THE ROLE OF HOMEGARDEN AGROFORESTRY IN BIODIVERSITY CONSERVATION AND HOUSEHLD LIVELIHOODS IN YAYU COFFEE FOREST BIOSPHERE RESERVE, CHORA DISTRICT, SOUTHWESTERN ETHIOPIA

MSc. THESIS

BY

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JIMMA, ETHIOPIA

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Gemeda Terfassa Fida

A Thesis

Submitted to Jimma University College of Agriculture and Veterinary Medicine, Department of Natural Resources Management in Partial Fulfillment of the Requirements for the Degree of Master of Science in Natural Resources Management (Forest and Nature Management) NRM-621

Major Advisor: Debela Hunde Feyssa (PhD, Professor)

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Thesis Submission Request Form (F-08)

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I have completed my thesis research work as per the approved proposal and it has been evaluated and accepted by my advisers. Hence, I hereby kindly request the Department to allow me to present the findings of my work and submit the thesis.

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We, the thesis advisers have evaluated the contents of this thesis and found to be satisfactory, executed according to the approved proposal, written according to the standards and format of the University and is ready to be submitted. Hence, we recommend the thesis to be submitted.

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DEDICATION

To the Almighty God the Savior and Redeemer, my family and my parents, for their continual support and motivation gave me additional strength to work towards achieving this dream.

STATEMENT OF AUTHOR

I undersignedand declare that this thesis entitledContribution of Homegarden Agroforestry for Biodiversity Conservation and Local Livelihoods: The Case of Chora District, Southwestern Ethiopiais my original work and has not been presented or submitted for any degree in any other university and that all sources of material used for this thesis have been duly cited and acknowledged. The thesis is deposed at the Jimma university library to make available to borrowers under the rules of the library.

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BIOGRAPHICAL SKETCH

The author, Gemeda Terfassa Fida was born on May 17, 1989, in Sedi Chanka District, Kelem Wollega zone. He attended his elementary education at Chanka elementary school and then continued secondary and preparatory schools at Dereje Keba and Kelem comprehensive schools respectively. Mr. Gemeda Terfassa Fida has received B.Sc. degree in General Forestry from Wondo Genet College of Forestry and Natural Resources, Hawassa University in July 2011. Soon he was employed by Oromiya Forest and Wildlife Enterprise and served for two years at west Harerge zone, and then employed by Oromia Agricultural Research Institute and worked at Adami Tulu Agricultural Research Center for three years. He joined Jimma University College of Agriculture and Veterinary Medicine to pursue his Masters in Natural Resources Management (Forest and Nature Management) September, 2016.

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LIST OF ACRONYMS AND ABBREVIATIONS

BRs	Biosphere Reserves
CBD	Convention on Biological Diversity
ECCCFF	Climate Change and Coffee Forest Forum
ECFF	Environment and Coffee Forest Forum
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agricultural Organization
FGDs	Focal Group Discussions
GPS	Geographic Positioning System
HG	Homegerden
IUCN	International Union for Conservation of Nature
JUCAVM	Jimma University College of Agriculture and Veterinary Medicine
MAB	Man andthe Biosphere Reserves
OARI	Oromia Agricultural Research Institute
SD	Standard deviation
SPSS	Statistical Package for Social Studies
UK	United Kingdom
UNESCO	United Nations Educational, Scientific and Cultural Organization
YCFBR	Yayu Coffee Forest Biosphere Reserve

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ABSTRACT

Traditional homegardens in southwest Ethiopia is well-known land use practices playing an important role in both biodiversity conservation and livelihood aspects. Thus, the objective of this study was to examine the contribution of homegardens towards of biodiversity conservation and local people livelihoods.Homegarden plant diversity assessment and household interview data collection methods were used.Systematic random and simple random sampling methods were used to select 139 households and 45 homegardens respectively. Descriptive statistics, diversity indices, one way ANOVA and Pearson correlation were used for analysis. A total of 79 plant species belonging to 41 families were identified. Family Fabaceae and Rutaceae have a relatively higher number of species (6 species each). In terms of habit, (34%) of the species were herbs followed by trees (30%), shrubs (27%) and climbers (9%). Farmers manage both exotic (61%) and indigenous (39%), from which 57% were food and 43% nonfood plant species. The Shannon, Simpson and evenness diversity indexes were 3.27, 0.053 and 0.87 respectively. Coffea arabica was the most frequent (86.67%) species followed by Persea americana (68.89) and Catha edulis (64.44) in homegardens of the area. Homegarden agroforestry was more important for a food source, and contribute about 4079.70Birr annual income on average. Total land and homegarden land sizes shown a positive correlation with species richness ($r = 0.199^*$, $r=0.170^*$) at $p<0.05$ level of significance. This study suggests that homegardens contribute to plant biodiversity conservation and the sustenance of the livelihoods of smallholder farmers in the study area. However, due to few market-oriented crops concentration, biodiversity of the system have been affected. Thus, gardeners should be encouraged to cultivate versatile plants in the practice for effective biodiversity conservation and livelihood improvements.

Keywords:*Yayu, Coffee Forest, Biodiversity Hotspot,*Buffer Zone, *CashCrop, Food Security*

1. INTRODUCTION

1.1. Background and Justification

Agroforestry is a dynamic land use practices that maintain overall farm productivity by combining herbaceous food crops with woody perennial and livestock on the same piece of land. Homegardens are among agroforestry practices with the most complex and diverse agroecosystem that have been developed by numerous human cultures worldwide. They played an important role towards the development of early agriculture and domestication of crops. Homegardens often show a promising option for biodiversity conservation and mitigation of ecosystem degradation. In some cases, they were found to be equally effective as natural forests in the conservation of tree species diversity (Abdoellah *et al*., 2006; Mohri *et al*., 2013; Jhariya *et al*., 2015).

Homegardens as an ecosystem contain multiple levels of diversity, including cultural, genetic and agronomic diversity. The high diversity of species in homegardens, which combines crops, trees and animals have different uses and production cycles is considered as an essential component of sustainable agriculture because of the wide socioeconomic and ecological roles it plays in these systems. Studies carried out in homegardens of various regions have recorded notable richness of species and varieties that provide an additional food supply and cash income for the people. They have been playing essential socioeconomic and ecological role due to the fact that it is related to the production of food and other products such as the source of firewood, fodder, medicinal plants, cash crops, and ornamentals (Das and Das 2005; Bharucha and Pretty, 2010; Olango *et al*., 2014).

In relation to conservation of biodiversity, Galluzzi *et al*. (2010), describes that homegardens are taken as key places for conserving plant biodiversity. It is exhibited that homegardens are serving as refugees camp for a number of plants species especially for those plant species that are not widely grown in the larger agroecosystem. They are microenvironments containing high levels of species and genetic diversity which serves not only as sources of food, fodder, fuel, medicines, spices, construction materials and income in many countries around the world, but are also important for *in-situ* conservation of a wide range of plant genetic resources. However, homegardens structure, composition, and species and cultivar diversity are influenced by changes in the socioeconomic circumstances and cultural values of the households that maintain these gardens (Emmett and Nye, 2017).

Integrating multipurpose trees with food crops and livestock in homegardens in the intimate association is an ancient activity in Ethiopia (Anjulo and Mezgebu, 2016). According to Berhanu and Asfaw (2014), Ethiopian homegardens as an ecosystem encompass multiple levels of diversity, including cultural, genetic and agronomic diversity. About 539 species belonging to 352 genera and 109 families were recorded in Ethiopian homegardens which make up nearly 9% of the Ethiopian higher flora, were reported. Conversely, the recent transition of the homegardens into commercial production of new cash crops, including khat (*Catha edulis*) is a farming strategy undertaken by smallholders to address demographic, market and socioeconomic changes in the country. The changing socioeconomic conditions and advent of commercial forces have introduced the concept of cash with homegardens (Bargali *et al.,* 2015; Gebrehiwot *et al.*, 2016).

On the other hand, the ongoing land fragmentation and the declining farm size in rural Ethiopia have limited the livelihood choices and opportunities of most smallholder farmers. The expansion of cultivated area is likely to require further infrastructure development that would result in further negative environmental implications with huge loss of biological diversity. In order to adapt to such socioeconomic changes, subsistence-oriented agroforestry homegardens are increasingly becoming more commercially oriented. This ongoing land use change has been carried out at the expense of diversity and stability of the long-existing farming practices important for sustainable livelihoods and food security (Gole *et al*., 2009; Seyoum *et al.*, 2012; Mohri *et al*., 2013; Gebrehiwot *et al*., 2016).

In addition, reduction of forest resources and increasing demand for its products especially in areas where people rely on natural resources for their livelihood needs are common. Finding alternative options to this widened gap between the demand and supply of forest products for local livelihood sustenance coupled with the natural resources conservation goal attainment is a fundamental concern. Homegarden seems to have the potential to provide options for sustained rural livelihoods and biodiversity conservation. It integrates protected areas with the surrounding landscapes and mediates the livelihood need of people within the conservation goal of the protected area. Thus it provides a potential to reduce land-use pressure and improve rural livelihoods in human-dominated landscapes and at the same time conserving a large proportion of biodiversity (Jose, 2012).

Although extensive areas of traditional agroforestry homegarden exist in southwestern Ethiopia, the locals' priorities to satisfy the immediate needs for food and cash under socioeconomic changes are being carried out at the expense of the diversity and stability of existing land use systems in the area (Abebe, 2005; Abebe *et al*., 2010). According to Kassa *et al*. (2012), the conversion of natural forest to monoculture in the area results in significant impacts on biodiversity richness of homegarden.

Moreover, following the nomination of Yayu Coffee Forest Biosphere Reserve (YCFBR), as a site for biodiversity conservation in southwestern Ethiopia (Gole*et al*., 2009), the local people dependency on homegarden as an alternative option is increasing. However, less emphasis is given towards of assessing existing plant diversity in homegarden, particularly in Chora district. The homegardens potential for conservation of biological diversity and economic returns are not fully studied. Thus, there is no inventoried documentation about structure, composition and plant diversity for the district.

According to Agbogidi and Adolor (2014), to determine how homegardens can best contribute to conservation, it is necessary to understand what diversity is being maintained by farmers. Hence, in order to strengthen and make the existing practice effective for plant diversity conservation and thereby to meet the homegarden products for locals need, scientific information is required. The study has a vital role for natural resources conservation and local people livelihood sustenance; it documents the role of homegarden towards of plant biodiversity conservation by describing floristic richness and diversity of the practice. It also describes their role to communities' livelihood, food security and income generation at the household level.

1.2. Objective of the Study

1.2.1. General objective

The main objective of the study is to assess the role of homegardens in sustaining plant biodiversity in the area and provide explicit information on homegardens role tohouseholds’ livelihoodin the area.

1.2.2. Specific objectives

- To assess and identify plant species composition and diversity of homegardens in the study area,
- To investigate homegardens role to households livelihood,
- To examine the relationship between household characteristics and existing plant diversity in homegardens of the study area.

1.3. Research Questions

The study was aimed to address the following research questions:

i What is the plant species constitute of homegardens in the study area?

ii What is the role of homegarden to the households’ livelihood in the study area?

iii What are the relationships between plant diversity in homegarden and household characteristics in the study area?

2. REVIEW OF LITERATURES

2.1. Homegarden Agroforestry

Homegarden refers to the deliberate management of multipurpose trees and shrubs (the woody component) grown in intimate association with herbaceous species (mainly annual, perennial, and seasonal agricultural crops) and invariably livestock within the compounds of individual houses the whole crop-tree-animal unit being intensively managed by family labor). It is an integrated system which comprises different things in its small area that produces a variety of foods and agricultural products including staple crops, vegetables, fruits, medicinal plants and so on (Panwar and Kaushal, 2017).

Homegarden agroforestry is an age-old and time-tested land use approach that makes the best use of nature's goods and services. These homegardens are evolved either through growing food crops in the forests or establishing tree crop production systems on arable lands. Furthermore, the homegarden agroforestry reflects the wisdom of the traditional culture and ecological knowledge of the local community. Most of the homegardens form a rich biodiversity source having several types of diversity, including cultural, genetic and agro-economic diversity (Lambin and Meyfroidt, 2011).

Homegardens are intensively cultivated agroforestry systems managed within the compounds of individual homes having diversity on the basis of local conditions. They comprise of a wide variety of productive trees, shrubs, vegetables, medicinal plants, herbs, fodder, and sometimes even staples and provide both economic and social benefits that are essential to the nutritional welfare and security of the household. These gardens, with their diversified agricultural crops and trees, fulfill the basic needs of the local population. Growing and maintaining plant species in the vicinity of home and making their products by household members were primarily intended for the family consumption. They are one of the best known traditional practices for livelihood, and sustainable development (Kittur and Bargali, 2013; Bargali *et al.*,2015; Parihaar *et al.*,2015).

Homegarden is a sustainable multiple-production system whose outputs can be adjusted to local needs. While the multistoried arrangement and high species diversity of the homegardens help to reduce environmental deterioration commonly associated with monocultural production systems. Moreover, it can be regarded as an informal plant introduction and distribution centers. Homegardens are commonly defined as a piece of land with a definite boundary surrounding a homestead, being cultivated with a diverse mixture of perennial and annual plant species, arranged in a multilayered vertical structure, often in combination with raising livestock, and managed mainly by household members for subsistence production (Kebede, 2010).

Homegardens appeared to have developed in the Indian subcontinent, Indonesia, Philippines, Malaysia, SriLanka and other parts of Southeast Asia, the tropical Pacific island, the Caribbean and various parts of tropical Latin America and Africa and can be found in almost all tropical-subtropical ecozones where subsistence land use systems predominate. The presence of homegardens in the highlands of Ethiopia (eastern Sidama highlands, enset, and cereals around Amhara settlements) similar to other tropical nations and they collectively house a large diversity of plant types that range from staple food crops to ornamental plants (Nayar, 2010; Jaganmohan *et al.*, 2012; Haile, 2017).

2.1.1. Structure and composition of homegardens

Lope-Alzina and Howard (2012), report that tropical homegardens consist of an assemblage of plants which may include trees, Shrubs, vines and herbaceous plants growing in or adjacent to a homestead or home compound. Okafor and Fernandes reported that in this system, multipurpose trees and Shrubs in a multistory association with agricultural crops are raised with livestock in the homestead. In agroforestry, it implies the intimate association of multipurpose trees and Shrubs with annuals and perennial crops and invariably livestock within the compound of individuals with the whole crop-tree-animal- the unit being managed by family labor.

Bijalwan (2012), also studied structure, composition, and diversity of fruit trees and shrub species in mid hill situation of Garhwal Himalaya (between 1000 to 2000 m asl), India, covering winter and summer season. This was also an aspect based study included the northern and southern aspects of the study area. A total of 12 fruit tree species (4 trees were common in northern and southern aspect and 6 trees were only noticed in northern aspect while 2 in the southern) were recorded in an agri-horticulture system with apple tree (*Malus domestica*) was a dominant fruit tree in both the aspects. A remarkable high agricultural crop diversity was also from the northern aspect in both the seasons.

Almost all homegardens have the most visible characteristics such as layered canopy and harmonious admixture of species, and specific place and functions but the main difference are seen in homegarden size, shape, and intensity of cultivation, the types of crops grown and complexity of species diversity. In general terms, all homegardens consist of three main layers, of this herbaceous layer near the ground, a tree layer at upper levels, and intermediate layers in between. The lower layer can usually be partitioned into two, with the lowermost (less than 1m height) dominated by different vegetable and medicinal plants, and the second layer (1 -3 m height) being composed of food plants such as cassava, banana, yam, and so on (Ajah, 2013; Sinku, 2016).

Zaman *et al.* (2010), conducted a study to assess the composition, structure, diversity of plant species and contribution of homegarden to household food security, conservation of plant species, socio-economic importance and the constraints of the total production system in Thakurgaon district of Northern Bangladesh. They stated that the homegarden size in average in the study area increased with the size of total land holding and total income was found higher in large farm category than that of marginal. They also recorded 37 useful plant species and mentioned the diversity and abundance of fruit tree species were higher in all farm categories followed by timber and fuelwood species. Mango and jackfruit were identified as an important cash-growing crop in the study area. Tree management practices and the scopes were very common but the farmer faced many problems during tree plantation including the animal and insect problems.

The compositions of crops grown in homegardens can be grouped based on function as ornamental, fruits, food crops, vegetables, medicinal, spices and fodder, building materials and fuelwoods. The patterns and compositions of homegardens are disordered due to the educational level of gardener, the indigenous knowledge of farmer, the market and the size of land availability. Thus, several patterns of homegarden have no particular patterns also sociocultural, environmental and ecological factors determine species composition and types of homegardens. Plant compositions in Ethiopian homegardens are grouped under the three main types of garden crops, live fence species, useful wild and semi-wild plants (Asfaw; 2001; Acheampong *et al.*, 2012).

Depending on the cultural factors, the size, shape and plant diversity of homegardens also vary across the globe. Homegardens in Ethiopia have variable shapes: some almost encircle the house others square, rectangle or irregular. Patterning of the crop also varies from place to place. For instance, the plants like bamboos are on the outer margins, some are planted inside margin next to the fence, chat, coffee, and enset are planted in the depressions of rows, others like perennial planted far apart with water collection depressions. Gardens usually have boundaries from home of other homegardens by fences; dry woody material, stones, and live plants (thorny shrubs) and sometime bounded by natural barriers like rivers, gorges (Tshiguvho, 2008; Goddard *et al.*, 2010).

2.1.2. Species diversity

Devi and Das (2013), recorded the tree diversity in traditional homegarden run by Meitei community (commonly known as Ingkhol) in the Barak Valley, Assam. They surveyed fifty homegardens and made an inventory of 71 tree species belonging to 60 genus and 35 families. Rutaceae was the dominant family with 4 genus and 7 species followed by Meliaceae (5 genera and 5 species), Arecaceae (4 genera and 4 species) and Moraceae (3 genus and 5 species). The dominant species with a maximum number of individuals was *Areca catechu* and other dominant trees documented are *Mangifera indica, Artocarpusheterophyllus, Syzygium cumini, Psidium guajava,* etc.

Species diversity is the variety of species and a measurement of species richness combined with evenness, meaning it takes into account not only how many species are present but also how evenly distributed the numbers of each species are (Schrothand and Sinclair, 2003). Homegardens are typically populated by a wide variety of plants, such as herbs, shrubs, and trees. Most gardeners try to optimize their homegardens by planting as many crops as they can in the limited space available and in physical constraints of their home environment. Homegardens are highly diversified in their components. For instance, in the homegardens of West Java, 56 species of plants were recorded in a single homegarden and in a hamlet of 41 households the number of species reached 272, and the presence of up to 100 varieties of banana was reported from the homegardens of Bukoba, Tanzania and 60 different species were recovered from well-managed climax homegardens Reported in Ethiopia, (Jaganmohan *et al*., 2012; Jeeva, 2016; Kaswanto, 2017).

Parihaar *et al.* (2015), analyzed the indigenous agroforestry system in Semalkhaliya village (Ramnagar block) situated in *bhabar*belt of Kumaun Himalaya. They reported a total of 15 tree species and 22 crop species from the village homegarden was another land use system commonly used by the farmers. In this system, seasonal vegetable crops were grown with mixed plantation of fodder and fruit trees. In homegarden annual energy input was 53 913 MJ/ha but in agroforestry system annual energy input was 81 905 MJ/ha. Highest per ha annual productivity or income was greater in agriculture followed by the homegardens.

Blanckaert *et al.* (2004), surveyed 30 homegardens of San Rafael Coxcatlan, a rural village in the semi-arid valley of Tehuaclan-Cuicatlan, Mexico and they have collected 233 plant species from the homegarden and found that 68% plants are cultivated, while 22% were spared and 10% protected. Based on the use, plants were categorized into ornamental (65.7%), edible (29.6%), medicinal (8.6%). They confirm that the homegardens are high biodiversity spots and are interesting for ethnobotanical research. The homegarden is also a good habitat for small wild animals such as birds, reptiles and amphibians. Stability of species diversity is affected by market demand, pests, ecological (soil, water, altitude), and economic factors among many others (Emmett and Nye, 2017).

Pandey *et al*. (2006), assessed the floristic wealth and structure of 19 homegardens and 10 home - forest-gardens in South Andaman. The similarity in species composition between homegarden and home-forest-garden was 72%. The diversity of plant species was greater in home - forest - garden whereas equitability, the concentration of dominance and species richness in homegarden. They revealed that the number of ligneous species was 18 in homegarden and 10 in home-forest-garden. Plantation crops (coconuts, arecanut) fruit plants (mango, banana, papaya) and spices (clove, nutmeg, and cinnamon) were encountered as major species in homegardens.

Tolera *et al. (*2008), studied woody species diversity in a changing landscape in the south-central highlands of Ethiopia. A systematic sampling was used to collect vegetation data from crop fields and natural forest, while simple random sampling within wealth categories was used to select sample households and their homegardens. A total of 70 woody species were recorded. Out of this highest number of wood species (64) was recorded in homegardens, followed by crop fields (32) and the lowest number (31) in the remnant natural forest. The diversity and density of woody species declined with increasing age of crop fields, while the diversity of woody species increased with increasing age and size of homegardens.

Chandrashekara (2009), studied the diversity of fruit trees with respect to abundance, distribution patterns, fruit collection and their management in coffee based homegardens of high altitude agro-climatic zones of Kerala and he found some non-crop fruit trees like *Baccaurea courtallensis, Carissa carandus, Chrysophyllum roxburghii, Feronia elephantum, Garcinia xanthochymus, Madhuca indica, longifolia, Mimusopselengi, Zizyphus mauritiana*etc were managed for shade, fuelwood, timber, soil fertility, fencing, and edible fruits. For the conservation of crop diversity and ensuring food security, he proposed tree improvement, domestication and sustainable cultivation of the non-crop fruit trees species in homegardens.

Zimik *et al.* (2012), carried out a comparative study of homegardens of Assam and Arunachal Pradesh in terms of species diversity and plant utilization pattern. They found that species richness per homegarden varied greatly and it ranged from to 87 with an average of 46 (SE ± 1.98) species. A total of 268 species (107 trees, 53 shrubs, and 108 herbs) belonging to 200 genera under 82 families in five vertical strata (emergent, canopy, understory, shrub, and herb) were identified in the studied homegardens with the highest percentage of species in herb stratum (37%). The occurrence of some of the rare /endangered species such as *Aquilaria malaccensis, Livistona jenkinsiana, and Clerodendrum colebrookianum*in the homegarden shows the importance of plant conservation by these homegardens.

Mekonnen *et al.* (2014), recorded a total of 69 plant species belonging to 40 families from Jabithenan District, Northwestern Ethiopia. *Musa paradisica, Brassicaintegrifolia, Coffea arabica,* and *Cordia africana*are listed as some of the common species in the homegarden. *Coffea Arabica and Cordia africana*show highest importance value of index among all the woody species.

Neelamegam *et al.* (2015), examined the status, composition, and diversity of plants in a rural village Swamithoppe village in Kanyakumari District, Tamil Nadu. They studied about 121 villages and the selection of villages was purely based on random sampling. They did an extensive study of number and abundance of species, species diversity, richness, evenness and dominance indices. Size of homegarden ranges between 20.23m^2 to 627.28m^2 and an average size was 73.21m^2 to 519.36m^2. They recorded a total of 3540 individual species. A total number of an individual is 3540 were recorded. The number species recorded ranged from 2 to 23/HG species with an average of 8.30 to 9.24 species/homegarden. The species density varied from1.65/100m^2 to 64.26/100m^2 with an average of 2.58 to 13.84/100m^2. Coconut nucifera was observed as an important tree in most of the homegardens with a maximum number of individual as 162.

2.1.3. Identification feature of homegardens

According to Calvet *et al*. (2016), homegardens are identified by five characteristics. First; the garden is located near the residence. Second, the garden contains a high diversity of plants. To these criteria, some add that the garden recycles nutrients in a sustainable manner that plants are planted densely, and that plants are layered to mimic natural forest. Third, garden production is additional rather than a main source of family consumption or income. Fourth, the garden occupies a “small” area. A fifth distinguishing characteristic of homegardens that offered by is that homegardens are a production system that the poor can easily enter at some level since it may be done with practically no economic resources, using locally available planting materials, natural manures and indigenous methods of pest control.

In the tropics, two types of homegardens are recognized based on their contribution to the benefits of households. The first types are small-scale supplementary food production systems around the house in areas where the subsistence of the owners is based on their land use. The Java monoculture rice production and homegardens in Latin America belong to this category. The second types of homegardens stretched from fields around the house that constitute the most important means of the livelihood for farming households. Most of the homegardens in the highlands of eastern Africa belong to this type. It is also a place for experiments and even fundamental research and the groundbreaking genetic research. Homegardens are also subdivided into two basic types as city or urban, and the Kebele or rural homegardens (Barthel and Isendahl, 2013; Kitalyi, 2013).

2.2. Homegarden and Biodiversity

Homegarden is an integrated system which comprises different things in its small area that produces a variety of foods and agricultural products including staple crops, vegetables, fruits, medicinal plants and so on. The importance of homegardens in the production of food, medicine, and other useful products for human beings is widely recognized. Traditional homegardens typically have a multilayered arrangement, resembling an agroforestry system, which brings different plant species together in a temporal and spatial succession. This stratified and dynamic architecture more than the identity of a single species has been shown to make a homegarden a sustainable and resilient ecosystem in which different root structures utilize nutrients from various soil levels and both ground and aerial space are efficiently utilized (Eyzaguirre and Linares, 2004; Smith *et al*., 2006; Polegri and Negri, 2010).

Biodiversity is the totality of genes, species, and ecosystems of a region. Biological diversity for food and agriculture can be managed to maintain or enhance ecosystem functions to provide options for the optimization of agricultural production and contribute to the resilience of ecosystems for risk mitigation. Maintenance of genetic variation within agricultural crops provides a broad range of essential goods and services which support ecosystems functioning, resilience and productivity (Smith *et al*., 2006).

Biodiversity, which is necessary for the maintenance of ecosystem functioning and services such as pollination, nutrient cycling, and pest control, are declining globally at an alarming rate. Conservation of biodiversity is therefore of immense concern, particularly in tropical developing nations where biodiversity is high, human development is low, and deforestation is rampant. Often overlooked as potential harbors for biodiversity, agricultural systems are of increasing interest to conservationists aiming to preserve ecosystem functioning in highly modified landscapes. Recent empirical evidence has shown that many tropical farming systems provide habitat and foraging ground to wild species otherwise displaced by human activities and that the biodiversity supported depends on the intensity of agricultural management (Hooper *et al.*, 2005; Scales and Marsden 2008).

The links between agriculture and biodiversity have changed over time and should be viewed in the context of global agricultural development trends. Agricultural intensification increased output per unit area of land have been shaped by demographic pressures (high population growth rates, the migration of people into frontier areas, and imbalances in population distribution), and the predominant paradigms of industrial agriculture and the Green Revolution. These paradigms generally emphasize maximizing yield per unit of land, uniform varieties, reduction of multiple cropping, standardized farming systems (particularly generation and promotion of high-yielding varieties), and the standardized applications of agrochemicals. The widespread adoption of high yielding varieties and other technologies has led to a reduction of biodiversity which in turn diminishes the ecosystem services provided by biodiversity and, therefore, undermines ecosystem health (Phelps *et al.*, 2013).

2.3. Biodiversity in Homegardens of Southwestern Ethiopia

Southern and southwestern parts of Ethiopia comprise most of the remaining natural forests of the country. The forest provide food, medicine, energy, fodder, farm implement and construction materials (Gobeze *et al*., 2009). Depending on Wakjira (2006), in the southeastern and southwestern rain forests of Ethiopia, the continuous management of the wild coffee in the semi-forest coffee system suppresses woody plant regeneration, reduces tree density and eventually leads to the disappearance of the forest species and finally the forest, while temporarily benefiting the coffee plants.

The *ensete-coffee*-livestock tree system of southwestern Ethiopia represents a typical multistory homegarden. The upper storey is dominated by broadleaved trees (e.g., *Cordia, Croton, Millettia*) fruit crops (avocado, mango), the middle storey containing ensete, coffee and maize while vegetables, spices, herbs cover the lower canopies. This results in a continuous food production throughout the year.The upper storey is dominated by broadleaved trees (e.g., *Cordia, Croton, Millettia*) fruit crops (avocado, mango), the middle storey containing ensete, coffee and maize while vegetables, spices, herbs cover the lower canopies. This results in a continuous food production throughout the year Reference?

According to Kebebew *et al*. (2011), homegarden, coffee farm and woodlot were traditional tree based land use system among households indicating potential agroforestry intervention areaand all farmers are practicing coffee farm and woodlot for source of cash in southwestern of Ethiopia. However, homegarden and woodlot were the land use types that households have been getting benefits directly from the tree itself. Homegardens were mainly dominated by fruit trees, which provide subsistence and cash to household.

2.4. Major Causes and Consequences of Loss of Biodiversity in Ethiopia

The biological complexity of the world is continually changing as evolution gives rise to new species. However, uncontrolled exploitation, consumption of natural resources and habitat destruction for agriculture, urbanization, and industrialization are degrading the environment which results in loss of biodiversity. Again in this way, the main challenge for much of Sub-Saharan Africa is how to design agricultural landscapes to resolve livelihood-environment, conflict and maintain forests' ecosystem benefits such as water storage, erosion control, biodiversity conservation and soil rehabilitation, in which agroforestry proven to be a better approach to the challenge (Carley and Christie, 2010; Black, 2016).

Habitat conversion or modification by humans to produce goods and services is the most substantial human alteration of ecosystems threatening biodiversity. The conversion of forestland to monocultures has irreversible effects on biodiversity loss. Desertification has emerged as an environmental crisis of global proportions, currently affecting an estimated 100 to 200 million people, and threatening the lives and livelihoods of a much larger number. As a result of desertification, persistent reductions in the capacity of ecosystems to provide services such as food, water, and other necessities, are leading to a major decline in the wellbeing of people living in drylands (Sileshi, 2007).

The accelerated extinction of species may disrupt vital ecosystem processes and services. Reductions in species abundance and richness are also likely to have far-reaching consequences, including the loss of agricultural pest control, and the spread of disease. The concern is growing about agricultural practices and the consequences of biodiversity loss for ecosystem functioning, for the provision of ecosystem services, and for human well-being (Mooney *et al*., 2009).

On the other hand, the agroecosystem biodiversity can be affected due to abandoning traditional, locally adapted crop varieties and intercropping for high yielding monocultures. Equally, there is probably more intrinsic biological diversity in areas of land use than in all the protected areas put together a claim that is probably impossible to verify, but nevertheless useful to support the importance of agricultural biodiversity. Ecological and conservation purists might counter that argument by saying that this is Unnatural biodiversity, full of alien and invasive species. Land use has destroyed the natural habitats, created biological seas of uniformity, and even eradicated small niches of interest such as hedgerows and field boundaries. They would have a point if one concentrated only on areas of commercial farming and forestry, where monocrop and single varieties prevail and single-species stands of trees line up in rows (Dorsey, 2009; Chappell and Valle, 2011).

Threats to species and ecosystems are the greatest recorded in recent history and virtually all of them are caused by human mismanagement of biological resources often stimulated by misguided economic policies and faulty institutions. In the tropics, habitat degradation and forest conversion pose a significant risk of widespread terrestrial species extinction. The IUCN results of 2009 show that among 47,677 species studied, 17,291 are threatened with extinction. Since the 1500s, 1159 species have already gone extinct or probably extinct, among which 65 species are extinct in the wild. According to the same IUCN results, 70 % of plants are considered threatened (Engels, 2001; Abrol, 2012)).

There are various factors that threaten Ethiopia's plant genetic resources base and causing genetic erosion. These included repeated drought in some areas of high crop diversity, indiscriminate diffusion of uniform exotic crop varieties that displace the genetic diversity of indigenous crops, degradation of agroecological systems and land fragmentation. The reduction in diversity often increases vulnerability to climate and other stresses raise risks for individual farmers and can undermine the stability of agriculture. With the disappearance of crop diversity, so does the associated knowledge and practices that aided the development and maintenance of the diversity. This implies a loss of biodiversity directly affects agricultural productivity which is the backbone of Ethiopian economic, social and political development (CBD, 2009).

2.5. Homegardens for Biodiversity Conservation and Development

Crop diversity is maintained in homegardens when it meets producers' needs. It may be maintained over long periods and in this sense, it may be said to be conserved "*in- situ*". However, conservation is rarely (if ever) the actual objective. Farmers who maintain diversity do so because they find it useful. Thus, any evaluation of *in-situ* conservation of crop diversity in homegardens has to place the desired conservation objectives (the amount of diversity maintained, the duration of maintenance etc.) in the context of farmers' production objectives. Three groups of interacting factors affect the maintenance of crop genetic diversity in Homegardens: the biological characteristics of the crops, the way in which farmers manage the production and reproduction of the material and the way in which environmental factors affect crop production (Altieri *et al*., 2009).

A large body of research has also demonstrated that conservation of tropical biodiversity in degraded tropical landscapes can be assisted through the management of diverse Agroforestry system. These systems allow people to diversify their income and represent an effective way to conserve moisture and control soil erosion. Agricultural biodiversity describes the situation of biological diversity in areas of agricultural activity and land use. Since land use or perhaps more exactly, land abuse is considered by most observers to be the major threat to biological diversity, it may appear to be something of an enigma that agricultural biodiversity should exist at all. Yet because biodiversity is a global concern and because most productive areas of the world, which contain most of the globe's biodiversity, are in areas of land use, agricultural biodiversity is far from being the contradiction that narrow ecologists would see it be (Gardner *et al*., 2009; Barrow, 2014).

The high and maintained diversity of both cultivated and wild plant species makes homegardens suitable for *in-situ* conservation of plant genetic resources. *In-situ* conservation refers in general to the conservation of whole agroecosystems that provide the habitats of target species and varieties Such a conservation technique allows for further crop evolution and adaptation to changing environments, while genetic diversity is regarded as „frozen" in ex-situ approaches as a result of this Homegardens are important *in-situ* conservation sites and in accordance with the Convention on Biological Diversity (CBD) Article 7, 8 and 10 (CBD, 2005).

Many authors have argued that human well-being and progress towards sustainable development are vitally dependent upon improving the management of the Earth‘s ecosystems to ensure their conservation and sustainable use. They also state that although demands for ecosystem services such as food, shelter and clean water are growing; human actions are at the same time diminishing the capability of many ecosystems to meet these demands. In Ethiopian montane rainforests, economically valuable fountains of biodiversity are vanishing at accelerating rates due to diverging private and social net benefits from land conversion (Gatzweiler *et al.*, 2007).

Homegardens provide numerous substantial environmental and ecological roles. For instance, as they are mostly produced without pesticides they contribute to environmental protection as well as public health and avoidance of environmental deterioration commonly associated with monocultural production systems. Homegardens take on the character of the surrounding ecological system and provide a place where plants, animals, insects, microorganisms and soil and air media mutually interact to maintain the agro-ecological stability. Besides, trees provide shade and clean air for the homestead and beautify the surroundings. Homegardens have a high potential for sequestering carbon as part of climate change mitigation strategies (Abebe, 2005).

According to the World Health Organization (Fabricant, 2001), medicinal plants form the bases of traditional or indigenous health care systems used by the majority of the population of most developing nations. Homegardens can be used to grow certain traditional herbs and spices. Plant-based medicinal systems, although in practice for thousands of years, are now coming to the forefront and attempts are being made to recognize their medicinal properties (Weber, 2011).

In Ethiopia, most medicinal plants used by the herbalists are collected from the natural vegetation. Home-based medicinal plant use relies on plants of the homegarden crops, weeds and that grow wild around human habitation. The cultivated medicinal plants are mostly produced in homegardens either for medicinal or other primary purposes. Medicinal plants of homegardens are known to the public as the knowledge of them is open or public. However, when the biological diversity in the area goes too depleted and plants distributions shrink to the faraway forest, some healers have been observed planting than gardens (Hunde, 2006).

Homegardens help ensures food security and is a buffer maintaining the sustainability of resource-poor households' livelihoods and sources of a major part of the vegetables and fruits circulating in local markets. Food production is the primary role of most, if not all, of the homegardens. Hence, the variety of annual and perennial crops and vegetables grown in these gardens provide a secure supply of fresh produce throughout the year and thereby contribute to household food security by providing direct access to food and important nutrients that may not be readily available or within their economic reach (Magcale *et al*., 2010).

In Java, an owner of homegardens have something available to harvest throughout the year, either for consumption, or for sale and this availability is specifically important to homegardens have important social and cultural functions. For instance, the front part of a homegarden is not planted being kept clean. This is an important place for socializing, where children learn cultural and social values from their elders, where religious rituals and cultural ceremonies take place. Many products of homegardens also have a social function, since neighbors can freely obtain certain fruits, leaves or tubers for religious or medicinal purposes from each other. Some plant species in homegardens are believed to have a magical value. Others are necessary for religious ceremonies, e.g., Hindu Balinese families need their homegardens as source and place for making sacrifices (Kumar and Nair, 2004).

In addition to other benefits, the scale of products produced in Homegardens significantly improves the family's financial status. Homegardens can contribute to a household with cash crops as well as food crops In fact; returns to land and labor are often higher for Homegardens than for field agriculture. Homegardens can contribute to household income in several ways. The household may sell products in the homegarden including fruits, vegetables, animal products, and other valuable materials. The household may use the homegarden site to conduct cottage industries to produce crafts or small manufactures that can be sold (Galhena *et al*., 2013).

In addition to direct earning from the sale of homegarden produce, products consumed by the household frees up household earning for other purchases. In the Bangladesh HKI homegardens project, the income value of homegarden production increased from 14% of average monthly income to 25% after taking into account purchased fruits and vegetables. In some cases, a portion of the cash income from homegarden is used to purchase additional food for household consumption. A study of urban homegarden in the Philippines revealed that homegardening families spend less on food than nonhomegardening families while homegardening families who plant a larger number of varieties of fruits and vegetables spend even less. Urban homegardeners in Papua New Guinea sell various fruits at local markets and obtain cash that allows them to purchase rice that produces several times the food energy of the sold fruits. Thus, homegardens provide households with a number of options by which they can satisfy their livelihood objectives (Abebe, 2005).

Generally, the non-market benefits potentially provided by homegarden systems, such as *in-situ* conservation of biodiversity, carbon sequestration, provision of materials for breeding of useful new crop varieties, aesthetics and ornamentation, wildlife habitat provision, are likely to be very valuable to the subsistence farmers of the tropics. Homegardens may become the principal source of household food and income during a period of stress, as in Kampala, Uganda after the civil war, where urban agriculture is reported to have substantially fed the city (Abdoellah *et al*., 2002).

2.6. The Concepts of Livelihood

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living (Table 1). It is the set of capability, assets, and activities that furnish the means for people to meet their basic needs and support their well-being. Livelihood is not simple phenomena for local people rather it is connected with the environment, economic, political and cultural processes to wider regional, national and global area. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base (Chambers and Conway, 1992; Schumacher, 2011).

The concept of livelihood is increasingly becoming central in the debate of rural development, poverty reduction, and natural resources management. Livelihood analysis has gone beyond the narrow definition and approach to poverty reduction. It had been narrow because it was focused on a certain aspect or implication of poverty such as low income and did not consider another vital aspect like shock and social factors. It is well recognized, that factors and conditions which constrain or enhance people ability to make a living needs emphasis around social, economic, and environmental aspects. In this regard, a livelihood concept is comprehensive and central. The livelihood framework helps in the analysis of a particular context (policy, history, agro-ecology, and socioeconomic situations), a mix of livelihood resources (capitals) result in the ability to follow what combination of livelihood strategies with what outcome. A livelihood is sustainable according to Ian Scoones ´´when it can cope up with and recover from stress and shocks maintain or enhance its capabilities and assets, while not undermining the natural resource base (Scoones, 1998) ´´

The objective of achieving sustainable livelihoods for everyone provides a focus for anticipating the 21st century through implications of policies and interventions that enhance capabilities, equity, and increase social sustainability for improving the livelihoods of the poor. Providing access to resource-based opportunities should be the minimum of state-provided social services and livelihood security of pro-poor intervention (Chambers and Conway, 1991).

Table 1: Assets or capitals of sustainable livelihoods

No.	Asset	Description
1	Natural assets	Represent natural resources such as land, water and wider environmental goods that are critical for the rural livelihoods;
2	Social assets	Refer to the institutions, relationships, and norms that shape the quality and quantity of social interaction;
3	Economic/financial assets	Denotes the financial resources that people use to achieve their livelihood objectives: incomes, profits, savings, and credits;
4	Human assets	Representing the skills, knowledge, experience, ability to work and good health that together enable people to pursue their livelihood strategies; and
5	Physical assets	Denotes asset Such as transport, shelter, road, market, adequate drainage facilities, electricity and telecommunications

Source: Adopted from (Morse *et al.*, 2009; Kaushal and Kala 2014).

2.7. Socioeconomic aspects of owners of homegarden

Mercer and Miller (1998), conducted a quantitative and qualitative analysis of published socioeconomic research papers and a survey of agroforestry socioeconomic researchers are used to evaluate the achievements over the past 14 years. Their study focused on the major advances, gaps in knowledge, and constraints for closing those knowledge gaps etc. They observed that both the scope and the quality of socioeconomic research are slowly improving. They suggested the priority areas for future research include theoretical and empirical analyses of agroforestry adoption decisions, improved economic analyses, and policy studies at local, national, and regional levels.

Kabir and Webb (2009), examined whether a household's socio-economic attributes had a quantitative and predictable relationship with homegardens. They analyzed the floral structure of randomly selected 402 homesteads of Southwestern Bangladesh. They reveal the importance of homegardens in job creation and women empowerment. Active participation of women in homegardening reduced gender inequalities in the family. However, increasing population density and the concomitant fragmentation of landholdings to homesteads may create an opportunity for homegarden promotion in Bangladesh.

John and Nair (1999), examined the socio-economic factors and constraints that affect farming in 400 homegardens of Southern Kerala, India. The found that the cattle (17.5%) and poultry (30.25%) raising as an important complementary enterprise. An average of 14-15 species and 397 plants per homestead was observed. These include coconut, rubber, spices, vegetable, timber, tuber crops, fruits, fuel trees, and fodder. Cultivation cost, labor availability, credit availability and technical information availability, availability of manures and fertilizers, availability of plant protection chemicals, marketing facilities, and storage facilities were considered as major constraints in the homegarden.

Puri and Nair (2004), evaluated benefits of various tangible and intangible benefits (social, cultural and economic benefits) of agroforestry but they didn't mention about the socioeconomic elements and their significance in the determination of success and failure of agroforestry. But some success tales such as wasteland reclamation and poplar-based agroforestry have shown that the technologies are widely adopted when their scientific principles are understood and socio-economic benefits are convincing.

2.8. Homegarden Contribution to households

Agroforestry homegardens plays a vital role in contributing to peoples livelihoods. Maroyi (2009) and Acheampong *et al*. (2011), reported that Agroforestry homegardens improve the family's nutritional status, health, and food security. Agroforestry homegardens, therefore, is part of a household livelihood strategy and has gained prominence as a natural asset through which sustainable use of resources, particularly for the livelihoods of the poor, may be achieved. Homestead gardening and Agroforestry systems provide an important contribution to sustainable agricultural production because of their potential to meet economic, social, ecological, and institutional conditions for sustainable livelihoods (Nair, 2006).

Homegarden plays an important role in sustainable livelihood needs of the household members**.** Brownrigg (1985), reported that in many parts of the world homegarden systems provide supplementary food, fuel, fodder and serve as a recovery area for the people such as homegardens in northeastern Brazil contributed to the sustainable use of natural resources by reducing pressure on the native vegetation ((Trinh *et al.,* 2003; Albuquerque *et al.,* 2005).

Tesfaye (2013), reported that supporting the potential of population densities of over 500 persons/ km^2 in the areas of southern Ethiopia and the rich species diversity shows its importance for simultaneous and combined biodiversity conservation, livelihood, and food security. Thus, agroforestry homegardens are used to produce all livelihood assets that generate and deliver multiple benefits for the livelihood of the rural people. Agricultural land as a natural asset is the primary means of enhancing and improving livelihoods for the overwhelming majority of the rural population.

2.8.1. Contribution of homegardens to household food security

Tynsong and Tiwari (2010), stated that the homegardens contribute a great deal to food supply especially for the people living in the rural areas because of the high production and diversity of cultivated edible species. Although the extent of household dependency on homegardens varies considerably, its contribution is quite significant towards the livelihood of the people because of low investment and easy accessibility. Homegardens function as ex-situ as well as in-situ conservation plots for plant genetic resources of the region. In the villages studied, 103 wild plant species were recorded from the homegardens which showed that homegardens are also a home to many wild plant species, thus they serve as a repository of wild plants.

In most tropical agroforestry homegardens, food production is the first function and role. One major aspect of the significant role of food production in homegardens is to hold up continuous production throughout the year (Kebebew *et al*., 2011), reported that in Southern Ethiopia 88.8% of the surveyed households were food secured throughout the year. Homegardens also can solve the problem of land scarcity by using a small land the households have by integrating various components in the same piece of land hence food security and income generation (Abebe, 2005).

The combination of crops with different production cycles and rhythms results in a relatively uninterrupted supply of food products. Depending upon the climate and other environmental characteristics, there may be peak and slack seasons for harvesting the various products, but generally, there is something to harvest daily from most homegardens. Additionally, these harvesting and maintenance operations require only a relatively small amount of labor from the members of the family. Hence homegardens are among the best solutions for household food security and income generation to smallholder farmers due to their diversity. This is especially in all areas of the tropics under pressure from increasing populations and unsystematic deforestation (Nair and Kumar, 2004; Kebebew *et al*., 2011; Lulandala, 2011).

2.8.2. Homegardens to income generation

Homegardens can contribute to household income in several ways. Income from homegardens comes from selling cereal crops, fruits, vegetables, and other cash crops (e.g., lime, rambutan, jackfruits, durian, cloves, and coffee) to local brokers or merchants. In many cases, sales of products produced in homegardens significantly improve the family's financial status. In Indonesia and Nicaragua homegardens contributed 21.1% and 35% of their total income respectively. In South-West Bangladesh and North Eastern Bangladesh, an average of 15.9% and 11.8% of household income is derived from homegardens respectively. Hence generally, homegardens play a great role in income generation as compared with other sources as it uses multiple components that produce diverse products (Motiur *et al.*, 2006; Tynsong and Tiwari, 2010).

2.9. The Biosphere Reserve Concept

Biosphere Reserves (BRs) are "areas of terrestrial and coastal/marine ecosystems or a combination, which are internationally recognized within the framework of UNESCO's programme on MaB". The BR concept, as the pillar of MaB conservation work, was developed in 1974 to encourage the establishment of protected areas and also to address the need to balance conservation of biological and cultural diversity with economic and social development. UNESCO BRs are currently served as "living laboratories for sustainable development" and are "the only sites under the United Nations system that calls for conservation and sustainable development to proceed along mutually supportive paths" (UNESCO 2010; Coetzer et al. 2013).

The biosphere reserve is a unique kind of protected area registered by UNESCO BRs with three main functions that are interdependent and equally important: Conservation of genetic resources, species and ecosystems, scientific research and monitoring; and promoting sustainable development (Jerneck and Olsson, 2013). UNESCO BRs have three clearly defined zonations; (Core area, buffer zone, and transition zone). The "core area" is strictly protected in a legal sense. It is typically small in comparison to entire biosphere reserve; of all human activity typically only research is allowed there. The' 'buffer' zone surrounds the core area, with some restrictions as well human activity in this area should be compatible with conservation goals. In the transition area, the focus is not restrictions, but the promotion of sustainable practices (Beery *et al*., 2015).

YCFBR is one of the Ethiopian BRs that have been registered as UNESCO Man and Biosphere (MaB) reserves in June 2010. Parts of the YCFBR were declared a National Forest Priority Area and gene reserve in 1998, and the whole zone was declared a United Nations Educational, Scientific and Cultural Organization (UNESCO) biosphere reserve in 2010. It is one of the biodiversity hotspots in Ethiopia. The YCFBR covers 167,021 ha, with the most important landscapes being forest, agricultural land, wetland, and grazing land (Table 2).

Yayu forests belong to the eastern Afromontane type and identified as one of the 34 biodiversity hotspot areas in the world by Conservation International. YCFBR is one of the habitats for a diversity of *Coffee arabica* and hence is important for *in-situ* conservation of the genetic diversity of the natural coffee. Coffee alone contributes around 70% of households' income in the area (Gole *et al*., 2009; Woldegeorgis and Wube, 2012; ECFF, 2016).

Table 2: Areas of Yayu Coffee Biosphere Reserve

YCBR	Total Area (ha)	Biosphere Zones	Area (ha)	Area (%)
	167,021	Transitional	117,736	70.5
		Buffer zone	21,552	12.9
		Core zone	27,733	16.6

Source: Adopted from ECFF (Environment and Coffee Forest Forum, 2017).

3. MATERIALS AND METHOD

3.1. Description of the Study Area

3.1.1. Yayu coffee biosphere reserve (YCFBR)

The study area YCFBR is located in the Oromiya state, south-western Ethiopia,between 8°10'-8°39' N and 35°30'-36°4' E. The area was registered in 2011 by the UNESCO as the 'Yayu Coffee Forest Biosphere Reserve' for the *in-situ* conservation of wild *Coffea arabica*. It covers about 167,021ha split into six *woreda*1, namely Algae Sachi, Bilo-Nopa, Chora, Doreni, Hurumu, and Yayu (Gole *et al.*, 2009). The area has a rolling topography where altitudes range from 1140 to 2562 m a.s.l., and is crossed by three major rivers, i.e., Geba, Dogi and Sese. The climate is hot and humid, and the mean annual temperature is around 20°C oscillating between the average extremes of 12°C and 29°C. The area exhibits a uni-modal rainfall pattern with mean annual precipitation of 2100 mm, with high disparity from year to year, and ranging from 1400to 3000 mm (Gole *et al.*, 2008). Dominant soil groups include nitosols, acrisols, vertisols, and cambisols (Senbeta *et al.*, 2005).The reserve is managed in zones, so that smallholder farmers can still use forest resources sustainably. The core zone encompasses 27,733 ha of undisturbed natural forest; the buffer zone 21,552 ha of mostly semi–coffee forest, where restricted use of forest resources is allowed (Schmitt *et al.*, 2010). The research was conducted in the YCFBR areas (specifically in Hawayember, Sololo and Uta None kebeles of Chora district (Figure 1).

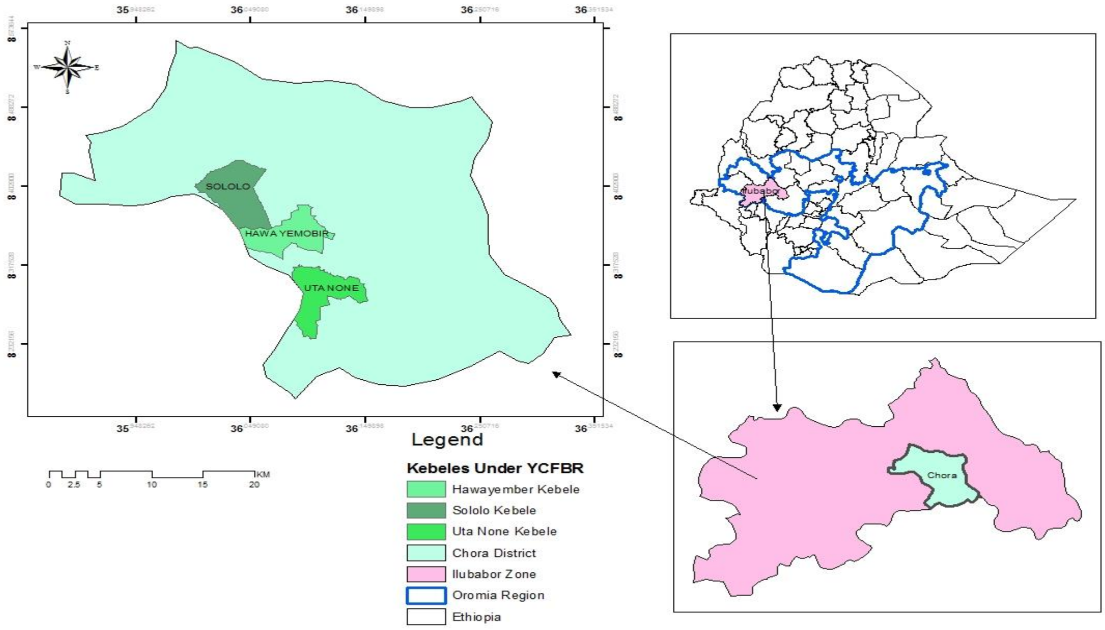

Figure 1: Map of study area

3.1.1.1. Population

In 2007, around 310,000 people lived in the six *woreda* (CSA, 2007). The Oromo ethnic group predominates and is considered indigenous. There are a significant number of Amhara, Tigreway and Kembata as they migrated from other parts of the country due to the government's forced resettlement program of 1984 (Kassa*et al*., 2009). Orthodox christian, muslim, protestant and indigenous beliefs are evenly practiced (Tulu, 2010). Currently, the population of Yayu is booming due to the high birth rate, and the intense internal migration due mainly to the thriving infrastructural development (Tadesse, 2015), such as the construction of fertilizer and coal factories, a network of roads planned to ease the trade of coffee, and the forthcoming hydroelectric dam on the Geba River (Bacha, 2014).

3.1.1.2. Land use systems

The major land-use types are forest, agricultural land, wetland, and grazing land (Figure 2). Forests cover most of the area, and consist of four major variations, namely undisturbed natural forest, semi-forest coffee systems, fully managed forest for coffee production, and old secondary forests (Gole *et al*., 2009).

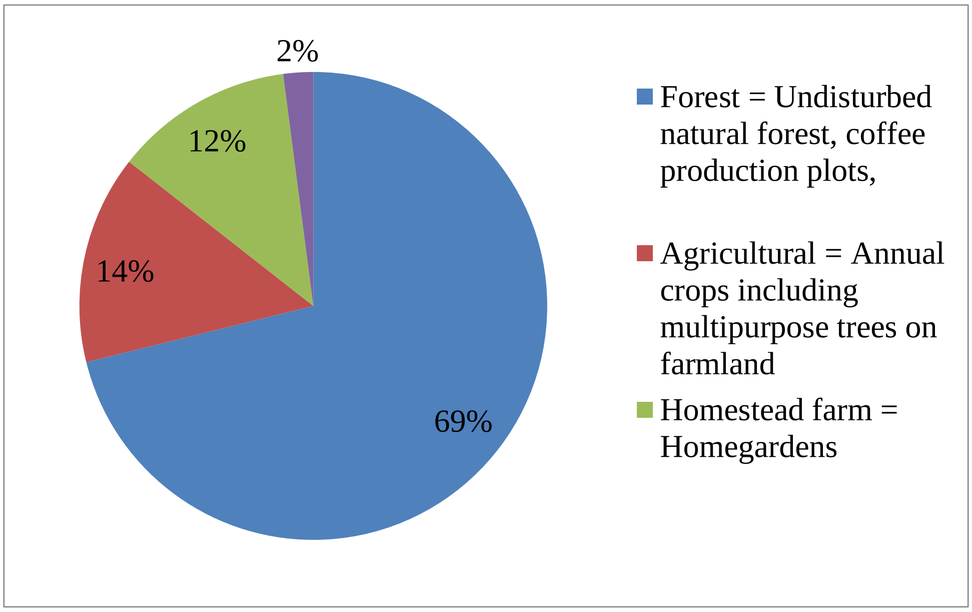

Figure 2: Major land-use type in YCFBR area (%) adapted from Assefa, (2010)

3.1.1.3. Transitional zone of YCFBR and householdslivelihood

The transition area is found adjacent to the buffer zone and it is composed of agricultural land, wetland, grassland, settlement area and fragments of forest land and covers area of 117,736 ha. It is the place of residence for all the human population in the biosphere reserve, the development organizations and local institutions. Around 154,300 permanent residents live in the transition areas of the Biosphere, including urban and rural settlements of whom the majority depend on agriculture for their livelihoods. Most income for the livelihood of the population of the area comes from the transition area(UNESCO 2010; Teketay *et al*., 2010).

The main livelihood source of the Yayu households is coffee-based agriculture, which employs over 90% of the active labour of the area (Assefa, 2010). Most coffee plots are small, however it is estimated that more than 60% of the population depends on coffee production and coffee-related activities, such as collection, processing and marketing (Gole, 2003; Ilfata, 2008). Besides coffee and the other cash crop khat, smallholders produce annual crops, such as *Zea mays*, sorghum *(Sorghumbicolor), teff (Eragrostis teff)*, and other cereals and pulses.

Farmers in the transitional zone own and cultivate land and are free to use it as they like. Many of them also own patches of private coffee forest in the transitional zone and have been assigned patches in the buffer zone.The agricultural landscape of the transition zone includes some of the semi-forest coffee production areas, garden coffee, small coffee plantations, cropland, and grazing land. Even though the area has abundant resources, which can support the local livelihood and the quality of important products like coffee, honey and spices, it has a large potential for improvement, mainly due to lack of improved production and processing technologies.The transition part of YCFBR has a lot of spices and herbs flora; among Korarima (*Aframomum korarima)* spice ranks first and other spices such as chilies, ginger, turmeric, coriander, etc. are grown widely (Etissa*et al*., 2016).

The agricultural landscape of smallholder surrounding the forest area is also important for the conservation of cultivated many horticultural crop landraces. The smallholder farmers in the this area grow cereals, legumes, coffee, vegetables, fruits, root and tubers, spices and herbs and other crops together either as sole crop or in a combinations others in the homegardens with the shade trees (Tadesse *et al*., 2009) as cited in (Etissa *et al*., 2016).

YCFBRarea is forest environment, its arabica species, and makes a meaningful contribution to the livelihoods of hundreds of smallholder farmers (Bharucha and Pretty, 2010). Also, according to Kuria *et al.* (2016), the farmers cultivate diverse crops in YCFBR areas. They do not solely rely on one cereal but many households cultivate a mix of two to four different staple items such as maize, sorghum, millet, wheat, barley and teff*(Eragrostis teff*).

In addition they grow different pulses (*beans, peas, and chickpeas*), root and tuber crops (potato, sweet potato, beetroot, carrot, anchote and enset (Ensete venricosum), vegetables (*hot/green pepper, tomato, pumpkin, Ethiopian kale, cabbage, Tarro, Abrango, onion and garlic*), fruits (*avocado, banana, mango, papaya, orange, lemon, and jackfruit*) and a variety of spices (*ginger, Ethiopian cardamom (Aframomum corrorima), and turmeric*. The most important cash crops in the area are coffee and khat (*Catha edulis*); sugarcane and eucalyptus tree are also cultivated in the study area. Livestock and their products are also common commodities produced in the area. The main livestock includes: cows (milk production), bulls, sheep and goats, poultry and apiculture. Maize and coffee are the dominant commodities produced with the aim of consumption and market, respectively.

3.1.1.3.1. Homegardens in YCFBR

The traditional agroforestry systems in YCFBR in south-western Ethiopia are among the most widespread and best performing agroforestry practices, and support the livelihoods of the local population while maintaining environmental integrity (Assesfa, 2010; Sentra *et al*., 2013).Homegardens of transitional zone of YCFBR encompass a mix of useful plants including staple crops like *Enseteventricosum* and *Zea mays*, tuber and root crops, e.g., *anchote (Coccinia abyssinica)*, taro *(Colocasia antiquorum)*, potato *(Solanum tuberosum)* and sweet potato *(Ipomoea batatas)*, leafy and othervegetables, e.g., kale *(Brassica oleracea)* and hot pepper *(Capsicum frutescens)*; exotic fruits, e.g.,papaya (*Carica papaya)*, mango (*Mangifera indica)* and avocado *(Persea americana)*, and some pulsecrops, e.g., haricot bean *(Phaseolus vulgaris)* and lima bean *(Phaseolus lunatus)* (Etissa *et al*., 2016;Jemal *et al*., 2018).

Species found in homegardens do not show a pre-determined spatial arrangement, with theexception of small plantations of *Catha edulis*. Rather, the location of individual plants and cohorts israndom and conveniently determined by the farmer’s needs. For instance, spices are planted closerto the homestead, or shade-loving crops under fruit trees. In addition, species density is also variable depending on the household and market demand,

and generally tends to increase based on the farmers aim to introduce and test potential useful species gathered elsewhere (Jemal *et al*., 2018).

3.2. Methods

3.2.1. Study site selection

The study sites (Kebeles, the smallest administrative unit in Ethiopia) and the district was selected purposefully. Three Kebeles (Hawayember, Sololo and Uta None) were selected for this study. The selection was based on their inclusion in YCFBR, and widespread practice of homegarden for the objective stated.

3.2.2. Sample size and sampling techniques

The sample size was determined using the method proposed by Yamane (1967).

$$n = \frac{N}{1 + N(e^2)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .3(1)$$

Where n is the sample size, N is the population size, and e is thedesired level of precision.

$n = 865/1+865(0.14)^2 = \approx 48$ Hawayember Kebele

$n = 381/1+381(0.14)^2 = \approx 45$; Sololo Kebele

$N = 447/1+447(0.14)^2 = \approx 46$; Sololo Kebele

Accordingly, a total of 139 households were determined and selected by systematic random sampling method from 1693 households list (of the three Kebeles) for an interview. Then, 45 homegardens (15 from each Kebele) which represented 32% of the households interviewed (Table 3 and Figure 3) were selected by simple random sampling method for homegarden plant inventory, following the method used by Regassa (2016). The resulting sampling distribution of the study site by Kebeles is shown as in Table 4 below.

Table 3: Total population and sample used for the study

Kebele	Total number of Households			Sample size per Kebele		
	Male	Female	Total	Random	Random	Sample Taken

				Interval	Start	Male	Female	Total	HG
Hawayember	807	58	865	18	13	43	5	48	15
Sololo	333	48	381	8	2	44	1	45	15
Uta None	445	22	447	10	7	44	2	46	15
	1585	128	1693			131	8	139	45

HG=Homegerden

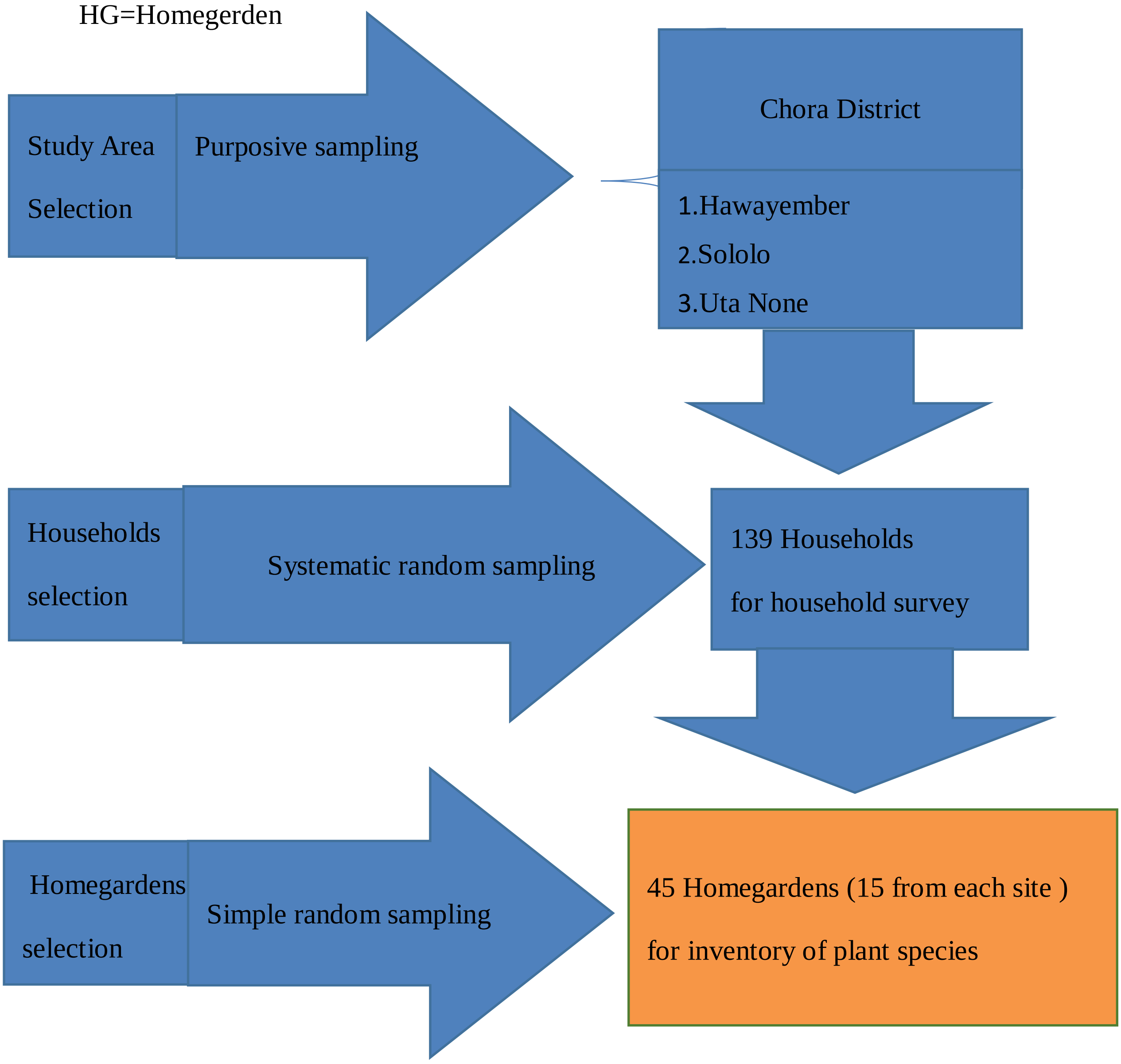

Figure 3: Schematic diagram of a sampling

3.2.3. Data collection methods

3.2.3.1. Assessments of species diversity

To assess the diversity and composition of plant species, a total of 45 homegardens (15 from each Kebele) were randomly selected. Three plots with the size of 5 × 5 m; in each homegarden were established. The three plots were taken from right, left and back side of the homegarden in order to assess the whole plant species following (Bekalo *et al*., 2009).

Plant species identification was supported by a local taxonomist and use of the following specialized literatures: flora of Ethiopia and Eritrea, a glossary of Ethiopian plant names, and 'Useful trees and shrubs of Ethiopia' (Kelecha, 1980; Edwards *et al*., 1995; Hedberg *et al*., 2004, 2006; Azene *et al*., 2007).

3.2.3.2. Household survey

Primary data were collected from the sample rural households using a semi-structured and structured questionnaire administered during October to December 2017. Prior to the actual administration of the general survey, the questionnaire was pre-tested, modified and refined.Data on homegarden contribution, with households demographic and socioeconomic(i.e. Age, family size, annual income, level of education, etc) were collected (Appendix 1-4).Household heads were interviewedto listtheir livelihood sources, products and their prices at the farm gate and/ or localmarket at the time of sellingto determine both totalincomes and that obtained from homegarden components (Appendix 1 and 4).

Note: The income determination in this study was based on the one year (2016/2017) yield and its prices estimationincluding both products consumed at home and sold in the market for income generation (i.e. those products around homestead were termed as homegardens and outside homestead as other sources) (Appendix 1 and 4).

In addition to the household survey, focus group discussions (FGDs)and key informant interviews (Table 4) and field observationwere undertaken. These methods were used to confirm the information given by an individual farmer and to catch important issues that were not raised by respondent farmers. Questions were asked in a structured conversational format (Appendix 5 and Appendix 6); allowing us to gather consistent data across gardens, while also learning about qualitative aspects of homegardens through farmers' perspectives and insights (Coomes and Ban, 2004).Secondary data were also collected from published and unpublished sources including information on the study area.

Table 4: Summary and descriptions of instruments

No	Types of instruments	Target group	Number of target group representations	Types of sampling
1	Household survey	Selected household heads	139	Systematic random sampling
2	Plant inventory	Selected homegarden	45	Simple random sampling
3	Key informants	Community leaders and experts, model farmers and members of	15	Purposive sampling

		the biosphere reserve management unit		
4	FGD	Local community members	41	Purposive sampling

In this study, plant species richness, Shannon, Simpson's diversity and evenness were assumed dependent variables, whereas the six selected household's characteristics (i.e. age, education, family member, farm size, homestead size, annual income) were independentassumed to influence the above mentioned dependent variables (diversity indices).To examine the relationships between independent and dependent variables, the independent or explanatory variables were quantified as in the following (Table5).

Table 5: Definition of explanatory variables

Variable name	Description
Age	Age of the household head in complete years at the time of study period
Education	Education of a respondent referred to the year passed from the formal educational institution at the time of interview.
Family size	Family size was measured by computing the total number of members of the respondent's family who jointly lived and ate together. It indicates the total number of members in a single family unit
Total land size	A farm is referred to an area of land that is devoted primarily to agricultural processes or an area of water that is devoted primarily to aquacultural processes, in order to produce and manage such commodities as fibers, grains, livestock, or fuel. It is the basic production facility in food production.
Homegarden land size	Land allocated for homegarden by household

Total annual income	Total annual income of sampled households from agriculture, off-farmlands other sources of income was also collected in order to compute the contribution of the homegardens towards peoples' total income and then to see the relationship between household income with garden plant diversity.

3.2.4. Data Analysis

3.2.4.1. Social data analysis

Descriptive analysis through (percentage, frequency, mean, range, and standard deviation) and one way ANOVA were applied using IBM statistical package for social science SPSS version 20.0.

3.2.4.2. Ecological data analysis

The plant inventory data were organized using Microsoft excels 2016. Then, floristic composition was analyzed for species diversity using equations of the parameters such as frequencies, relative frequencies, Shannon and Wiener, Simpson's and evenness indices for species diversity and Sorenson's similarity indices were computed for the 15 homegardens of each Kebele following (Shannon and Wiener 1949; Kent and Coker, 1992).

Frequency

Frequency describes the distribution of a species through a stand. It is determined by calculating the percentage of plots/quadrats in a sample area in which a given species occurs by following Lamprecht (1989).

$$F = \frac{\text{Number of homegardens in which a species occurs } 100}{\text{Total number of sampled homegardens}} \ldots\ldots\ldots\ldots 3\ (3)$$

Relative Frequency

Relative Frequency (RF) is the distribution of one species in a sample relative to the distribution of all species. This was calculated by the formula: $RF = \frac{\text{The frequency of a species in the homegardens Ax 100}}{\text{Total frequency of all species in the sampled homegarden}} \ldots\ldots\ldots\ldots 3\ (4)$

Species richness

Species richness was determined by recording plant species in a study area, regardless of abundance.

Shannon Wiener diversity index

Shannon's Index is the most applicable index of diversity and accounts for both richness and evenness of the species present (Shannon and Wiener, 1949). Thus, species diversity is a product of species richness and evenness or equitability. Species diversity index provides information about species endemism, rarity, and commonness. Measures of species diversity are usually seen to be key indicators for the wellbeing of ecological systems (Heywood, 1998). The diversity of each site is calculated using this index based on the frequency of species as the input source. The Shannon Diversity Index (H') is calculated using the following formula.

$H' = -\sum Pi * \ln Pi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..3(5)$, Where, H' = Index of species diversity, Pi = No. of individual of one species/Total no. of individuals in the samples

Simpson's Dominance index (λ),

Simpson's Dominance index (λ) was used to describe the dominance i.e. the degree that a community is dominated by one or a few common species.

$\lambda = \Sigma\,(pi)2.\ldots\ldots\ldots$……………………………………………………….3(6)

The index measures dominance on a 0-1 scale. If only one species is present in the community, Pi = λ = 1 will be the maximum value.

Species evenness index,

Evenness index (E = H'/lnS) was used to describe the diversity in terms of evenness i.e. how equally abundant the species were in the homegardens. This standardizes evenness on a scale from 0−1. $E = \frac{H'}{\ln s}$ ……………………………………….……3(7), Where, E = Species evenness index, H' = Shanon-Winner index of diversity, S = Total no. of species

Similarity among homegardens

Sorenson’s similarity ratio was used to evaluate the similarity between plant communities in homegardens of the three Kebeles. It was calculated with the help of formula by (Peet, 1974) and (Kent and Coker, 1992). This index measures the degree to which the species composition of quadrats or samples is alike, whereas the dissimilarity coefficient assesses which two quadrats or samples differ in composition. Sorensen’s index is the most common binary similarity coefficient because it relies on presence or absence data.

$SS = \frac{2a}{2a+b+c}$. ……………………………………………………..3(8), Where a = number of species common to both quadrats/samples b = number of species unique to quadrat/sample 1 c = number of species unique to quadrat/sample 2.

Eventually, the relationship between independent and dependent variables (Table 6) was analyzed by Pearson's Correlation analysis.

Table 6:Variables hypothesized

Independent variables	Dependent variables
Household characteristics	Plant richness and diversity indices
Age	Species richness
Educational level	Shannon's diversity index
Family size	Simpson's dominance index
Total land size	

Homegarden land size	Evenness index
Total annual income	

4. RESULTS AND DISCUSSION

4.1. Plant Diversity

A total of 79 plant species belonging to 41 families were recorded from homegardens of the study area. The most commonly represented family was Rutaceae containing the largest number of species (7 species), followed by Fabaceae and Rosacaea that represented six and five speciesrespectively (Table 7). This result is slightly similar with a finding of Aragaw (2017), who reported that a total of 94 plant species representing 41 families in homegardens of the surrounding area, around YCFBR. Similarly, the least plant species numbers were recorded in 25 families those representing one species and four families each containing two species (Table7).

Table 7: Plant families with their respective number of species

Family name	Number of species	Family name	Number of species
Rutaceae	7	Capparidaceae	1
Fabaceae	6	Boraginaceae	1
Rosacaea	5	Caricaceae	1
Euphorbiaceae	4	Chenopodiaceae	1
Asteraceae	3	Celastraceae	1
Acanthaceae	3	Convolvulaceae	1
Brassicaceae	3	Cupressaceae	1
Lamiaceae	3	Dioscoreaceae	1
Moraceae	3	Dracaenaceae	1
Musaceae	3	Lauraceae	1
Solanaceae	3	Lythraceae	1
Zingiberaceae	3	Malvaceae	1
Alliaceae	2	Meliaceae	1
Cucurbitaceae	2	Myrsinaceae	1
Myrtaceae	2	Phytolaccaceae	1
Rubiaceae	2	Poaceae	1
Amaranthaceae	1	Proteaceae	1

Anacardiaceae	1	Rhamnaceae	1
Annonaceae	1	Ulmaceae	1
Apocynaceae	1	Verbenaceae	1
Araceae	1		

Homegarden plant diversity assessment, Chora district, 2017

The Shannon Wiener index shows a higher diversity of plant species in Hawayember homegarden (H'=3.31) as compared to the homegardens of Uta None (H'=3.28) and Sololo (H'=3.22) (Table 8). The findings of this study slightly disagree with findings of Feleke *et al.* (2016), in which they reported H'=1.43 in homegarden of Basketo Special Woreda in Southern Ethiopia. This difference might be because of agroecological variation of the two sites. The diversity index was least in the Sololo homegardens that means only a few species plants were more abundant. Species like *Catha edulis, Coffea arabica, Colocasia esculent, Ipomoea batata, and Brassica napus* were more abundant than others in the Sololo Kebele homegardens, but many other fruit and tree species were equally abundant in the Hawayember and Uta None homegardens like *Mangifera indicia, Musa paradisiaca, Citrus sinensis, Carica papaya, Eucalyptus comaldulesis, Cordia africana, and Croton macrostachys* etc.

The dominance index also shows that only a few species dominated the homegardens in Sololo (λ=0.058) as compared to Hawayember (λ=0.049) and Uta None (λ=0.052) homegardens. The evenness index shows that in Hawayember homegardens most of the species are almost equally abundant (E = 0.9) than Sololo (E=0.86) and Uta None (E=0.85), (Table 8).

Table 8: Species richness, Shannon and evenness indexes of plant species in homegarden agroforestry per Kebeles

Kebele	Total	Richness	Shannon index	Evenness index	Simpsons index
Hawayember	3859	39	3.31	0.90	0.049
Sololo	4304	42	3.22	0.86	0.058

Uta None	5412	48	3.28	0.85	0.052
Mean	4525	43	3.27	0.87	0.053
SD	799.74	4.58	0.05	0.03	0.005

SD=Standard deviation

Homegarden plant diversity assessment, Chora district, 2017

4.1.1. Growth habits and origin of plant species

Plants biodiversity in the homegardens of the study areas were grouped into four life forms. Accordingly, among the recorded 79 plant species herbaceous, trees, shrubs, and climbers plants account for 34%, 30%, 27%, and 9% respectively. In all the three Kebeles, herbaceous plants followed by trees and shrubs dominate homegarden (Table 9). This is also in agreement with the findings of panda *et al*. (2018), which stated that the grand total number of common plant species comprising perennials, annuals and seasonal.

In terms of origin, the studied homestead flora consists of both native and exotic species. About 47 (59%) species were identified as exotic while the rest 32(41%) were indigenous plant species; among which fruits account for the larger number (12 species) of the exotic plants, whereas most of the medicinal and woody species were native plants (Appendix 8). The fact that the majority of homegarden plants were exotic might be attributed to their market profitability and management suitability like fast growth ability of the species. This result is in agreement with Jemal *et al*. (2018), that reported a higher number of exotic species observed in homegarden, in comparison with the majority of native species (about 70%) plant species from the two practices, namely multistorey-coffee-system and multipurpose-trees on-farmland in the same area, around Yayu, southwest Ethiopia.

Table 2: Composition of different plant habits (growth form) across the three Kebeles

Kebele	Tree	Shrub	Herb	Climber
Hawayember	14	7	17	1
Sololo	13	8	19	2
Uta None	16	8	22	2

Overall	24 (30%)	21 (27%)	27 (34%)	7 (9%)

Homegarden plant diversity assessment, Chora district, 2017

4.1.2. Floristic Composition

The most common plant species in occurrence was *Coffea arabica* which occurred in 39 homegardens (86.7%) followed by *Persea americana*, *Catha edulis* and *Ensete ventricosum* (68.9%), (64.4%) and (62.2%) respectively (Table 10 and Appendix 9). This result is consistent with Abebe*et al*. (2013), which reported Coffea arabica as the most frequent species occurring in all (100 %) of the gardens, in Sidama, Southern Ethiopia. Also, the above findings are in line with the findings of Dagar and Tewari (2017), stating that the main structural arrangements in most homegardens are primarily *coffee arabica* mixed with trees and shrubs. Members of the focus group discussion and the owners of the garden revealed that enriching the homegarden with different plant species in the area is mostly based on their livelihood contribution. The more the plant species contribute to livelihood, the more the households value them for conservation in homegarden.

Among those species, *Brassica napus* were herbs with considerable use as family food, followed by *Citrus sinensis* and *Musa sapietum* those are among the most prominent fruit tree species mainly used for income generation for a family, occurring in the top 10 speciesin homegardens of the area. In the same manner, this study was found out that *Catha edulis* as one of the top five most abundant homegarden plant components in homegardensof the area (Table 10). This *Catha edulis* expansion in the traditional homegarden of the area could be probably taken as one of the most plant diversity declining cause emerging in recent days. The conversation held during the focus group discussion also imply that farmers attitudes are being inclined towards of intensively enriching their garden with *Catha edulis* with the aim of earning more money and /or intentionally to escape from homegarden food crops (fruit bearings) damage by wildlife (Baboons and Monkeys) which are recently being increased rapidly in the area. This result is in agreement with a similar study conducted in the same area around YCFBR by Nischalke *et al.* (2017) , stated that farmers were concerned about wildlife damage to vegetables in coffee forests, negative effects on coffee trees and their root systems and potentially deteriorating coffee yields, and low performance of vegetables under shade.

The above result is also in agreement with a similar study conducted in south Ethiopia by Gebrehiwot (2017), Stating that the traditional agroforestry homegarden in Ethiopia is being challenged by the transition to monoculture production of new cash crops. Additionally, the study conducted in Jibithenan District, Ethiopia, showed that *Catha edulis* as one of the top five most abundant species in homegardens as owners focus to grow few cash crops by neglecting other beneficial crops that could reduce the diversity of species managed in homegardens (Mekonen *et al.*,2015). This result is also in agreement with Nair (2006), who reported that homegarden diversity is constantly changing both as part of adaptive traditional practices and as traditional systems are abandoned. Again, this result is supported by Scales and Marsden (2008), stating that the anthropogenic influences, increased prevalence of cash crops are the issue that has received the most attention.

Table 3: Top 10 plant species in frequency across homegardens of chora district

Scientific name	Local name (AO)	Frequency	% Frequency
Coffee arabica	Buna	39	86.67
Persea americana	Avokaadoo	31	68.89
Catha edulis	Caatii	29	64.44
Ensete ventricosum	Qoccoo	28	62.22
Hypoestes restate	Darguu	27	60
Brassica napus	Raafuu Habashaa	26	57.78
Achyranthes aspera	Maxxannee	25	55.56
Citrus sinensis	Burtukaana	24	53.33
Musa sapietum	Muzii faranjii	24	53.33
Woodfordia uniflora	Tuufoo	24	53.33

AO=Afan Oromo

4.1.3. Species Similarity among homegardens

Sorenson's similarity index showed that moderate plant species similarity (52% to 66%) in homegardens of the three study Kebeles. More specifically, Sololo and Uta None homegardens are more similar in floristic composition (66%), than the Similarity of the two sites (Sololo and Uta None) with Hawayember by 52% and 56% respectively (Table 11). This could be possibly because of the closeness of the two Kebeles Sololo and Uta None to the natural forest areas, as compared to Hawayember which is a little bit far away from the forest area.

Table 11: Plant species Similarity among homegardens of the three study sites

Site	Hawayember	Sololo	Uta None
Hawayember	1		
Sololo	0.56	1	
Uta None	0.52	0.66	1

4.1.4. Food crop raised by the owners of homegardens

The homegarden flora in the study area is composed of both food and nonfood plants, accounting for about 57% and 43% of the recorded total of species respectively (Appendix 8). Among the food crops fruit constitute the largest number (18), followed by spices and root and tuber plant species consisting 9 and 5 respectively, while the remaining were field crops cereals, pulses, and oils, whereas from non-food plant species accounting 43% medicinal plants, Shade plants, and construction and fuelwood etc were recorded (Appendix 8). These imply that most of the homegarden plant species were edible and make significant contributions to the nutritional well-being.

This result is in agreement with Woldemariam (2003), conducted a species inventory of the YCFBR across the 3 zones and identified 220 plant species, of which 84 are edible and widely available in the reserve; a large number are highly nutritious, especially the indigenous green leafy vegetables.

Similarly, this finding is consistent with the findings of Van and Bongers stating (2013), that People that manage homegardens for multiple goods to satisfy their social, cultural and economic needs, mainly food. This result is similar to the findings of Regassa (2016), in southern Ethiopia around Hawassa stating that the largest food crops as fruit, accounting for about 23%. Also, this result is agreed with the findings of Pulido *et al*. (2008), that reported People that manage homegardens get multiple goods to satisfy their social, cultural and economic needs, mainly food.

According to focus group discussion, plant species richness in homegarden is significantly increased in summer season during peak rainy season of the area. Importantly many herbaceous crops like*Brassica napus*, maize (Zea Mays), Phaseolus vulgaris; sorghum and pumpkin (Cucurbita pepo) are grown from June to October in most cases. Thus, the diversity composition of homegarden agroforestry increases significantly during this growing season of a year (Figure 4). This result is also in agreement with Semu (2018), that reported significant amounts of food-producing cultivated plants and nutrient supplying homegarden products are more available during the main rainy season between June and September at Eastern Harerge Ethiopia, around Kombolcha.

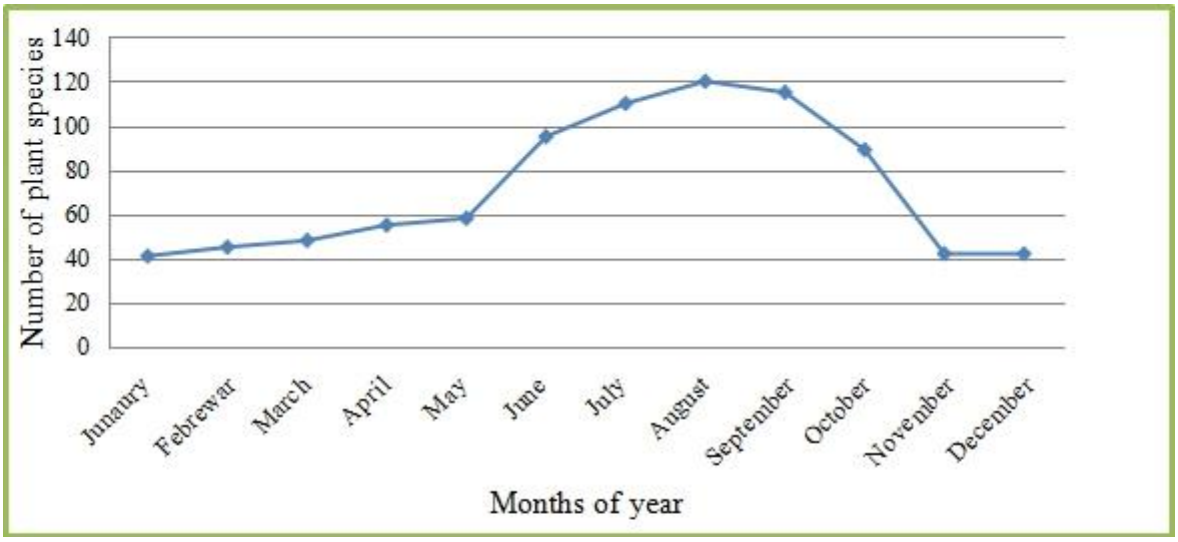

Figure 4: Plant species richness variation throughout the year

4.2. Homegardensfor Households Livelihood

4.2.1. Households characteristics

The average age of the respondents was 42.9 with a standard deviation of 7.23. The family size of the sampled households on average was six. The largest frequency in family size is seven family members per household, which was 27.8% of the sample households. The sampled household education level in the study area ranges from illiterate to complete secondary school. The total land size of each household mostly consists of the cropland, coffee plantation, and homegardens. The average farmland size was 1.6 hectare with the range of 0.5 to 3.5 hectare whereas about 56.5% of the households have farmland ranging from 1.5 to 2 hectare. Regarding the households annual income, the average household annual income is 31848.48 Birr. The size of homegarden in the study area ranges between 0.02 to 0.27 hectare, with the average of 0.14 hectare (Table 12), which is less than the mean homegarden size (0.185) reported by Linger (2014), for homegarden around Jabithenan District, Northwestern Ethiopia. About 29.3% homegarden area was 0.18 hectare, while about 85.8% was less than 0.2 hectare.

Table 12: Characteristics of sampled households, (n = 139)

Household characteristics	Measuring system	Observed range	Mean	SD
Age	Year	28-67	42.91	7.23
Total land size	Hectare	0.5-3.5	1.60	0.67
Homegarden land size	Hectare	0.02-0.27	0.14	0.07
Education	Year	0-10	3.5	2.78
Family size	Numbers	3-17	6.2	1.86
Annual income	Thousand	10-65	31535.96	10017.49

SD=Standard deviation

Source: Own data, Chora district, 2017,

4.2.2. Major benefits of homegarden for households

About 86.5% of the respondents agreed that homegarden provides high food products for their family. Whereas about 21. 8 % of the respondents agreed that homegarden used for high income generating and 47.4% of the respondents said that homegarden had a medium potential for income generating (Figure 4). These perceptions of the gardeners could probably imply that food crops in homegardens of the study area had a significant role to enhance nutritional and income status of the local people. Thus, along with the ecological benefits, homegardens provide potential food security to the householder. This result is agreed with Jemal *et al.* (2018), stating that homegarden, multistorey-coffee-system is mainly used to generate money and, for the majority of households, is the main, if not the only, source of cash. Most farmers use multipurpose-trees-on-farmlands to produce food, and homegarden is used for both a source of food and cash to supplement the other two practices.This result is agreed with Regassa (2016), reported that about 75% of the homegardeners explained that they conserve useful plant species for foods, around Hawassa, Ethiopia. Again, the result is also supported with the Mengistu and Fitamo (2016), in which they reported that diverse mixture of crops that are harvested at different times, and constant supply of food in a different form is available from homegardens.

The discussion held during the focus group discussion also supported that homegarden agroforestry used for a long period of food sustenance during the time of food shortage. They revealed that the canopy of the tree used as shade during high sunlight and warm weather. Although there is a shortage of land for homegarden, households get diverse products from such land as they cultivate it intensively. In general members of the group discussion household head respondents were agreed that homegarden practice contributes a lot and provide multiplebenefits from a small unit of land (Figure 5). This result is in agreement with findings of Kassa *et al*. (2015), stated that the agroforestry practices contribute to the conservation of biodiversity, while providing multiple products and services, in Yem district southern Ethiopia.

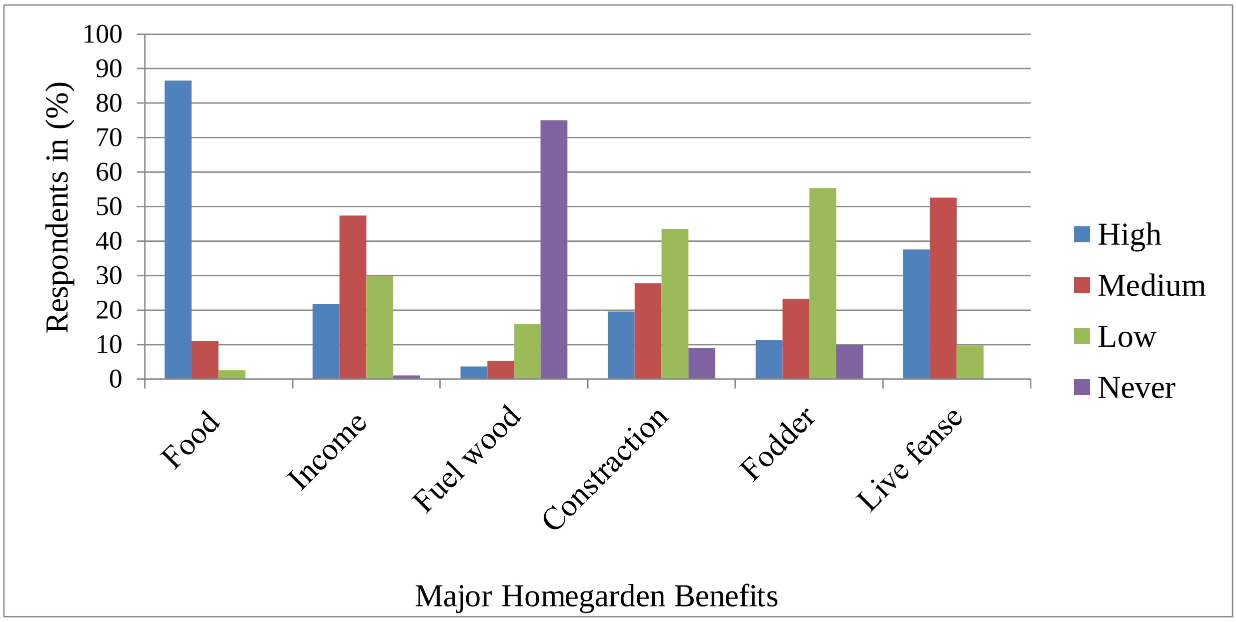

Figure 5: Major benefits of homegardens

4.2.3. Homegardens as a source of income

Homegarden annual income contribution for the households of the three Kebeles was not shown significant differences statistically, ($F_{136, 2}$= 0.281; p=0.755). However, households in the study area generate income from different homegarden products. The homegardens contributions to household's annual income on average was about 13% of the total annual income (table 12 and Table 13), among which *Catha edulis* and *coffee arabica* homegardens produce share the main role, while the rest household income/economic contributors are from foodsource plants, such as fruit, spices, root and tubers, and vegetables in the practice (Figure 6).

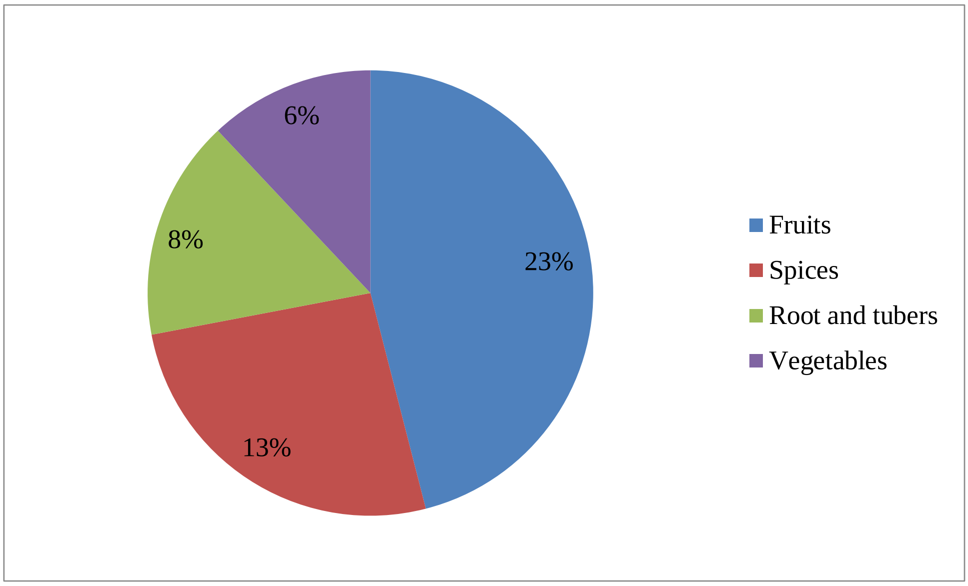

Figure 6: Income generating food source components of homegarden (of the total recorded species)

Concurrently, over 90% of the respondents reported that coffee (which is mainly from coffee plantation site) is their greatest household financial source (i.e. total household annual income). Similarly, the discussion held during the focus group discussion also implies that villagers cultivate and maintain plants in their homegardens mainly for household consumption and surplus vegetables and fruits were sold in the nearby market for monetary benefits. The most marketed fruits and vegetables *Persea americana, Mangifera indica, Musa sapietum, Lycopersicon esculentum, Brassica napus,* and *Brassica integrifolia.* Similar findings were obtained by Jemal *et al.* (2018), Coffee forest production is mainly practices used to generate money for the majority of households, where homegarden is used as both a source of food and cash income generation for local community around Yayu, southwest Ethiopia.

The above finding is in agreement with the findings of Nischalke *et al.* (2017), reported Coffee is an important part of the cultural identity and the most important livelihood source for households around YCFBR.Similarly, the above finding is in agreement with the findings of Etissa *et al.* (2016), reported that many crops such as coffee, avocado, mango, banana, *Enset*, root and tubers, and many other crops grow in the sample homegardens of the households around YCFBR. The main structural arrangements in most homegardens are primarily coffee mixed with trees and shrubs, fruit trees or planted in strips, or planted as a boundary and fence, edges of plots and fields mainly for coffee shades, and live fence. From these trees including fruit trees farmers get food, fodder for their livestock, fuel wood and other wood products and other uses such as a windbreak and shades.

However, the above findings are slightly different from the findings of Regassa (2016), who reported that 35% household's annual income contribution from homegardens around Hawassa, Southern Ethiopia. The difference might be due to the livelihood sources and lifestyles of society living in the two areas (Hawassa city and those of Chora rural villages), and finding of Gebrehiwot (2017), in the same area, reported that over 50% of the Sidama community generate their household financial income mainly from coffee. Similarly, Mbow *et al.* (2014), stated that homegardens enhance smallholder's resilience by providing food for household consumption and to sell surplus food products to supply other needed items. Hence, this farming practice enhances and maintains human capital (health and education) for the rural community. It accomplishes this through continuous production and supply of food, nutrition, and financial income. According to Morse *et al.* (2009), livelihood outcomes include more stable income, increased human wellbeing, improved food security, and sustainability.

Table 4 : Annual incomes from homegarden

Level of income	Income in Ethiopian Birr per site		
	Cash income (Birr) 1$ = 27Birr when the research conducted (the Year 2017)		
Level of income	Hawayember	Sololo	Uta None
Max income	17000.00 Birr	19700.00 Birr	23500.00 Birr
Min income	1200.00 Birr	900.00 Birr	1100.00 Birr
Average income	4095.65 Birr	4351.16.00 Birr	3797.73 Birr

Average annual income	4079.70 Birr

Source: Household survey, Chora, 2017

4.3. Homegarden Plant Diversity and Socioeconomic Characteristics

Household's socioeconomic features can influence plant diversity (Richness, Shannon, Evenness and Simpsons) in homegarden. Out of the six socioeconomics variables considered, age, educational background of the households, households' family size and annual income did not show a significant relationship with plant diversity indices. However, although the relation is weak, total land size and homegarden land size indicated direct correlation with plant richness significantly at ($r = 0.199*$, $r = 0.170*$, p-value < 0.05) (Table 14).

This could be probably implied that households with enough farmland and homegarden land would have a probability of having more number of plant species in their garden than those with smaller land size. This result is consistent with the findings of Tesfaye (2005) that stated larger farms had more tree species. The increasing of tree species richness with increasing landholding was also reported by other studies from homegardens by(Mendez *et al*., 2001). A similar study conducted in Sebeta-Awas District, southwest Ethiopia reported that with increasing size of homegardens, more richness of species composition was observed (Mekonen *et al.,* 2015*)*. This result is also partly agreed with the reports of Kehlenbeck *et al*. (2007), stating that homegarden agrobiodiversity is often positively correlated with homegarden size, age, soil fertility, and the available labor force.

Table 14: Pearson correlation coefficients between household characteristics and plant diversity indices

characteristics	Richness	Shannon	Evenness	Simpsons
Age	0.069	0.119	-0.003	-0.119
Family size	0.032	0.094	0.016	-0.094
Education	0.000	-0.069	-0.031	0.069
Total Land size	0.199*	0.049	-0.119	-0.049

Homegarden land size	0.170*	0.049	-0.119	-0.049
Annual income	-0.074	0.000	0.061	0.000

** Correlation is significant at the 0.01 level (2-tailed) and * Correlation is significant at the 0.05 level (2-tailed).

Source: Household survey and field tree species inventory, 2017

4.4. Limitation of the Research

Even though this research was carefully prepared, I am still aware of its limitations and shortcomings.First of all, the research was conducted based the data collected for three months, which is not enough for the researcher to assessenough information on the homegarden role. It would be better if it was done in a longer time. Second, the population of the experimental group is small, only one hundred thirty nine households and forty five homegardens might not represent the majority of the households in the biosphere reserve. Third, since the questionnaire designed to measure the households' annual income of one year.It might give useful information about the role of homegarden to local household livelihood; it seems not to provide enough evidence of the exact role played by homegarden.

4.5. Conclusions and Recommendation

4.5.1. Conclusions

Homegarden agroforestry practices in YCFBR plays a remarkable role in both biodiversity conservation and improving food and nutrition security for households residing in transitional (utilization zone) of the biosphere. The results of the study revealed that homegarden agroforestry practices in the present study area have been providing multiple benefits for the locals and playing significant contribution for the conservation of plant biodiversity and thereby sustainability of the natural resources conservation in the area. The livelihood of the society mainly dependent on diverse plants of different uses in the system for food sources of the family. However, more of the plant species were exotic species in their origin and concentration on few species in the garden were observed. Cultivation of cash crop production particularly, *coffee arabica* and *Catha edulis* in homegarden agroforestry practices are attracting more attention of the farming households with the objective of maximizing their cash benefit and concurrently to escape from increased wildlife damage to food crop components in the garden. These situations are happening at the expense of species diversity and bringing a reduction in food provision for poor rural households. Thus, both plant biodiversity conservation and local people livelihood sustenance have been affected. Yet, clear capacity exists to make a homegarden contribution more effective towards of plant biodiversity conservation and livelihood improvement.

4.5.2. Recommendations

Based on the findings of this study, the following recommendations are suggested:

- Attention should be given to make homegarden more effective in biodiversity conservation and local people livelihood improvement.

- The composition of homegardens plant species in Chora district is dominated by exotic plant species, thus, planting of indigenous plant species that have better qualities and multiple outputs need to be promoted.
- Improving locals' awareness on homegarden biodiversity conservation roles to increase floristic diversity and diversity preservation in the practice should be encouraged.
- Promotion of homegardens should be included in the programmes of conservation agency and others concerned bodies to enhance the livelihoods of rural poor and conservation of natural resources on a sustainable basis.
- Further study is recommended and needed to find available opportunities in supplying plant varieties of ecological and locals' needs.

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6. APPENDICES

Appendix 1: Households Interview Questionnaires

Jimma University

College Of Agriculture and Veterinary Medicine

Dear respondents: My name is Gemeda Terfassa, this is the research questionnaires to collect the research data from households in Chora for the objective of MSc thesis work to study **''Contribution of Homegarden Agroforestry for Biodiversity Conservation and Local Livelihoods: The Case of Chora District, Southwestern Ethiopia''** this study is conducted is conducted within the NutriHAF Africa project In collaboration with ECFF. It is research for my Masters thesis. This is for generating information about the system in contribution in the area. I would like to assure you that the information that you are giving used only for this study and honestly your name will not be mentioned in the report. Thank you in advance!

Part I: Basic information

Name ---------------------------- Kebele ------ specific site -------- GPS coordinates of residence (coordinates): North: ____East:______Altitude (m.a.s.l.):_______Accuracy:_________Gender --------

Part II: Information on households Socioeconomic Characteristics

Current….?

1 Age in year _______________

2 Family size________________

3 Total land size in ha_______________

4 Homegarden land size in ha___________

5 Education level completed in year __________

6 Total annual income_______________

Appendix 2: Check list for total income calculation

Main Sources of household income		Major products				
Cropland		Maize	Sorghum	Millet	Others	
	Yields in Kg or kuntal/ha/year					
	Price					
Coffee from the forest (coffee plantation)		Coffee	Fuelwood	Contraction wood	Honey	Others
	Yield in Kg or kuntal/ha /year					
	Price					
Woodlot		Fuelwood	Contraction wood			Others
	Load/ha /year					
	Price					
Livestock		Present	Sold			
	Number					
	Price					
Business	Type	Trade				
	Income/ha /month					
Employment	Type	Wage	Others			
	Income/month					
Others	Type					
	Income/month					
Total income/year in Birr						

Appendix 3: Homegarden Household livelihoods contribution

1 What is your major source of income?

2 Which one of the following practice is your main source of household income? 1. Homegarden 2. Forest land 3. Farmland 4. if others specify_________

3 Why does your household maintain a homegarden? To: 1. spend time with my family 2. To produce food for my family 3. To generates additional income 4.For mental and physical relaxation 5. To beautify my home surrounding 6.Have no significant benefit 6. Others, Specify

4 Please, list common plants you have been growing in your homegarden with their main uses:

No.	Tree species	Plants primary use	Other Uses	Remark

9. Do you agree that the contribution of your garden products for family food and income generation is ____?

For family food	For income generation	Remark
High	High	
Medium	Medium	
Low	Low	
Never	Never	

10. Would you list your homegarden products with their major contribution?

Appendix 4: Check list for homegarden income calculation

Sources		Main products								
Homegarden		Coffee	Chat	Fruits	Vegetable	Spice	Root & tuber	Fuelwood	Contraction wood	Others
	Yield in Kg or kuntal/ha /year									
	Price									

13. What are the major benefits that you get from homegarden and how do you evaluate them as (1. High 2. Medium 3. Low 4. None)?

How do you evaluate the benefit that you get from homegarden?	Option	Remark
Food		
Income		
Construction		
Fodder		
Shade		
Fuelwood		
Life fence		

Thank You So Much for Your Cooperation

Respondent: sign ________________

Appendix 5: Checklist for Focus Group Discussions (FGDs)

Introduction:

The Group Discussions is for the aim of the MSc thesis work to study "Contribution of Homegarden Agroforestry for Biodiversity Conservation and Local Livelihoods: The Case of Chora District, Southwestern Ethiopia" I would like to assure you that any ideas raised here are used only for this research. Your contribution has a vital role in the success of the study. Any of your opinions that will be included in this thesis report will not mention your name.

Thank you very much for your active participation essential ideas!

Instruction:

1. All members of the group should be equally participating.

2. Time allowed to one participation is ___minute in one turn.

3. All ideas raised here are equally important for the study.

4. There are no wrong ideas, feel free to react to the issues raised.

5. All participants should listen properly when one of the members his/her idea

Questions prepared for the discussion

1. Understanding the components, plant diversity in homegarden Agroforestry practices and its socioeconomic contribution, Please briefly tell us about your experience in
2. In what ways are you more aware of the importance of the homegarden in plant biodiversity conservation? And would you describe the conservation roles of homegarden?
3. What is the contribution of homegarden for local community livelihood in your area?
4. Would you explain please, the contribution of homegarden to the local community in both income generation and family food production terms?
5. What type of plants do people in your area more interested to conserve in their garden?, Why?
6. Do you think are there criteria for gardeners to preserve plants in their garden?

7. Would you mention plants or tree varieties commonly observed in your area homegardens? What do you think is the most probable reason for the plants to be common in the homegardens of the area?
8. For what purpose do people, in this area practice homegarden mostly?
9. What are the purposes of trees component in homegarden? ________
10. Where do people in this area get forest products for their construction materials or firewood at most?
11. Do you think that is homegarden in your area effective enough for plant biodiversity conservation? If not why?
12. What is the most important constraint/problems for homegarden practices inefficiency for plant conservation in your area?
13. What options do you suggest in bringing sustainable plant biodiversity conservation in the area?

Appendix 6: Key Informants Interview

1. Please briefly tell us about your experience homegarden management and its contributions to the plant biodiversity conservation.
2. What do you think about homegardens and their contributions to the plant biodiversity in your areas?
3. What type of trees and crops that are commonly being managed in homegardens of this area and why?
4. How do you describe the contribution of the homegarden practice to YCFBR and plant biodiversity conservation in your areas?
5. Do you think homegardens have a role in household food security and income generation ?
6. Describe the value of homegarden to: 1. Livelihood and socioeconomic of the locals 2. plant biodiversity conservation and YCFBR
7. What do you think is the best alternative practice that may compensate products from YCFBR for surrounding community in favor of sustaining biodiversity conservation practices in this area?
8. What are the main problems locals are facing in relation to the diversifying of homegarden components?

Appendix 7: Homestead Plant Species Diversity Assessment Data Collection Sheet

Study site: Region: Oromia Zone: Buno Bedele District: Chora Kebele: ______________Name of data Collector: Gemeda Terfassa Date (day/month/year) ____/___/2017 Line/Transection: _____ Plot No: ______ GPS reading; Longitude (X): ______________ Latitude (Y): ____________________ Altitude/ Elevation: ___________Accuracy/Precision

Homegarden Species Diversity Assessment Data Collection sheet

No.	Local name	Scientific name	Family Name	Growth habit	Primary Use	Abundance in the system	Remark

Appendix 8: Scientific name of Plants in homegarden agroforestry Practices of the three Kebeles

No.	Local name (AO)	Scientific name	Family name	Growth habit	Origin	Uses	Primary use category
1	Abbayyii	*Maesa lanceolata*	Myrsinaceae	S	I	5	Shade
2	Abiraangoo	*Brassica oleracea*	Brassicaceae	H	I	1,4	Vegetable
3	Adongaaree	*Phaseolus lunatus*	Fabaceae	C	I	1,5	Pulse crop
4	Ambabbeessa	*Albizia gummifera*	Fabaceae	T	I	5	Shade
5	Ancootee	*Coccinia abyssinica*	Cucurbitaceae	H	I	1,4	Root and tuber
6	Appilii	*Malus sylvestris*	Rosaceae	T	E	1,4	Fruit
7	Avokaadoo	*Persea Americana*	Lauraceae	T	E	1,5	Fruit
8	Baargamoo diimaa	*Eucalyptus camaldulensis*	Myrtaceae	T	E	2,4	Construction
9	Bakkanniisa	*Croton macrostachyus*	Euphorbiaceae	T	I	3	Medicinal plant
10	Balaan waraantee	*Leonotis raineriana*	Acanthaceae	S	I	5	Others
11	Barbaree	*Capsicum fruitescens*	Solanaceae	H	E	1,4	Spice
12	Basoobilaa	*Ocimum santumvar*	Lamiaceae	H	E	1,4	Spice
13	Boloqqee	*Phaseolus vulgaris*	Fabaceae	C	E	1,4	Pulse crop
14	Booynaa	*Dioscorea cayenensis*	Dioscoreaceae	C	I	1,5	Others
15	Buna	*Coffee Arabica*	Rubiaceae	S	I	4,5	Stimulants
16	Buqqee	*Cucurbita pepo*	Cucurbitaceae	C	E	1	Vegetable
17	Burtukaana	*Citrus sinensis*	Rutaceae	S	E	1,4	Fruit
18	Caatii	*Catha edulis*	Celastraceae	S	I	3	Stimulants
19	Cadaa	*Euphorbia tirucalli*	Euphorbiaceae	T	I	2,5	Others
20	Darguu	*Hypoestes restate*	Acanthaceae	H	E	5	Others
21	Dhummuugaa	*Justicia schimperiana*	Acanthaceae	H	E	2,5	Others
22	Dinnicha	*Solanum tuberosum*	Solanaceae	H	E	1,4	Root and tuber
23	Eebicha	*Vernonia amygdalina*	Asteraceae	S	I	3,5	Animal feed
24	Gaattiraa faranjii	*Cupresus lustanica*	Cupressaceae	T	E	2,5	Construction
25	Geeshoo	*Rhamnus prinoides*	Rhamnaceae	S	I	4	Stimulants
26	Giraaviiliyaa	*Grevillea robusta*	Proteaceae	T	E	2,5	Construction

27	Gishxaa	*Annona senegalensis*	Annonaceae	T	I	1,4	Fruit
28	Godarree	*Colocasia esculenta*	Araceae	H	E	1,4	Root and tuber
29	Goraa	*Rubus apetalus*	Rosaceae	S	I	1,5	Fruit
30	Harangamaa	*Maerua aethiopica*	Capparidaceae	C	I	5	Others
31	Hudduu fardaa	*Trema guineensis*	Ulmaceae	S	E	2,5	Others
32	Hundee diimaa	*Beta vulgaris*	Chenopodiaceae	H	E	1,4	Root and tuber
33	Incinnii	*Hibiscus boranensis*	Fabaceae	S	E	5	Others
34	Indoodee	*Phytolacca dodecandra*	Phytolaccaceae	C	I	2	Medicinal plant
35	Injoorii faranjii	*Morus alba*	Moraceae	T	E	1,4	Fruit
36	Irdii	*Curcuma longa*	Zingiberaceae	H	E	1	Spice
37	Jacfruitii	*Artocarpus hetrophyllum*	Rosaceae	T	E	1	Fruit
38	Kaashimiirii	*Casimiroa edulis*	Rutaceae	T	I	1,4	Fruit
39	Kefoo	*Ocimum bacilicum*	Lamiaceae	H	E	1,4	Spice
40	Kookii	*Prunus persica*	Rosacaea	T	E	1,5	Fruit
41	Kusaayee	*Lippia adoensis*	Verbenaceae	C	E	1	Spice
42	Loomii	*Citrus aurantiifolia*	Rutaceae	S	E	1,3,4	Fruit
43	Luugoo	*Ficus palmata*	Moraceae	T	I	5	Shade
44	Maangoo	*Mangifera indica*	Anacardiaceae	T	E	2,4,5	Fruit
45	Mandariinii	*Citrus reticulate*	Rutaceae	T	E	1,4	Fruit
46	Maxxannee	*Achyranthes aspera*	Amaranthaceae	H	I	5	Others
47	Mixaaxisa	*Ipomoea batatas*	Convolvulaceae	H	E	1,4	Root and tuber
48	Muka bofaa	*Psychotria kirkii*	Rubiaceae	S	I	3,5	Medicinal plant
49	Muuzii	*Musa paradisiaca*	Musaceae	H	E	1,4	Fruit
50	Muzii faranjii	*Musa sapietum*	Musaceae	H	E	1,4	Fruit
51	Nim tirii	*Melia azedarach*	Meliaceae	T	E	3,4	Shade
52	Oogiwoo/kororiimaa	*Aframomum korarima*	Zingiberaceae	H	E	1,4	Spices
53	Paappayyaa	*Carica papaya*	Caricaceae	T	E	1,4	Fruit
54	Qilxuu	*Ficus vasta Forssk*	Moraceae	T	I	5	Shade

55	Qobboo	*Ricinus communis*	Euphorbiaceae	S	I	5	Others
56	Qoccoo	*Ensete ventricosum*	Musaceae	H	I	1,5	Root and tuber
57	Qomxaaxxee	*Citrus aurantium*	Rutaceae	T	E	1,5	Fruit
58	Qoricha bowwuu	*Carissa spinarum*	Apocynaceae	S	I	3,4	Medicinal plant
59	Qoricha michii	*Ocimum lamiifolium*	Lamiaceae	S	E	3	Medicinal plant
60	Qullubbii	*Allium sativum*	Alliaceae	H	E	1,3,4	Spices
61	Raafuu habashaa	*Brassica napus*	Brassicaceae	H	I	1,4	Vegetable
62	Raafuu maraa	*Brassica integrifolia*	Brassicaceae	H	E	1,4	Vegetable
63	Reejjii	*Vernonia rueppellii*	Asteraceae	S	I	5	Others
64	Riga-arbaa	*Bridelia micrantha*	Euphorbiaceae	T	I	1,5	Others
65	Sarxee	*Dracaena steudnery*	Dracaenaceae	T	I	2,5	Others
66	Sasbaaniyaa	*Sesbania grandflora*	Fabaceae	S	E	3	Animal feed
67	Shonkoora	*Saccharum officinarum*	Poaceae	H	E	1,4	sugar
68	Shunkurtii	*Allium cepa*	Alliaceae	H	E	1,3,4	Spices
69	Sooyyoma adii	*Vernonia leopoldii*	Asteraceae	S	I	2,5	Construction
70	Timaatima	*Lycopersicon esculentum*	Solanaceae	H	E	1,4	Vegetable
71	Tsigeredaa	*Rosa hybrida*	Rosaceae	H	E	5	Ornamental
72	Turungoo	*Citrus medica*	Rutaceae	S	E	1,4	Fruit
73	Tuufoo	*Woodfordia uniflora*	Lythraceae	H	I	5	Animal feed
74	Ulmaayaa	*Clausena anisata*	Rutaceae	S	E	5	Others
75	Waddeessa	*Cordia Africana*	Boraginaceae	T	I	2,5	Construction
76	Xeenaaddaam	*Ruta chalepensis*	Rutaceae	H	E	1,4	Spice
77	Yewof ater	*Cajanus cajan*	Fabaceae	S	E	1,5	Pulse crop
78	Zeetunaa	*Psidium guajava*	Myrtaceae	T	E	1,4	Fruit
79	Zinjibila	*Zingiber officinale*	Zingiberaceae	H	E	1,3,4	Spice

Plant habit: T= Tree, S= Shrub=Herb, and C=Climber. Origin: I= Indigenous E=Exotic
Use: 1= Food, 2=Construction /fuelwood, 3=Medicinal plants, 4= Income generation (Cash crops, stimulant crops, industrial and etc crops), 5=others (i.e. forage plants, Ornamental plants, and others multipurpose plants of different uses).

Appendix 9: Plant species frequency in homegarden agroforestry Practices of the three Kebeles

No.	Local name	Scientific name	Frequency	Freq%	RF
1	Abbayyii	*Maesa lanceolata*	22	48.89	1.90
2	Abiraangoo	*Brassica oleracea*	13	28.89	1.16
3	Adongaaree	*Phaseolus lunatus*	10	22.22	0.85
4	Ambabbeessa	*Albizia gummifera*	23	51.11	2.01
5	Ancootee	*Coccinia abyssinica*	5	11.11	0.42
6	Appilii	*Malus sylvestris*	19	42.22	1.69
7	Avokaadoo	*Persea Americana*	31	68.89	2.75
8	Baargamoo diimaa	*Eucalyptus camaldulensis*	13	28.89	1.16
9	Bakkanniisa	*Croton macrostachyus*	10	22.22	0.85
10	Balaan waraantee	*Leonotis raineriana*	10	22.22	0.85
11	Barbaree	*Capsicum fruitescens*	15	33.33	1.27
12	Basoobilaa	*Ocimum santumvar*	17	37.78	1.48
13	Boloqqee	*Phaseolus vulgaris*	2	4.44	0.21
14	Booynaa	*Dioscorea cayenensis*	11	24.44	0.95
15	Buna	*Coffee Arabica*	39	86.67	3.39
16	Buqqee	*Cucurbita pepo*	5	11.11	0.42
17	Burtukaana	*Citrus sinensis*	24	53.33	2.12
18	Caatii	*Catha edulis*	29	64.44	2.54
19	Cadaa	*Euphorbia tirucalli*	10	22.22	0.85
20	Darguu	*Hypoestes restate*	27	60	2.33
21	Dhummuugaa	*Justicia schimperiana*	20	44.44	1.69
22	Dinnicha	*Solanum tuberosum*	18	40	1.59
23	Eebicha	*Vernonia amygdalina*	21	46.67	1.80
24	Gaattiraa faranjii	*Cupresus lustanica*	12	26.67	1.06
25	Geeshoo	*Rhamnus prinoides*	7	15.56	0.63
26	Giraaviiliyaa	*Grevillea robusta*	20	44.44	1.69
27	Gishxaa	*Annona senegalensis*	17	37.78	1.48
28	Godarree	*Colocasia esculenta*	21	46.67	1.80

29	Goraa	*Rubus apetalus*	9	20	0.74
30	Harangamaa	*Maerua aethiopica*	15	33.33	1.27
31	Hudduu fardaa	*Trema guineensis*	8	17.78	0.74
32	Hundee diimaa	*Beta vulgaris*	11	24.44	0.95
33	Incinnii	*Hibiscus boranensis*	6	13.33	0.53
34	Indoodee	*Phytolacca dodecandra*	4	8.89	0.32
35	Injoorii faranjii	*Morus alba*	3	6.67	0.32
36	Irdii	*Curcuma longa*	11	24.44	0.95
37	Jacfruitii	*Artocarpus hetrophyllum*	5	11.11	0.42
38	Kaashimiirii	*Casimiroa edulis*	22	48.89	1.90
39	Kefoo	*Ocimum bacilicum*	15	33.33	1.27
40	Kookii	*Prunus persica*	10	22.22	0.85
41	Kusaayee	*Lippia adoensis*	11	24.44	0.95
42	Loomii	*Citrus aurantiifolia*	17	37.78	1.48
43	Luugoo	*Ficus palmata*	10	22.22	0.85
44	Maangoo	*Mangifera indica*	22	48.89	1.90
45	Mandariinii	*Citrus reticulate*	15	33.33	1.27
46	Maxxannee	*Achyranthes aspera*	25	55.56	2.22
47	Mixaaxisa	*Ipomoea batatas*	6	13.33	0.53
48	Muka bofaa	*Psychotria kirkii*	11	24.44	0.95
49	Muuzii	*Musa paradisiaca*	22	48.89	1.90
50	Muzii faranjii	*Musa sapietum*	24	53.33	2.12
51	Nim tirii	*Melia azedarach*	10	22.22	0.85
52	Oogiwoo/kororiimaa	*Aframomum korarima*	16	35.56	1.38
53	Paappayyaa	*Carica papaya*	20	44.44	1.69
54	Qilxuu	*Ficus vasta Forssk*	10	22.22	0.85
55	Qobboo	*Ricinus communis*	16	35.56	1.38
56	Qoccoo	*Ensete ventricosum*	28	62.22	2.43
57	Qomxaaxxee	*Citrus aurantium*	7	15.56	0.63
58	Qoricha bowwuu	*Carissa spinarum*	15	33.33	1.27

59	Qoricha michii	*Ocimum lamiifolium*	7	15.56	0.63
60	Qullubbii	*Allium sativum*	7	15.56	0.63
61	Raafuu habashaa	*Brassica napus*	26	57.78	2.22
62	Raafuu maraa	*Brassica integrifolia*	20	44.44	1.69
63	Reejjii	*Vernonia rueppellii*	13	28.89	1.16
64	Riga-arbaa	*Bridelia micrantha*	14	31.11	1.27
65	Sarxee	*Dracaena steudnery*	21	46.67	1.80
66	Sasbaaniyaa	*Sesbania grandflora*	10	22.22	0.85
67	Shonkoora	*Saccharum officinarum*	2	4.44	0.21
68	Shunkurtii	*Allium cepa*	13	28.89	1.16
69	Sooyyoma adii	*Vernonia leopoldii*	10	22.22	0.85
70	Timaatima	*Lycopersicon esculentum*	12	26.667	1.06
71	Tsigeredaa	*Rosa hybrida*	10	22.22	0.85
72	Turungoo	*Citrus medica*	15	33.33	1.27
73	Tuufoo	*Woodfordia uniflora*	24	53.33	2.12
74	Ulmaayaa	*Clausena anisata*	11	24.44	0.95
75	Waddeessa	*Cordia Africana*	22	48.89	1.90
76	Xeenaaddaam	*Ruta chalepensis*	15	33.33	1.27
77	Yewof ater	*Cajanus cajan*	2	4.44	0.21
78	Zeetunaa	*Psidium guajava*	11	24.44	0.95
79	Zinjibila	*Zingiber officinale*	12	26.67	1.06

Freq%= frequency percentage, RF=relative frequency,

7. Annexes


Picture during data collection, 2017




Picture during data collection, September- November 2017