



**Composition of Crop Plants and their Determinants in Homegardens (*Gone*)
of Ezha District, Gurage Zone, Southern Nations Nationalities and Peoples
Region, Ethiopia**

By

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Ezha District, Gurage Zone, Southern Nations Nationalities and Peoples Region,
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This is to certify that the thesis entitled: “Composition of crop plants and their determinants in Homegardens (Gone) of Ezha District, Gurage zone, Southern Nations, Nationalities and Peoples Region, Ethiopia” is my own work under the supervision of Dr. Ermias Lulekal and Dr. Debissa Lemessa. All sources used in this thesis have been fully acknowledge.

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Abstract

Composition of Crop Plants and their Determinants in Homegardens (*Gone*) of Ezha District, Gurage Zone, Southern Nations Nationalities and Peoples Region, Ethiopia.

Emebet Getachew Fekade “MSc Thesis”

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The aim of this study was to assess composition of crop plants and their determinants in Homegardens of Ezha District. Reconnaissance survey was conducted from October 27-31, 2018. Eleven kebele were selected purposively. From each kebele 11 households were selected randomly sampling and 121 households were used for the study. Crop plant inventory and socio-economic survey were conducted using plant inventory collection format and semi-structured questionnaire. Plant specimens were collected and identified at the National Herbarium, Addis Ababa University. The location and altitude of each HGs were recoded using GPS. The data were analyzed using descriptive statistics and the effects of ecological and socio-economic factors on homegardens crop plant species richness were analyzed using the Linear Mixed Effect Model (LMER) and One-way ANOVA within R statistical program. Totally, 47 crop plant species belonging to 40 genera and 25 families were recorded. Family Rutaceae was represented by the higher number of species (5) followed by Brassicaceae (4), Rosaceae (4) & Solanaceae (4). The most frequent crop plant species were *Enset ventricosum* (100%), *Coffea arabica* (66 %) and *Persea americana* (59%). The result showed that the crop species richness in homegardens were affected by household wealth status, distance from forest, altitude and woody species richness ($P < 0.007$). The species richness was higher in homegardens of rich households when compared with that of the poor households. Moreover, the species richness increased with increasing distance from forest edges, while decreased with increasing altitude. Overall, the present study denoted that the importance of homegardens for crop biodiversity conservation is determined by ecological and socio-economic characteristics of the human modified landscapes. As these sites are high potential agricultural areas, strengthening can be achieved by integrating high-value and more productive crops while maintaining the integrated and complex nature of the systems.

Keywords: Ezha, Gone, Ecological factors, Socio-economic factors, Crop plant

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Table of Contents

List of Figures	I
List of Tables	II
List of Appendices	III
Acronyms	IV
CHAPTER ONE	1
1. Introduction.....	1
1.1. Background and Justification	1
1.2 Statement of the Problem	3
1.3 Research questions and hypothesis.....	4
1.3.1 Research questions	4
1.3.2 Research hypothesis	5
1.4. Objectives.....	5
1. 4.1 General objective.....	5
1.4.2 Specific objectives.....	5
1.5 Significance of the study.....	5
CHAPTER TWO	7
2. Literature Review.....	7
2.1 Homegardens in tropical region	7

2.2 Structure and composition of homegardens	9
2.3 Homegardens in Ethiopia	10
2.3.1 Homegardens in Southern Ethiopia.....	11
2.3.2 Crop plant diversity of Homegardens of Southern Ethiopia	13
2.3.3 Contribution of homegardens to food security and nutrition.....	15
2.3.4 Factors affecting crop plant species diversity and composition of homegardens	16
2.3.5 Traditional conservation and management of homegardens	16
CHAPTER THREE.....	19
3. Materials and methods.....	19
3.1 Reconnaissance survey	19
3.2 Description of the study area.....	19
3.2.1 Geographic location	19
3.2.2 Population	21
3.2.3 Climate.....	21
3.2.4 Agriculture	22
3.3 Selection of study sites and informants	23
3.3.1 Selection of study sites	23
3.3.2 Sample size determination and informant selection.....	23
3.4 Data collection.....	26
3.4.1 Plant inventory	26

3.4.2 Semi-structured interview	26
3.4.3. Direct field observation and guided garden walk	27
3.5 Data analysis.....	27
CHAPTER FOUR.....	29
4. Results	29
4.1 Crop plant species composition.....	29
4.1.1 Crop species richness	29
4.1.2 Diversity of crop species	32
4.1.3 Richness in functional groups of crops	33
4.2. Factors that affect crop plant species composition and diversity	34
4.2.1 Topographic factor	34
4.2.1.1 Altitude (Elevation).....	34
4.2.1.2 Distance of homegardens to forest edge.....	35
4.2.1.3 Non -crop woody plant species richness.....	36
4.2.2 Socio-economic factors	39
4.2.2.1 Wealth status.....	39
CHAPTER FIVE	41
5. Discussion Conclusion and Recommendations	41
5.1 Discussion	41
5.1.1 Crop plant species composition	41

5.1.2 Ecological and socio-economic factors of crop plant species composition and diversity	46
5.2 Conclusion.....	54
5.3 Recommendations.....	55
References	57
Appendices	67

List of Figures

Figure 1. Locational and administrative map of the study area, Gurage zone, SNNPR, Ethiopia.....	20
Figure 2. Crop plant species family, growth habit and occurrence of frequency across the homegardens.....	32
Figure 3. Pie chart showing functional groups.....	34
Figure 4. The line graph showing that the crop species richness in homegardens decrease with increasing altitude.....	36
Figure 5. The line graph showing that the crop species richness increases with increasing distance from the nearest forest edge.....	37
Figure 6. The line plot showing positive relations between crop and non-crop woody plants species richness of the homegardens.....	39
Figure 7. Matured fruit of <i>Cordia africana</i> grown in the homegardens in shubraden kebele.....	39
Figure 8. Box plots showing the variation in crop plant species richness by households wealth status categories.....	41
Figure 9. Fruit crops such as <i>Persea americana</i> , <i>Musa x paradisiaca</i> , <i>Citress sinensis</i> sold in the local market on Monday and Wednesday, Segno gebeya at Agena (A) and in Irob gebeya Bozjubar (B).....	47

List of Tables

Table 1. Land use patterns of Ezha district.....	22
Table 2. Forest cover of the study area.....	23
Table 3. The variables used in the analysis and their characteristics.....	25
Table 4. Total and average numbers of crop species ,mean value of Shannon (H') and evenness index.....	33

List of Appendices

Appendix 1. Study site and their corresponding altitudinal ranges.....	68
Appendix 2. Farmer's wealth status classifying criteria's forwarded by key informants.....	68
Appendix 3. Socio-economic status of all surveyed households	69
Appendix 4. Data collection form (Plant inventory).....	75
Appendix 5. Checklist of questions used to data collection by using semi-structured interview.....	76
Appendix 6. Crop plant species identified in the homegardens of the study area.....	79
Appendix 7. Non crop woody plant species identified in the homegardens of the district.....	83

Acronyms

ANOVA	Analysis Of Variance
CSA	Central Statistical Agency
ETH	National Herbarium of Ethiopia
FAO	Food and Agricultural Organization
GPS	Global Positioning System
HGs	Homegardens
HH	Household
Km	Kilometer
LMER	Linear Mixed Effect Model
M.a.s.l	Meter above sea level
NGO	Non-Governmental organization
SNNPR	Southern Nations, Nationalities and Peoples Region

CHAPTER ONE

1. Introduction

1.1. Background and Justification

Homegardens are most often considered as a refugia for both woody plant and crop species in human managed landscapes. Homegardens comprise of an assemblage of plants with different form of habit including trees, shrubs, vines, and herbaceous plants, growing in home compound (Melese Mengitu and Daniel Fitamo, 2016). According to Fernandes and Nair (1990) cited in Mulugeta Kebebew (2018) and Solomon Tamrat (2011), homegardens are commonly defined as a piece of land with a definite boundary surrounding a homestead cultivated with a diverse mixture of perennial and annual plant species often in combination with raising livestock, and managed mainly by household members for subsistence production. With this combination of useful plants and animals homegardens are accepted as a sustainable agroforestry systems and characterized as proper land use systems located near to house, and woody and non woody species are closely arranged in many overlapping canopy layers in association with domestic animals (Peyre *et al.*, 2006). Homegardens have been considered as sustainable and productive agricultural systems supporting very dense populations as compared to other agricultural systems (Tesfaye Abebe, 2013).

The high diversity of species in homegardens have a wide range of socioeconomic and agro-ecological roles including production of food, firewood, fodders, spices, medicinal plants and ornamentals, and avoidance of environmental deterioration of climate related hazards commonly associated with monoculture production systems (Ewuketu Linger *et al.*, 2014). Homegardens preserve cultural history, as many useful plant species have

been subjected to intense human management regimes on such sites over extended periods (Molebatsi *et al.*, 2010). The daily nutrition and healthy food required by household members can be obtained from home garden production of crop plants. Therefore homegardens play a significant role to household food security and wellbeing in a sustainable manner. Homegardens enhance household food security directly by enabling families to have a diversity of nutritionally rich food, increased purchasing power from savings on food bills and income from sales of garden products as well as contingency food provision during seasonal lean periods.

The history of home gardening practices in Ethiopia is closely related with the founding of agricultural practices from 5000 - 7000 BC (Abiyot Berhanu and Zemedu Asfaw, 2014). Considering the long history of agriculture in Ethiopia and the presence of ancient crop domestication in home gardens, it could be presumed that gardening was probably the earliest form of farming ever practiced in the country (Abiyot Berhanu and Zemedu Asfaw, 2014). In relation to the house, Ethiopian homegardens may occupy different positions such as the back yards, front yards, and side yards and yards that almost encircle the house, and have variable shapes and sizes and composition of plant species (Tefera Mekonen *et al.*, 2015).

In Ethiopia, homegardens show a sustainable agricultural practice that is environmentally friendly and allows collection of diversified products in response to the needs of farming families and urban settings (Habtamu Hailu and Zemedu Asfaw, 2011). In broader areas of southern Ethiopia there are traditional agroforestry homegardens. Most of these

homegardens are located at altitudes of 1500–2300 m.a.s.l. where moisture and temperature conditions are favorable for agricultural activities. These gardens are characterized by a unique combination of two known native perennial crops that are Enset and coffee (Melese Mengitu and Daniel Fitamo, 2016). Gurage zone traditional homegardens (*Gone*) is also the one which belongs to southern Ethiopia and characterized by Enset and Coffee.

1.2 Statement of the Problem

The present study on traditional Homegardens at Ezha district of Guraghe Zone in SNNPR of Ethiopia will contribute to a better understanding and identification of better management and conservation practice for homegardens and composition and diversity of crop plants and associated factors that mediate it. There are many researches on homegardens of southern Ethiopia conducted by many researchers such as Zemedu Asfaw and Zerihun Woldu (1997), Feleke Woldeyes (2000), Belachew Wassihun *et al.* (2003) and Tesfaye Abebe (2005), Melese Mengitu and Daniel Fitamo (2015) in general and in specific Alemtsehay Teka, (2008) in Ezha district but investigation on the factors that affect crop plant species composition and diversity on homegardens of the Ezha district has not been done before. Hence, it demands detailed study and analysis of homegardens crop species diversity and composition as well as the associated factors. Therefore, based on the results of the current study, it would be possible for further development of traditional Gurage homegardens, and get more viewpoints to forward recommendations to address threats to these systems.

Diversified crop types were found managed by the traditional Gurage people. As time goes, population size increased and hence population pressure intensified. This had led to further fragmentation of already available cultivable land in to pieces and hence the local people are facing a problem to cultivate field crops intensively. Nair (2001) reported a similar cause as factors that contributed to and have accelerated the evolution of tropical homegardens. Therefore, Gurage people in the study area are forced to depend on products of their homegardens for subsistence of their livelihood. However, not so much was done with regard to these systems for their composition, diversity, and factors that determine its composition of crop plants. Hence, this study focused attention to the homegardens of Gurage people at ezha district. The district is preferred in this study for high diversity and composition crop plants homegardens but lack of information on main environmental and socio-economic factors contributed for the variation in crop plant species diversity and richness among the homegardens.

1.3 Research questions and hypothesis

1.3.1 Research questions

1. What are the diverse crop plant species of Ezha homegardens?
2. What are the socio-economic factors that affect composition and diversity of crop plant species in the homegardens of Ezha district?
3. What are ecological factors that affect the species composition and diversity of crop plants in homegardens of the study area?

1.3.2 Research hypothesis

The hypothesis set for this work were:

Null hypothesis (Ho): the species composition of crop plants in homegardens of Ezha district is not dependent on ecological and socio-economic characteristics in the landscapes of the study area.

Alternative hypothesis (H1): the species composition of crop plants in homegardens of Ezha district is dependent on ecological and socio-economic characteristics in the landscapes of the study area.

1.4. Objectives

1. 4.1 General objective

- ❖ To assess and understand the composition of crop plant species and their determining factors in Homegardens of Ezha District.

1.4.2 Specific objectives

- ✓ To assess the species composition of crop plants in homegardens of Ezha District.
- ✓ To assess the ecological factors that affect the species composition of crop plants of Ezha District.
- ✓ To assess the socio-economic factors that affect the species composition of crop plants of Ezha District.

1.5 Significance of the study

This study is believed to provide platform information for the conservation, management and sustainable utilization of the homegardens species in the study area. The study reveal the current status of the home gardening practice and its crop species composition and the

link between different ecological and socio-economic determinants and crop plant species composition/crop plant species richness and allow to give recommendations based on the result obtained from this work. Scientific information on crop species composition of homegardens and its determinant factors is important for concerning on appropriate conservation and management approaches. So this study provide baseline information for government and other stakeholders about homegardens and determining factors and as means of identifying proper conservation and management approaches. It also provide a basis for further studies.

CHAPTER TWO

2. Literature Review

2.1 Homegardens in tropical region

Countries located in the tropics are faced with constant pressure of change brought by different factors including demographic, economic, technological and social pressures on Small-holder farming systems. Population growth (Galhan *et al.*, 2013), increasing commercialization of products and the use of modern inputs are the most important factors that contribute to land use changes (Tilman *et al.*, 2002). On the other hand, the rainforests are almost closed systems with very little input and high species diversity. In between, there are farming systems of intermediate complexity and species diversity that include different agroforestry and intercropping systems (Wiersum, 1997).

Recently, more concerns have developed on the long-term sustainability and environmental consequences of the magnification of agricultural systems. Increasing attention is being given to achieving stability in land utilization on the longer term basis while fulfilling the needs of the local population (Tilman *et al.*, 2002). Therefore tropical homegardens are one of the most complex and diverse agroforestry systems worldwide and played an important role towards the development of early agriculture and domestication of crops and fruit trees (Melese Mengitu and Daniel Fitamo, 2018; Megabit Beyene *et al.*, 2018). 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 (Krishnal and Weerahewa, 2014).

In the tropical region two types of homegardens are recognized on the basis of their contribution to the welfare of households (Tesfaye Abebe, 2005). The first ones which is common in much of the tropics, are small-scale supplementary food production systems around houses in areas where livelihood of the owners is based on other land use or other activities (Reta Regassa, 2016). This category of homegardens includes a wide range of rural, semi-urban and urban gardens. The renowned homegardens of Java that supplement monoculture rice production and most homegardens from Latin America (Mendez and Somarriba, 2001) belong to this category. Urban homegardens used to produce vegetables and ornamental plants to supplement non-agricultural income of owners also fall in this category.

The second category of homegardens are extended farm fields around houses that form the principal means of livelihood for farming households. Most of the homegardens in the highlands of Eastern Africa (Rugalema *et al*, 1994) were belong to this category. Here, the farmers have no additional land, or it is small and supplementary to the homegardens. Homegardens are found throughout the tropics, but they are more common in the humid lowlands. In addition, they occur also in several tropical highland regions. Ethiopia is one of the tropical countries where homegardens are prevalent in the highlands. In Ethiopia, both types of homegardens exist. In the cereal-crop based farming systems, staple food crops such as tef (*Eragrostis tef* , barley (*Hordeum vulgare*), wheat (*Triticum sativum*) and Sorghum (*Sorghum bicolor*) are grown in outer farm fields, while supplementary vegetables, fruits and spices are grown in homegardens. Such gardens are also common in most of the urban areas in Ethiopia. The second category of homegardens is common in the perennial-crop based farming systems of the south and south-western highlands.

Here, staple food crops (enset and maize) as well as other cash and food crops are grown in the homegardens and these garden farms make the principal means of livelihood for almost all the households.

2.2 Structure and composition of homegardens

Tropical homegardens are characterized by vegetation layers (stories), imitating the tropical forest structure. The top storey consists of a canopy of tall trees which reduces radiation and mechanical impact of rainfall, creates a relatively constant micro-climate in the lower layers and through leaf fall contributes to the maintenance of soil fertility by addition of organic matter after decomposition of dead body parts. The lower layer features staple food and fruit production (e.g. banana (*Musa x paradisiaca*), mango (*Mangifera indica*), papaya (*Carica papaya*), etc.,) followed by bush level growth (e.g. maize (*Zea mays*), peppers (*Capsicum species*), etc.) in the third layer. In-ground and ground-covering species (roots and tubers and others) form the last layer, while climbing species transverse the lower stories (Fernandes and Nair, 1986).

Despite the fact that the spatial arrangement of the species seems to lack order and pattern, compatible species are often mixed (Fernandes and Nair, 1986). Moreover, spatial arrangement in these systems often reflects their functional adaptation in a multitude of factors including utilization of plant-symbiotic relationships through mixed cropping. Species composition and structure of homegardens differ across sites that may be influenced by ecological, socio-economic and cultural factors, such as distance from urban markets, household size and composition, environmental degradation and family tradition (Megabit Beyene *et al.*, 2018; Soemarwoto and Conway, 1991).

2.3 Homegardens in Ethiopia

Homegardens are one of the most complex and diverse agro-ecosystems worldwide and played an important role towards the development of early agriculture and domestication of crops (Abdoellah *et al.*, 2006). There is no direct evidence as to when people began the practice of homegardening in Ethiopia (Zemedu Asfaw, 2001a). Ethiopian homegardens are unique in their architecture, crop mix and the key species which include a significant number of indigenous crop taxa and some that are truly endemic such as *Coffea arabica*, *Enset ventricosum* and many others (Zemedu Asfaw, 2002; Arayasilassie Abebe Semu, 2018). In Ethiopia homegardens come into existence under different modes of initiation influenced by biotic, abiotic, socio-economic and cultural factors.

As described in research conducted by Zemedu Asfaw (2001) and Tesfaye Abebe (2005) homegardens in Ethiopia may broadly be categorized into two types. The first category of home gardens is small-sized gardens in which vegetables, spices, oil seeds and fruits are cultivated to supplement cereals and pulses raised in adjoining fields. This type of gardens is characteristic of cereal crop based farming areas of the country and is also found in urban centers (Reta Regassa, 2016). The other type of homegardens, which are characterized by a diverse mixture of crop plants with enset (*Ensete entricosum*) making the basic framework, are that found in the south and southwestern part of the country. In these systems, crop diversity is generally high and enset and coffee are still dominant in most of the sites (Melese Mengitu and Daniel Fitamo, 2015). However, there exists variation among sites and between farms within a site. In some sites and farms, the share of the two major crops, enset and coffee, is declining while monoculture fields of new cash and food crops are expanding (Tefaye Abebe, 2013).

Homegardens have different locations. Research conducted by Asfaw Zemedu (2001b) indicated that the locations of homegardens differs in between backyards being the major ones (48%), front yards (26%), side yards (13%) and those encircle the house (13%) are found as common garden locations in Ethiopia. A clean green meadow as a family resting and social gathering place was observed in front of houses. In some areas, live and/or dry fences confine gardens while in others they simply merge with crop fields and may be fenced together (Zemedu Asfaw, 1997). The living house, animal pens, grain stores, drying places and plots of garden plants are components of garden areas in Ethiopia. It is usually fenced and the fence is frequently reinforced with multipurpose live trees and shrubby species. Common garden sizes range from about 100 m² to more than 2000 m², but in extreme cases, sizes as low as 20 m² and as high as 6000 m² has been recorded. Larger gardens, approaching the upper limit, are more frequent in the southwest Ethiopia (Zemedu Asfaw, 1997a; 2002).

2.3.1 Homegardens in Southern Ethiopia

Homegardens are agro-ecosystems located close to the area that serves as a permanent or temporary residence. The beginning of Ethiopian home gardens is believed to be closely linked with the advent of agriculture from 5000 - 7000 BC (Abiyot Berhanu and Asfaw Zemedu, 2014; Solomon Tamirat, 2011). Ethiopian homegardens are unique in their architecture, crop mix and the key species which include a significant number of indigenous crop taxa and some that are truly endemic such as *Coffea arabica*, *Ensete ventricosum* and many others (Solomon Tamirat, 2011; Arayaselassie Abebe Semu, 2018).

Extensive areas of traditional agroforestry homegardens exist in the south and southwestern parts of Ethiopia (Melese Mengitu and Daniel Fitamo, 2015; Tesfaye Abebe, 2005). Most of these gardens are located at altitudes of 1500–2300 meters above sea level where moisture and temperature conditions are favorable for agriculture (Tadesse Kippie, 2002). These gardens are characterized by a unique combination of two native perennial crops: enset and coffee. Enset (*Ensete ventricosum*, family. Musaceae) is widely distributed in eastern and southern Africa but cultivated only in southern and southwestern Ethiopia as staple food for about 15 million people in mixed subsistence farming systems. Enset leaves are a key livestock feed and used as mulch to reduce soil erosion and runoff and hence, enset fulfils both productive and protective functions (Beyene Teklu Mellisse *et al.*, 2018). Coffee, which is produced in these predominantly small-holder agroforestry systems is also the major foreign currency earner of the country. Obviously, these agroforestry systems ensure food security in the areas, play a significant role in the regional and national economies. Other components of these multi-species agroecosystems include chat (*Chata edulis*), a mild stimulant, root and tuber crops, fruits, vegetables, cereals, spices and other crops (Tefaye Abebe, 2005).

One of the characteristics of the enset-coffee homegardens is that they often display a mosaic of patches or farm units which are distinct from one another because of the dominant crop grown on them. For instance, a coffee unit can be recognized where coffee is the dominant crop but grown in association with other crops and trees, or a maize unit that is intercropped with few crops and trees. Near the house, enset is dominant and as

one goes further away, other units dominated by coffee, maize, or other crops prevail (Tesfaye Abebe, 2005). The enset-coffee homegardens have been stable agricultural systems for centuries supporting very dense populations of up to 500 persons per square kilometer (Kippie, 2002). The diversity of the systems, and the ability of enset to produce a relatively large amount of food per unit area and time (Admasu Tsegaye and Struik, 2001), could be the main factors that contributed to this stability. Moreover, due to its multi-annual production time and its flexibility on harvesting, enset is an ideal crop to overcome food shortage in drought times (Desalegne Rahmato, 1995). Coffee, which is produced in these predominantly small-holder agroforestry systems is also the major foreign currency earner of the country. Obviously, these agroforestry systems ensure food security in the areas, play a significant role in the regional and national economies, and also contribute to environmental resilience.

2.3.2 Crop plant diversity of Homegardens of Southern Ethiopia

Homegardens are typically spaces with rich agrobiodiversity, basically vegetables and quick growing fruit trees (for the outer boundaries) (Sthapit *et al.*, 2004). Home-gardens are microenvironments containing high levels of species and genetic diversity within larger farming systems (Eyzaguirre and Watson, 2002). The crops selected for the homegardens depends on the region, the size of the area available, and the preferences of the family. The crops chosen to be grown should be highly adaptable to the area with high yields. For subsistence and poor farmers, crop varieties and cultivars adapted to particular micro-niches around homesteads are crucial and accessible resources available to provide a secure livelihood (Sthapit *et al.*, 2004).

Crop diversification is a deliberate strategy of farmers to ensure subsistence and it has several advantages. These include, yield stabilization, risk reduction, staggered use of family labour, multiple production, making use of a variety of soils and agro-climatic conditions, and increased resource productivity over time (Tesfaye Abebe, 2013; Habtamu Hailu, 2008). The diversity and the space taken by crops of the crops vary spatially and temporally. Spatial variation refers to vertical stratification of the integrated enset-coffee multistorey units. Temporal variation at time interval in plant species richness and composition are other characteristics of these agroecosystems (Tesfaye Abebe, 2005).

The homegardens are widely distributed throughout the country and are home to a range of taxa of cultivated perennial and annual crop species and varieties (Belachew Wassihun *et al*, 2003). Homegardens in Ethiopia provide a wide diversity of crop plant species in human managed landscapes with different indigenous knowledge's about management practices and other significant roles to food security and ecological importance. The high diversity of crop plants of homegardens are showed by researcher such as Reta Regassa (2016) and Debissa Lemessa and Abayneh Legesse (2018) 122 and 37 crop plants species from a total of 285 and 93 useful plants species were recorded in surveyed homegardens. Other research conducted by Mekonnen Anberber *et al.*, 43 species were recorded. Among those fruits are the most usable parts (39.96%) and roots were least usable parts (4.35%).

2.3.3 Contribution of homegardens to food security and nutrition

Homegardens agroforestry systems in the tropics are known for their structural complexity and diversity in crop and other plant species (Megabit Beyene *et al.*, 2018). Homegardens are traditional food systems that have been adapted over generations to fit local cultural and ecological conditions. They provide a year-round diversity of nutritious foods for smallholder farming communities in many regions of the tropics and subtropics (Whitney *et al.*, 2017). Homegardens are very helpful in times of food shortage and failures of staple crops. They are a means of promoting crop diversity which can provide a wide range of resources, such as nutritious foods, marketable products, firewood, herbs, spices, and medicinal plants. Household gardens are also an efficient way of using limited resources such as time, energy, money and land among the low-income groups (Chadha *et al.*, 2017). They offer women, who are usually the providers of family meals, with an important means of earning income without overtly challenging cultural and social restrictions on their activities. In addition, other family members such as the children and the elderly can provide labor.

The rural women use these gardens as diversified agricultural spaces to cultivate vegetables and spices to fulfil a variety of household needs as well as generate some income (Gari, 2003). The homegardens have a distinctive role to play in agriculture, food security and nutrition. The nutrient rich crop diversity of homegardens enriches local diets by supplementing the staple crops with high vitamins and minerals; they ensure year round supply of safe vegetables even in case of scarce resources; aid in the conservation of plant genetic resources, for agricultural experimentation, and for the transmission of indigenous agricultural knowledge; provide income if adequately linked with markets;

and also, being located in the vicinity to the homestead, help women to harmonize their farming and household tasks, thereby contributing to gender equality in agricultural production (FAO, 2001a; Gari, 2003).

2.3.4 Factors affecting crop plant species diversity and composition of homegardens

Plant diversity and productivity in the homegardens is affected by different environmental factors and cultural preferences. The factors such as socio-economic status, soil fertility, garden size, rainfall pattern), distance from home, management system, lack of access to water, proximity to market and roads, cultural preferences, personal preferences/perception and occurrence of pests and weeds have their own influence(Tefera Mekonen *et al.*, 2015; Talemso Seta *et al.*, 2013).

Even though the uses of home gardens are comparable and complementary with crop fields in many areas of Ethiopia, they have been considered primitive and less productive and less attention has been given until recently. Home gardens face major threats such as land use change, displacement of indigenous crops by introduced species/cash crops and climate change. This has resulted in loss of the traditional home garden management systems, loss of taxa and indigenous knowledge (Abiyot Berhanu and Zemedu Asfaw, 2014).

2.3.5 Traditional conservation and management of homegardens

The highly complex structure of homegardens architecture as well as the patterning of plant categories in it has been designed and developed by indigenous skills and practices (Zemedu Asfaw, 1997a; Shrestha *et al.*, 2002). The culture of home gardening has

developed a general structure that allows owners to produce crops of their choice and they manage and direct much of the development process for their gardens. There is free exchange of germplasm among relatives, friends, neighbors and acquaintances. Traditional ways of restricting uncontrolled transfer of germplasm from homegardens developed by households was also observed (Shrestha *et al.*, 2002).

Considering ownership, individual families own most gardens, the head being in charge of the overall management. Management of garden space and plant components fall on shoulders of the male family head in addition to designing the structure, identifying appropriate locations for positioning major crops, and monitoring the structure and direction of garden development (Fernandes *et al.*, 2002). The contribution of males is more important in large gardens and gardens dominated by cash crops such as chat and coffee in addition to banana and ENSET gardens that require arduous work (Fernandes *et al.*, 2002; Zemedu Asfaw, 2002).

A number of conservation and management practices are performed in the homegardens in different parts of Ethiopia in which the effort is to maintaining diverse plant species in the garden as much as possible. Intercropping is a multiple cropping practice involving growing two or more crops in proximity. The purpose behind intercropping is to increase yields by doubling up on available growing space. This is a common case of homegardens management practice observed in south Ethiopia (Mulugeta Kebebew, 2018). Spatial (horizontal or vertical) and temporal arrangements of useful plants of gardens is other method of managing homegardens. Plants in homegardens organized into at least three vertical strata where the assemblage matches plant use a lower, herbaceous

layer containing vegetables and medicinal plants, upper tree layer consisting of fully grown timber and fruit trees and an intermediate layer in between the lower and upper layers (Diana *et al.*, 2012). The owner arrange the homegardens Horizontally the front yards, side yards, back yard with different composition of plant species (Mulugeta Kebebew, 2018) and homegardens owners manage their homegardens plants by growing vegetables in the rainy season as well as in dry season by fetching water from where its available (Tefera Mekonen *et al.*, 2015).

Homegardens could be observed with open areas, fenced or semi-fenced. Live fences with trees and shrubs to protect home garden species from predators-domestic animals (Tefera Mekonen *et al.*, 2015; Arayaselassie Abebe Semu, 2018). According to Mekonen Amberber *et al.*, 2014 females played more roles than males in managing homegardens. Females are more involved in weeding, watering and planting, whereas, males' activity is limited to fencing so labor division with high responsibility for women is another way for managing homegardens (Mekonen Amberber *et al.*, 2014). Women are aware of the use of plants and the means of maintaining them in addition with identifying local varieties and managing mainly minor plants like vegetables, spices, tasty varieties and plants of medicinal value (Talemos Seta *et al.*, 2013).

CHAPTER THREE

3. Materials and methods

3.1 Reconnaissance survey

Reconnaissance survey was conducted at first to have a general impression of the study area. It was conducted from October 27-31, 2018 in order to obtain an intuition about home gardening practice, crop plant species composition in their garden and a general understanding of the characteristics of the study area and to identify the focus areas in the study district. During the survey, general information about the districts was obtained from agriculture office and local community of the district.

3.2 Description of the study area

3.2.1 Geographic location

The Enset-Coffee dominated homegardens agroforestry systems are largely practiced in the Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) of Ethiopia. The study was conducted in homegardens locally known as “*Gone*” of Ezha district which is located in the South Nation Nationality and People’s Regional State (SNNPRs) of Gurage Zone. It is located 197 km south west of Addis Ababa, Capital City of Ethiopia. Geographically, the study area is located within latitudes of 7° 59' 30" – 8° 16' 00" N and longitudes of 37° 53' 30" -38° 10' 00" E (Figure 1). Ezha district has an area of 34,500 hectare (Source: Ezha district agriculture office, 2013). The elevation of Ezha district ranges from 1950 m to 3200 m above sea level. It is divided in to 28 kebeles (the lowest administrative unit). Ezha district is bordered in the Southeast by Silte zone, in the South by the Gumer district and in the North by the Kebena and Muhorna Aklil district. The major town of Ezha district is Agena.

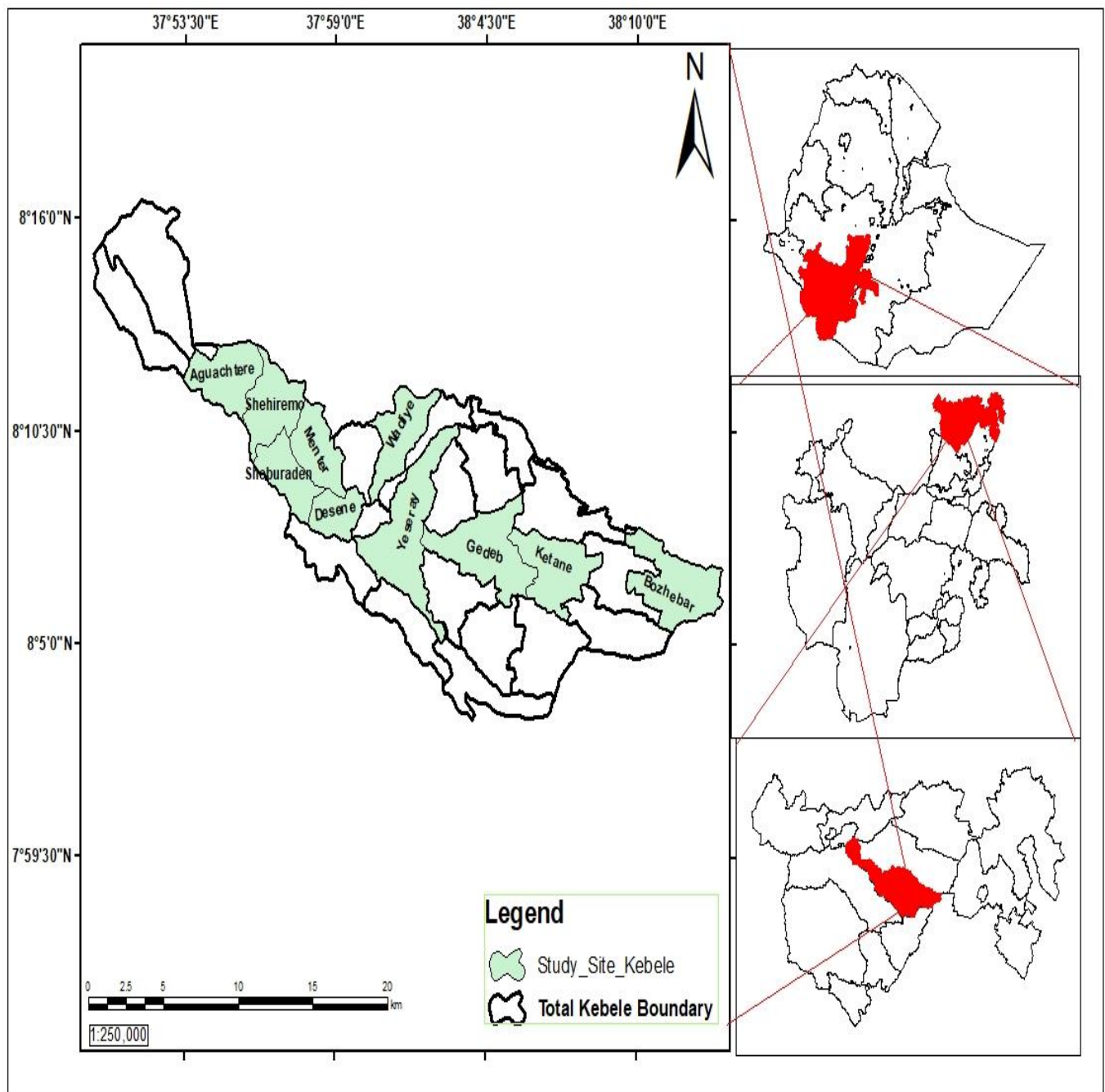


Figure 1. Location and administrative map of the study area, Gurage zone, SNNPR, Ethiopia.

3.2.2 Population

The total number of population of Ezha district is 84,905 of which 40,261 are male and 44,644 are female (CSA, 2007). The district has an estimated population density of 187 persons per km² of arable land and the average arable land holding is 1.2 hectares per household, varying from 0.25 ha to 2.0 hectares. More than 85% of households own less than one hectare of farmland (Source: Ezha district agricultural office, 2013). In religious perspective majority of inhabitants are Ethiopian Orthodox Christianity (65.61%) followed by Muslims (31.47%) and Protestants (2.35%). Concerning with sanitary conditions 70.58% of the urban houses and 24.7% of all houses had access to safe drinking water at the time of the survey (CSA, 2007). Guragigna is an Afro-Asiatic language spoken in the Gurage Zone of the Southern Nations, Nationalities, and People's Region in Ethiopia.

3.2.3 Climate

The annual average temperature of the district ranges between 16.5-25⁰c and the annual rainfall ranges between 900-1200 mm. According to information obtained from the district agricultural office rainfall tends to be bimodal with rainfall becoming more continuous as elevation increases. Most of the rainfall falls during the "Meher" season from June to September (it is most intense during July and August). There is short rainy season called "Belg" which falls during the months of mid-February-March. However, the short rains are highly variable and since they often fail, farmers claim they are relying on them for grain production less and less.

3.2.4 Agriculture

Agriculture in the area is characterized by small-scale subsistence mixed farming-system with livestock production as an integral part. Crop production is mainly rain-feed. Almost all of the crop land is planted to annual food crops, including cereals such as maize (*Zea mays*), barley (*Hordium vulgare*), wheat (*Triticum aestivum*) and teff (*Eragrostis tef*), pulses (beans (*Vicia faba*), pea (*Pisum sativum*)), and root crop (potato (*Solanum tuberosum*)). A very small fraction of farmers produce vegetables or fruits. These crops are grown mainly in homestead gardens or where irrigation exists. Perennial crops such as enset (*Ensete ventricosum*), stimulants (coffee (*Coffea arabica*), chat (*Catha edulis*)), timber (*Eucalyptus globulus* and *Eucalyptus camaldunensis*), are also grown in considerable amounts. Livestock are also very important to agriculture in the district. Donkeys are the most common pack animals. The availability of feed and water are serious constraints to livestock production in the district. Communal grazing areas, private pastures and crop residues are the principal sources of feed (Source: Ezha district agricultural office, 2013). According to the FAO soil classification the area is covered by Leptosols, Luvisols, Nitisols, and Vertisols soil types.

Table 1. Land use pattern of Ezha district (Source: Ezha district agricultural office, 2013)

No	Land Use	Coverage (ha)	Percent (%)
1	Annual Crops	7308.25	21.1
2	Perennial Crops	6579	19.06
3	Grazing Land	5726	16.59
4	Forest Land	8280	24
5	Degraded Land	1800	5.21

6	Potentially uncultivated	1910.77	5.53
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Table 2. Forest cover of the study area (Source: Ezha district agricultural office, 2013)

Forest cover type	Cover (Hectare)	Cover (%)
Natural forest	2828.25	8.19
Government forest	118	3.34
Man-made forest	3963.75	11.5
Others	1370	3.97
Total	8,280	27%

3.3 Selection of study sites and informants

3.3.1 Selection of study sites

Study sites within Ezha district were selected based on the road accessibility and topographic setting of the landscapes. Eleven kebeles which have access to road for transportation and topographic settings were selected for this study based on the observation made during reconnaissance survey. The study kebeles selected for these studies based on the above criteria are listed in Appendix 1.

3.3.2 Sample size determination and informant selection

From eleven selected kebeles, informants from Household head were selected to collect information on crop plant species of the homegardens of the study area. According to the Central Statistical Agency (CSA, 2007) the total households (HH) of Ezha district is 947.

For this study, 11 household from each kebele were randomly selected for the survey, in total 121 sample households were selected from a total of 947 households. Sample size for this study was determined by calculating proportion of the number of households of the districts. The number of household heads (informants) included in the survey was determined by using Cochran (1977) sample size calculation formula as follow:

$$n_0 = \frac{Z^2(P)(q)}{d^2} \qquad n_1 = \frac{n_0}{(1+n_0/N)}$$

Where n_0 = desired sample size Cochran's (1977) when population greater than 10,000

n_1 = finite population correction factors (Cochran's (1977) less than 10,000

Z = standard normal deviation (1.96 for 95% confidence level)

P = 0.1 (proportion of population to be included in sample i.e. 10%)

q = is 1-P i.e. (0.09)

N = total number of population

d = degree of accuracy desired (0.05)

$$n_0 = \frac{1.96^2 \times 0.9}{0.05^2} = \underline{138.24}, \quad n_1 = \frac{138.24}{(1+138.24/947)} = \underline{121}$$

Table 3. The variables used in the analysis and their characteristics

Factors	Range of values	Overall mean	Remarks
Altitude of the homegardens	1980-3271 (m. a.s.l.)	2404.84 (m.a.s.l.)	
Distance of homegardens to market	0.66 – 15.5 kms	7.14km	
Distance from homegardens to forest edge	0.6-0.91 kms		
Farm size	0.11-1.5 hec	0.4 hec	
Involvement in off farm activity	Yes/No		15% of the farmers involve in wage labor, government employ, trading ,pottery or other income generating activities
Family size	2-8 persons	5.24 persons	
Educational status of the household head	0-12		38.8 % of the respondents were illiterate, 61.2% had one form of formal education
Gender of the household head			16% were female-headed households and 84% were male-headed households
Wealth class			76.03% medium (M), 15.7% poor (P) and 8.26 % rich (R)

3.4 Data collection

3.4.1 Plant inventory

The homegardens crop plant composition were assessed through field observation. During the observation, plant inventory survey was performed by using a structured format, which included common and botanical names of crop plants, use of plants, parts of the plant used and habitat of each crop plant species (Appendix 4). The survey were carried out with observations and plant identifications with local names. Voucher specimen were collected, processed and dried in the field. These specimens were taken to and identified at The National Herbarium (ETH), Addis Ababa University/Ethiopia. Following Martin (1995) specimens of useful plants of homegardens of the area were collected using appropriate plant specimen collection methods. Specimens containing flowers and/or fruits were also collected for simplicity of identification.

3.4.2 Semi-structured interview

Checklist of topics or open questions was arranged and forwarded to the informants in a semi-structured way (Appendix 5). The interview was carried out in local language (Guragigna) assisted by local translator for translating from local language to Amharic for better understanding between interviewer and informants. It was focused on basic questions concerning the information on uses type of crop plant species, crop raider types, off farm activities of households, household size and educational level of HH head and local name of crop plants grown in their homegardens.

3.4.3. Direct field observation and guided garden walk

The direct field observation was used to observe the interaction between local people and plants on their surroundings (Alexiades, 1996). Guided garden tour is a method that involves the combination of observations and interviews while walking in the garden. It involves recording the habitat, the habit and characteristics of crop plants known to be lost after specimens are dried. Such characters include flower, fruit and leaf color; leaf scent and any other important characteristic feature expected to be difficult to observe (Martin, 1995). Information were also collected by observing and making guided walk in the homegardens of sampled households (Figure 3). The geographic location and altitude of each of the surveyed homegardens were also recoded using GPS.

3.5 Data analysis

To determine crop species composition diversity, species richness and species evenness of the homegardens were calculated. Species richness is the total number of crops on a farm. This index doesn't indicate the relative proportion or abundance of a particular species in the farm. Hence, indices that incorporate both richness and the evenness of abundance were required. Shannon index (Shannon and Wiener, 1949) and Evenness measure (E), which are commonly used tools for these purposes (Magurran, 1988), were computed. The Shannon diversity index (H') is high when the relative abundance of the different species in the sample is even, and is low when few species are more abundant than the others. It is based on the theory that when there is a large number of species with even proportions, the uncertainty that a randomly selected individual belongs to a certain species increases and thus the diversity. It is calculated using the formula (Magurran, 1988).

$$H' = - \sum p_i \ln p_i \quad \text{Where,}$$

H' = Shannon-wiener diversity index

p_i = Proportion of individuals found in i th species ($p_i =$

n_i / N , n_i is number of individuals of i th species and N is total number of individuals of all species).

S = Number of species

Before the final data analysis was run, the multicollinearity-unnecessary correlation among independent variables, was checked. In the next, to attain the assumption of normal distribution and homoscedasticity, crop species richness and woody species richness were square-root-transformed and altitude was also standardized (scaled) to bring to the values to similar level with other values of the independent factors. Finally, the effects of altitude, woody species richness, wealth status, distance from forest edge to household and households' plant use types on crop species were tested using Linear Mixed Effect Model and One- way ANOVA. In the linear mixed effects model, the independent factors were entered as fixed factors while the 11 kebeles were considered as random factors with the assumption that each has its own specific factors that were either measured or controlled for. To reach at the final model the backward selection procedure was followed in which first all the variables were included in the model and then the model simplification was made by removing one variable at each step that did not contribute to the model and this was stopped when all the factors that significantly contributed to the models. Moreover, the multiple comparison HSD Tukey test was applied for the mean separation of wealth category which had significant effect on crop species richness. For all the analyses R statistical program (version 3.5.3) was used.

CHAPTER FOUR

4. Results

4.1 Crop plant species composition

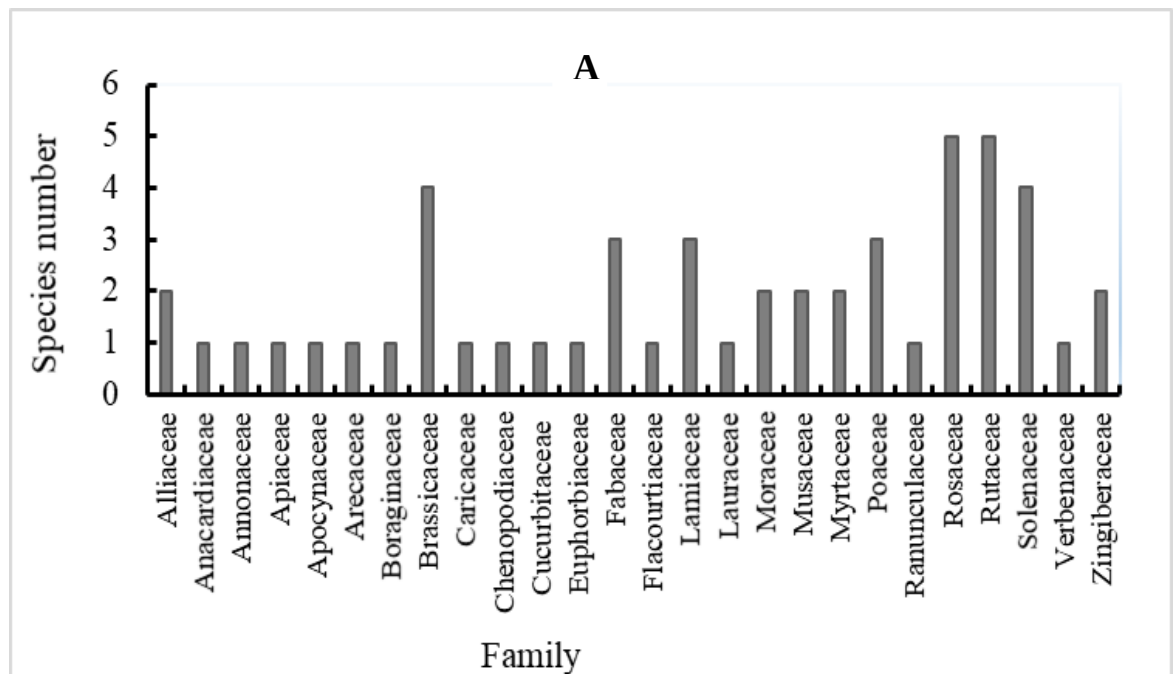
4.1.1 Crop species richness

A total of 47 crop plant species belonging to 40 genera and 25 families were recorded from homegardens of eleven selected kebeles of the study area (Appendix 6). The mean number of crop species per farm ($\bar{x} \pm SD$) was (10 ± 2.57) with values ranging from 4 to 19. In terms of the habit of plant species that homegardens of the study area contain, 51% from the total inventoried crop plants were included under herb followed by shrub (34%), tree (11%) and climber (4%) respectively (Figure 2 B).

Regarding plant families represented by different crop species, Rutaceae have provided five species in the first rank while Rosaceae, Brassicaceae & Solanaceae contributed four each. Poaceae, Lamiaceae, Fabaceae and Rosaceae were represented by three species each, followed by Musaceae, Myrtaceae, Zingiberaceae and Alliaceae that shared two species each (Figure 2A). However, the families Musaceae, Poaceae and Brassicaceae are the most important families providing crop plants to the Gurage people of the area, based on discussion with the local people. The other families contribute one species each (Figure 4A).

The number of crop species recorded varied across the study site. Among the study site, menter kebele had the highest number of crops (40) accounting for 85% of the total number of species in the sample while few species were recorded in the homegardens Ketane site that record a total of 24 crop species. The perennial crops such as enset

locally known as “Eset “(*Enset ventricosum*) occurred in all (121) surveyed homegardens were the most frequent crop plant species existing in all homegardens included in the study followed by coffee (*Coffe arabica*) with occurrence of frequency of 79 homegardens and Avocado (*Persea americana*) with occurrence of frequency of 72 homegardens (100%, 66 % and 59% of the homegardens respectively). Moreover, enset (*E. ventricosum*), being common in all homegardens, was the daily sources of food for most households in the study area after passing different processing procedures (Figure 2C). In addition to *Enset ventricosum* and *Coffea arabica* which are the key species in the system, crops such as *Persea americana*, *Solanum tuberosum*, *Brassica carinata* and *Rhamnus prinoides* that contribute to the daily diet of the family, are widely grown in the area. The Evenness value of 0.98 at menter kebele indicated that evenness in abundance of the species would have been under uniform or even distribution. The least uniform composition of crop species with evenness value of 0.77 at ketane kebele.



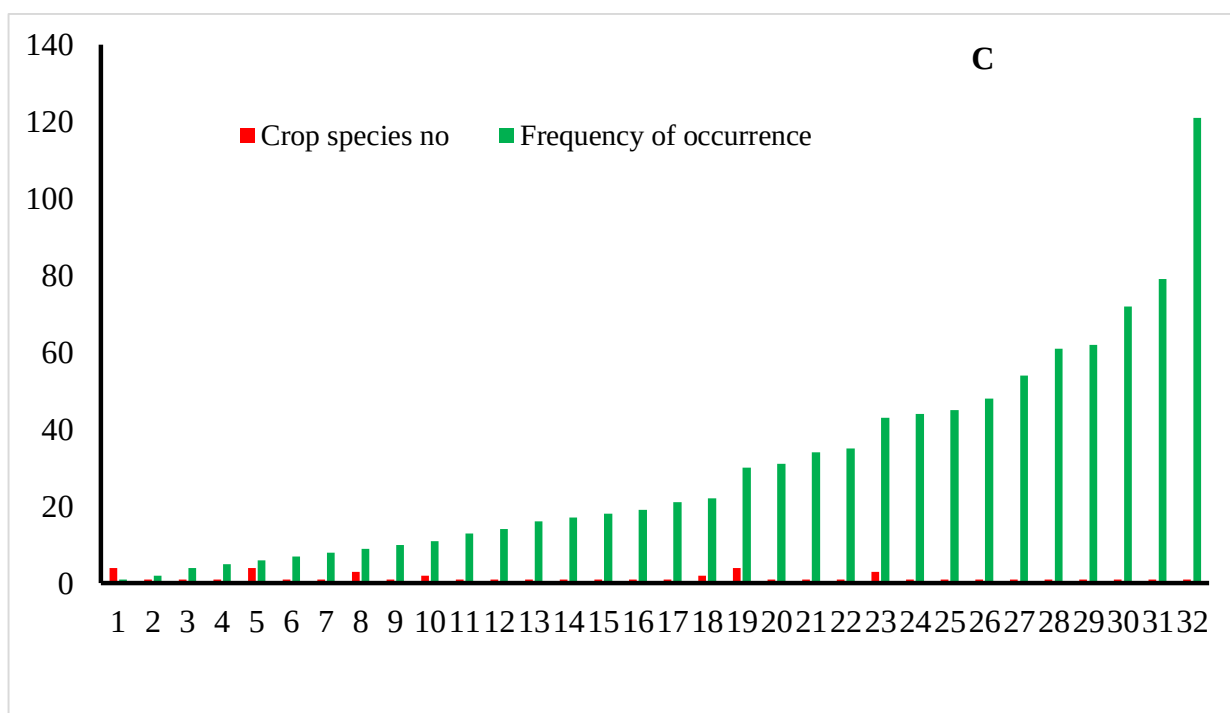
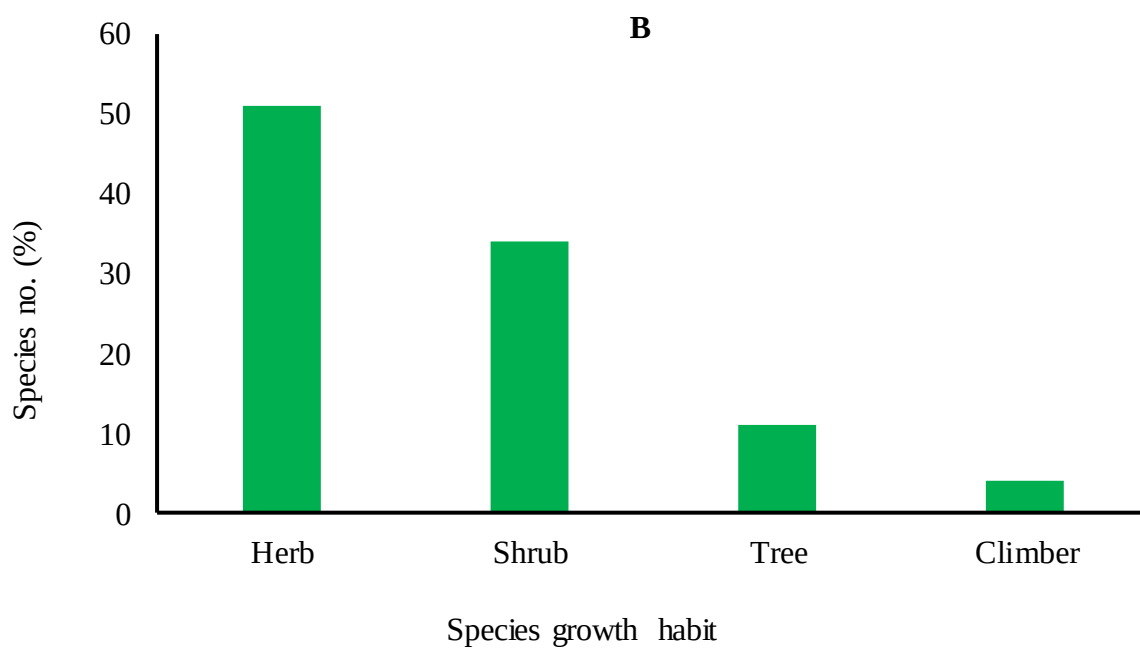


Figure 2. Crop plant species of homegardens with family (A) (Rutaceae and Rosaceae consisting five species each), Habit (B) (Herb with higher proportion followed by shrub,

tree and climber) and occurrence frequency of crop species across the homegardens (n=121) (C).

4.1.2 Diversity of crop species

Shannon diversity index were calculated and expressed as the mean average Shannon diversity index (H') of crop plants for each selected site (Table 4). The higher diversity were recorded at site nine (Gedeb) ($H'=1.53\pm0.22$) and eleven (Bozjubar) ($H'=1.53\pm0.08$) and the lower diversity were recorded at site ten (Ketane) ($H'=1.18\pm0.22$). The mean average Shannon diversity value of crop plant species for all surveyed household were $H'=1.33\pm0.28$.

Table 4. Total and average number of crop species, mean values of the Shannon (H') and Evenness index

Site (n/site=11)	No of crop species			Shannon Index	Evenness Index
	Total	Mean	SD	H'	$E=H'/H'_{\max}$
Agaujtereh	29	11	1.54	1.29	0.84
Shehremo	33	10.54	1.9	1.3	0.85
Shubraden	34	9.72	2.45	1.23	0.8
Desene	32	10.9	1.3	1.32	0.86
Yesiray	33	10.09	2.07	1.4	0.9
Menter	40	11.27	1.42	1.5	0.98
Wera debane	34	11.18	4.79	1.47	0.96
Wadye	31	10.81	1.66	1.25	0.81
Gedeb	26	10.09	1.57	1.53	1
Ketane	24	8.36	0.92	1.18	0.77
Bozjubar	28	5.9	1.57	1.53	1

4.1.3 Richness in functional groups of crops

A total of 47 crop plant species recorded in homegardens the study area were classified into different functional groups based on the discussion made with informants during data collection. A total of 9 functional groups of crops were recognized. This include fruit, beverage, cereals, tuber, pulse, vegetables, and stimulant spice and root crops. Identified functional groups provide number of species each represented in ranges from 1 to 16 species of crops (Appendix 6), and an average of 6.9 groups were found in each homegardens. Out of the average 47 crop plants, fruit crops contributed 34%, followed by spice (21.27%) and vegetables (14.9%) (Figure 3). It should be noted that this proportion shows the number of crop species in the commodity groups and it doesn't have any relation with their abundance or area coverage in the homegardens.

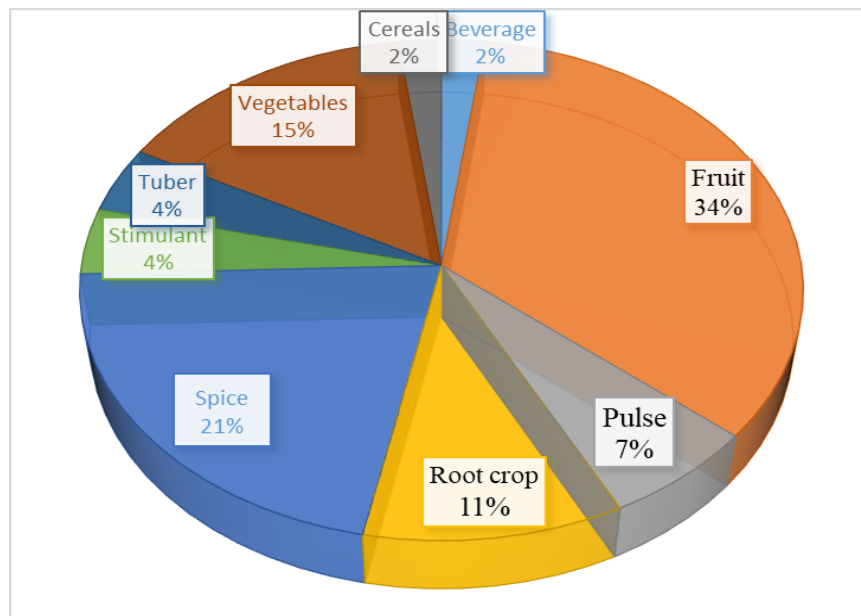


Figure 3. Pie chart showing functional groups with higher proportion by Fruit (34%) and lower proportion by Beverage and Cereals (2%)

4.2. Factors that affect crop plant species composition and diversity

The results of the characterization of crop composition of homegardens have shown variations in crop species richness among surveyed homegardens. A number of socio-economic and ecological factors related to households of farmers were hypothesized to affect the species richness of crops in homegardens including off-farm activity of the household, distance from the market, use type, educational background of the household head, number of family in the household, size of the homegardens and sex of the head of the household but only some of them were found important. Furthermore, the effects of each factor on species richness varied considerably. The analysis also discovered that not all factors are important in influencing crop plant species richness of homegardens. Wealth status, distance from the nearest forest edge, altitude and non-crop woody plant species richness were among the most important factors that influenced species richness of crops in the homegardens of the study area. The following section explains the effect of each identified factor on crop diversity and composition.

4.2.1 Topographic factor

4.2.1.1 Altitude (Elevation)

The species richness in homegardens was significantly affected by the altitudinal variation (1980-3271 m.a.s.l) of the study area and species richness monotonically decreased with increasing altitude ($P=0.004$, Figure 4). At the altitude of between 1900-2400 m, fruit crops including *Persea americana* and *Mangifera indica* and other perennial crops such as, *Coffea arabica*, *Catha edulis* spices like *Ruta chapalensis* and *Rosmarin officinale* were found predominantly, while above the altitude of 3000 m, the crop plants

were dominated by few crop species including *Lipia adoensis*, *Brassicca carinata*, *Solanum tuberosum* and *Malus sylvestris* in combination with *Enset ventricosum* which is the staple food in the district. Respondents in this study site informed that many crop species planted in their homegardens can't grow because of harsh environmental conditions/ poor adaptation capacity of the plant itself for this harsh environment.

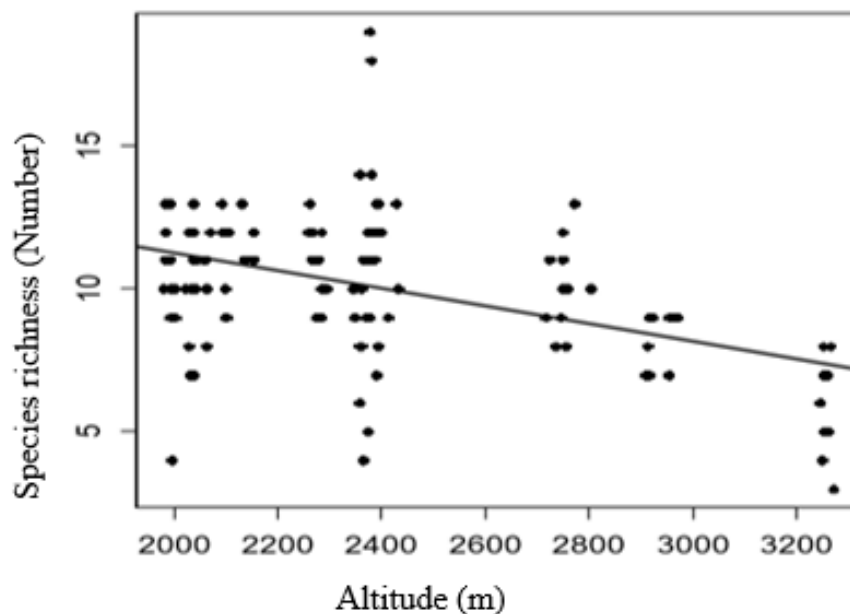


Figure 4 .The line graph showing that the crop species richness in homegardens decreases with increasing altitude in the study landscapes.

4.2.1.2 Distance of homegardens to forest edges

The distance of homegardens from forest edge was also one of the significant determinants that affect crop plant species richness of the homegardens at a significant level of ($P= 0.02$) (Crop plant species richness of homegardens were increased when the distance from forest edges to the homegardens increase (Figure 5)). The range of the distance from forest to homegardens were between 0.06 - 0.91 km. In the study area most

crop species were sensitive to attacks from wild raiding animals which are sheltered in the nearby forest. According to respondents *Enset ventricosum* which has the highest share of the homegardens and the staple food of the district was highly attacked by Hedgehog and Pig fruits like *Musa x paradisica* and *Persea americana* were also attacked by Ape and Monkey at a time when there is no any human observed in the homegardens. Crop species richness were affected by distances from nearby forest.

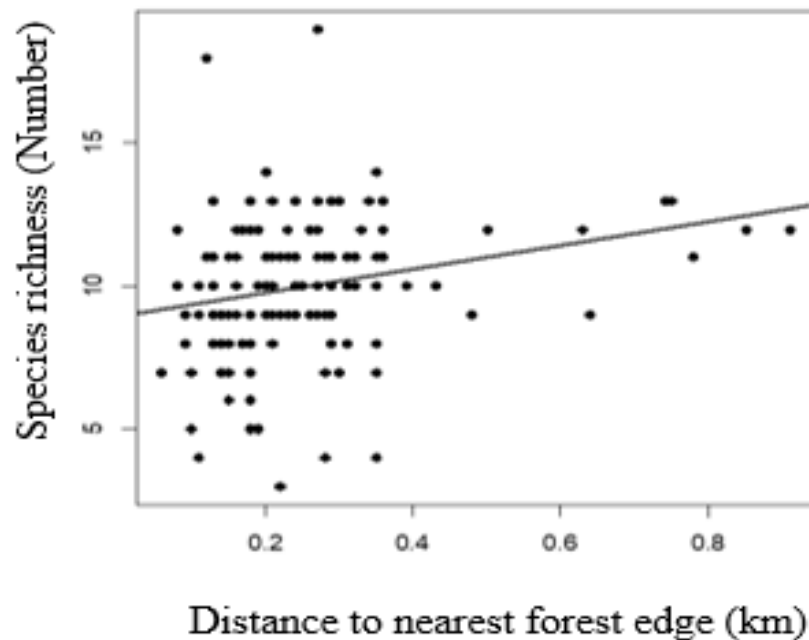


Figure 5. The line graph showing that crop species increases with distance from forest edges.

4.2.2.3 Non-crop woody species richness

Non-crop woody plant species richness of homegardens was positively related with crop plant species richness of the homegardens. It has significant effect at significant level of

($P= 0.002$) (Species richness of crop plant species of homegardens was increased with an increasing in non-crop woody plant species richness of homegardens of surveyed household (Figure 6)). The minimum number of woody species (3) and crop species (3) were recorded at HG 115 respectively while the maximum number of species of woody plants (6) and crop species (19) were recorded at HG 70 respectively. Woody species were mostly found in the lower parts of the back side of the gardens.

It was indicated that a total of 21 non-crop woody plant species were recorded in the homegardens, but some trees are more common occurring in most of the homegardens, while others are rare such as *Cordia africana*. Four tree species, namely *Eucalyptus camaldulensis*, *Eucalyptus globulus*, *Cupressus lucitanica* and *Juniperus procera* were the most common in terms of their occurrence and abundance in the homegardens of surveyed household. *Eucalyptus globulus* was presented by 83 % of the surveyed household followed by *Cupressus lucitanica* (70%), *Eucalyptus camaldulensis* (62%) and *Juniperus procera* (60%). Farmers markedly have awareness about how the competitive effects of the *Eucalyptus species* on crop plant species and they do not grow it with crops. During the field visits, there was no observation where *Eucalyptus species* was grown inside crop fields rather it was grown at the boundary of the homegardens. Other non-crop woody plant species including *Cordia africana* were grown in the homegardens and serve as edible fruits at their maturity stage (Figure 7) which are deliberately leave in their homegardens.



Figure 6. The line plot showing positive relations between crop and non-crop woody plant species richness of the homegardens.



Figure 7. Matured fruit of *Cordia africana* grown in the homegardens of Shubraden kebele (Photo by: - Emebet Getachew (2019))

4.2.2 Socio-economic factors

4.2.2.1 Wealth status

The crop plant species richness of the homegardens significantly varied among the wealth class of the households ($P = 0.007$). The crop plant species richness was higher in rich (R) and medium (M) households when compared with that of the poor (P) households (Figure 8). The mean value ($\bar{x} \pm SD$) plant species recorded in homegardens of poor HH (13.3 ± 2.33), medium HH (13.39 ± 2.29) and rich HH (13.5 ± 2.43). The result indicated that less plant species were recorded in the poor class while large number of species were recorded in rich and medium class of surveyed households. Homegardens of rich households were produce crop species with use category including stimulants such as *Catha edulis* and *Coffea arabica* Fruits were *Persea americana* and *Mangifera indica* and spices like *Lippia adoensis* and *Ruta chalapensis* and *Rosmarin officinale* for the purpose of income generation in addition to household consumption. While homegardens of poor class were produce small amounts of crop species for the sake of household consumption only.

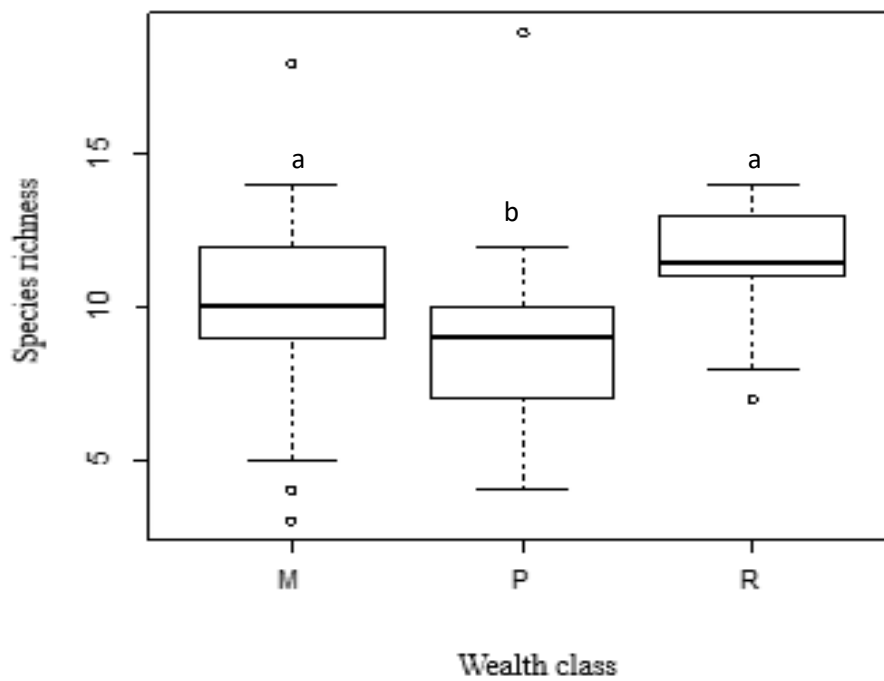


Figure 8. The boxplot showing the variation in crop species richness by households wealth status categories rich (R), medium (M) and poor (P); the crop species richness was higher in the homegardens of rich and medium households when compared with that of poor households ($P=0.046$, HSD Tukey Test).

CHAPTER FIVE

5. Discussion Conclusion and Recommendation

5.1 Discussion

5.1.1 Crop plant species composition

5.1.1.1 Crop plant Species richness and evenness

With the present study, a total of 47 plant species were recorded in the studied homegardens. *Enset ventricosum* and *Coffea arabica* were more frequent crop species in the homegardens of the study area. Enset is the main staple food which is produced in large quantities, while coffee is the major cash crop. They can be grown in combination with each other. Homegardens in the tropical areas have a high plant species diversity because rainfall and temperature conditions are more favorable than in the tropical areas (Tesfaye Abebe, 2005). Therefore the study area, included in tropical areas with favorable environmental condition were have high crop species composition.

The abundance of crops in these gardens is generally uneven because some species, particularly enset and coffee are more dominant. The dominance of the two crops is due to their wide socioeconomic and ecological roles in the systems. Enset is the main staple food which is produced in large quantities, while coffee is the major cash crop. They can be grown in integration with each other and with under-storey as well as upper-storey crops. This intricate combination of plants plays an important ecological role by reduction of erosion, provision of organic matter, and regulation of water and temperature. Distinct storey were observed in these gardens because of the dominant crops in them. The presence of such distinct zones in homegardens was also reported by Mendez *et al.* (2001) for the homegardens of Nicaragua.

The finding shows higher number of food crop composition than reported by other researches such as Debissa lemessa and Abayneh Legesse (2018) and Mekonnen Amberber *et al.* (2014) who reported 37 and 43 crop plant species in homegardens of Abay Chomen District, Western Ethiopia and Holeta Town, Oromia National Regional State, Ethiopia respectively. The finding also revealed few species presence compared to that of Seta *et al.* (2012) who reported 59 crop plant species in Home gardens of Wolayta, Southern Ethiopia, and Whitney *et al.*, (2018) who reported 136 crop plants in the Homegardens of South western Uganda. A total of 77 crop plants was reported in homegardens of Loma and Gena Bosa Districts of Dawro Zone, Southern Ethiopia (Mathewos Agize *et al.*, 2013) and 78 species reported by Tesfaye Abebe (2013) from Enset-coffee agroforestry homegardens of Southern Ethiopia.

The greater share in species number of crop plants available at homegardens were that of the family Rutaceae and this finding disagree with the general scenario that Fabaceae is taxonomically diverse and most important that contributed more to the ethnobotanical database of our country, Ethiopia (Solomon Tamrat, 2011 and Debissa Lemessa and Abayneh Legesse, 2018) and Agree with the result reported by Habtamu Hailu (2008). The probable cause for the occurrence of crop species in family rutaceae over fabaceae may be the time of data collection were after harvesting time of annual crops which belongs to family fabaceae. The variation in crop species richness among different locations may be the result of socio-economic differences, land use and management intensities, farmers' management strategies and environmental factors (Getahun Haile *et*

al., 2017) and the area availability in their homegardens (Debissa Lemessa and Abayneh Legesse, 2018). Composition diversity and unique composition of plants in homegardens of crop plants varies with spiritual beliefs, religion, farmers and his family perception about those crop plants and the environmental conditions they grow Sthapit *et al.*, (2004).

Ensete ventricosum is the most frequently maintained crop in the home-gardens of the area followed by *Coffea arabica* and *Catha edulis*. *Ensete* is an indigenous root-crop cultivated and processed for human food as a main source of carbohydrate only in Ethiopia (Brandt, 1996) and its key position in the country's home-gardens as a dominant species is mentioned by Zemed Asfaw (2002). Zemed Asfaw and Ayele Nigatu (1995) also commented that the Ethiopian home-gardens house many indigenous taxa of crops as *Ensete ventricosum*. *Coffea arabica* is the other most significant crop encountered in the area next to *Ensete ventricosum* that is consumed in the households as stimulant and as an income source.

The crop possesses the highest cultural significance being equally important as that of enset. The farming system of southern Ethiopia were found to contain coffee and/ or Chat as a major cash crop and enset as a basic staple food maintained as the keystone species of homegardens components in various nations and nationalities of southern peoples and this was suggested by findings of Tadesse Kippie (2002); Belachew Wassihun *et al.* (2003); Tesfaye Abebe (2005); Talem Seta (2007). In general, the difference in species richness from place to place could be attributed to income difference, altitude, personal preference of species, soil type Ewuketu Linger *et al.* (2014).

5.1.1.2 Crop species diversity

There were variation in the diversity of crop species among sites. The findings of this study disagree with (Debissa Lemessa and Abayneh Legesse, 2018) report that the crop plant species diversity in Abay Chomen District of South Ethiopia was 1.17 ± 0.51 SD. The finding of this study revealed that the diversity is lesser compared to the result of (Tesfaye Abebe, 2005) conducted in homegardens of Sidama zone of southern Ethiopia and (Whitney et al., 2017) who recorded $H' = 1.41$ and $H' = 1.61$ at district level respectively. At study sites or kebele level the finding of current study also recorded (minimum value of $H' = 1.18$ and maximum value of 1.53) smaller than the result of the above findings who were recorded minimum value of $H' = 1.21$ and maximum $H' = 1.75$.

Environmental conditions and adaptation potential of crop species are probable cases for the observed variation. Knowledge and seed exchanges among kin and neighbors, elevation (temperature, rainfall and soil characteristics) labor force shortage, micro environmental conditions and prevalence of crop disease may affect and create variation on the diversity of crops among study sites (Whitney et al., 2017). Respondents in the study area also told that crop species especially on *Ensete ventricosum* and *Citrus sinensis* were affected by crop disease. Crop diversity may increase during the growing period and decline seasonally when herbaceous and annual crops are harvested. It also affected by other factors like management suitability (Tesfaye Abebe, 2005).

5.1.1.3 Functional groups of crop plant species

A total of 47 crop plant species recorded in the study area were grouped in to different functional groups. *Catha edulis* and *Coffea arabica* were grouped under stimulant while *Capsicum annum*, *Capsicum frutescens*, *Mentha spicata*, *Rosmarinus officinalis* and *Ruta chalpensis* were grouped as spice. The study conducted in homegardens of kombolcha by Arayaselassie Abebe (2018) also include those species under stimulant and spice category. Some spices including *Capsicum annum*, *Capsicum frutescens*, *Ocimum basilicum*, *Rosmarinus officinalis* and *Ruta chalpensis* have high market value in the study area. Paulos Abebe *et al.* (2018) reported the same result.

Fruit are the main functional group by providing higher number of species (16 species). Fruits were the top functional group by providing 16 crop species. Reta Regassa (2016) and Mekonnen Amberber *et al.*, (2014) in homegardens of Hawassa and Holeta respectively. This is also similar to the results of Belachew Wassihun *et al.* (2003) and Habtamu Hailu (2008) in the fact that fruits are the major horticultural categories managed in homegardens being the top in terms of number of species recorded. Similar results were reported for the Guatemalan and Nepalese homegardens in the fact that fruits are the most important components of garden edible plants (Leiva *et al.*, 2002; Shirestha *et al.*, 2002). The possible reason for this might be the higher market values for fruits and the household nutritional requirements for vegetables in addition. Other reason may fruits are the main source of cash crop due to its higher market value than others.



Figure 9. Fruit crops such as *Persea americana*, *Musa x paradisiaca* and *Citrus sinensis* sold in the local market on Monday and Wednesday, Segno gebeya at Agena (A) and in Irob gebeya Bozjubar (B). Photo by Emebet Getachew (2019)

5.1.2 Ecological and socio-economic factors of crop plant species composition and diversity

Altitude

Altitude is an important factor in habitat diversity because it presents changes in the availability of resources, such as heat and water. Species composition are decrease when we go from site 1(Aguajtereh kebele) where altitude ranges 1980-2002 m to site 11(Bozhubar) where elevation reaches from 3257-3244 m. Altitude of the area affected the heterogeneity of crop species. Precipitation, temperature and topography in collaboration with altitude affect crop plant species richness. High altitudinal range correlate with higher rate of rain fall while minimum rate of temperature. At this area, plants with good adaptation capacity with the extreme environmental conditions were

survive. At the lower altitudinal areas, where temperatures are high and optimum rain fall, the distribution of fruit and perennial crops were increased because of their good adaptability to the climatic conditions and availability of resources such as water and soil fertility in the area.

The result of Getahun Haile *et al.* (2017) in homegardens of Ethiopia and Kehlenbeck *et al.* (2007) in homegardens of Indonesian support the finding of the current study that Altitude negatively influenced plant species richness. Study by Yirefu Tefera *et al.*, (2016) conducted in Gedeo Zone also agrees with the result obtained in current study. The finding of current study disagrees with the results obtained from Tesfaye Abebe (2005) who reported that altitude has no significant effect on species richness but has an effect on species diversity.

Altitude and climate are important ecological factors that influence species diversity. Soemarwoto and Conway (1991) in their study on Javanese homegardens have also indicated that the diversity of plant species decreased with increasing elevation. This is because of the drop in temperature that could affect the growth of some species. Rainfall and temperature are the two important factors of climate that influence species diversity. Diversity of species increases with increased amount of rainfall and temperature.

The elevation of an area have linked with the existence of slope among homegardens. This could be attributed to the presence of different micro-environments that are suitable to different types of crops. In hilly homegardens of the study area, the house is often located on the top and the crop fields stretch down the slope up to a swampy field at the

bottom of the slope. Steep slopes are often covered with perennial crops. The bottom of the slope is often used to grow plants such as eucalypt species. The presence of such different soil and microclimatic conditions suitable only for specific types of crops could have therefore contributed to a better composition in crop species. The same result were reported from study conducted by Tesfaye Abebe (2013) in homegardens of Sidama administrative zone of southern Ethiopia.

Distance of homegardens to nearest forest edge

As the distance to forest increases crop species richness showed increasing pattern and when it decreases the species richness of homegardens were also decreasing. Most of the homegardens in the study area situated near to small forest patches. This result implies that factors related to the existence of the nearest forest including raiding animals like Monkey, Baboon, Hedgehog can't enter to the homegardens due to distance constraint, thus species richness increased.

Residents live near forest edge collected products from the forests, supplementing homegardens production. The remoteness of these villages from forest edge forces farmers to produce all the needed crop and non-crop plant species and supported by same result by Whitney et al., (2017). The probable reason for this may to maintain year-round food and nutrition security, residents far from forest edge cultivate different crop plant species for the maintenance of their livelihoods. In the study area respondents explains that *Ensete ventricosum*, one of the root crops and tubers are highly attacked by Babbons, hyena and pigs while *Persea americana* and *Musa x paradisica* were attacked by Ape.

Whitney et al., (2017) agreed with the result of current study that suggested residents near to forest edge have low plant species richness than residents far from forest edges.

Finding of Debissa Lemessa *et al.*, (2013) also discovered that tubers and root crops are highly attacked by Babbons and Pigs and the number of raiding events and visit of those raiding animals decrease as the distance from forest decreases. The reason for the reduction in occurrence of crop raiders away from forest edges suggests that forests might be their prime habitat. Along this a study from New Zealand found that fragmentation and discontinuity of forest remnants may limit the movement and emigration of animals in the landscape (Ewers and Didham, 2007).on the other hand crop raiders may adapt to forest margins and to human grown foods over time following the modification of natural habitats. Studies show that primates such as baboons and monkeys are intelligent and fast to adapt to habitat change and human behavior, which can make protection against them challenging (Strum, 2010). The reason why crop raiders are less common far from the forest may thus not necessarily have to do with their habitat preferences per se, but to the fact that they easily get a refuge in the forests from where they move out again after having been chased away by the farmers.

In the study area the respondents claimed that the problem of crop raiding varies from time to time. Time based variation in the population of raiding animal population variation in growing patterns of crop species and scarcity of wild fruits in the forest were pointed out as a contributing factor for the variation crop damage by raiding animal. Hockings *et al.* (2009) report similar result with the current study. Farmers in the study site use fences to protect the entrance of those raiding animals listed above (Personal

observation). In this case from discussion of the respondents, participation of whole family members including Husband, Wife and children is basic need to protect their crop products from crop raiding animals.

Non –crop woody species richness

Non- crop woody plant species of the homegardens were increased with an increment of crop species in the study area. The most important tree species in these systems are *Eucalyptus camaldulensis*, *Eucalyptus globulus*, *Cupressus lucitanica* and *Juniperus procera*. They are the most common and abundant because of their significant and wide economic roles in the systems. *Eucalyptus globulus* and *Eucalyptus camaldulensis* are fast growers and have easily propagated grows (Yirefu Tefera *et al.*, 2016) that produces posts and split wood that are highly demanded for housing construction and source of fire wood. It is therefore an important cash source for the farmers. *Juniperus procera* and *Cupressus lucitanica* are mostly used for live fence and house construction and in some extent with household tools production. *Juniperus procera* wood is termite resistant (Azene Bekele-Tessema, 1993) by its nature so in the study area farmers highly used this species for house construction.

C. africana is also a very important shade tree in these homegardens. The most important functions obtained from this tree species include provision of shade and mulch for the integrated enset-coffee systems that have advantage in controlling soil erosion, regulation of soil moisture and temperature, improved soil nutrition, that ultimately create favorable conditions for crop growth. It is also reported that *Cordia africana* is popular popularity

by its nature to serve as an important coffee shade in Eastern Ethiopia (Demel Teketay and Assefa Tegineh, 1991).

Furthermore, *Cordia africana* has a good quality timber (Habtamu Hailu and Zemedu Asfaw, 2011) that is widely marketed in urban areas and similarly it's important for household and agricultural tools production in rural setting. The presence of shade tree is important for effective grain production through reducing temperature and helps for climate change adaptation especially for coffee. The report also Zebene Asfaw *et al.* (2015) from Ethiopia and Helton *et al.*, (2012) from Brazil shows that coffee in a shade gets better quality and has a guarantee for good market price. Pandey *et al.* (2006) argued that the gradient of light and relative humidity creates different niches in an ecosystem and influence species richness.

Podocarpus falcatus is also one of non-crop woody plants found in the homegardens of the study area with small distribution and abundance and it's popular for its excellent timber that is used for furniture, paneling and other purposes. Farmers in the study area often grow the *Podocarpus* tree scattered in the front yards. The front yards are used as grazing areas, as meeting places during cultural ceremonies such as weddings or funerals, and also as burial places. The tree is also grown alongside homegardens boundaries but rarely grown scattered in the crop fields. The existence of *Podocarpus falcatus* tree were also reported study conducted in the homegardens of Sidama zone by Tesfaye Abebe, 2005). In general, 90.38% farmers in the study area are motivated to plant the tree because of its high cash return (Income), but they plant it in such a way that it doesn't

compete directly with agricultural crop plants (Tesfaye Abebe, 2005) and compatibility with agricultural crops (Debissa Lemessa and Abayneh Legesse, 2018). Farmers in the study sites plant various tree and shrub species based on availability of space and their compatibility with agricultural crops plants in their homegardens (Yirefu Tefera *et al.*, 2016).

Wealth status

Rich farmers had significantly higher number of species than poor farmers. This is may be due to the fact that farmers that experience income constraint tends to focus on few selected species which generate money to satisfy immediate needs, which is in line with research in homegardens of Jabithenan district, Ethiopia Ewuketu Linger *et al.* (2014). Wealth status of the local people in the study area was one of the major determinant factor of crop plant species richness. It affects the area share of crop plants. Poor farmers who are constrained with shortage of land allocate higher portion of the land to enset (*Ensete ventricosum*) at available land and they don't have concern to grow others due to lack of land or other resources with the yield insufficient to cover household consumption requirements (Tesfaye Abebe (2013).

Livestock holding, which is critical for enset cultivation because of the manure, natural fertilizer, is also low and this negatively affects the yield of enset. When the yield of enset is not sufficient to feed the family members and when farmers do not expect enset yield in the immediate future, they give more land share for the cultivation of annual

crops and put their contribution for mono-cropping which give high yield with available land. The same case for also reported by research by Tesfaye Abebe (2005). In the study area respondents who are in poor class were planted *Solanum tuberosum* in their homegardens in larger share of their land. The poor class are also face with shortage or no access to fertilizer and advanced technologies due to lack of money to have it.

It is also known that rich households having large farms and capital allocate more resources (e.g., space, labor, good management practices such as fencing, watering, weeding and soil fertility maintenance and capital) for maintaining a large number of crop species in their gardens. As reported by Melese Mengitu and Daniel Fitamo (2015) and Tesfaye Abebe (2013) in homegardens of dilla zuriya woreda of Gedeo zone, access to labor force for the management of homegardens plant also other causes for the variation in species composition and diversity. Hence, the more land a household owns, the higher the chance is to grow more crop plant species. They produce ample amount of major crops for household consumption and plant other kind of species to use them as source of additional income for the family. They observe as the model for the locality and encourage them by bringing seedling of different crop species. Rich farmers also have access to hire labor force when they face shortage of labor force for the management of their homegardens. Farmers that allocate and cultivate more land had greater crop species richness (Jones, 2017).

5.2 Conclusion

Homegardens play a significant role within the agricultural system of the country. Homegardens provide a diversity of fresh foods that have diverse quality and quantity of nutrients available to a family in a sustainable manner. The homegardens of Southern Ethiopia are the backbone for rural livelihoods being as a source of diversified crop plant species. Farmers in the area collected a high number of cultivated crop plant species from their homegardens.

A total of 47 crop plant species were recorded from homegardens in the district. *Ensete ventricosum*, *Coffea arabica*, *Catha edulis* and *Persea americana* were frequently observed species in the surveyed homegardens. *Enset ventricosum* was found the basic staple food while coffee is important cash crop followed by *Catha edulis*. *Brassica carinata* was the most important additives used with “Qocho” the major product of enset and it is widely used in the district. *Ensete ventricosum*, *Coffea arabica* and *Catha edulis* are perennials while other annual crops are incorporated in various ways and trees and shrubs are encouraged in these systems to create an ecological balance and sustainability, in addition to provision of sustenance and cultural services. Nine functional groups were identified in the homegardens of the study area based on data recorded from informants at the time of data collection.

Home gardening practices were highly practiced in the study area and play great role for plant diversity conservation and livelihood food security and providing wide range of other products including firewood, fodders, spices and medicinal. With these importance

there are different ecological and socioeconomic factors that negatively or positively affect species richness of the homegardens of the district. Here, the species richness was higher in homegardens of rich households when compared with that of the poor households. Moreover, the species richness increased with increasing distance from forest edges, while it decreased with increasing altitude. Overall, the present study denoted that the importance of homegardens as a refuge for crop biodiversity conservation is determined by both ecological and socioeconomic characteristics of the human modified landscapes.

5.3 Recommendations

Based on findings of the current research, the following recommendations are made

1. Special consideration and endeavors must be made by Ezha district administration and other concerned governmental or non-governmental sectors to provide unreserved agricultural support in promoting home gardening and in motivating the practitioners in general and specifically the poor HHs of the study area so as to improve their wellbeing on sustainable basis.
2. Zonal and regional agricultural research centers should be work on identifying crop plant species that can tolerate cold climatic conditions in the high altitude areas of the district and should provide for local community.
3. Different management and conservation methods should be identified and manipulated by district agricultural office and incorporated with traditional management practice and knowledge's.

4. Further researches should be conducted on identifying the major environmental and socio-economic factors that mediate the crop plant species composition and diversity in homegardens of Ezha district for identifying and formulating better management and conservation strategies.
5. Community members in the study area should, therefore, be made aware of the role of homegardens in conserving crop plant biodiversity that have high contribution for food and nutrition security and on sustainable utilization of these crops.

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Appendices

Appendix1. Study sites and their corresponding altitudinal ranges

Study sites Name	Altitudinal ranges (m.a.s.l)	District	Region
Agujtereh	1980-2002 m	Ezha	SNNPR
Shehremo	2021-2041 m	Ezha	SNNPR
Shubraden	1995-2070 m	Ezha	SNNPR
Desene	2258- 2294 m	Ezha	SNNPR
Yesiray	2345-2394 m	Ezha	SNNPR
Menter	2092- 2153 m	Ezha	SNNPR
Wera debane	2357- 2389 m	Ezha	SNNPR
Wadye	2369- 2431 m	Ezha	SNNPR
Gedeb	2716- 2804 m	Ezha	SNNPR
Ketane	2907- 2971 m	Ezha	SNNPR
Bozjubar	3257- 3244 m	Ezha	SNNPR

Appendix 2 . Farmers Wealth status classifying criteria's forwarded by key informants

Rich farmers

- ❖ Have wider homegardens with many varieties of Enset
- ❖ Large number of Livestock mostly greater than five means a minimum of two milk giving cow, more than 2 oxes, and calf, many goats and sheep's.

- ❖ Have separated guest house constructed by corrugated iron only for guests.
- ❖ Farmers who fully participate in Extension services including fertilizer usage.

Medium

- ❖ Have wide homegardens with many varieties of Enset
- ❖ Livestock mostly milk giving cow, oxes for farming and Some Goats and Sheep more than five.
- ❖ Have house constructed by corrugated iron with master room and kitchen.
- ❖ Farmers who participate in Extension services including fertilizer usage in collaboration with others.

Poor

- ❖ Have small sized homegardens with many varieties of Enset
- ❖ Single cow or ox or usually with no livestock.
- ❖ Farmers who mostly aren't participate in Extension services including fertilizer usage.
- ❖ Farmers who give labor force for rich classes by hiring or bringing ox when ploughing season start.

Appendix 3. Socioeconomic status of all surveyed households (wlr); R=Rich, M=Medium, P= Poor, HHead (F =Female,M= Male),Hhsize= the number of family within the household; Hhead edn.= household head educational background.

Homegardens (Hgs)	Wlr	Hhead edn.	Hhead	Hhsize
Hgs01	M	4	F	5
Hgs02	M	0	M	8

Hgs03	M	8	M	3
Hgs04	R	8	M	6
Hgs05	M	7	M	3
Hgs06	M	1	F	4
Hgs07	M	5	M	7
Hgs08	M	5	M	6
Hgs09	M	6	M	5
Hgs10	P	2	M	7
Hgs11	M	3	F	6
Hgs12	P	4	M	3
Hgs13	M	5	M	3
Hgs14	M	10	M	4
Hgs15	M	9	M	6
Hgs16	M	9	M	6
Hgs17	M	0	F	8
Hgs18	M	1	M	4
Hgs19	M	2	M	8
Hgs20	M	9	M	6
Hgs21	M	8	M	8
Hgs22	M	7	F	4
Hgs23	P	3	M	6
Hgs24	M	4	M	7
Hgs25	P	0	F	2

Hgs26	M	0	M	3
Hgs27	R	0	M	5
Hgs28	M	0	F	6
Hgs29	M	4	M	5
Hgs30	R	4	M	4
Hgs31	M	0	M	5
Hgs32	P	2	M	6
Hgs33	M	0	M	4
Hgs34	M	0	F	5
Hgs35	M	10	M	4
Hgs36	M	0	M	6
Hgs37	M	10	M	4
Hgs38	M	3	F	4
Hgs39	M	7	M	6
Hgs40	M	0	M	4
Hgs41	M	0	M	6
Hgs42	M	5	M	5
Hgs43	P	0	M	5
Hgs44	M	5	M	7
Hgs45	M	3	M	2
Hgs46	R	6	M	6
Hgs47	M	0	F	2
Hgs48	M	7	M	7

Hgs49	P	2	M	6
Hgs50	M	0	F	6
Hgs51	M	0	M	7
Hgs52	M	4	M	4
Hgs53	M	2	M	6
Hgs54	M	0	M	6
Hgs55	M	0	M	7
Hgs56	M	8	M	5
Hgs57	P	12	M	4
Hgs58	M	0	M	5
Hgs59	P	0	M	8
Hgs60	P	0	M	4
Hgs61	M	0	M	6
Hgs62	M	3	M	5
Hgs63	M	7	M	4
Hgs64	R	10	M	6
Hgs65	M	1	M	5
Hgs66	M	0	M	4
Hgs67	M	0	M	8
Hgs68	P	3	M	6
Hgs69	M	0	F	7
Hgs70	P	5	M	5
Hgs71	P	0	M	3

Hgs72	M	12	M	5
Hgs73	M	0	F	6
Hgs74	M	8	M	8
Hgs75	M	2	F	5
Hgs76	R	0	M	3
Hgs77	R	0	M	8
Hgs78	P	0	F	4
Hgs79	M	4	M	5
Hgs80	P	0	M	6
Hgs81	M	0	M	4
Hgs82	M	2	M	5
Hgs83	M	0	M	7
Hgs84	M	0	M	5
Hgs85	M	0	F	4
Hgs86	M	3	M	5
Hgs87	M	0	M	4
Hgs88	M	0	M	5
Hgs89	M	4	M	4
Hgs90	P	3	M	5
Hgs91	R	0	M	8
Hgs92	M	3	M	6
Hgs93	M	0	M	5
Hgs94	M	7	M	4

Hgs95	M	0	M	5
Hgs96	M	0	M	7
Hgs97	M	2	M	6
Hgs98	M	0	M	5
Hgs99	R	0	F	6
Hgs100	M	0	F	4
Hgs101	P	2	M	5
Hgs102	M	3	M	3
Hgs103	R	0	F	8
Hgs104	M	0	M	8
Hgs105	M	8	M	4
Hgs106	M	1	M	7
Hgs107	M	7	M	3
Hgs108	M	5	M	3
Hgs109	M	6	M	5
Hgs110	M	4	M	8
Hgs111	M	8	M	5
Hgs112	M	7	M	6

Hgs113	M	4	M	4
Hgs114	M	0	M	5
Hgs115	M	6	M	6
Hgs116	P	4	M	3
Hgs117	M	4	F	3
Hgs118	M	2	F	6
Hgs119	M	8	M	5
Hgs120	P	9	M	6
Hgs121	M	9	M	5

Appendix 4. Data collection form (Plant inventory)

Botanical name	Local Name		Family	Habit	Parts used	Use category/ functional group
	Guragigna	Amharic				

Growth form: S= Shrub, T= Tree, H= Herb, Cli= Climber

Functional group/ use category: Rc=root crop, T= tuber, St=stimulant, F= Fruit, Sp=

Spice, Ve= Vegetables, P= Pulse, Be=Beverage, Ce= Cereals

Appendix 5. Checklist of questions used to collect data using semi-structured interview

1. Information on the respondents:

❖ Name: -----

❖ Age: -----

❖ Sex ☐ Male ☐ Female (Tick)

❖ **Educational status:** illiterate/ elementary school or grade1-8/ secondary school or grade 9-

12/ College graduate or diploma holder, University graduate or 1st degree holder
(Underline)

❖ **Locality:** Region: *SNNPR*; Zone: *Gurage*; District: *Ezha*; Kebele: -----.

2. What are the local names of crop plant species that you know in you village. Start from your garden and your surrounding or villeges?
3. Mention the local names of those crop plant species
4. In which category or functional groups are listed crop plant species are found?

Spice_____

Forage _____

Stimulant_____

Pulse_____

Medicinal_____

Cereals_____

Fiber_____

Tubers_____

Root _____

5. Which parts are of the crops are edible?

Root_____

Leaf_____

Seed_____

Stem_____

6. Which parts are more preferred in your locality? What is the reason for preferring that parts?

Is that cultural, personal or spiritual reason?

7. List problems that affect crop species richness and diversity of your homegardens.

7.1 Raiding animal-----,-----,-----

7.2 Fungal disease (Tick) Yes

☐

No

☐

8. Do you use any mechanism or management practice to control problems that affect crop species faced with your homegardens?

9. What are non-crop woody species found in your homegardens? And their significant effect on crop species? Is there any beneficial effect on crop species composition/richness?

10. Is non crop woody species are cultivated or deliberately leave in your homegardens from wild?

11. How do you grow and manage crop and non-crop woody species combination in your homegardens?

12. What are the local plant harvesting methods that are the most destructive or non-destructive for the plant?

13. What are crop plant species products from your homegardens that are marketable? Non crop woody plant species? Is that fruit, root, leaf and the like.

14. Is there any indigenous knowledge or practice how crop plant species and non woody plant species grow in combination in your homegardens? Do they have positive or negative correlation between them?

Appendix 6. Crops plant species identified in the homegardens of the study area

Botanical name	Family	Habit	Local name	Amharic name	Parts used	Functional group
<i>Aframomum</i> <i>corrorima</i> (Braun) Jansen	Zingiberaceae	H	Correrima	Correrima	Fruit	Spice
<i>Allium cepa</i> L.	Alliaceae	H	Key shinkurt	Key shinkurt	Bulb	Vegetables
<i>Allium sativum</i> L.	Alliaceae	H	Tuma	Nech shinkurt	Bulb	Vegetables
<i>Annona squamosa</i> L.	Annonaceae	S	Gishta	Gishta	Fruit	Fruit
<i>Beta vulgaris</i> L.	Chenopodiaceae	H	Key sir	Key sir	Root	Tuber
<i>Brassica carinata</i> A. Br.	Brassicaceae	H	Ambir	Yehabesha gomen	leaf	Vegetables
<i>Brassica oleracea</i> L.	Brassicaceae	H	Tiklil	Tikil Gomen	leaf	Vegetables
<i>Brassica rapa</i> L.	Brassicaceae	H	Kosta	Kosta	Leaf	Vegetables
<i>Capsicum annum</i> L.	Solanaceae	H	kariya	Kariya	Fruit	Spice
<i>Capsicum frutescens</i> L.	Solanaceae	H	Afinje	Mitmita	Fruit	Spice
<i>Carica papaya</i> L.	Caricaceae	H	Papaya	Papaya	Fruit	Fruit
<i>Casimiroa edulis</i> La	Rutaceae	T	Kazmir	Kazmir	Fruit	Fruit

Liave						
<i>Catha edulis</i> (Vahl.) Forssk. ex Endl.	Celasteraceae	S	Chat	Chat	Leaf	Stimulant
<i>Citrus aurantifolia</i> (Christm.) Swingle	Rutaceae	S	Lomi	Lomi	Fruit	Fruit
<i>Citrus medica</i> Lin.	Rutaceae	S	Tiringo	Tirngo	Fruit	Fruit
<i>Citrus sinensis</i> (L.) Osborne	Rutaceae	S	Birtukan	Birtukan	Fruit	Fruit
<i>Coffea arabica</i> L.	Rubiaceae	S	Kawa	Buna	Fruit	Stimulant
<i>Colocasia esculenta</i> (L.) Schott.	Araceae	H	Godore	Godere	Root	Root crop
<i>Cucurbita pepo</i> L.	Cucurbitaceae	C	Kichiwe	Duba	Fruit	Fruit
<i>Daucus carota</i> L.	Apiaceae	H	Carrot	Carrot	Root	Root crop
<i>Enset ventricosum</i> (Welw.) Cheesman	Musaceae	H	Eset	Enset	Root + pseudostem	Root crop
<i>Lactuca sativa</i> L.	Asteraceae	H	Selata	Selata	Leaf	Vegetables
<i>Lepidium sativum</i> L.	Brassicaceae	H	Dimbilal	-	Seed	Spice
<i>Lipia adonensis</i> Hochst. ex Walp. Var. <i>koseret</i> Sebsebe**	Verbenaceae	S	Koseret	Koseret	Leaf	Spice
<i>Lycopersicon</i> <i>esculentum</i> Mill.	Solanaceae	S	Timatim	Timatim	Fruit	Vegetables

<i>Malus sylvestris</i> Mill.	Rosaceae	S	Pom	Apple	Fruit	Fruit
<i>Mangifera indica</i> L.	Anacardiaceae	T	Mango	Mango	Fruit	Fruit
<i>Mentha spicata</i> L.	Lamiaceae	H	Kimem	Nana	Leaf	Spice
<i>Musa x paradisiaca</i> L.	Musaceae	H	Muz	Muz	Fruit	Fruit
<i>Nigella sativa</i> L.	Ranunculaceae	H	Tikur Kimem	Tikur Kimem	Seed	Spice
<i>Ocimum basilicum</i> L.	Lamiaceae	S	Bosobla	Besobila	Seed	Spice
<i>Persea americana</i> Mill.	Lauraceae	T	Avocato	Avocado	Fruit	Fruit
<i>Phaseolus vulgaris</i> L.	Fabaceae	C	Adenguare	Adenguare	Seed	Pulse
<i>Pisum sativum</i> L.	Fabaceae	H	Getere	Ater	Seed	Pulse
<i>Prunus persica</i> (L.) Batsch	Rosaceae	T	Kok	Kok	Fruit	Fruit
<i>Prunus x domestica</i>	Rosaceae	S	Brugna	Pom	Fruit	Fruit
<i>Psidium guajava</i> L.	Myrtaceae	S	Zeyituna	Zeyituna	Fruit	Fruit
<i>Rhamnus prinoides</i> L 'Herit.	Rhamnaceae	S	Geshe	Gesho	Leaf and Stem	Beverage
<i>Rosmarinus</i> <i>officinalis</i> L.	Lamiaceae	S	Metbesha	Siga metibesha	Leaf	Spice

<i>Rubus apetalus</i> Poir.	Rosaceae	S	Engiya	Enjori	Fruit	Fruit
<i>Ruta chapalensis</i> L.	Rutaceae	H	Chirakuye	Tena adam	Seed	Spice
<i>Saccharum officinarum</i> L.	Poaceae	H	Shonkora	Shenkora	Stem	Tuber
<i>Solanum tuberosum</i> L.	Solenaceae	S	Diniche	Dinich	Root	Root crop
<i>Syzygium guineense</i> (Willd.) DC.	Myrtaceae	T	Guareba	Dokima	Fruit	Fruit
<i>Vicia faba</i> L.	Fabaceae	H	Baela	Bakela	Seed	Pulse
<i>Zea mays</i> L	Poaceae	H	Bokolo	Bokolo	Seed	Cereal
<i>Zingibera officinale</i> Roscoe	Zingiberaceae	H	Zingibil	Zingibil	Root	Root crop

Growth form: S= Shrub, T= Tree, H= Herb, C= Climber

Appendix 7. Non crop woody plant species identified in the homegardens of the study area

Species	Family	Habit
<i>Acacia abyssinica</i> Hochst. ex Benth.	Fabaceae	Tree
<i>Acacia decurrens</i> Willd.	Fabaceae	Tree
<i>Azadirachta indica</i> A. Juss.	Meliaceae	Tree
<i>Carrisa spinarum</i> Linn.	Apocynaceae	Shrub
<i>Casuarina equisetifolia</i> L.	Casuarinaceae	Tree

<i>Cordia africana</i> Lam.	Boraginaceae	Tree
<i>Croton macrostachyus</i> Del.	Euphorbiaceae	Tree
<i>Cupressus lucitanica</i> Mill.	Cupressaceae	Tree
<i>Dodonea angustifolia</i> L. f.	Sapindaceae	Shrub
<i>Dovyalis abyssinica</i> (A.Rich.) Warb.	Flacourtiaceae	Shrub
<i>Eucalyptus camaldulensis</i> Dehnh.	Myrtaceae	Tree
<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Tree
<i>Grevillea robusta</i> R. Br.	Proteaceae	Tree
<i>Hagenia abyssinica</i> (Bruce) J. F. Gmel.	Rosaceae	Tree
<i>Jacaranda mimosifolia</i> D. Don	Bignoniaceae	Tree
<i>Juniperus procera</i> Hochst. ex Endl.	Cupressaceae	Tree
<i>Olea europea</i> L. subsp. <i>cuspidate</i> (Wall. Ex G. Don) Cif.	Oleacea	Tree
<i>Podocarpus falcatus</i> (Thunb.) R. B. ex Mirb.	Podocarpaceae	Tree
<i>Pterolobium stellatum</i> (Forssk.) Brenan	Fabaceae	Shrub
<i>Rosa abyssinica</i> Lindley	Rosaceae	Shrub
<i>Vernonia amygdalina</i> Del.	Asteraceae	Shrub