2001). *Eucalyptus camaldulensis* found in all woodlots sample plots and other species found in 4.6% to 26% of the total plots number (Tyynelä, 2001).

Shannon index of diversity varies between 0.86 and 1.88 in traditional agroforestry of Southern Ethiopia (Tesfaye, 2005), 2.22 in crop fields and 1.98 homegardens of South-Central Ethiopia (Motuma *et al*., 2008). The overall Shannon index of woody species with homegarden of Jebithenan district, Northwestern Ethiopia varies from 2.26 to 2.43 (Ewuketu *et al.*, 2014) and 1.31 in homegarden, 1.12 in cropland and 2.04 in grazing land (Etefa and Raj, 2013). The diversity index (H′) of *Eucalyptus camaldulensis* plantation and its neighboring native woodland were 1.568 and 2.091, respectively (Shiferaw and Pavlis, 2012).

Woody species evenness of traditional agroforestry varies between 0.37 and 0.64 in Southern Ethiopia (Tesfaye, 2005), 0.39 inhomegarden agroforestryof Tigray Region, Ethiopia (Etefa and Raj, 2013), ranges between 0.65 and 0.73 in Jebithenan district Northwestern Ethiopia (Ewuketu *et al.*, 2014), 0.48 in South-Central of Ethiopia (Motuma *et al*., 2008) and 0.813 to 1.00 in Sebeta-Awas District (Tefera *et al.*, 2015). Woody species evenness crop field agroforestry are 0.41 in Tigray Region, Ethiopia (Etefa and Raj, 2013) and 0.64 in South-Central of Ethiopia (Motuma *et al*., 2008).Species evenness of grazing land is 0.71 in Tigray Region, Ethiopia (Etefa and Raj, 2013).

Woody species evenness of homegarden agroforestry, cropland and grazing land are 0.39, 0.41 and 0.71, respectively (Etefa and Raj, 2013) and ranges between 0.65 and 0.73 (Ewuketu *et al.* (2014). Species evenness of crop field and homegarden are 0.64 and 0.48, respectively (Motuma *et al*., 2008). Shannon evenness index of woody species was 0.21 in Debark District, northern Ethiopia (Belay *et al.*, 2014). In southwest Ethiopia, small coffee farm holders Shannon index and Evenness of species are 3.5 and 0.87 respectively (Getachew *et al.*, 2014).

Species with the highest IVI are the most dominant in the particular vegetation (Simon and Girma, 2004) and in the *Eucalyptus camaldulensis* plantation ranges between 0.72 and 192.68 (Shiferaw and Pavlis, 2012). Variation of IVI among agroforestry practice is related to difference in species preference by farmers, difference in growth performance of species, number/existence of individual/dominance per plot, basal area and agroforestry plot area (Bajigo and Tadesse, 2015).

The density of woody species varies between 432 and 1176 plants per hectare in Nigeria (Akinbisoye *et al.*, 2014). The total density of woody plants in Debark District, northern Ethiopia is 246 individuals/ha (Belay *et al*., 2014). The average density of tree stand is 1450 stems per hectare (Aklilu *et al.*, 2013) and an average of 475 (Tesfaye, 2005) in the homegarden agroforestry systems. Eucalyptus species found as the highest density (192 individuals/ha) and other species were much less dense (Belay *et al*., 2014). In crop field average tree stand density ranged from 21 to 127 stems per hectare (Aklilu *et al.*, 2013). A total of 1401 individual trees (shade) were recorded across all site in West Africa (Dawoe *et al*, 2016) and the average density of coffee trees is about 3,600 stems/ha in Yayu forest (Tadesse, 2003). The average density of tree stand on woodlots is 5000 stems per hectare (Aklilu *et al*., 2013).

3. MATERIALS AND METHODS

3.1 Description of Study Site

Location

The study was conducted in Mazoria (Mana district), Merewa (Kersadistrict) and Waro-Kolobo (Dedo district) sites around Jimma town, Oromia National Regional State, Southwestern Ethiopia (Figure 1). Jimma zone located in between 7°23' and 8°47' N and 35°52' and 37°30' E and its capital town is Jimma which located 352 Km away from Addis Ababa, the capital city of Ethiopia (BOFED, 2007). The study sites found within 18 Km radius around Jimma town in Mana, Kersaand Waro-Kolobo districts. The altitudes of disticts were1470-2610m, 1740-2660m and 880-2400m above sea level, respectively (BOFED, 2007). The annual rainfall of Jimma town ranges from 1138 – 1690millimeters.The Maximum precipitation occurs during the three months, June to August, with minimum rainfall in December and January (Abebe *et al.*, 2011).

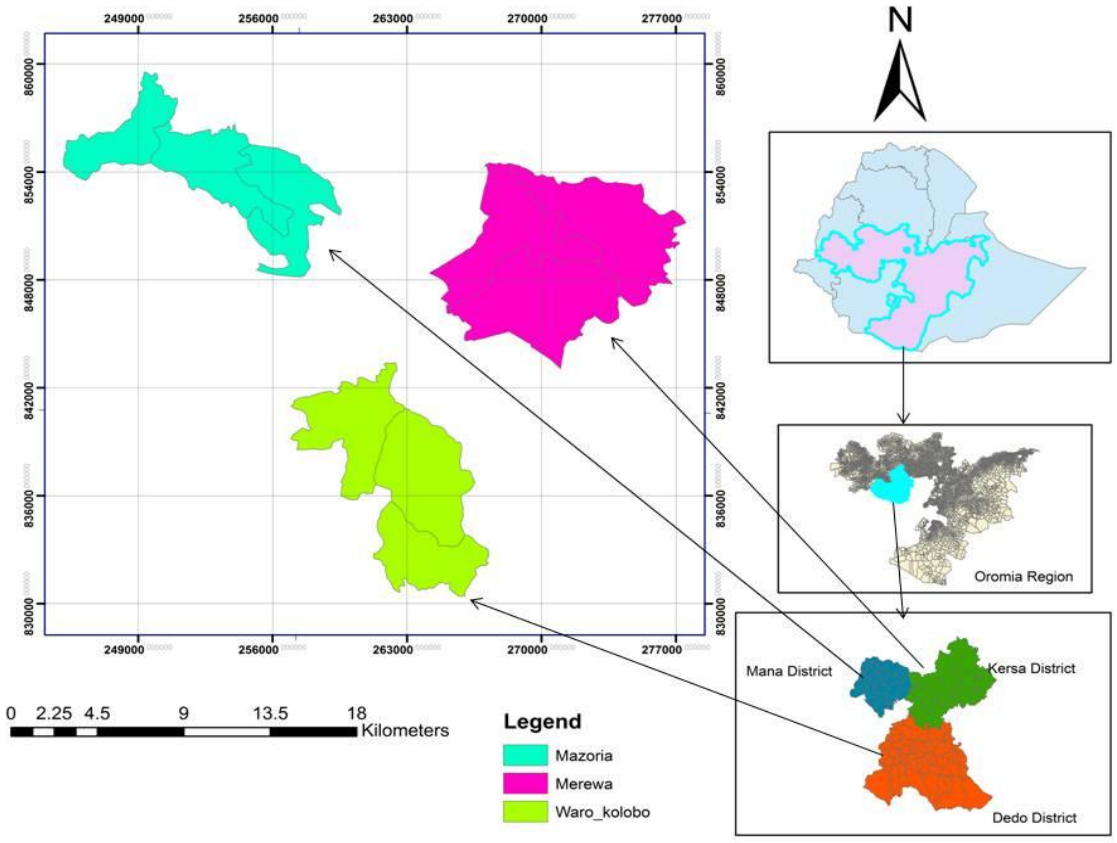

Figure 1: Map of Study Site (Source: Produced by the Author, 2016)

Soil and Geology

Dystric Nitosol, Orthic Acrisols, Chromic and Pellic Vertisols are the major soil types found in Jimma zone **(**BOPED, 2000**).** The dominant soil types are Dystric Nitosols and Orthic Acrisols in Manadistrict and, Orthic Acrisols and Pellic Vertisols in Kersa and Dedo districts (BOPED, 2000). According togeological surveys Mana and Dedo district are fallen under the tertiary volcanic and Kersa district consists of alkali olivine basalt and tufts (BOFED, 2007).

Demographic Information

The total population of the study area is 43,486 (Male 22,538 female 20,948) and total house hold is 6671 (Table 1).

Table 1: Total Population and household of study sites

SN	**Study Site**	**District Name**	**N$^{o.}$ of Kebeles**	**Population**			Household head
				Male	**Female**	**Total**	
1	Waro-Kolobo	Dedo	3	7616	7665	15281	2204
2	Mazoria	Mana	3	4660	4880	9540	1908
3	Merewa	Kersa	3	10,262	8403	18665	2559
Total			**9**	**22538**	**20948**	**43486**	**6671**

Source: Mana, Kersa and Dedo Agriculture and Natural Resource Management office (WANRMO), 2016

Socio-economic Activities

Agriculture is the means of the livelihood of the people. Most agricultural producers are subsistence farmers with smallholding. The major crops grown in the area are Maize, teff, sorghum, barley, Pulses crops and coffee (BOPED, 2000)**.** Coffee is the most important cash crop in the area (Zerihun *et al.,* 2011). Cattle production is characterized mainly by traditional smallholders that are kept in freely-grazing communal rangelands throughout the year (Yisehak *et al.,* 2013).

3.2 Methods

3.2.1 Types and Sources of Data

In this study both primary and secondary data sources were used. The primary data includes biophysical information (DBH, Height and numbers of woody species, slope and elevation of plots) in different land use system.

The primary data were gathered through field survey and measurement. Information on land use practices and trees/shrubs based land use were collected along transects from sampled plota. In this case local name, number of all live individuals and diameter at breast height (DBH) of all woody species with DBH $\geq$2.5cm and height $\geq$2.5m were recorded. Secondary data were gathered from different sources like journal articles, district documents and regional documents to enrich literatures and Knowledge gap.

3.2.2 Methods of Sampling and Sample Size Determination

Reconnaissance survey: A reconnaissance survey was conducted in December 2015. Reconnaissance survey was carried out before actual survey and data collection using transect line within 18 Km radius of Jimma town. A reconnaissance surveys were done after consultation with expert from zonal office, districts agricultural office and development agents of study areas

3.2.2.1 Sampling Techniques

Mazoria, Merewa and Waro-Kolobo sites were selected purposely to address the study objectives. Actual survey was carried out afterreconnaissance survey to collect data using transect line within 18 km radius of Jimma town.

Two transect lines (total 6) were established in each study sites across different land use types. Systematic sampling method was applied to locate the sample plots to study woody species. The first sample plots were assigned randomly and the next sample plots were systematically allocated within 2 Km intervals. Inventory of woody species were done using plots size of 25mx 25m ($625m^2$) for homegardens, coffee farms and pasture land (Egodawatta

and Warnasooriya, 2014), 40m x 40m (1600m^2) for crop field (Nikiema, 2005) and 10m x 10m plots size for woodlots following Feyera *et .al* (2002) (Figure 2). The assessment was carried out in every 2 Km intervals with a total of 100 sample plots in six transect lines for all selected land use types. Two transect lines laid out in each site with 20 plots of homegarden, 24 plots of crop field, 19 plots of coffee farm, 20 plot of pasture lands and 17 plots of woodlots were used along the transect line.

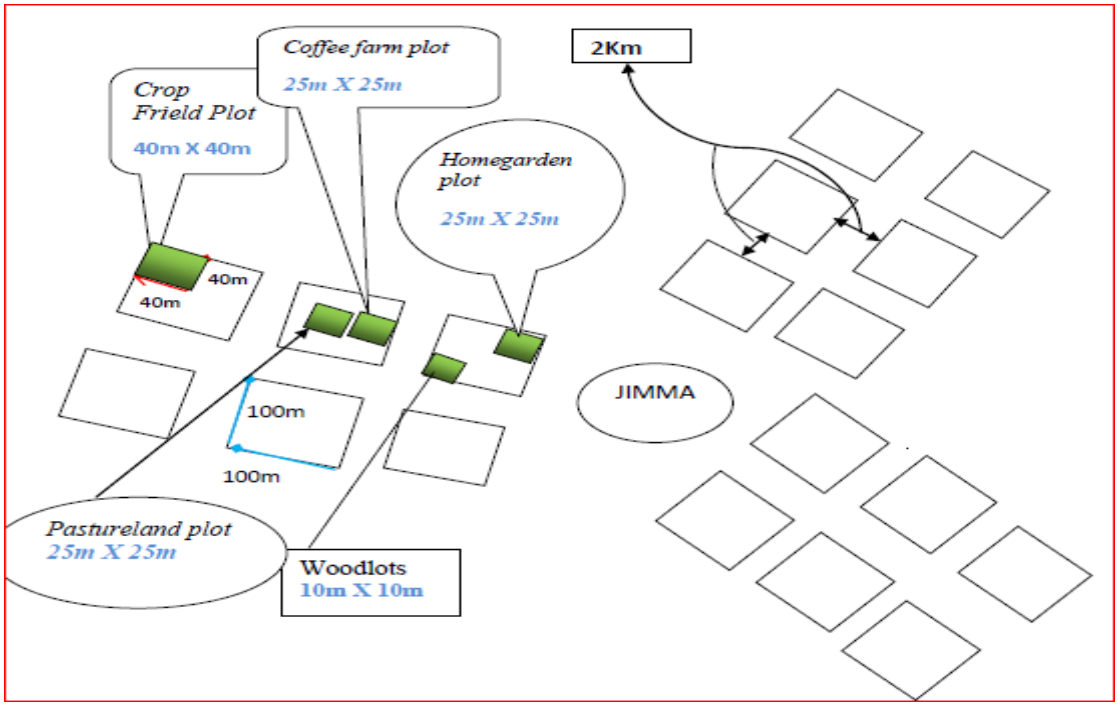

Figure 2: Illustration of plots along transect lines around Jimma in Mazoria, Merewa and Waro-Kolobo district, southwest Ethiopia

3.2.3 Data Collection

Actual field survey was carried out from February to March 2016. Quantitative data were collected directly from field survey and measurement of necessary information. It was used to determine composition and diversity of woody species in agroforestry system. Species number, height and Diameter at Breast Height (DBH) were measured for all woody plant species with height ≥2.5m and DBH ≥2.5cm in each land use type. Elevation of sample plots was measured using Global Position System (GPS Garmin-62). Height of woody species was measured by using clinometer. The slope of each plot was determined using clinometers and

DBH was measured by diameter tape. Trees and shrubs that are branched, the circumference was measured separately and averaged. All individuals of each study species were then categorized into DBH and Height classes.

Key informants (KIs) were selected to conduct discussion. Five individual farmers were selected randomly to identify key informants with Kebele leader members and development agents. They were asked to give the names of three key informants and a total of 10-12 KIs were selected from identified individuals at each Kebeles. They were selected based on their knowledge and experience regarding local name of woody species identification. Key informant interview were conducted with the selected individual. Key informants discussions were carried out at each study sites to get more information and important issues that are not observed by survey.

3.2. 4 Plant Identification

Local name of all woody species present in each site were recorded with the help of KIs and DAs. Species names were identified using specimen with the help of Useful Trees and Shrubs for Ethiopia (Azene, 2007) and the Honey bee Flora of Ethiopia (Fichtl and Admasu, 1994) at the field. Some difficult species identified with advisors using collected, pressed and brought specimen to college following the published volumes of the Flora of Ethiopia and Eritrea.

3.2.5 Methods of Data Analysis

The quantitative and qualitative approaches used to analyze data. Agroforestry structures were determined based on the proportion of each plant encountered; density of tree species that were obtained by counting the total numbers of individual tree/shrub species present in the farmland of each sampled area. All woody species present in each site were identified and grouped according to their nature and uses.

The population structure of all individuals $\geq$2.5cm diameter and $\geq$2.5 m height woody species encountered from the fields were grouped into diameter and height. Table and histograms frequency were developed using the diameter and height classes versus the number of individuals categorized in each of the classes (Temesgen *et al* ., 2015).

Data collected from the survey were entered into a computer (Microsoft Excel) and computed.To describes population structure, importance value index (IVI), height, frequency, Density, diameter at breast height (DBH) and basal area were used. Based on the biophsical informations from survey woody species were classified into categories and described in various structure distributions. DBH classes were categorized according to its thickness (Temesgen *et al.,* 2015). It is the ratio of circumference to π. Basal area was calculated using the formula: $BA = \pi d^2/4$ where d is diameter at breast height and π is 3.14. Densities are a count of the numbers of individuals of a species within the unit area (Kitessa *et al.,* 2007). Density of the woody species was calculated by converting the total number of individuals of each woody species encountered in plots to hectare.

Frequency is defined as the probability of chance of finding a species in a given sample area or quadrant (Kent and Coker, 1992). Thus, it shows the presence or absence of a given species within each sample plot.

Importance value indices were computed for all woody species based on their relative density (RD), relative dominance (RDO) and relative frequency (RF) to determine their dominance. Importance value index (IVI) was used for the assessment of the distribution of species abundance which is calculated in (Kent and Coker, 1992) formula:

IVI= Relative Frequency+ Relative Density+ Relative Dominance

$$\textbf{RelativeDensity} = \frac{\textbf{Total number of stems all of trees}}{\boldsymbol{samplesizeinhectare}} x\ 100$$

$$\textbf{RelativeFrequency} = \frac{\textbf{Number of individuals of tree species}}{\textbf{Frequencyofallspecies}} x\ 100$$

$$\textbf{Relativedominance} = \frac{\textbf{Basal Area per species}}{\textbf{TotalBasalArea}} x\ 100$$

Species Diversity, Richness and Evenness Indices

Diversity indices provide important information about rarity and commonness of species in a community. The indices can be used to compare diversity between habitat types (Kent and Coker, 1992).This index is used to determine the overall importance of each species in the community structure (relative density, relative dominance and relative frequency) which describes the structural role of a species.

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

Where:

H'= the Shannon-Wiener index, **S** = total number of species

Pi= the proportion of individuals belonging to species ***i,*** **ln**=the natural log

Evenness (E') is the ratio of H' to natural log of species richness(Magurran, 1988).

$$E = H' / \ln S$$

Where, E = evenness and S = species richness.

In the analysis of the data from the three sites, similarity index was used with the following formula (Kent and Coker, 1992),

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

Where:

Ss = Sorensen's similarity coefficient;

a = number of woody species common to both sites/ land uses in comparison;

b = Number of woody species found only in first site/ land use;

c = Number of woody species found only in the second site/land use

4 RESULTS AND DISCUSSION

4.1 Species Diversity, Richness and Evenness

The present study result showed that a total of 60 woody species belonging to 34 families and 54 genera were identified in the three study sites (Appendix 2). From identified woody species 39 species were from homegardens, 25 species in crop fields, 33 species in the grazing land, 34 in the coffee farm and 13 species in the woodlots. Out of identified woody species 32 (53.3%) trees, 27 (45 %) shrubs and 1(1.7 %) were climbers (Figure 3). This study indicated that the largest proportion of identified woody species covered by trees growth habit followed by shrubs in study sites.

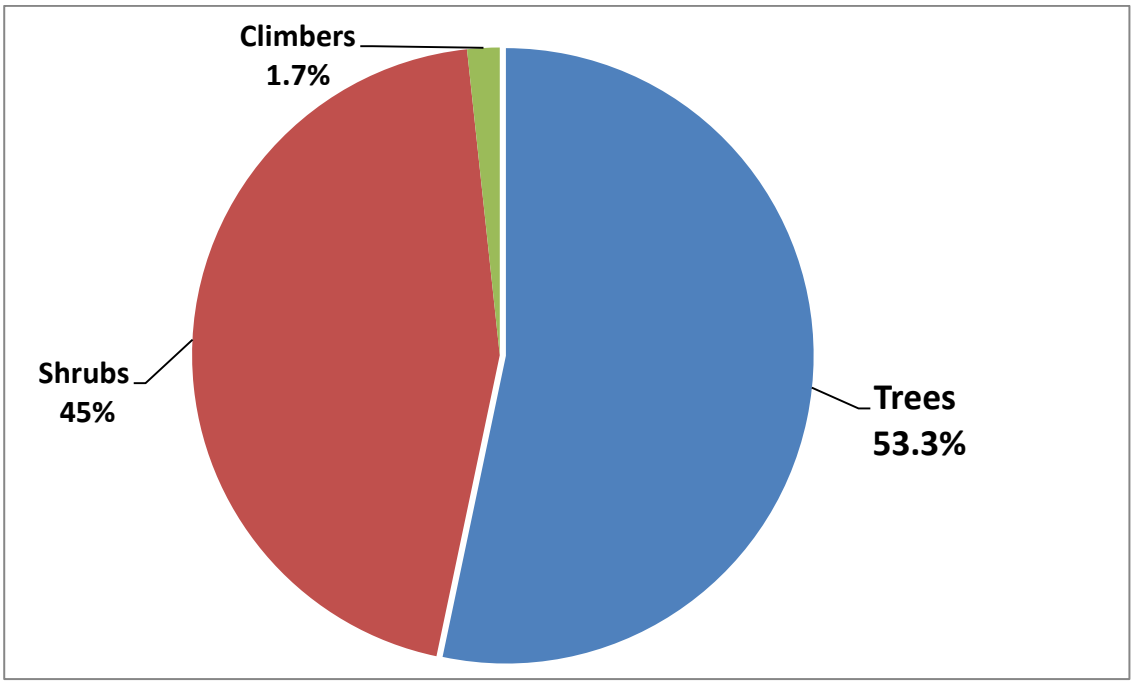

Figure 3: Growth habit percentage of the woody species in all Land Use Types

This study result is in agreement with the findingof Tefera *et al*. (2015), Mekonnen*et al.* (2014), Abiot and Gonfa (2015) and Motuma *et al.* (2008) also reported that the identified woody species dominated by trees.

A total of 39 woody species recorded in homegarden and characterized by a higher numbers of woody species than other land use types. This study is in line with the finding of Belay *et al.* (2014), Motuma *et al.* (2008), Etefa and Raj (2013), Tesfaye (2005) and Abiot and Gonfa (2015) who reported that higher number of woody plant species than most other land use types and Zaman *et al. (*2010) also reported similar number of woody species in homegardens of Thakurgaon, Bangladesh.

A total of 25woody species were identified from crop field of study sites. It was sparsely distributed in the field and relatively few as compared with homegarden, grazing land and coffee farm in species richness and individual numbers during inventory whereas higher than woodlots in species richness. In the study sites, the crop fields are owned by small-scale farmers who keep the woody species on their lands randomly in most case. Woody species was different from site to site in the crop field.This study result lower than similar study report of Motuma *et al. (*2008) in South-Central Ethiopia (32) and Tola *et al. (*2014) in Southern Ethiopia (49) and higher than study result of Etefa and Raj (2013) in Tigray Region (15).

In the study area (Mazoria, Waro-Kolobo and Merewa) 33 woody plants species were identified and distributed as the small size of the patches of vegetation remained in some part of grazing land.This study result indicated that lower number of woody species identified as compared with similar study report of Mideksa *et al.* (2015) in South East Ethiopia. Whereas higher than similar studies in Tigray Region, Ethiopia (Etefa and Raj, 2013), South Omo Zone, Southern Ethiopia *(*Terefe *et al.,* 2010), the westernshewa, Ethiopia *(*Kindu *et al.,* 2006) and much higher than Belay *et al* (2014) report in northern Ethiopia.

A total of 13 woody species identified in woodlots of three study sites. The number of species identified in this study was much lower than the study result of Shiferaw and Pavlis (2012) in South Western Ethiopia (37) and Tyynelä (2001) in Northeastern Zimbabwe (39). The difference might be associated with the high relative density of *Eucalyptus camaldulensis* plantation, *Cupressus lusitanica* and *Grevillea robusta.* Light levels are positively associated with plant species richness and permanent open spaces in plantation forests provide an

opportunity for enhancing biodiversity in the plantations (Georgie *et al.*, 2007). Woodlots characterized by simple structure due to its composition (single species).

Dominant and Common Species

Eucalyptus camaldulensis, Ficus vasta, Croton macrostachyus, Albizia gummifera, Cordia africana, Millettia ferruginea, Grevillea robusta, Acacia abyssinica, Ficus thonningii, Persea americana, Cupressus lusitanica and *Catha edulis* are the top 12 woody species dominating the study area. The commonly available and overlaps woody species in three studies sites (Mazoria, Merewa and Waro-Kolobo) identified (Table 2).

Table 2: Woody species overlap between study sites

Species Name	Local Name	Study sites		
		Mazoria	Merewa	Waro-Kolobo
Euphorbia cotinifolia	Ababo dima	✓	✓	
Maesa lanceolata	Abayi	✓	✓	✓
Euphorbia candelabrum	Adami	✓		✓
Carissa spinarum	Agamsa		✓	
Flacourtia indica	Akuku		✓	
Dracaena steudneri	Yuddoo/Alge			✓
Albizia gummifera	Ambabessa	✓	✓	✓
Millettia ferruginea	Askira	✓	✓	✓
Persea americana	Avocado	✓	✓	✓
Syzygium guineense	Badessa		✓	✓
Clematis hirsuta	Hidda		✓	
Eucalyptus camaldulensis	Bargamo	✓	✓	✓
Olea welwitschii	Baya		✓	
Citrus sinensis	Birtukan		✓	✓
Sapium ellipticum	Bosoka		✓	
Coffea arabica	Buna	✓	✓	✓
Manihot esculenta.	Casava			✓
Euphorbia tirucalli	Chada		✓	✓
Calpurnia aurea	Cheka	✓	✓	✓
Ocimum lamifolium	Damakase		✓	
Ficus thonningii	Dambi		✓	
Delonix regia	Dire dawa	✓		
Acacia etbaica	Dodota		✓	✓
Vernonia amygdalina	Ebicha	✓	✓	✓
Dodonaea angustifolia	Etacha/ kitkita			✓

Cupressus lusitanica	Gatira	✓	✓	✓
Rhamnus prinoides	Gesho	✓		
Annona senegalensis	Gishta	✓	✓	
Grevillea robusta	Gravilia	✓	✓	✓
Vepris dainellii	adessa		✓	
Caesalpinia decapetala	Harangama/Gora	✓	✓	✓
Ficus sur	Harbu	✓		✓
Jacaranda mimosifolia	Jacaranda	✓		
Catha edulis	Jima	✓	✓	✓
Gossypium hirsutum	Jirbi			✓
Casimiroa edulis	Kazmeri		✓	
Ficus vasta	Kiltu			✓
Ricinus communis	Kobo	✓	✓	
Prunus persica	Koki	✓		
Brucea antidysenterica	Komagno	✓	✓	
Maytenus arbutifolia	Kombolcha		✓	
Acacia abyssinica	Lafto	✓	✓	✓
Bersama abyssinica	Lolchisa	✓	✓	✓
Croton macrostachyus	Makanissa	✓	✓	✓
Mangifera indica	Mango	✓	✓	✓
Arundinaria alpina	Maqaa	✓		
Galiniera saxifraga	Mito	✓	✓	✓
Acacia mearnsii	Muka Guracha	✓		
Carica papaya	papaya	✓	✓	✓
Vernonia auriculifera	Reji	✓	✓	✓
Combretum molle	Rukessa			✓
Senna septemtrionali	Samamaki	✓	✓	✓
Sesbania sesban	Sasbania	✓	✓	
Ekebergia capensis	Sombo	✓	✓	✓
Ehretia cymosa	Ulaga	✓	✓	
Premna schimperi	Urgessa		✓	
Cordia africana	Wadessa	✓	✓	✓
Erythrina brucei	Walensu	✓	✓	✓
Bougainvillea spectabilis	Ababo/Yeresa Abeba	✓		
Psidium guajava	Zaythun	✓	✓	✓

In terms of woody species distribution across sites, 40% (24 species) of woody species were common to all sites, 10% (six species) occurred only in Waro-Kolobo whereas 11.7% (seven species) and 18.3% (eleven species) occurred only in Mazoria and Merewa sites, respectively. Again, 10% (6 species) were found in both Mazoria and Merewa, 6.67 % (four species) in Merewa and Waro-Kolobo, and only 3.3% (two species) species were found in Mazoria and Waro-Kolobo commonly (Table 2 and Figure 4).

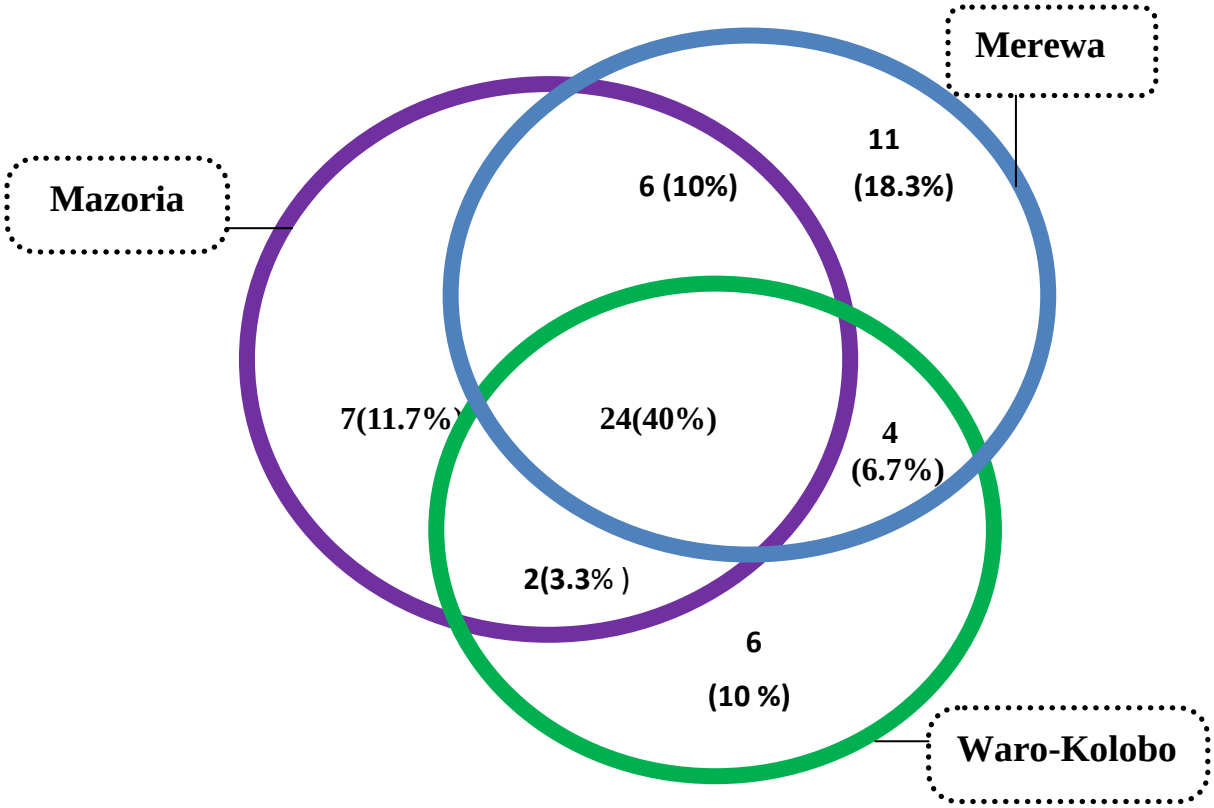

Figure 4: Venn diagram shows species richness and number of species overlap between three study sites

The dominant families were Fabaceae represented by 18.3% of species, Euphorbiaceae 11.7% of total species, Moraceae, Myrtaceae and Rutaceae families each with 5% of total species, Asteraceae, Boraginaceaae, Celastraceae and Rubiaceae families each with 3.3% of total species in the study area. The other remaining families (25) were represented by one species (Table 3).

Fabaceae and Euphorbiaceae were the major woody species in the study area. This study result in line with study of Mesele *et al. (*2012) in south-eastern rift valley escarpment of Ethiopia, Balcha (2013) in Jimma, Belay *et al*. (2014) in northwestern Ethiopia and Bajigo and Tadesse (2015) in Gununo watershed at Wolayitta zone.

Table 3: Families with their corresponding number of species

Family Name	Nº of species	%	Family Name	Nº of species	%
Fabaceae	11	18.3 %	Flacourtiaceae	1	1. 7%
Euphorbiaceae	7	11.7 %	Lamiaceae	1	1. 7%
Moraceae	3	5 %	Lauraceae	1	1. 7%
Myrtaceae	3	5 %	Malvaceae	1	1. 7%
Rutaceae	3	5 %	Meliaceae	1	1. 7%
Asteraceae	2	3.3%	Melianthaceae	1	1. 7%
Boraginaceae	2	3.3%	Myrsinaceae	1	1. 7%
Celastraceae	2	3.3%	Nyctaginaceae	1	1. 7%
Rubiaceae	2	3.3%	Oleaceae	1	1. 7%
Annonaceae	1	1. 7%	Proteaceae	1	1. 7%
Apocynaceae	1	1. 7%	Ranunculaceae	1	1. 7%
Bambusaceae	1	1. 7%	Rhamnaceae	1	1. 7%
Bignoniaceae	1	1. 7%	Rosaceae	1	1. 7%
Caricaceae	1	1. 7%	Sapindaceae	1	1. 7%
Combretaceae	1	1. 7%	Simarrobaceae	1	1. 7%
Cupressaceae	1	1. 7%	Verbenaceae	1	1. 7%
Dracaenaceae	1	1. 7%	Anacardiaceae	1	1. 7%
Total				**60**	**100%**

The ANOVA result showed highly significant difference ($P<0.05$) by mean Shannon diversity index, species richness and evenness between land use types. Whereas no significant difference ($P > 0.05$) between sites (Table 4). It was significantly different between homegardens, crop field, grazing land, coffee farm agroforestry and woodlots of study sites. This may be due to woody species function and serice. Woody species have various functions and purposes in different land use types. The Shannon diversity index (H') is high when the relative abundance of the different species in the sample is even and low when few species are more abundant. It is based on the theory that when there is a large number of species with even proportions, the uncertainty that a randomly selected individual belongs to a certain

species increases and thus diversity increases. It relates proportional weight of the number of individual's perspective (Kent and Coker, 1992). This study result is in line with Chane *et al.* (2003) who reported that land use types determine the vegetation attributes of species and disagrees with Lozada *et al*. (2006) who reported that there is no significant variation of trees species richness among land-use types.

Species diversity of grazing land, Homegarden, crop field, woodlots and coffee farm were 3.1, 2.87, 2.555, 0.667 and 0.643 respectively. The grazing land was recorded with highest species diversity than other land use system in overall study sites. Whereas species diversity of homegardens in each sites were higher than crop field, coffee farm, woodlots and grazing land with the exception of Merewa site grazing land and Mazoria site crop field (Table 4). This difference was observed might be because of difference in land use types and functions of woody species. Similarly, Lalisa and Herbert (2010) also reported that species richness, abundance and diversity of species are different among different land use practices.

The result indicated that the species diversity was higher in Merewa (H'= 2.58) followed by Mazoria (H'=2.32) and Waro-Kolobo (H'=2.48) and species evenness ranged between 0.773 and 0.788 in the homegarden agroforestry of study sites. It was lower in both species Shannon diversity and evenness than traditional agroforestry practice in Dellomenna District, Southeastern Ethiopia (Abiot and Gonfa, 2015) and higher than homegarden in Tigray region northern Ethiopia (Etefa and Raj, 2013).

In crop field, the highest species diversity recorded in Mazoria (H'=2.346) than Waro-Kolobo (H'=2.253) and Merewa (H'=1.819) sites and evenness index of woody species were ranges between 0.656 and 0.915(Table 4). This study report in line with similar study report of Mekonnen *et al.* (2014) who stated that the occurrence of species across crop field land use system of the study sites were variable. Shannon diversity index of woody species was more or less comparable with study report of Motuma *et al*. (2008) in South-Central Ethiopia (H'= 2.22, E= 0.64). The result of Shannon diversity index and evenness was higher than study result of Etefa and Raj (2013) in Tigray region, Ethiopia (H'= 1.12, E=0.41) and much higher than study result of Belay *et al.* (2014) in northern Ethiopia (H'=0.58, E=0.21).

Table 4: Species richness, Shannon Diversity index and Species Evenness along slope and elevation classes

Variables	Species richness					Shannon Diversity index					Species Evenness				
	HGAF	**CrAF**	**CoFAF**	**GLAF**	**WLAF**	**HGAF**	**CrAF**	**CoFAF**	**GLAF**	**WLAF**	**HGAF**	**CrAF**	**CoFAF**	**GLAF**	**WLAF**
Sites	**39**	**25**	**34**	**33**	**13**	**2.87**	**2.555**	**0.643**	**3.10**	**0.667**	**0.784**	**0.794**	**0.182**	**0.886**	**0.260**
Mazoria	19	13	14	17	11	2.32	2.346	0.661	2.248	0.682	0.788	0.915	0.258	0.793	0.285
Merewa	28	16	22	18	7	2.58	1.819	0.573	2.816	0.494	0.773	0.656	0.186	0.974	0.254
Waro-Kolobo	24	13	15	16	2	2.48	2.253	0.532	2.249	0.439	0.780	0.878	0.196	0.811	0.633
P-Value	0.0025*					0.000*					0.000*				
Slope															
≤10%	30	18	20	15	3	1.62	1.58	0.59	0.75	0.42	0.48	0.55	0.20	0.28	0.38
10.01-20%	28	17	15	21	9	1.30	1.28	0.48	1.52	0.52	0.39	0.45	0.18	0.50	0.24
20 - 40%	13		15	15	9	0.60		0.58	1.26	0.72	0.23	-	0.21	0.46	0.33
P-Value	0.280					0.424					0.398				
Elevation															
1718-1900	31	16	19	12	7	1.734	1.834	0.538	2.328	0.62	0.505	0.66	0.183	0.937	0.319
1901-2082	26	17	23	23	10	1.592	2.634	0.667	2.816	0.64	0.489	0.93	0.213	0.898	0.279
P-Value	0.885					0.930					0.788				

* Statistically significant difference $P < 0.05$ between land use type

HGAF= Homegarden agro forestry, CrAF=crop field, CoFAF= Coffee Farm, GLAF= grazing land, WLAF=Woodlots

The highest species recorded in Merewa than Mazoria and Waro-Kolobo sites and evenness index of woody species were ranges between 0.793 and 0.974 in the grazing land.The Shannon diversity index and evenness of this niche were higher than similar study result of Etefa and Raj (2013) in Tigray region, Ethiopia.

In coffee farm agroforestry relatively the highest species diversity recorded in Mazoria than Merewa and Waro-Kolobo sites and evenness index of woody species were ranges between 0.186 and 0.258 (Table 4).The result shows that single species dominated the coffee fam (*Coffea arabica*), less shade tree species number and not heterogeneous among species. This result in line with study result of Bikila and Zebene (2016) who reported that due to intensive human interference /selective tree thinning shade tree species diversity are less in number and Belay *et al* (2014) also reported that low diversty occurring when single or few species dominated the area. The study result indicated that lower Shannon diversity and evenness than study result of Tesfaye (2005) in the Southern Ethiopia, Dawoe *et al. (*2016) in West Africa and much lower than small holder coffee farm (Getachew*et al.*, 2014) in southwest Ethiopia.

In woodlots relatively higher diversity identified in Mazoria (0.682) followed by Merewa (0.494) and Waro-Kolobo (0.439). Woodlots was composed of some woody species, the diversity index was relatively lower in all sites than other land use types. The highest species number was recorded in Mazoria than Merewa and Waro-Kolobo sites.

Generally, this study showed that species richness, diversity and evenness varied with land use type/agroforestry practice. Lalisa and Herbert (2010) also reported that species richness, abundance and diversity of farm land tree species are different among different land use practices. Homegarden is more diversified followed by cropfield and grazing land inWaro-Kolobo site. Abreha and Gebrekidan (2014), Motuma *et al.* (2008) and Belay *et al*. (2014) reported that homegarden is more diversified than crop land and grazing land. Grazing land of Merewa more diversified than other land use types. This result is in line with Abreha and Gebrekidan (2014) in Andabet Woreda and Etefa and Raj (2013) who reported that grazing land diversified than cropland and homegardens.

The species richness, diversity index and evenness group mean of agroforestry system were not significantly different from one another with the slope variation (Table 4). LSD Comparisons test also shows that the species richness, diversity index and species evenness mean values of all land use (Homegarden, crop field, coffee farm, grazing land and woodlots agroforestry) systems were not significantly different ($P > 0.05$) in slope variation. This study result disagrees with Mamo *et al*. (2013) who reported that significant different with the slope variation with species richness and Chane *et al*. (2003) also reported that slopes are determined the vegetation attributes of species

The species richness, diversity index and evenness of agroforestry system group mean were not significantly different from one another with the elevation classes (Table 5). This may due to low difference between elevation classes and similar agro-ecological condition of the area. The current finding disagree with similar study report of Fantahun (2008) who reported that species richness is favorably influenced by altitude and Mamo *et al*. (2013) who reported elevation and slope significantly correlated negatively with species richness.

Key informants who participated in a discussion also reported that woody species cultivated in different land use are more or less similar to the result obtained with the survey result. Farmers hanging traditional beehives on larger trees in coffee farm, homegarden and grazing land. Key informants also articulated that woodlots of Eucalyptus increase onward due to a necessity of wood product (construction, fuel wood, etc), income and fast growing nature of the tree. This explanation is in agreement with Tola *et al*. (2014) who reported that the expansion of woodlots as due to increasing demand for various wood products.

4.2 Similarities Index between Sites

Sorenson's index of similarity of Merewa and Mazoria sites showed the highest similarity (72.3 %) followed by Mazoria and Waro-Kolobo sites (69.33%). Merewa and Waro-Kolobo sites had lowest similarity index (68.3%) as compared with other sites (Table 5). The similarity indexes of species showed the highest similarity (60.61%) between coffee farm and grazing land. Because grazing land is remnant of natural forest and woodlots are grown through artificial plantation.

Whereas woodlots and homegardens agroforestry systems had a lowest similarity index (37.74%) as compared with other agroforestry systems (Table 6).

Table 5: Sorenson Species Index of Similarity (%) along three sites

Sites	Mazoria	Merewa	Waro-Kolobo
Mazoria	-	72.3 %	69.33%
Merewa	-	-	68.3%
Waro-Kolobo	-	-	-

Table 6: Sorenson Species Index of Similarity (%) in three sites land use system

land use Type	Homegarden	Crop field	Coffee farm	Grazing land	woodlots
Homegarden	-	-	-	-	-
Crop field	59.38%	-	-	-	-
Coffee farm	56.67%	52.63%	-	-	-
Grazing land	48.72%	59.65%	60.61%	-	-
woodlots	37.74%	42.11%	39.13%	47.83%	-

4.3 Population Structure

4.3.1 Density

The ANOVA result showed that the mean density of woody species were significantly difference ($P < 0.05$) among overall agroforestry practices. Comparatively, overall densities of woodlots were higher than other land use types following by coffee farm and homegarden in all slope classes and study sites (Table 7). It also relatively higher in middle slope classes with exception of crop field and woodlots, and stand densities were not consistent within slope in all land use. The variation of woody species density in slope shows that there is no proper and sustainable use of land resource as land use capability. Because, the higher density recorded in gentle slope as compared to medium and higher slope which indicate no conservation and extension intervention service.

There was no significant (P > 0.05) variation in woody species density between group mean from one another with the slope and elevation classes (Table 7).The study result in line with study result of Mideksa *et al.* (2015) who reported that there is no significant variation of woody species density among altitude zone and disagree with study result of Tesfaye (2005) who reported that altitude variation can determine species density.

Table 7: Total density of woody species along sites and slope classes

Variable	Density per hectare				
	Homegarden	**Crop field**	**Coffee Farm**	**Grazing land**	**Woodlots**
Slope					
≤13%	1673.7	422	1900.7	304	3914.3
13.01-26%	1818.7	240.6	1980	822.4	5883.3
26.1 - 40%	960	-	1865.6	594.7	11,715
Site					
Mazoria	1603.2	181.3	2021.2	520.0	7170.0
Merewa	917.9	400	2135.73	809.3	5725.00
W/Kolobo	1470.67	157.5	1616.00	512	8833.33
Elevation					
1718-1900	1617.5	405.2	1867.5	380.0	7972.22
1901-2082	1617	220.8	2245.5	1014.4	6877.14

In overall homegarden agroforestry system of three study sites *Eucalyptus camaldulensis, Erythrina brucei, Euphorbia tirucalli, Cupressus lusitanica, Grevillea robusta, Coffea arabica and Persea americana*have the highest density (77 to 352 individuals per hectare) and other species were ranging from 16-72 individuals per hectare (Appendix 3). During the vegetation survey *Euphorbia tirucalli* had by far the highest density (269 individuals/ha) while others much less dense, ranging from 6.25 to 25 individuals/ha in the crop field (Appendix 4). *Coffea arabica* and *Arundinaria alpina* were densely populated (1401 and 224

individuals/ha respectively) in coffee farm agroforestry (Appendix 5). In grazing land agroforestry system *Cupressus lusitanica, Acacia mearnsii and Grevillea robusta* species were densely populated (144, 128 and 91 individuals/ha respectively) and in woodlots *Eucalyptus camaldulensis* with 4250 individuals/ha and *Cupressus lusitanica* with 2650 individuals/ha were much higher density, while others also ranging between 100 and 600 individuals of woody species per hectare. Generally, *Eucalyptus camaldulensis* were densely plantedspecies inwoodlots (Appendix 7).Because *Eucalyptus camaldulensis* planted mostly with narrow spacing, *Erythrina brucei*, *Euphorbia tirucalli* and *Euphorbia cotinifolia* species were commonly planted as life fence for protection purpose.

The inventory result of this study also revealed that there was variation in woody species density across the land use of study sites. This result coincides with Aklilu *et al* (2013) in terms of density in homegarden agroforestry, but the density is higher in woodlots and farmland. The density of woody species in woodlots result was much higher than similar study report of Shiferaw and Pavlis (2012) in South Western Ethiopia, Tyynelä (2001) in Northeastern Zimbabwe, Abyot *et al. (*2014) in Gololcha District, Eastern Ethiopia (1845 stems/ha) and Tesfaye (2005) southern Ethiopia (4500 stems/ha).

The density of woody species also varies in different land use types within slope classes. In homegarden agroforestry system *Citrus sinensis* (352 individuals/ha*), Calpurnia aurea* (272 individuals/ha*), Rhamnus prinoides (*192 individuals/ha*)* and *Vepris dainellii* (128 individuals/ha*)* were recorded with higher density at gentle slope class, *Erythrina brucei (*752 individuals/ha), *Vernonia auriculifera* (208 individuals/ha) and *Persea americana (*96 individuals/ha) at medium slope class and at higher slope class *Persea americana* (176 individuals/ha), *Cupressus lusitanica* (176 individuals/ha), *Grevillea robusta (*128 individuals/ha), *Sesbania sesban (*128 individuals/ha)and *Euphorbia cotinifolia (*128 individuals/ha) were recorded highest density.

In crop field *Euphorbia tirucalli (*269 individuals/ha) species observed with highest density at and other species observed with lower density (0- 25 individuals/ha) at medium slope class. *Coffea arabica* recorded with 1386, 1320 and 1463 individuals/ha in gentle, medium and

higher slope class, respectively in coffee farm. Woody species observed with relatively higher densities were *Albizia gummifera* and *Catha edulis* at gentle slope, *Arundinaria alpine, Acacia abyssinica, Cupressus lusitanica* and *Grevillea robusta at* medium slope class and *Croton macrostachyus, Albizia gummifera and Millettia ferruginea at* higher slope class in this land use. Because *Coffea arabica* is the main crop in the farm and *Albizia gummifera, Acacia abyssinica, Millettia ferruginea and Croton macrostachyus were* purposely required for shade. *Arundinaria alpine, Cupressus lusitanica* and *Grevillea robusta* planted with very low spacing, densely grown and not common for shade rather side part of farm.

In grazing land Acacia *abyssinica* at gentle slope class, *Senna septemtrionali* and *Acacia mearnsii* at medium slope and *Cupressus lusitanica, Grevillea robusta and Croton macrostachyus* at higher slope class was observed woody species with relatively higher density.

The small scale house holders have been commonly practicing woodlots of *Eucalyptus camaldulensis* in the area. *Eucalyptus camaldulensis* identified with highest density in all slope classes. Higher density of *Eucalyptus camaldulensis, Maesa lanceolata* and *Grevillea robusta* at gentle slope class, *Eucalyptus camaldulensis, Cupressus lusitanica* and *Syzygium guineense* at medium slope class, *Eucalyptus camaldulensis, Vernonia amygdalina* and *Grevillea robusta* at thigher slope class were identified in woodlots (Appendix 7).

4.3.2 Frequency

Frequency was the number of plots in which a specific species occurred per the total plots number of land use in the study area. Species were grouped into **A** (0-2 0%), **B** (20-40%), **C** (40-60%), **D** (60-80%) and **E** (80-100%) frequency classes with in each land use.No species were recorded in **D** and **E** frequency class of crop field and grazing land and frequency class **C** and **D** frequency class in woodlots (Table 8).

Table 8: Percentage of woody species in different land use system Frequency class

Land use type	Frequency Class				
	A (0-20%)	**B** (20-40%)	**C** (40-60%)	**D** (60-80%)	**E** (80-100%)
Homegarden Agroforestry	64.10%	25.64%	5.13%	5.13%	0%
Crop field agroforestry	84%	12%	4%	0%	0%
Coffee farm agroforesytry	79.41%	5.88%	2.94%	8.82%	2.94%
Grazing land	81.82%	15.15%	3.03%	0%	0%
Woodlots	69.23%	23.08%	0%	0%	7.69%

The most frequently observed woody species in homegarden agroforestry system were *Persea americana and Catha edulis* (75% and 60%, respectively) in overall study site (Figure 5). Whereas *Persea americana (*83.33%*), Sesbania sesban (*66.67%*)* and *Catha edulis* (50%) *in Mazoria site , Persea americana (*75%), *Catha edulis (*75%), *Millettia ferruginea(*75%) and *Croton macrostachyus (*62.50%) in Merewa and in Waro-Kolobo *Persea americana (*83.33%), *Mangifera indica (*83.33%), *Catha edulis* (66.67%), *Coffea arabica (66.67%)* and *Acacia abyssinica (*50.00%) were mostly frequented woody species in homegarden agroforestry system (Appendix 3). Most of the species were frequently cited in another homegarden (Abreha and Gebrekidan, 2014; Ewuketu *et al.,* 2014).

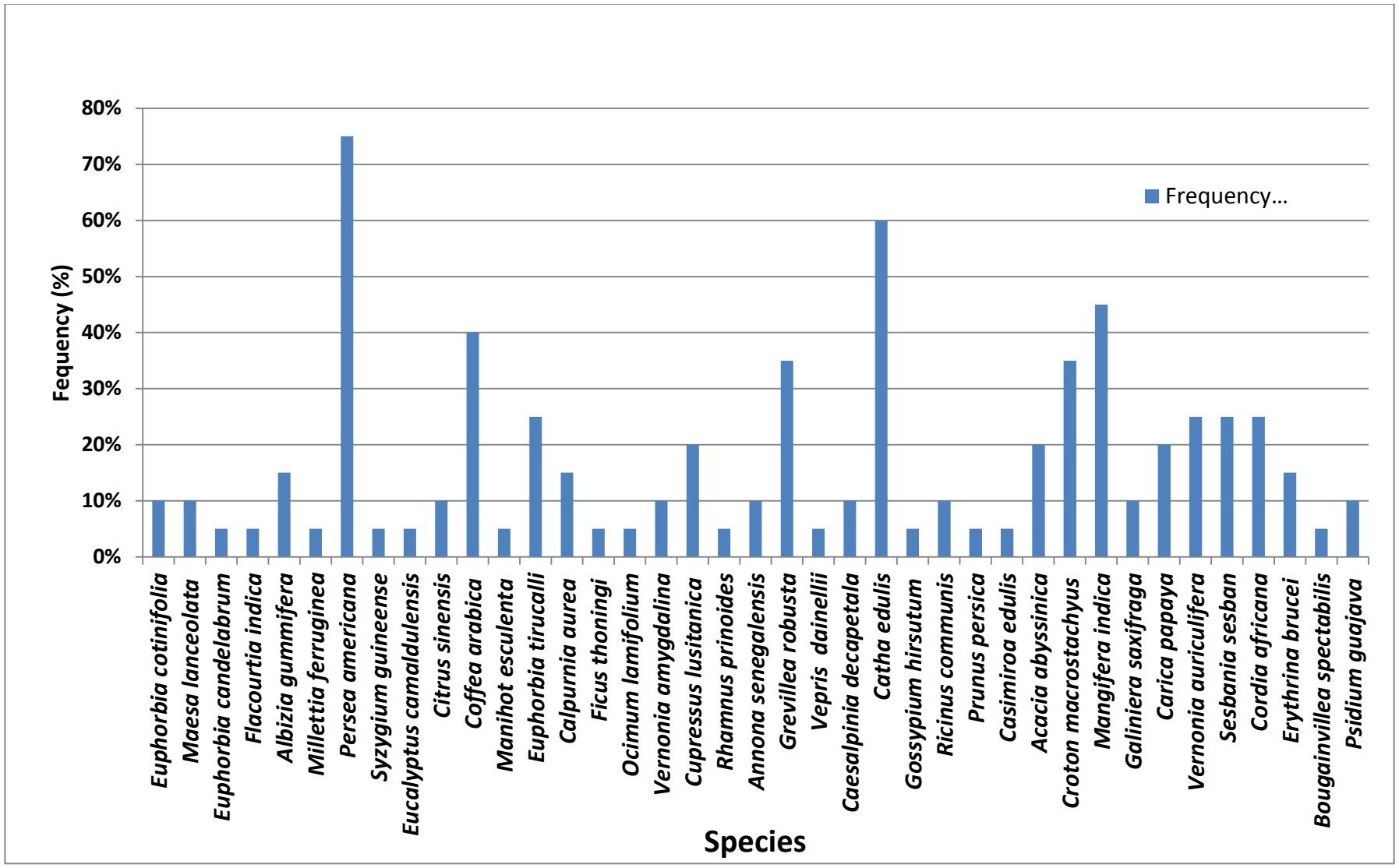

Figure 5: Frequency of woody species in homegarden across three study site around Jimma town, Southwest Ethiopia

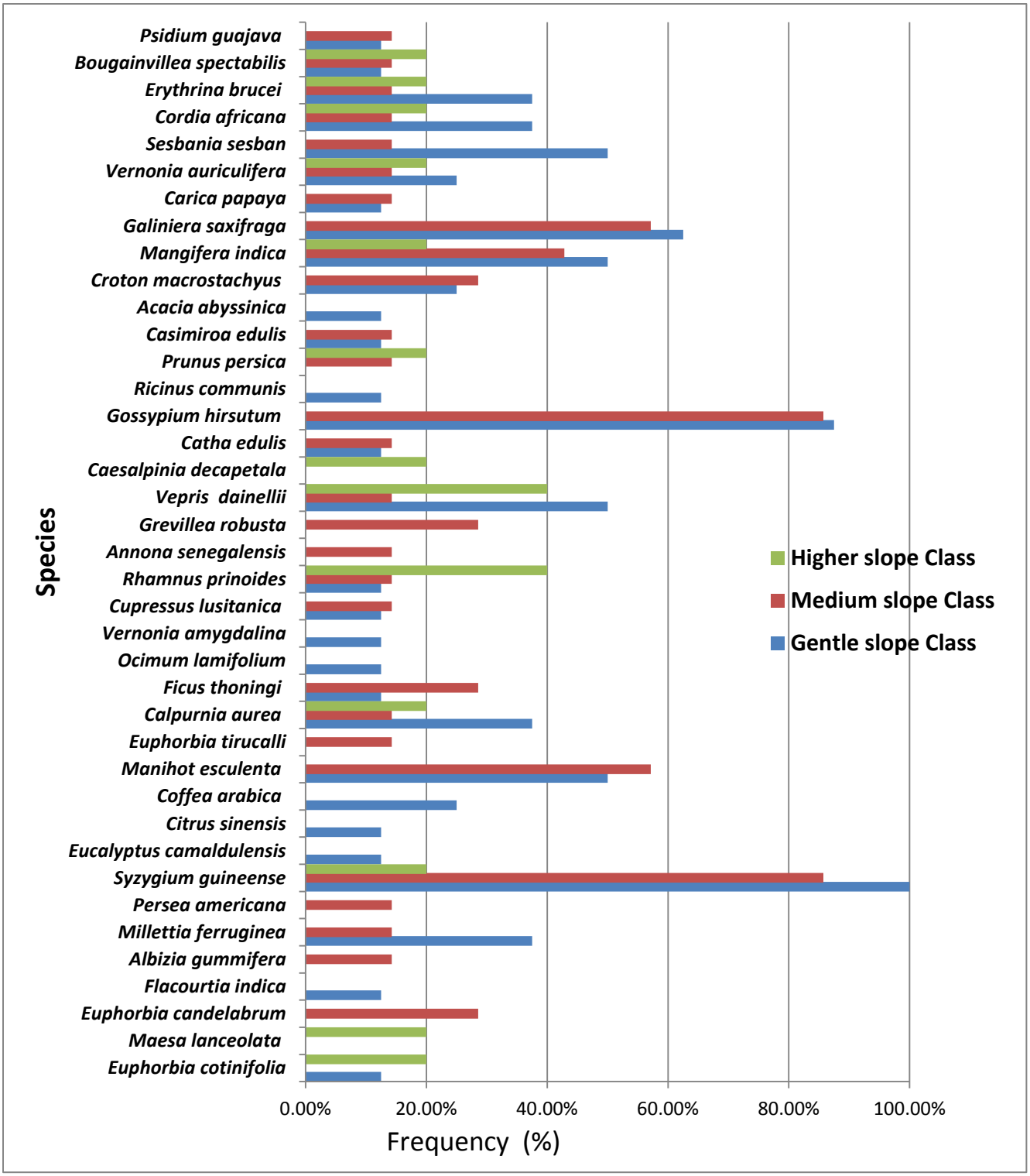

Figure 6: Frequency of woody species in homegarden across slope classes around Jimmatown, southwest Ethiopia

Cordia africana (41.67%) is observed in overall sites of crop field. *Albizia gummifera* (42.86%) in Mazoria, *Albizia gummifera (50%)* and *Cordia africana (50%) in Merewa* and *Cordia africana (55.56%)* were frequently observed than other woody species (Appendix 4). The least frequently observed woody species in class '**C** 'and most species (84%) fall between 0-20% (class 'A') frequency class in this land use type than others.

The most frequently observed woody species were *Coffea arabica (*100%), *Croton macrostachyus (*78.95%), *Albizia gummifera (*73.68%), *Cordia africana (*63.16%) and *Acacia abyssinica (*52.63%) in overall study coffee farm agroforestry. *Albizia gummifera (100%), Coffea arabica (100%), Croton macrostachyus (87.5%)* and *Cordia africana (50%)* in Mazoria, *Coffea arabica (*100*%), Croton macrostachyus (*83.33%*), Cordia africana (*66.67*%), Acacia abyssinica (50%), Albizia gummifera* (50%) and *Vernonia auriculifera* (50%) in Merewaand in Waro-Kolobo*Coffea arabica (*100%), *Acacia abyssinica (*80%), *Cordia africana (*80%), *Albizia gummifera* (60%) and *Croton macrostachyus (*60%) were frequently observed woody species than others in coffee farm agroforestry (appendix 5).

Eucalyptus camaldulensis was the most frequently observed species during the survey in woodlots around Jimma town. The frequency of *Eucalyptus camaldulensis* were about 94.12% in overall study sites, 100% in Mazoria and Merewa at each site and 85.71% at Waro-Kolobo site. Woodlots of study sites were dominated by single species i.e *Eucalyptus camaldulensis* and relatively gots special attention than other woody species in study area. Tyynelä (2001) also reported that *Eucalyptus camaldulensis* found in all wood sample plots and other species found in 4.6% to 26% of the total plots number.

In various slope classes woody species frequency also various with land use type. *Persea americana, Catha edulis* and *Mangifera indica* were recorded with highest frequency classes at gentle and medium slope class. *Persea americana was* observed in all sampled homegardens at gentle slope class and most of homegardens (85%) at Medium slope class. *Grevillea robusta* and *Cupressus lusitanica* relatively higher density than other species at higher slope class in homegarden agroforestry (Figure 6).Whereas in crop field *Cordia africana* and *Albizia*

gummifera at gentle and medium slope class, respectively. In coffee farm agroforestry system *Acacia abyssinica, Cordia africana, Albizia gummifera, Millettia ferruginea and Croton macrostachyus* were observed frequently in all slopeclasses in the study areas. *Acacia abyssinica* at gentle slope class, *Croton macrostachyus at* medium slope class and *Acacia etbaica*and *Vernonia auriculifera* at higher slope class were observed withhighest frequently in grazing land. *Eucalyptus camaldulensis* was the single highest frequently recorded species at all slope classes.

The distribution frequency of woody species on different land use types in the study sites and slope gradient were variable. The result also indicated that higher percentage of woody species frequently observed at the frequency classes 'A' in all land use system (Table 9). It may due to its greater economic or ecological value or social importance. This study report inline with Abiot and Gonfa (2015) report that the frequency of tree species variable in different farm and Yirefu *et al.* (2016) reported that most of the trees and shrubs species recorded in frequency class 'A' (61.5%).

4.3.3 Diameter at Breast Height (DBH) Distribution

The distribution of woody species in different DBH classes was analyzed and classified into 6 classes: 1) 2.5-10cm, 2) 10.1-20cm, 3)20.1-30cm, 4) 30.1 – 50 cm, 5) 50.1 – 60 cm, 6) > 60cm

DBH class distribution of all individuals in different size classes showed inverted J- shape in overall land use (Figure 7). The majority of the species had the highest number of individuals in the lowest DBH class distribution with gradual reduction toward high DBH classes. Out of total Woody species 61.26%, 26.50%, 6.91% and 2.77% distributed in the first, second, third and fourth diameter classes, respectively. Whereas about 2.56% of identified woody species in study area were found under fifth and sixth diameter classes. This study result was similar with the study result of Abyot*et al*. (2014), Temesgen *et al.* (2015) and Mohammed *et al.* (2015).

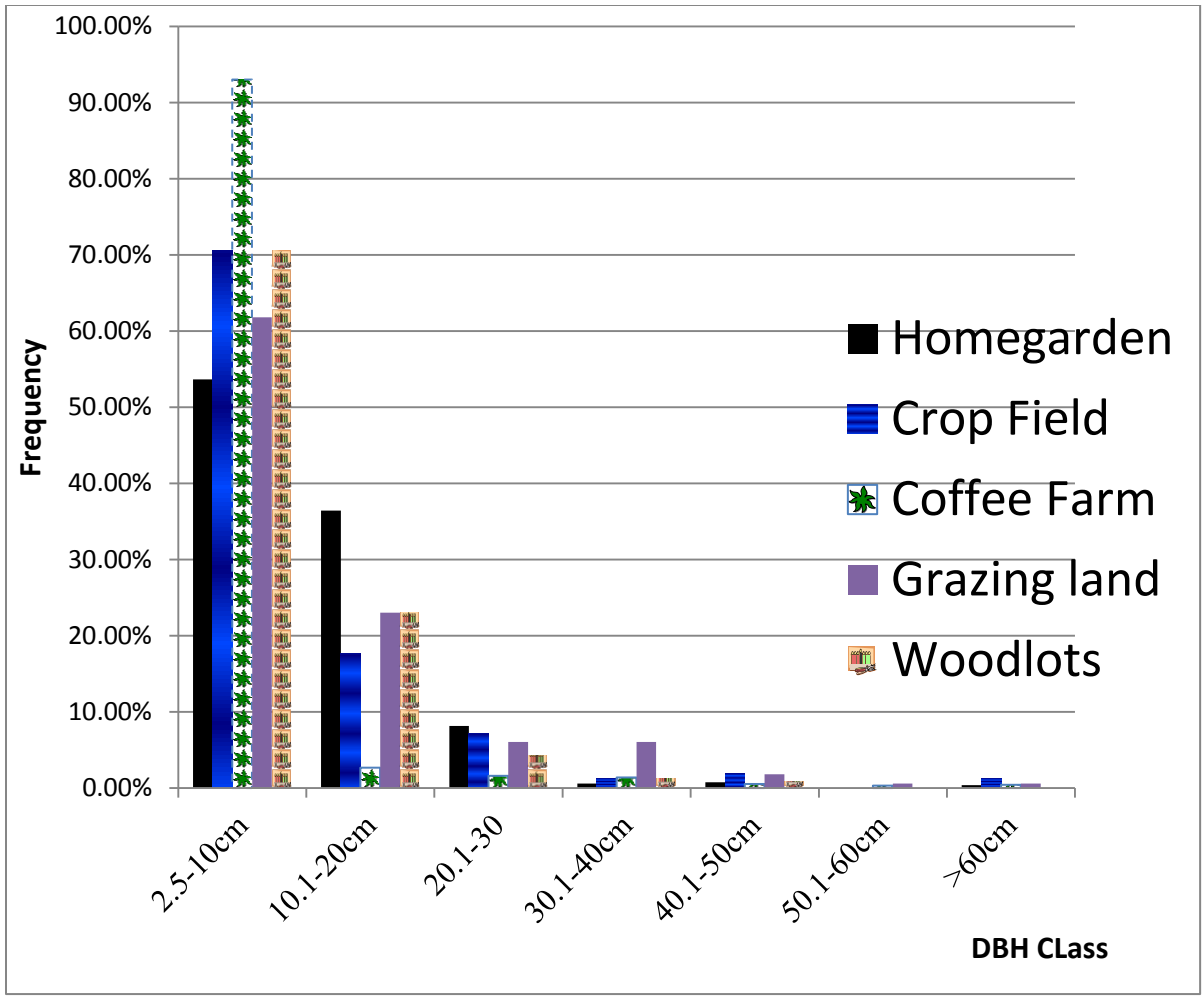

Figure 7: DBH of woody species in homegarden, Crop field, Coffee farm, Grazing land and woodlots of Study site

4.3.4 Importance value index

The most abundant plant species encountered in Mazoria, Merewa and Waro-Kolobo were *Persea americana, Catha edulis, Coffea arabica, Grevillea robusta, Mangifera indica , Croton macrostachyus, Vernonia auriculifera, Carica papaya* and *Calpurnia aurea*in homegarden, *Cordia africana, Albizia gummifera, Acacia abyssinica, Euphorbia tirucalli, Catha edulis, Coffea arabica ,Croton macrostachyus, Grevillea robusta, Vernonia auriculifera* and *Mangifera indica* in crop field, *Albizia gummifera, Acacia abyssinica, Croton macrostachyus, Ficus vasta, Cordia africana, Vernonia auriculifera, Millettia ferruginea, Persea Americana* and *Calpurniaaurea* in coffee farm, *Albizia gummifera, Senna septemtrionali, Croton*

macrostachyus, Vernonia auriculifera, Acacia abyssinica, Grevillea robusta, Cordia africana and *Ficus vasta* in grazing land and *Eucalyptus camaldulensis* in woodlots.

The IVI indicates the importance of individual woody species in the land use systems which associated with farmers' species preference and objectives. The interest of farmers for selection of species is linked with species market demand and service value.

IVI is a composite index based on the relative measures of species frequency, abundance and dominance (Kent and Coker, 1992). The relative density, frequency and dominance values of each woody species in homegardens, crop fields, grazing lands, coffee farms and woodlots were computed to analyze IVI and over all IVI of each land use analyzed (Table 8). The highest basal area of *Ficus vasta, Ficus thonningii, Millettia ferruginea* and *Albizia gummifera*made the species to have larger value of relative dominance (34.76%, 9.75%, 9.48% and 4.16% respectively) and hence got the highest IVI in over all study sites. *Eucalyptus camaldulensis (*38.34%*), Grevillea robusta (6.05%), Cupressus lusitanica (5.83%)* and *Croton macrostachyus (4.19%)* have higher relative density and *Croton macrostachyus (*10%), *Albizia gummifera (7.8%), Cordia africana* (7.8%) and *Acacia abyssinica* (5.37%) have larger relative frequency values contributed to getting the highest IVI. The current result agrees with Aklilu *et al.* (2013) who repoted IVI value determined by density, frequency and basal area. Simon and Girma (2004) also revealed that species with the greatest importance values are the most dominant of particular vegetation.

Table 8: Woody species in five land use system and their corresponding importance value index (IVI) of overall study sites.

Nº	Species name	Importance value index of Species					Average IVI
		Home garden	Crop field	Grazing land	coffee -farm	Woodlots	
1	*Eucalyptus camaldulensis*	6.31	-	8.72	-	125.35	28.08
2	*Cordia africana*	14.58	53.56	18.03	23.56	15.56	25.06
3	*Croton macrostachyus*	8.54	14.90	28.46	33.51	24.94	22.07
4	*Albizia gummifera*	6.62	33.00	32.87	37.03	-	21.91
5	*Acacia abyssinica*	19.43	20.29	16.11	24.30	-	16.03
6	*Ficus vasta*	-	-	9.97	68.33	-	15.66
7	*Grevillea robusta*	16.84	9.21	15.64	5.87	24.89	14.49
8	*Cupressus lusitanica*	10.35	4.94	6.93	3.97	46.22	14.48
9	*Euphorbia tirucalli*	15.51	29.89	-	-	-	9.08
10	*Ficus thonningii*	43.14	-	-	-	-	8.63
11	*Catha edulis*	18.33	18.98	-	3.38	-	8.14
12	*Vernonia auriculifera*	7.96	6.78	12.78	11.51	-	7.81
13	*Persea americana*	28.26	-	3.31	6.83	-	7.68
14	*Ekebergia capensis*	-	5.61	3.94	1.59	20.35	6.30
15	*Mangifera indica*	11.75	10.98	6.35	2.28	-	6.27
16	*Maesa lanceolata*	5.01	7.16	5.26	-	13.03	6.09
17	*Coffea arabica*	14.89	15.32	-	-	-	6.04
18	*Sapium ellipticum*	-	24.38	-	-	-	4.88
19	*Psidium guajava*	2.53	3.57	11.88	1.63	4.69	4.86
20	*Millettia ferruginea*	2.52	-	5.44	15.72	-	4.74
21	*Erythrina brucei*	15.49	4.99	1.99	-	-	4.49
22	*Calpurnia aurea*	3.07	3.69	8.55	6.62	-	4.39
23	*Senna septemtrionali*	-	-	11.92	1.60	3.10	3.32
24	*Vernonia amygdalina*	2.69	-	6.68	3.58	3.62	3.31
25	*Syzygium guineense*	1.04	2.55	7.83	-	4.67	3.22
26	*Premna schimperi*	-	-	15.98	-	-	3.20
27	*Ficus sur*	-	-	-	3.86	8.59	2.49
28	*Delonix regia*	-	-	11.49	-	-	2.30
29	*Citrus sinensis*	2.60	-	-	2.09	-	0.94
30	*Euphorbia cotinifolia*	3.49	5.57	-	1.56	-	2.12
31	*Acacia mearnsii*	-	-	9.74	-	-	1.95
32	*Euphorbia candelabrum*	2.21	4.57	2.80	-	-	1.92
33	*Sesbania sesban*	6.78	-	-	2.23	-	1.80
34	*Acacia etbaica*	-	-	8.55	-	-	1.71
35	*Arundinaria alpina*	-	-	-	1.71	-	1.60

36	*Maytenus arbutifolia*	-	-	6.33	1.56	-	1.58
37	*Annona senegalensis*	2.77	-	4.79	-	-	1.51
38	*Ricinus communis*	2.53	-	-	-	5.00	1.51
39	*Carissa spinarum*	-	3.03	3.79	-	-	1.36
40	*Ehretia cymosa*	-	-	2.86	3.78	-	1.33
41	*Galiniera saxifraga*	2.33	-	2.58	1.56	-	1.29
42	*Bersama abyssinica*	-	-	3.91	2.50	-	1.28
43	*Caesalpinia decapetala*	1.99	2.38	1.98	-	-	1.27
44	*Carica papaya*	6.19	-	-	-	-	1.24
45	*Flacourtia indica*	2.79	-	-	3.35	-	1.23
46	*Combretum molle*	-	5.74	-	-	-	1.15
47	*Clematis hirsuta*	-	-	-	5.26	-	1.05
48	*Brucea antidysenterica*	-	2.59	-	2.33	-	0.98
49	*Dracaena steudneri*	-	-	-	4.84	-	0.97
50	*Prunus persica*	3.19	-	-	-	-	0.64
51	*Casimiroa edulis*	1.03	-	-	1.61	-	0.53
52	*Dodonaea angustifolia*	-	-	2.54	-	-	0.51
53	*Olea welwitschii*	-	6.31	-	2.20	-	1.70
54	*Jacaranda mimosifolia*	-	-	-	1.95	-	0.39
55	*Vepris dainellii*	1.51	-	-	-	-	0.30
56	*Manihot esculenta*	1.44	-	-	-	-	0.29
57	*Gossypium hirsutum*	1.15	-	-	-	-	0.23
58	*Ocimum lamifolium*	1.03	-	-	-	-	0.21
59	*Rhamnus prinoides*	1.03	-	-	-	-	0.21
60	*Bougainvillea spectabilis*	1.06	-	-	-	-	0.21
	Total	**300**	**300**	**300**	**300**	**300**	**300**

Homegarden Agroforestry

The IVI was estimated for the woody species recorded in homegaden to evaluate the importance of each species in the study site. Accordingly, *Persea americana, Erythrina brucei, Catha edulis, Grevillea robusta, Euphorbia tirucalli, Coffea arabica, Acacia abyssinica, Cordia africana, Mangifera indica* and *Cupressus lusitanica* were the ten top importance species among the 39 woody species that recorded in homegarden agroforestry system of the study sites (Table 9). This finding also inline with similar study report of Ewuketu *et al.* (2014) in Jabithenan district, Northwest Ethiopia

Table 9: Woody species in homegardens of three study sites and their corresponding importance value index (IVI)

Species Name	IVI of Study sites			Average IVI
	Mazoria	Merewa	Waro-Kolobo	
Euphorbia cotinifolia	7.67	2.589	-	3.42
Maesa lanceolata	-	11.069	-	3.69
Euphorbia candelabrum	-	-	4.951	1.65
Flacourtia indica	-	3.023	-	1.01
Albizia gummifera	-	7.219	9.732	5.65
Millettia ferruginea	-	-	3.408	1.14
Persea americana	63.22	47.609	37.184	49.34
Syzygium guineense	-	-	2.896	0.97
Eucalyptus camaldulensis	-	-	25.100	8.37
Citrus sinensis	-	2.669	3.437	2.04
Coffea arabica	7.83	10.041	29.231	15.70
Manihot esculenta	-	-	4.154	1.38
Euphorbia tirucalli	-	15.839	46.607	20.82
Calpurnia aurea	3.56	2.510	2.900	2.99
Ocimum lamifolium	-	2.397	-	0.80
Ficus thonningii	-	17.386	-	5.80
Vernonia amygdalina	3.60	-	3.272	2.29
Cupressus lusitanica	15.17	17.677	-	10.95
Rhamnus prinoides	3.50	-	-	1.17
Annona senegalensis	4.25	2.817	-	2.36
Grevillea robusta	31.66	33.146	5.107	23.30
Vepris dainellii	-	2.569	-	0.86
Caesalpinia decapetala	-	2.397	2.899	1.77
Catha edulis	18.34	30.954	20.736	23.34
Gossypium hirsutum	-	-	2.935	0.98
Casimiroa edulis	-	2.40	-	0.80
Ricinus communis	-	5.809	-	1.94
Prunus persica	8.27	-	-	2.76
Acacia abyssinica	-	11.293	32.614	14.64
Croton macrostachyus	5.51	15.453	2.893	7.95
Mangifera indica	9.12	8.769	19.273	12.39
Galiniera saxifraga	3.66	2.472	-	2.04
Carica papaya	4.57	7.356	5.25	5.72
Vernonia auriculifera	14.96	2.397	7.645	8.33
Sesbania sesban	19.88	2.587	-	7.49
Cordia africana	-	27.045	16.786	14.61
Erythrina brucei	71.73	-	6.759	26.16
Bougainvillea spectabilis	3.51	-	-	1.17
Psidium guajava	-	2.511	4.237	2.25

Crop Field

The IVI was estimated for the woody species recorded in the crop field to evaluate the importance of each species in the study site. In this land use agroforestry *Cordia africana, Albizia gummifera, Euphorbia tirucalli, Coffea arabica, Catha edulis, Croton macrostachyus, Acacia abyssinica, Grevillea robusta, Vernonia auriculifera* and *Mangifera indica* were the top ten important among the 25 woody species that recorded in crop field land use system of the study sites (Table 10). The value of IVI shows species importance.

Table 10: Woody species in Crop field of three study sites and their corresponding importance value index (IVI)

No	species Name	Local Name	IVI of Study sites			
			Mazoria	Merewa	W/Kolobo	**Ave. IVI**
1	*Cordia africana*	Wadessa	29.94	44.26	143.47	72.56
2	*Albizia gummifera*	Ambabessa	73.87	62.14	15.24	50.42
3	*Euphorbia tirucalli*	Chada	-	57.68	-	19.23
4	*Coffea arabica*	Buna	32.44	13.94	7.95	18.11
5	*Catha edulis*	Jima	-	26.11	25.36	17.16
6	*Croton macrostachyus*	Makanissa	10.17	18.04	16.28	14.83
7	*Acacia abyssinica*	Lafto	17.14	17.83	9.27	14.74
8	*Grevillea robusta*	Gravilia	28.14	-	11.95	13.36
9	*Vernonia auriculifera*	Reji	18.05	-	10.56	9.54
10	*Mangifera indica*	Mango	-	5.48	21.20	8.89
11	*Cupressus lusitanica*	Gatira	24.25	-	-	8.08
12	*Euphorbia candelabrum*	Adami	21.31	-	-	7.10
13	*Euphorbia cotinifolia*	Ababo dima	13.75	5.17	-	6.31
14	*Maesa lanceolata*	Abayi	10.51	6.96	-	5.82
15	*Erythrina brucei*	Walensu	10.03	5.20	-	5.08
16	*Sapium ellipticum*	Bosoka	-	14.46	-	4.82
17	*Calpurnia aurea*	Cheka	-	-	13.22	4.41
18	*Brucea antidysenterica*	Komagno	10.40	-	-	3.47
19	Combretum molle	Rukessa	-	-	8.67	2.89
20	*Ekebergia capensis*	Sombo	-	-	8.64	2.88
21	*Psidium guajava*	Zaythun	-	-	8.18	2.73
22	*Olea welwitschii*	Bayan	-	6.63	-	2.21
23	*Carissa spinarum*	Agamsa	-	6.16	-	2.05
24	*Syzygium guineense*	Badessa	-	5.01	-	1.67
25	*Caesalpinia decapetala*	Gora	-	4.93	-	1.64

Grazing land

The IVI was estimated for the woody species recorded in the grazing land to evaluate the importance of each species in the study site. In this niche woody species recorded were *Albizia gummifera, Croton macrostachyus, Senna septemtrionali, Vernonia auriculifera, Grevillea robusta, Acacia abyssinica, Cordia africana, Acacia mearnsii, Ficus vasta, Psidium guajava, Calpurnia aurea and Vernonia amygdalina* were the top twelve important woody species in the study sites. Specifically, *Vernonia auriculifera, Senna septemtrionali* and *Grevillea robusta* spieces in Mazoria; *Albizia gummifera, Croton macrostachyus, Cordia africana and Premna schimperi* in Merewa and in Waro-Kolobo *Albizia gummifera, Croton macrostachyus, Acacia abyssinica and Ficus vasta species* were recorded with high IVI value (Table 11).

Table 11: Woody species in grazing land of three study sites and their corresponding importance value index (IVI)

No	Species name	Local Name	IVI of Study sites			Average IVI
			Mazoria	Merewa	W/Kolobo	
1	*Albizia gummifera*	Ambabessa	-	45.68	62.61	36.1
2	*Croton macrostachyus*	Makanissa	8.46	42.53	39.53	30.173
3	*Senna septemtrionali*	Samamaki	51.45	3.83	29.72	28.33
4	*Vernonia auriculifera*	Reji	60.56	14.14	7.4	27.37
5	*Grevillea robusta*	Gravilia	43	12.72	-	18.57
6	*Acacia abyssinica*	Lafto	-	17.06	35.6	17.55
7	*Cordia africana*	Wadessa	-	31.15	8	13.05
8	*Acacia mearnsii*	Muka Guracha	31.67	-	-	10.56
9	*Ficus vasta*	Kiltu	-	-	31.04	10.35
10	*Psidium guajava*	Zaythun	8.65	19.85	-	9.5
11	*Acacia etbaica*	Dodota	-	9.03	19.28	9.44
12	*Calpurnia aurea*	Cheka	-	7.64	17.82	8.5
13	*Vernonia amygdalina*	Ebicha	18.84	4.45	-	7.76
14	*Maesa lanceolata*	Abayi	-	5.26	9.78	5.01
15	*Annona senegalensis*	Gishta	11.12	3.95	-	5.02
16	*Syzygium guineense*	Badessa	-	14.33	-	4.78
17	*Delonix regia*	Dire dawa	14.31	-	-	4.77
18	*Cupressus lusitanica*	Gatira	-	14.23	-	4.74
19	*Mangifera indica*	Mango	8.7	5.2	-	4.633
20	*Ekebergia capensis*	Sombo	-	-	13.21	4.4
21	*Maytenus arbutifolia*	Kombolcha	-	12.67	-	4.22
22	*Eucalyptus camaldulensis*	Bargamo	-	11.34	-	3.78

23	*Bersama abyssinica*	Lolchisa	-	3.83	7.35	3.73
24	*Galiniera saxifraga*	Mito	-	-	9.61	3.2
25	*Premna schimperi*	Urgessa	-	9.19	-	3.063
26	*Millettia ferruginea*	Askira	9.09	-	-	3.03
27	*Dodonaea angustifolia*	Etacha	-	-	9.05	3.02
28	*Euphorbia candelabrum*	Adami	8.61	-	-	2.87
29	*Ehretia cymosa*	Ulaga	8.62	-	-	2.873
30	*Caesalpinia decapetala*	Gora	8.46	-	-	2.82
31	*Erythrina brucei*	Walensu	8.46	-	-	2.82
32	*Carissa spinarum*	Agamsa	-	7.59	-	2.53
33	*Persea americana*	Avocado	-	4.33	-	1.44

Coffee Farm

Coffea arabica, Albizia gummifera, Acacia abyssinica, Croton macrostachyus, Cordia africana, Ficus vasta, Millettia ferruginea, Vernonia auriculifera, Persea american, Calpurnia aurea and *Grevillea robusta* were the most important woody species relatively in the coffee farm. The species IVI was vary in coffee farm agroforestry. *Albizia gummifera, Acacia abyssinica, Croton macrostachyus* and *Millettia ferruginea* in Mazoria and Waro-Kolobo site,and also *Albizia gummifera, Acacia abyssinica, Croton macrostachyus, Cordia africana* and *Vernonia auriculifera* in Merewa site relatively most important than other species. Therefore, these species with higher IVI were most important for coffee shade. All woody species identified in Mazoria, Waro-Kolobo and Merewa sites were distributed in the coffee farm for the purpose of shade (Table 12). Tadesse (2003) stated that nearly all Ethiopia traditional coffee production systems are cultivated under shades and Bikila and Zebene (2016) also reported that woody species with the highest IVI are *Coffea arabica* and other shade tree species.

Key informants also pointed out that *Albizia gummifera, Acacia abyssinica* and *Millettia ferruginea* species were most preferred as shade for coffee in their discussions. They were stated that the leaves of these woody species are allowed an appropriate amount of light to reach the coffee and other undergrowth species due to leaf structure and size. Tola *et al.* (2014) also reported that small leaf tree species (*Albizian gummifera, Acacia abyssinica* and *Millettia ferruginea*) are most preferred for coffee shade. Small trees and shrubs were used for shade when

farmers convert other land use and/or treeless field to coffee farm due to fast growing and soil fertility improvement. This justification also agree with Tola *et al*. (2014) who reported that due to fast-growing and shorter lived trees provide enough shade to the newly planted coffee until the preferred shade trees have grown big enough.

Table 12: Woody species in coffee farm of three study sites and their corresponding importance value index (IVI)

No	Species Name	Local Name	IVI of Study sites			Ave. IVI
			Mazoria	Merewa	Waro-Kolobo	
1	*Coffea arabica*	Buna	115.28	118.36	114.04	115.9
2	*Albizia gummifera*	Ambabessa	82.59	18.56	16.03	39.06
3	*Acacia abyssinica*	Lafto	16.83	31.82	36.37	28.34
4	*Croton macrostachyus*	Makanissa	29.44	27.41	17.89	24.91
5	*Cordia africana*	Wadessa	15.81	21.15	21.05	19.34
6	*Ficus vasta*	Kiltu	-	-	50.33	16.78
7	*Millettia ferruginea*	Askira	11.06	6.46	7.27	8.26
8	*Vernonia auriculifera*	Reji	4.52	15.64	3.99	8.05
9	*Persea americana*	Avocado	3.94	7.83	-	3.92
10	*Calpurnia aurea*	Cheka	-	2.55	7.92	3.49
11	*Grevillea robusta*	Gravilia	2.83	4.85	-	2.56
12	*Clematis hirsuta*	Hidda	-	5.81	-	1.94
13	*Dracaena steudneri*	Yuddoo	-	-	5.77	1.92
14	*Ehretia cymosa*	Ulaga	-	5.76	-	1.92
15	*Vernonia amygdalina*	Ebicha	5.16	-	-	1.72
16	*Cupressus lusitanica*	Gatira	-	5.17	-	1.72
17	*Ficus sur*	Harbu	-	-	5.08	1.69
18	*Arundinaria alpina*	Maqaa	4.33	-	-	1.44
19	*Catha edulis*	Jima	-	4.27	-	1.42
20	*Flacourtia indica*	Akuku	-	4.13	-	1.38
21	*Jacaranda mimosifolia*	Jacaranda	-	-	3.74	1.25
22	*Senna septemtrionali*	Samamaki	-	-	3.50	1.17
23	*Psidium guajava*	Zaythun	-	-	3.52	1.17
24	*Ekebergia capensis*	Sombo	-	-	3.49	1.16
25	*Brucea antidysenterica*	Komogno	-	3.24	-	1.08
26	*Mangifera indica*	Mango	-	3.14	-	1.05
27	*Olea welwitschii*	Baya	-	3.12	-	1.04
28	*Citrus sinensis*	Birtukan	-	3.03	-	1.01
29	*Bersama abyssinica*	Lolchissa	2.90	-	-	0.97
30	*Sesbania sesban*	Sasbania	2.79	-	-	0.93
31	*Casimiroa edulis*	Kazmeri	-	2.60	-	0.87
32	*Euphorbia cotinifolia*	Ababo Dima	-	2.56	-	0.85
33	*Maytenus arbutifolia*	Kombolcha	-	2.56	-	0.85
34	*Galiniera saxifraga*	Mito	2.52	-	-	0.84

Woodlots

Most important woody species were *Eucalyptus camandulasis, Cupressus lusitanica andGrevillea robusta* in woodlots. Number of species identified in this study was lower than the study result of Shiferaw and Pavlis (2012). The difference might be associated with the high relative density of*Eucalyptus camaldulensis* plantation, *Cupressus lusitanica* and *Grevillea robusta. Eucalyptus camaldulensis* was the dominant tree and accounts for most of the woody plants within the study area in woodlots (Table 13).

Table 13: Woody species in Woodlots of three study sites and their corresponding importance value index (IVI)

No	Species Name	Local Name	IVI of Study sites			
			Mazoria	Merewa	Waro-Kolobo	**Average IVI**
1	*Eucalyptus camaldulensis*	Bargamo	166.64	201.34	176.31	181.43
2	*Cupressus lusitanica*	Gatira	-	19.12	123.69	47.60
3	*Grevillea robusta*	Gravilia	64.81	-	-	21.60
4	*Maesa lanceolata*	Abayi	9.31	29.05	-	12.79
5	*Croton macrostachyus*	Makanissa	15.76	19.53	-	11.76
6	*Ekebergia capensis*	Sombo	8.52	8.35	-	5.62
7	*Syzygium guineense*	Badessa	-	13.72	-	4.57
8	*Cordia africana*	Wadessa	12.54	-	-	4.18
9	*Psidium guajava*	Zaythun	-	8.90	-	2.97
10	*Ricinus communis*	Kobo	5.91	-	-	1.97
11	*Ficus sur*	Harbu	5.76	-	-	1.92
12	*Vernonia amygdalina*	Ebicha	5.60	-	-	1.87
13	*Senna septemtrionali*	Samamaki	5.13	-	-	1.71

4.3.5 Height of Woody Species in Agroforestry System

All individuals with ≥2.5 cm diameter at breast height and ≥2.5 m height woody species encountered from the fields were categorized into diameter and height classes. Based on height category woody species was classified into three height class in homegardens, crop fields, coffee farms, grazing lands and woodlots. Woody species individuals recorded in the study area were class: I) 2.5-5m lower class height II) 5.01 – 10 m medium class height and III) ≥10 m upper class height woody species described as overall land use types (Figure 8) and across each land use types with sites (Figure 9).

There was a higher frequency percentage of lower height class distribution of woody species in homegardens, crop field and coffee farm. In case of coffee agroforestry practice the system is covered by some individual numbers of woody species used for shade and higher coffee shrubs. Due to competition factors with the under growth plants and use of tree parts in crop field and homegardens, the tree height managed repeatedly. Most woody species cultivated in homegardens are fruit tree species its height are managed to collect fruits. Woodlots purposely required for woody product it is dominated by higher height woody plants in overall study sites (Figure 8).

This study result is in agreement with study report of Bikila and Zebene (2016) who reported that repeated management of trees height in homegardens and multi-use of tree species in the farmers' field affects the height growth. Kufa and Burkhardt (2011) also reported that a larger tree species that characterized by broad-leaved dominated upper canopy and coffee plants and small shrubs found at the middle and lower height class.

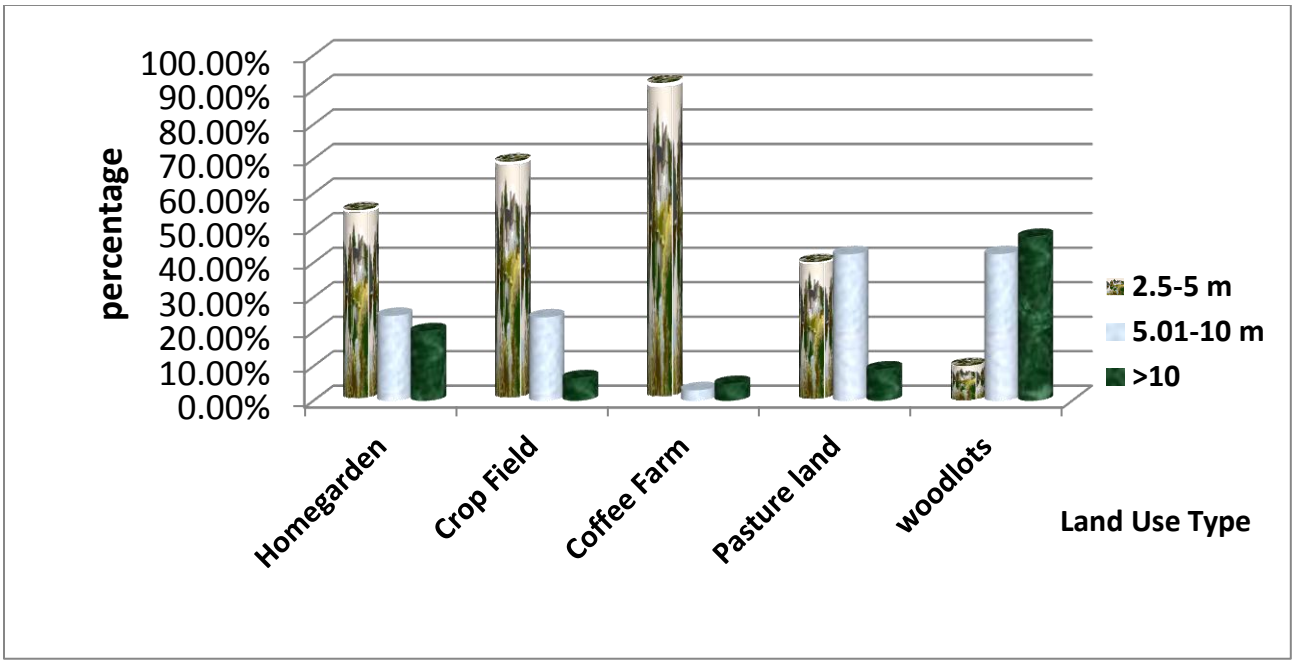

Figure 8: Height class of woody species in land use type of study sites

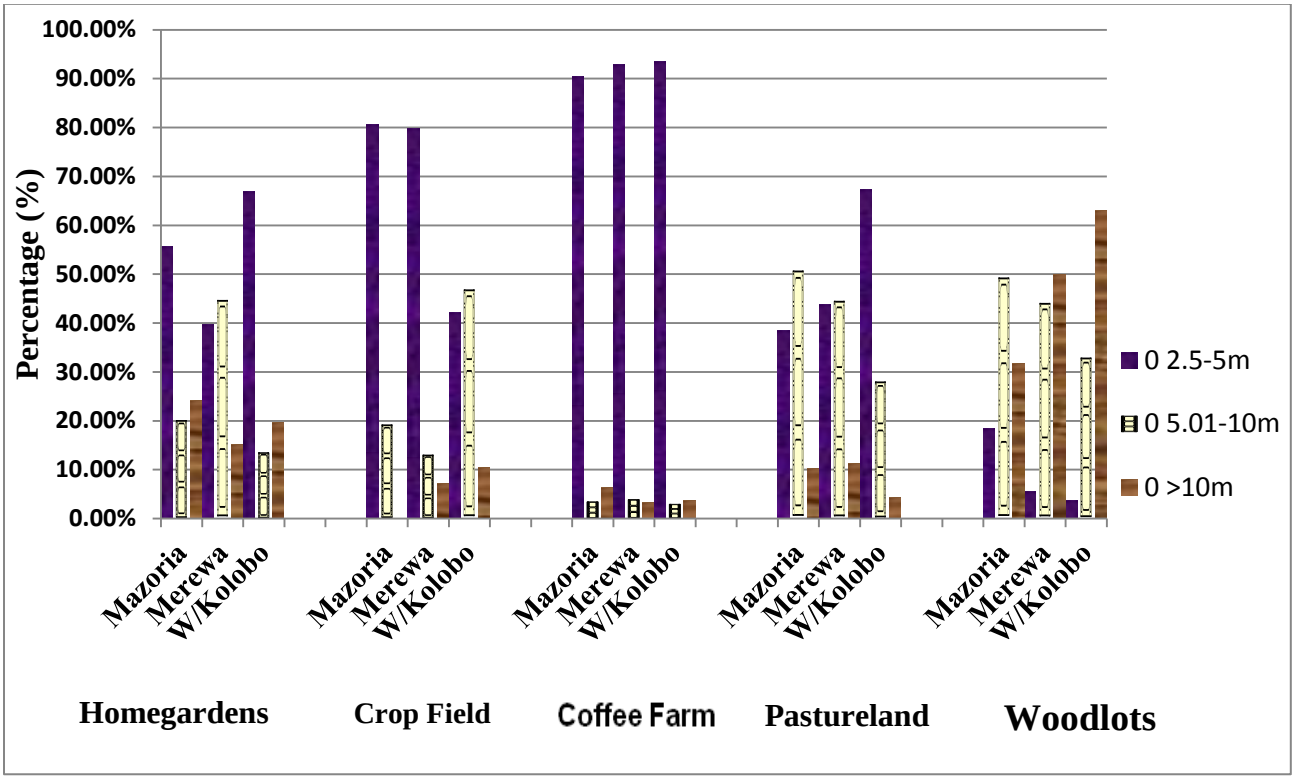

Figure 9: Height class of woody species in homegarden, coffee farm, grazing land, woodlots and crop field in Mazoria, Merewa and Waro-Kolobo sites

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Farmers' were mainly cultivating tree and shrubs on their homegardens, crop fields, coffee farms, grazing lands and woodlots randomly or intentionally in the study area. Species richness, diversity, evenness and density were statistically significant difference between land use type and no significant difference between sites, slope and elevation classes. The type of land use determines the composition and diversity of woody species due to its various functional uses and integrity of species with other components among agroforestry practices.

Comparatively, the highest diversity was recorded in the grazing land followed by homegardens in overall study sites and lowest species richness and diversity were recorded in woodlots. Because grazing lands are known in evenly distributed ruminants of forest and naturally grown very large size trees, whereas single species dominated in woodlots. Woody species are mainly grown naturally and at very scattered in crop field as compared to other land use type.

The total density of woodlots were higher than coffee farm, homegarden, grazing land and crop field and *Eucalyptus camaldulensis* was the most densely populated plant woody species in the area. The declining trend of woody species of diversity and density across slope shows that there is no proper and sustainable use of land resource as land carrying capacity and conservation policy. Because, the higher density recorded in gentle slope and lower densities in medium to higher slope this shows that there is no sufficient conservation and extension intervention service or may be unidentified reasons.

The majority of the species had the highest number of individuals in the lowest DBH class distribution with gradual reduction towards high DBH classes and it seems reversed J- shape in land use.

5.2 Recommendations

Agroforestry is one of the most common agricultural practices in the south western Ethiopia to address the economical, social and ecological needs of community. Adoption of agroforestry technology depends on the magnitude of biophysical, social and economic factors. This study focused mainly on the assessment of woody species in different land use type from some biophysical point of view.

Further studies are advisable on other physical factors (slope aspect, soil and climate) and their interaction in the system to enhance scientific based justification since biophysical factors linked with socioeconomic factors directly or indirectly.

Rural agricultural land policies and extension service has to encouraged the inclusion of diverse woody species and densities at the higher value without hindering production and ensuring sustainability of production and food security.

Agroforestry serve as source of diversification, maintain ecosystem and conserve biodiversity therby enhance environmental resilience to combatct devrsification and adverse effects of climate change. It should be promoted and encouraged as development and management approach for prevention and maintain indigenous plant species within the system since some species are already endangered

Sustainable training and awareness creation should be conducted to the local community regarding the importance, integration and sustainable management of agroforestry system to conserve and more diversify than the current existing status of species.

Therefore more basic and applied researches should be encouraged and done to support agroforstry system production a plan and manage the system through integration with institutions, researchers, communities and other practitioners.

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APPENDIX

Apendix 1: Key Informant and Field Data collection format

A) Biophysical Data Collection Format for Key Informant

The transect walk will be conducted in the study site with development agents, elders both from male and female, youth and others who know the area well. The assumption is that those key informants can identify and show us the area easily without any fear of problems related with representation.

I) General information

Region_____woreda/district_____kebele_____Village/site_____
Agro-ecology (highland/midland/lowland) _____ Distance from roads (km) ___
Land use types_____ Slope (%) _____
Altitude (m)_____ Latitude _____
Plot _____ Area_____ (ha)

II) Questioners for Agroforestry component arrangements

1) Name the components or what components do you have in your homegarden? Circle them.
   a) Crops b) Trees c) Grasses d) Animals e) Bee hives f) Vegetables g) Others (Specify) ……
2) Describe the components vertically (Try to draw vertical diagrams on ground/ field).

3) Could you tell us the kind of agroforestry system being practiced in your locality?
……
…… …… …… …… ……
…… …… ……
…… …… …… …… ……

4) Can you tell us the major components of Area agroforestry system?

5.1) Homegarden
…… ……
… … ……..… …… ……
…… …… … ……

5.2) Cultivated land

……

…… …… ……..

5.3) Wood lots

……

… … …… ……. ……

5.4) Coffee farm

……

…… …… ……

5.5) Shelter belt

……

…… …… …… ……

……..

5.6) Pasture land

……

…… …… ……

…… …… …… ……

5.7) List livestock that are commonly practiced

……

……

5.8) Other (specify)

……

…… ……

5) Which crops do you think is often planted with trees and shrubs or mutually grown with trees and shrubs?

……

…… …… … … …… …… …… ……

6) Mention trees and shrubs which have harmful effects on the growth of ground and/or shrub layer

……

…… …… …… …… …… ……

7) What are trees and shrubs that have good contribution to the growth of ground and /or shrub layer

……

…… …… … …… …… ……

8) Can trees/shrubs be grown without affecting the system?

……

…… …… ……

9) How do you see/compare the agroforestry coverage of present and past time? Is there any difference? I) Yes II) No If yes a) increasing b) decreasing: Why is the difference?

……
…… … …… …… …… ……

10) How do the people maintain the sustainability of the agroforestry system?

……
…… …… ……

11) What types of agricultural activities are suitable in your locality? Do other activities suit to the local conditions other than agroforestry?

……
…… … …… …… …… ……

12) Is there fixed places for forest and trees?

……..……
…… …… …… ……

13) How agroforestry arranged horizontally?

……..……
…… …… …… ……

14) What are the Problems related with arrangement of Agroforestry systems?

……
…… … …… …… …… …… ……

Name of the enumerators: ..... Date..... Signature.....

I) Field Data collection format

Region_____ woreda/district_____kebele_____Village/site_____
Land use types_____ Slope (%) _____
Altitude (m) _____ Latitude _____
Plot _____ Area_____ (ha)

Table 1: Describe the Agroforestry components horizontally (establish some zonation from center to the edge of the boundary)

Horizontal arrangement	**0-10m**	**10-20m**	**20-30m**	**30-40m**	**Is this intentional or randomly arranged?**
Homegarden					
Cultivated land					
Woodlot					
Coffee farm					
Shelterbelt/hedgerows					
Pasture land					
Others if any (specify)					

Note: Components of the system

GC-Grain crops (Teff, wheat, maize, barley, sorghum), LC- legume crops (green gram, black gram, soybean, pea, cowpea);

OC- Oil crops (Groundnut, Mustard, Sunflower,etc):VC-Vegetables crops (Water melon, Onion, tomato):

RTC-Roots and Tuber crop (sweet, potato, sugar beet, carrot, beetroot, kotehare, etc.) FC-Fiber crops (Cotton, steam, Kocho.);

MS-Medicinal Trees (list at the back)SB – shelter belt/ life fence (koshim, bamboo, gravilia, ecu.)

FT- Fruit Tree (Mango, papay, Zaytun, Gishta, banana,) TW- timber wood, Construction

F- Fodder tree (saspania, Lucinia) FW- Fuel wood(kombolcha, agamsa, Sokoru

Table 2: Vertical arrangement of woody species in Agroforestry component

Vertical arrangement	**Ground layer (<1m)**	**shrub layer (1-5m)**	**Middle layers (5-10m)**	**Upper layers (>10m)**	**Is this intentional or randomly arranged?**	**Remark**
Homegarden						
Cultivated land						
Woodlot						
Coffee farm						
Shelterbelt /hedgerows						
Pasture land						
Others if any (specify)						

Note: Components of the System: - FT- Fruit trees C- Coffee ST- shade trees TW- Timber wood CH-Chat, FW- fuel wood Fo- fodder co- construction

Table 3:- Horizontal arrangements across interfaces (Just record the slope and distance)

Land use types	**Across road**	**Slope**	**Distance from town/village**	**Remark**
Homegarden				
Cultivated land				
Wood lots				
Coffee farm				
Shelter belt / hedgerows				
Pasture land				
Others if any (specify)				

Table 4:- Sheet for Species Recording

Plot Nº	**Species Name**	**Vernacular Name**	**Dbh (cm)**	**Height (m)**	**Niche**	**Functional Roles /Type of use**	**Habit**	**Remark**

Habit: - T- Tree S- shrub C- Climber H- Herb

Table 5:- Woody species in land use system

	Type of crop	**woody species grown**	**Target Locations ***
1	Teff		
2	Wheat		
3	Barley		
4	Maize		
5	Sorghum		
6	H/Coat Bean		
7	Bean		
8	Pea		
9	Coffee		
10	Chat		
11	Eucalyptus		
12	*Gravilia*		
13	Tid		
16			

*Homestead (near villages), cultivated land, Boundary, Range land, Woodlots, Upland, near roads, other (specify)

B) Field Data Collection Format

Region Oromia Zone Jimma WoredaKebele Village_____

Land use _____ Slope ____% Enumerators _____ Date _____

Points A; N- _____ E-_____ El^{n}_____ m B; N-_____ E-_____ El^{n} ____ m

C; N- _____ E-_____ El^{n}_____ m D; N- _____ E-_____ El^{n}_____ m

No	Tree Name	Upper reading		Lower reading		Height (cm)	Circumference (cm)	Diam (Cm)	Remark
		%	Deg	%	Deg				

Appendix 2: Species name, local name, family name, habit and functionl use of woody species identified in the study area

No	Species Name	Local Name	Family Name	Habit	Functional Use
1	*Euphorbia cotinifolia L.*	Ababo dima	Euphorbiaceae	S	livefence, boundary mark,
2	*Maesa lanceolata Forssk.*	Abayi	Myrsinaceae	S	Firewood,Live fence
3	*Euphorbia candelabrum Kotschy*	Adami	Euphorbiaceae	T	fence , live fence
4	*Carissa spinarum L.*	Agamsa	Apocynaceae	S	Firewood, food (fruit), soil conservation.
5	*Flacourtia indica (Brm.f.) Merr*	Akuku	Flacourtiaceae	T	Firewood, timber (tools), farm tool
6	*Dracaena steudneri Schweinf. Ex Engel.*	Yuddoo/Alge	Dracaenaceae	T	cover the dough in baking bread(dabo), Fodder, local ridge, shade
7	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Ambabessa	Fabaceae	T	shade,Firewood, timber,bee forage, soil conservation, envirnomental balance
8	*Millettia ferruginea Hochst*	Askira	Fabaceae	T	Shade, Firewood, timber,bee forage, too handles,
9	*Persea americana Mill.*	Avocado	Lauraceae	T	Food (fruit),shade,Income,
10	*Syzygium guineense (Willd.) DC.*	Badessa	Myrtaceae	T	Firewood, charcoal, timber, handtools,beeforage,
11	*Clematis hirsuta Guill.and Perr.*	Hidda	Ranunculaceae	C	Tiefunction, bee forage
12	*Eucalyptus camaldulensis Dehnh.*	Bargamo	Myrtaceae	T	Timber,income,Firewood,windbreak, boundry mark
13	*Olea welwitschii (Knobl.)Gilg. & Schellenb*	Baya	Oleaceae	T	Firewood (branches),Shade, timber, medicine
14	*Citrus sinensis (L.) Osbeck (pro. sp.)*	Birtukan	Rutaceae	T	Food (fruit), medicine
15	*Sapium ellipticum (Hochst.) Pax*	Bosoka	Euphorbiaceae	T	Firewood, farm tools, tool handles, fodder
16	*Coffea arabica L.*	Buna	Rubiaceae	S	Income (Cash crop)

17	*Manihot esculenta (Crantz).*	Casava	Euphorbiaceae	S	Food(root and tuber)
18	*Euphorbia tirucalli L.*	Chada	Euphorbiaceae	S	Boundary marker, live fence.
19	*Calpurnia aurea (Ait.) Benth.*	Cheka	Fabaceae	S	shade,washing materials
20	*Ocimum lamifolium Hochst. ex Benth*	Damakase	Lamiaceae	S	Medicine,
21	*Ficus thonningii Blume*	Dambi	Moraceae	T	firewood,shade,
22	*Delonix regia (Boj. ex Hook.) Raf.*	Dire dawa	Fabaceae	T	Bee forage, shade, area beauty
23	*Acacia etbaica Schweinf.*	Dodota	Fabaceae	S	shade, lifefence, fence
24	*Vernonia amygdalina L.*	Ebicha	Asteraceae	S	Firewood, medicine , fodder, live fence,Bee forage, Cleaner
25	*Dodonaea angustifolia Jacq.*	Etacha/ kitkita	Sapindaceae	S	Firewood, poles,Farm and handles tool, bee forage, windbreak, fence,
26	*Cupressus lusitanicaL.*	Gatira	Cupressaceae	T	Timber, Firewood, shade, ornamental, windbreak.
27	*Rhamnus prinoides L'Hér.*	Gesho	Rhamnaceae	S	favouring (leaves), tooth brush,income
28	*Annona senegalensis*	Gishta	Annonaceae	T	food (fruit),tool handles,Firewood,
29	*Grevillea robusta R.Br.*	Gravilia	Proteaceae	T	timber, poles,bee forage, shade, windbreak, environmental balance
30	*Vepris dainellii*	adessa	Rutaceae	T	Firewood, charcoal, timber,poles, tool handles,
31	*Caesalpinia decapetala(Roth) Alston*	Harangama/Gora	Fabaceae	S	lifefence, firewood,
32	*Ficus sur Forssk.*	Harbu	Moraceae	T	food (Fruit), Timber ,shade, Hanging bee hives,
33	*Jacaranda mimosifolia D.Don*	Jacaranda	Bignoniaceae	T	Bee forage, shade, windbreak.
34	*Catha edulis (Vahl) Forssk. ex Endl.*	Jima	Celastraceae	S	stimulant drug, cash crop, Firewood, fodder
35	*Gossypium hirsutum L.*	Jirbi	Malvaceae	S	Fiber,

36	*Casimiroa edulis La Llave*	Kazmeri	Rutaceae	T	Food (fruit), bee forage,
37	*Ficus vasta Frssk.*	Kiltu	Moraceae	T	soil fertlity and conservaion, shade (human and livestock)
38	*Ricinus communis L.*	Kobo	Euphorbiaceae	S	Lubricant (making injera, skin softening, reduce friction of Yoke and oxen neck),
39	*Prunus persica (L.) Batsch*	Koki	Rosaceae	T	food (fruit),Firewood,
40	*Brucea antidysenterica J.F.Mill.*	Komagno	simarrobaceae	S	firewood,handles and farm tools,
41	*Maytenus arbutifolia Hochst. ex A.Rich.*	Kombolcha	Celastraceae	S	firewood, farm tools, f live fence, fencing
42	*Acacia abyssinica Hochst.ex Benth*	Lafto	Fabaceae	T	shade,Firewood, charcoal, fodder, bee forage, fence (cut branches),
43	*Bersama abyssinica subsp. abyssinica*	Lolchisa	Melianthaceae	S	Firewood, bee forage, live fence.
44	*Croton macrostachyus Del.*	Makanissa	Euphorbiaceae	T	shade, handle tools, medicine, bee forage, balance envirnoment, poles for "mager or Dalge" ,Firewood ,
45	*Mangifera indica L.*	Mango	Anacardiaceae	T	Food (fruit),shade,Income, Bee forage
46	*Arundinaria alpina K. Schun*	Maqaa/Shomboko	Bambusaceae	S	Furniture, roofing poles, soil conservation, material making (feeding , basket,containers for grain, local spinning tools),Home fence
47	*Galiniera saxifraga (G. coffeoides)*	Mito	Rubiaceae	S	Firewood, timber (construction), food
48	*Acacia mearnsii(Racosperma mearnsii)*	Muka Guracha	Fabaceae	T	firewood, charcoal, poles, posts, bee forage, shade,bee forage,
	Carica papaya L	papaya	Caricaceae	T	food/Juice (fruit) , bee forage
50	*Vernonia auriculifera Hiern*	Reji	Asteraceae	S	shade, Medicine, lifefence,Beehive
51	*Combretum molle R.Br. ex G.Don*	Rukessa	Combretaceae	T	Firewood, charcoal, timber, handtools,

52	*Senna septemtrionali (Viv.) H.S.Irwin & Barneby*	Samamaki	Fabaceae	S	shade, Medicine, lifefence
53	*Sesbania sesban (L.) Merr.*	Sasbania	Fabaceae	S	Fodder, shade, soil and water conservation,
54	*Ekebergia capensis sparrm.*	Sombo	Meliaceae	S	Firewood, poles, tool handles, fodder (leaves), bee forage, shade,Medicine, Environmental balance,
55	*Ehretia cymosa Thonn.*	Ulaga	Boraginaceae	T	Shade,firewood, farmtools,bee forage, farm tools,medicine,
56	*Premna schimperi Engl.*	Urgessa	Verbenaceae	S	Firewood, charcoal, fencing material (branch cutting).
57	*Cordia africana Lam.*	Wadessa	Boraginaceae	T	shade, timber, firewood, bee forage, shade, ornamental, environmetal balance
58	*Erythrina brucei Schweinf*	Walensu	Fabaceae	T	lifefence,Firewood, carving (bee-hives), soil and water coservaton
59	*Bougainvillea spectabilis willd*	Ababo/Yeresa abeba	Nyctaginaceae	S	garden beauty ,bee forage
60	*Psidium guajava L.*	Zaythun	Myrtaceae	T	food (fruit), Firewood, handle tools, bee forage, poles(horizotal pole of house and grain storage), carving (Bee hives),Tough (Animal feeding)

T- Tree S- shrubs C- climber

Appendix 3: Density and frequency of species across site and along slope class of woody species in homegarden around Jimma town, Southwest Ethiopia

species Name	Density (indiv/ha) site				Density (indiv/ha) along slope			Frequency (%) across site				Frequency (%) along slope		
	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%
Euphorbia cotinifolia	72	128.0	16.0	-	16.0	-	128.0	10%	16.67%	12.5%	-	12.5%	0.00%	20.00%
Maesa lanceolata	40	-	40.0	-	-	40.0	-	10%	-	25%	-	-	28.57%	
Euphorbia candelabrum	48	-	-	48.0	48.0		-	5%	-	-	16.67%	12.5%	-	
Flacourtia indica	16	-	16.0	-	-	16.0	-	5%	-	12.5%	-	-	14.29%	
Albizia gummifera	20	-	16.0	24.0	21.3	16.0	-	20%	-	25%	33.33%	37.5%	14.29%	
Millettia ferruginea	16	-	-	16.0		16.0	-	5%	-	75%	16.67%	0%	14.29%	
Persea americana	76.8	83.2	88.0	41.6	50.0	96.0	176.0	75%	83.33%	75%	83.33%	100%	85.71%	20.00%
Syzygium guineense	16	-	-	16.0	16.0	-	-	5%	-	-	16.67%	12.5%	-	
Eucalyptus camaldulensis	352	-	-	352.0	352.0	-	-	5%	-	-	16.67%	12.5%	-	
Citrus sinensis	16	-	16.0	16.0	16.0	-	-	10%	-	12.5%	16.67%	25%	-	
Coffea arabica	88	112.0	32.0	124.0	88.0	88.0	-	40%	16.67%	37.5%	66.67%	50%	57.14%	
Manihot esculenta	48	-	-	48.0	-	48.0	-	5%	-	-	16.67%	-	14.29%	
Euphorbia tirucalli	176	-	74.7	328.0	272.0	48.0	16.0	25%	-	37.5%	33.33%	37.5%	14.29%	20.00%
Calpurnia aurea	16	16.0	16.0	16.0	16.0	16.0	-	15%	16.67%	12.5%	16.67%	12.5%	28.57%	
Ficus thonningii	16	-	16.0	-	16.0	-	-	5%		12.5%	-	12.5%	-	
Ocimum lamifolium	16	-	16.0	-	16.0	-	-	5%		12.5%	-	12.5%	-	
Vernonia amygdalina	16	16.0	-	16.0	16.0	16.0	-	10%	16.67%	-	16.67%	12.5%	14.29%	
Cupressus lusitanica	144	320.0	85.3	-	192.0	32.0	176.0	20%	16.67%	37.5%	-	12.5%	14.29%	40.00%

Rhamnus prinoides	16	16.0	16.0	-	-	16.0	-	5%	16.67%	12.5%	-	0%	14.29%	
Annona senegalensis	24	32.0	-	-	-	24.0	-	10%	16.67%	-	-	0%	28.57%	
Grevillea robusta	116.6	101.3	149.3	64.0	128.0	48.0	128.0	35%	50%	37.5%	16.67%	50.0%	14.29%	40.00%
Vepris dainellii	16	-	16.0	-	-	-	16.0	5%	-	12.5%	-	-	-	20.00%
Caesalpinia decapetala	16	-	16.0	16.0	16.0	16.0	-	10%	-	12.5%	16.67%	12.5%	14.29%	-
Catha edulis	54.7	58.7	53.3	40.0	43.4	58.7	-	60%	50%	75%	66.67%	87.5%	85.71%	-
Gossypium hirsutum	16	-	-	16.0	16.0	-	-	5%	-	-	16.67%	12.5%	-	
Ricinus communis	24	-	24.0	-		32.0	16.0	10%	-	25%	-	0.00%	14.29%	20.00%
Prunus persica	16	16.0	-	-	16.0	16.0	-	10%	33.33%	-	-	12.5%	14.29%	
Casimiroa edulis	16	-	16.0	-	16.0	-	-	5%	0.00%	12.5%	-	12.5%	-	
Acacia abyssinica	24	-	16.0	26.7	24.0	24.0	-	20%	-	12.5%	50.00%	25%	28.57%	
Croton macrostachyus Del.	20.6	32.0	19.2	16.0	20.0	16.0	16.0	35%	16.67%	62.5%	16.67%	50%	42.86%	20.00%
Mangifera indica	28.4	32	40.0	22.4	25.6	32.0	-	45%	33.3%	25%	83.33%	62.5%	57.1%	-
Galiniera saxifraga	16	16	16.0	-	16.0	16.0	-	10%	16.7%	12.5%	-	12.5%	14.3%	-
Carica papaya	28	32	24.0	32.0	24.0	32.0	32.0	20%	16.7%	25%	16.67%	25%	14.3%	20%
Vernonia auriculifera	64	112.0	16.0	40.0	28.0	208.0	-	25%	33.3%	12.5%	33.33%	50%	14.29%	-
Sesbania sesban	41.6	48	16.0	-	16.0	32.0	128	25%	66.7%	12.5%	-	37.5%	14.3%	20%
Cordia africana	28.8	-	32.0	24.0	21.3	48.0	32.0	25%	-	37.5%	33.33%	37.5%	14.3%	20.%
Erythrina brucei	304	416	-	80.0	80.0	752.0	80.0	15%	33.3%	-	16.67%	12.5%	14.3%	20.%
Bougainvillea spectabilis	16	16	-	-	-	-	16.0	5%	16.7%	-	-	-	-	20%
Psidium guajava	32	-	16.0	48.0	48.0	16.0	-	10%	-	12.5%	16.67%	12.5%	14.3%	-

Appendix 4: Density and frequency of species across site and along slope class of woody species in Crop field around Jimma town, Southwest Ethiopia

species Name	Density (indiv/ha) site				Density (indiv/ha) along slope			Frequency (%) across site				Frequency (%) along slope		
	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%
Euphorbia cotinifolia	9.38	12.5	6.25		6.25	12.50		8.33%	14.29%	12.5%	0%	6.67%	11.11%	
Maesa lanceolata	6.25	6.25	6.25		6.25	6.25		8.33%	14.29%	12.5%	0%	6.67%	11.11%	
Euphorbia candelabrum	18.75	18.8				18.75		4.17%	14.29%		0%		11.11%	
Carissa spinarum	12.5		12.50		12.50			4.17%	0.00%	12.5%	0%	6.67%		
Albizia gummifera	7.81	6.25	6.25	18.75	6.25	9.38		33.33%	42.86%	50%	11.11%	26.67%	44.44%	
Syzygium guineense	6.25		6.25		6.25			4.17%	0.00%	12.5%	0%	6.67%		
Olea welwitschii	6.25		6.25		6.25			4.17%	0.00%	12.5%	0%	6.67%		
Sapium ellipticum	6.25		6.25		6.25			4.17%	0.00%	12.5%	0%	6.67%		
Coffea arabica	20.3	43.8	15.63	6.25	15.63	25.00		16.67%	14.29%	25.%	11.11%	13.3%	22.22%	
Euphorbia tirucalli	268.8		268.8		268.8			4.17%	0.00%	12.5%	0%	6.67%		
Calpurnia aurea	18.75			18.75		18.75		4.17%	0.00%		11.11%		11.11%	
Cupressus lusitanica	25	25				25.00		4.17%	14.29%		0.00%		11.11%	
Grevillea robusta	15.63	18.8		12.50		15.63		8.33%	14.29%		11.11%		22.22%	
Caesalpinia decapetala	6.25		6.25		6.25			4.17%		12.5%	0.00%	6.67%		
Catha edulis	20		22.92	15.63	18.75	25.00		20.83%	0.00%	37.5%	22.22%	26.67%	11.11%	
Brucea antidysenterica	6.25	6.25				6.25		4.17%	14.29%		0.00%		11.11%	
Acacia abyssinica	6.25	6.25	6.25	6.25	12.50	6.25		12.50%	14.29%	12.5%	11.11%	6.67%	11.11%	
Croton macrostachyus	11.25	6.25	8.33	25.00	7.81	25.00		20.83%	14.29%	37.5%	11.11%	26.67%	11.11%	
Mangifera indica	8.33		6.25	9.38	12.50	6.25		12.50%	0.00%	12.5%	22.22%	6.67%	22.22%	
Vernonia auriculifera	15.63	18.8		12.50		15.63		8.33%	14.29%		11.11%		22.22%	
combretum molle	6.25			6.25	6.25			4.17%	0.00%		11.11%	6.67%		
Ekebergia capensis	6.25			6.25		6.25		4.17%	0.00%	0%	11.11%		11.11%	
Cordia africana	11.25	6.25	9.38	13.75	11.11	12.50		41.67%	14.29%	50%	55.56%	60.00%	11.11%	
Erythrina brucei	6.25	6.25	6.25		6.25	6.25		8.33%	14.29%	12.5%	0.00%	6.67%	11.11%	
Psidium guajava	6.25			6.25	6.25			4.17%			11.11%	6.67%		

Appendix 5: Density and frequency of species across site and along slope class of woody species in Coffee farm around Jimma town, Southwest Ethiopia

Species Name	Density (indiv/ha) site				Density (indiv/ha) along slope			Frequency (%) across site				Frequency (%) along slope		
	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%
Euphorbia cotinifolia	16.00		16.00			16		5.26%		16.67%			25%	
Flacourtia indica	16.00		16.00				16.00	5.26%		16.67%				14.29%
Dracaena steudneri	16.00			16	16.0			5.26%			20%	12.5%		
Albizia gummifera	41.14	48.00	16.00	48	56.0	21.3	41.14	73.7%	100%	50.00%	60%	50%	75%	100%
Millettia ferruginea	36.57	58.67	24.00	16	24.0		41.6	36.8%	37.5%	33.33%	40%	25%	0.00%	71.43%
Persea americana	26.67	32.00	24.00		32.0	16	32.0	15.8%	12.5%	33.33%		12.5%	25%	14.29%
Clematis hirsuta	16.00		16.00				16.0	5.26%		16.67%				14.29%
Olea welwitschii	16.00		16.00		16.0			5.26%		16.67%		12.5%		
Citrus sinensis	16.00		16.00		16.0			5.26%		16.67%		12.5%		
Coffea arabica	1400	1366.	1546.7	1280	1386	1320	1463	100%	100%	100%	100%	100%	100%	100%
Calpurnia aurea	37.33		16.00	48	48	16		15.8%		16.67%	40%	25%	25%	
Vernonia amygdalina	24.00	24.00					24.0	10.5%	25%					28.57%
Cupressus lusitanica	80.00		80.00			80		5.26%		16.67%			25%	
Grevillea robusta	56.00	48.00	64.00			64	48.0	10.5%	12.5%	16.67%			25%	14.29%
Ficus sur	16.00			16			16.0	5.26%			20%			14.29%
Jacaranda mimosifolia	16.00			16	16			5.26%			20%	12.5%		
Catha edulis	64.00		64.00		64			5.26%		16.67%		12.5%		

Casimiroa edulis	16.00		16.00			16		5.26%		16.67%			25%	
Ficus vasta	16.00			16	16.00			5.26%			20 %	12.5%		
Maytenus arbutifolia	16.00		16.00			16		5.26%		16.67%			25%	
Brucea antidysenterica	16.00		16.00			16		5.26%		16.67%			25%	
Acacia abyssinica	32.00	32.00	32.00	32	26.67	64	32.0	52.6%	37.5%	50.00%	80%	75%	25%	42.86%
Bersama abyssinica	16.00	16.00			16.00			5.26%	12.5%			12.5%		
Croton macrostachyus	35.20	52.57	22.40	16	16.00	36	50.7	78.95%	87.5%	83.33%	60%	62.5%	100%	85.71%
Mangifera indica	32.00		32.00		32.00			5.26%		16.67%		12.5%		
Arundinaria alpina	224.0	224.				224		5.26%	12.5%				25%	
Galiniera saxifraga	16.00	16.00					16.0	5.26%	12.5%					14.29%
Vernonia auriculifera	32.00	32.00	26.67	48	32.00	32		26.32%	12.5%	50.00%	20 %	37.5%	50%	
Senna septemtrionali	16.00			16	16.00			5.26%			20%	12.5%		
Sesbania sesban	32.00	32.00			16.00		32.00	5.3%	12.5%			12.5%		14.3%
Ekebergia capensis	16.00			16				5.26%			20%			
Ehretia cymosa	32.00		32.00		32.00			5.26%		16.67%		12.5%		
Cordia africana	28.00	40.00	28.00	16	24.00	42.67	21.3	63.16%	50%	66.67%	80%	75.%	75%	42.86%
Psidium guajava	16.00			16			16.0	5.26%			20%			14.29%
	2485.34	2021.24	2135.73	1616	1900.7	1980	1865.6							

Appendix 6: Density and frequency of species across site and along slope class of woody species in Pasture/grazingland around Jimma town, Southwest Ethiopia

species Name	Density (indiv/ha) site				Density (indiv/ha) along slope			Frequency (%) across site				Frequency (%) along slope		
	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%	All	Mazoria	Merewa	Waro-Kolobo	<13%	13-26%	26-40%
Maesa lanceolata	32.00		32.00	32.00		32.00		10.00%		11.11%	16.67%	0.00%	28.57%	0.00%
Euphorbia candelabrum	16.00	16.00					16.00	5.00%	20.00%			0.00%	0.00%	20.00%
Carissa spinarum	64.00		64.00			64.00		5.00%		11.11%		0.00%	14.29%	0.00%
Albizia gummifera	19.20		16.00	24.00	32.0	32.00	16.00	25.00%		33.33%	33.33%	25.00%	14.29%	40.00%
Millettia ferruginea	16.00	16.00			16.0			5.00%	20.00%	0.00%		12.50%	0.00%	0.00%
Persea americana	16.00		16.00			16.00		5.00%		11.11%		0.00%	14.29%	0.00%
Syzygium guineense	32.00		32.00			32.00		10.00%		22.22%		0.00%	28.57%	0.00%
Eucalyptus camaldulensis	16.00		16.00		16.0	16.00		10.00%		22.22%		12.50%	14.29%	0.00%
Calpurnia aurea	20.00		16.00	24.00	32.0	16.00	16.00	20.00%		22.22%	33.33%	12.50%	14.29%	40.00%
Delonix regia	32.00	32.00				32.00		5.00%	20.00%			0.00%	14.29%	0.00%
Acacia etbaica	56.00		64.00	48.00	48.0		16.00	10.00%		11.11%	16.67%	12.50%	0.00%	80.00%
Vernonia amygdalina	48.00	80.00	16.00				48.00	10.00%	20.00%	11.11%		0.00%	0.00%	40.00%
Dodonaea angustifolia	16.00			16.00		16.00		5.00%	0.00%		16.67%	0.00%	14.29%	0.00%
Cupressus lusitanica	144.00		144.00				144.00	5.00%	0.00%	11.11%		0.00%	0.00%	20.00%
Annona senegalensis	24.00	32.00	16.00		48.0			10.00%	20.00%	11.11%		25.00%	0.00%	0.00%
Grevillea robusta	90.67	88.00	96.00		16.0		128.00	15.00%	40.00%	11.11%		12.50%	0.00%	40.00%

Caesalpinia decapetala	16.00	16.00					16.00	5.00%	20.00%	0.00%		0.00%	0.00%	20.00%
Ficus vasta	16.00			16.00		16.00		5.00%	0.00%	0.00%	16.67%	0.00%	14.29%	0.00%
Maytenus arbutifolia	48.00		48.00			48.00		10.00%	0.00%	22.22%		0.00%	28.57%	0.00%
Acacia abyssinica	25.60		24.00	26.67	96.0	32.00		25.00%	0.00%	22.22%	50.00%	50.00%	14.29%	0.00%
Bersama abyssinica	16.00		16.00	16.00		16.00	16.00	10.00%	0.00%	11.11%	16.67%	0.00%	14.29%	20.00%
Croton macrostachyus	35.20	16.00	29.33	53.33	48.0	38.40	56.00	50.00%	20.00%	66.67%	50.00%	37.50%	71.43%	40.00%
Mangifera indica	16.00	16.00	16.00		16.0		16.00	10.00%	20.00%	11.11%		12.50%	0.00%	20.00%
Galiniera saxifraga	32.00			32.00		32.00		5.00%	0.00%	0.00%	16.67%	0.00%	14.29%	0.00%
Acacia mearnsii	128.00	128.00				128.00		5.00%	20.00%	0.00%		0.00%	14.29%	0.00%
Vernonia auriculifera	32.00	16.00	56.00	16.00	16.0	16.00	42.67	25.00%	40.00%	22.22%	16.67%	12.50%	14.29%	60.00%
Senna septemtrionali	69.33	16.00	16.00	176.00	16.0	176.00	16.00	15.00%	20.00%	11.11%	16.67%	12.50%	14.29%	20.00%
Ekebergia capensis	16.00			16.00		16.00		5.00%	0.00%	0.00%	16.67%	0.00%	14.29%	0.00%
Ehretia cymosa	16.00	16.00			16.0			5.00%	20.00%	0.00%		12.50%	0.00%	0.00%
Premna schimperi	16.00		16.00				16.00	5.00%	0.00%	11.11%		0.00%	0.00%	20.00%
Cordia africana	26.67		32.00	16.00		16.00	32.00	15.00%	0.00%	22.22%	16.67%	0.00%	14.29%	40.00%
Erythrina brucei	16.00	16.00			16.0			5.00%	20.00%	0.00%		12.50%	0.00%	0.00%
Psidium guajava	25.60	16.00	28.00		32.0	32.00		25.00%	20.00%	44.44%		25.00%	42.86%	0.00%

Appendix 7: Density and frequency of species across site and along slope class of woody species in Woodlots around Jimma town, Southwest Ethiopia

species Name	Density (indiv/ha) site				Density (indiv/ha) along slope			Frequency (%) across site				Frequency (%) along slope		
	All	Mazoria	Merewa	W/Kolobo	<13%	13-26%	26-40%	All	Mazoria	Merewa	W/Kolobo	<13%	13-26%	26-40%
Maesa lanceolata	375	1200	100		1200	100		23.53%	16.67%	75.00%		25.00%	50.00%	
Syzygium guineense	600		600			600		5.88%	0.00%	25.00%			16.67%	
Eucalyptus camaldulensis	4250	4450	4125	4133	3314.3	4083	5075	94.12%	100 %	100.00%	85.71%	100%	100%	75 %
Vernonia amygdalina	200	200					200	5.88%	16.67%	0.00%				25.00%
Cupressus lusitanica	2650		600	4700.		600	4700	11.76%	0.00%	25.00%	14.29%		16.67%	25.00%
Grevillea robusta	620	620			500	100	1000	29.41%	83.33%	0.00%		28.57%	16.67%	50.00%
Ficus sur	100	100					100	5.88%	16.67%	0.00%				25.00%
Ricinus communis	200	200					200	5.88%	16.67%	0.00%				25.00%
Croton macrostachyus	100	100	100			100	100	23.53%	33.33%	50.00%			50.00%	25.00%
Senna septemtrionali	100	100			100			5.88%	16.67%	0.00%		14.29%		
Ekebergia capensis	100.	100	100.00			100		11.76%	16.67%	25.00%			33.33%	
Cordia africana	100	100				100	100	11.76%	33.33%	0.00%			16.67%	25.00%
Psidium guajava	100		100.00			100		5.88%	0.00%	25.00%			16.67%	
	9495	7170	5725	8833	5667	5883	16550							

Appendix 8:- Field Photo

Field Inventory (**height Measuement)_**