HAWASSA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE, DEPARTMENT OF BIOLOGY, POSTGRAGUATE PROGRAM

TRADITIONAL HOME- GARDEN AGRO –BIODIVERSITY SYSTEMS, AGROECOSYS-TEM SERVICES AND MANAGEMENTS IN WONDO DISTRICT, WEST ARISI ZONE, OROMIA REGION, ETHIOPIA

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This is to certify that the thesis entitled "Traditional home- Aarden agro –Biodiversity Systems, Agroecosystem Services and Managements in Wondo District, West Arisi Zone, Oromia Region State, Ethiopia" and submitted in partial fulfillment of the requirements for the Degree of Master of Science in General Biology Program under Department of Biology and has been carried out by Sori Alemayehu under our supervisions. Therefore, I recommend that the students fulfilled the requirements and hence hereby can submit the thesis to department.

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I Sori Alemayehu, do hereby declare that, this Thesis is my original work and that it has not been submitted partially; or in full, by any other person for an award of a degree in any other university/institution.

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Date----------

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Abbreviations and Acronyms

ARDO = Agricultural and Rural Development Office

CBD = Convention on Biological Diversity

CSA = Central Statistical Agency

DA = Development Agent

FAO = Food and Agricultural Organization

FGDs = Focus Group Discussion

GPS = Global Positioning System

H' = Diversity

HG = Home garden

HH = Households

IBC = Institute of Biodiversity Conservation

IUCN = International Union for Conservation of Nature and Natural Resources

m.a.s.l = Meters above sea level

MoHE = Minster of Higher Education

NGOs = Non-Governmental Organization

NMSA = National Meteorological Service Agency

SDARDO = Wondo District Agricultural and Rural Development Office

SPSS = Statistical Package for Social Studies

WDFPO = Wondo District Finance, Planning and Economic Development Office

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ABSTRACT

Agro-biodiversity is subset of biodiversity that includes all components of biological diversity which are used for agri-food production system. Traditional home-garden management techniques have become crucial for improving and diversifying the livelihood of smallholder farmer. The present study was carried out in two different altitudes in Gutanama Kebele (highland) and Entaye kebele (midland) of Wondo District, West Arsi Zone, Oromia, Ethiopia. The aim of the study was to assess agro-biodiversity in traditional home-gardens, agro-ecosystem services and management practicein. Multistage sampling techniques were employed to conduct the study. A total of 351 households (194 from mid altitude and 157 from highland) were randomly selected for the study. Ethnobotanical data were collected using homegarden observation, semi-structured interviews, preference ranking and direct matrix ranking .For species diversity and related parameters, plant species inventory were carried out in homegardens of 60 households.. Data were analysed by using descriptive and infferencial statistical methods.Besides Shannon-Weiner diversity index and Soreson`s index of similarity were used to analye by using Microsoft Excel 2010 and SPSS version 25 software. In the two study sites, *a total of 104 plant species belonging to 41 families were idenitified. Of these crops, 58 species were idenitified in midland 29 species were idenitified in highland and 18 species were idenitified in common. The difference was statistically significant (P*=0.001. The socioeconomic benefit results show that 13 *agroeccological survices* were identified in both altitudes.. *From the identified homegarden plants Poaceae was the most frequently observed family (containing 11 species), followed by Fabaceae (containing ten species). The diversity indices value was higher for the middle (H"= 2.86) compared with the highland (H"= 2.35). Like wise the evenness index value was higher for the midland (E = 0.7) compared with the highland (E =0.6). The Soreson's index of similarity was 29%. Out of the 104 crops, 28.8% of species were food crops 14.2% were medicinal crops and 11.1%) were spices. Traditional knowledge was use to manage homegardens including weeding, watering, fencing and soil fertility management through adding organic and inorganic fertilizer. The major challenges were unstable market prices, poor access to market places, and diminishing home-garden sizes poor extenstion surice and poor access to the main road. The traditional homegardens are rich in agro-biodiversity and are resvior of crop genetic and species diversity; delivers multiple agroecosystem services; and are managed primarly by indigenous knowledge. Moreover, midlands favour agro-bidiversity compared to highlands, reassing that agro-biodiversity decrease with increasing altitudes and altitude- associated environmental conditions. To combat the challenge limiting the level of agro-biodiversity and agro-ecosystem service, all actors including government, localy-based organizations and local communuities need to give more attention to harness the important perspectives of traditional home-garden agro-biodiversity systems.*

Key words*:* Agro-biodiversity, agro-ceosystem survice, indigenous knowelage, traditional homegarden.

CHAPTER ONE

1. INTRODUCTION

1.1 Background of the study

Home-gardens have been reported mainly the tropical and sub-tropical regions of Asia, Mesoamerica and also from other regions like North America and Europe (Nair and Kumar, 2019), Many studies provide descriptive evidence and analysis of traditional home-gardens agro- biodiversity system in developing countries in Asia, Africa, and Latin America pinpoints their numerous benefits to communities and families (Galhena *et al*., 2013), Traditional home-gardens have been common practices for indigenous communities in many developing countries such as Ethiopia. According to (Polegri and Negri, 2010) homegarden is an integrated system which comprises different things in its small area that produces a variety of foods and agricultural products including staple crops, vegetables, fruits, medicinal plants and so on. The importance of home gardens in the production of food, medicine and other useful products for human beings is widely recognized .Consequently, regular attempts to improve the productivity of this wide spread agroecosystem have usually been initiated with specific objectives in mind. The realization that home garden‘ farming ’system is also an important reservoir of unique genetic diversity has more recently led to initiatives to study this system more carefully in order to obtain a better understanding of the role of home gardens in the management and conservation of genetic diversity in situ.

The definition of biological diversity, also known as biodiversity, is the variety of life, which includes variation at all levels of complexity, including genetic, species, ecosystem, and biome variation, as well as functional diversity and diversity across ecosystems (Palumbi *et al*., 2009). Agro-biodiversity is a part of biodiversity, which is also known as agricultural biodiversity, is the collective term for all biological diversity elements relevant to food and agriculture as well as all biological diversity elements supporting the primary functions of agro-ecosystems (Johns *et al.*, 2013). Agriculture depends on biodiversity for the supply and production of food. One viewpoint sees agro-biodiversity as a part of natural capital, and another sees the flow of services as the interest on the capital (Kontoleon *et al.*, 2009). In the view of sustainability, it can withstand stresses and shocks, recover from them, and retain or improve its capacities and

resources both today and in the future without compromising the natural resource base (FAO, 2019).Agricultural biodiversity includes all components of biological diversity of relevance to food and agriculture: the variety and variability of plants, animals and micro-organisms at genetic, species and ecosystem level which are necessary to sustain key functions in the agro-ecosystem, its structures and processes (Kazemi *et al.,* 2018).Agro-biodiversity is essential to the world for the following functions: sustainable production of food and other agricultural products, including providing the building blocks for the evolution or deliberate breeding of useful new crop varieties; biological support to production, for example, soil biota, pollinators and predators; wider ecological services provided by agro-ecosystems, such as landscape protection, soil protection and health, water cycle and quality, and air quality. Home-gardens involve integration of various woody perennials, herbaceous crops and/or livestock on the same unit of land management with the aim of increasing production and income generation (Panda *et al.,* 2018).

Traditional home-gardens agro-biodiversity are usually identi¦ed as important social and economic units which can play a crucial role in ensuring livelihood as well as food security of rural households and can be considered as an income diversi¦cation strategy under risky circumstances (World Bank, 2016). FAO (2015) indicated that home-gardens productivity declined due to gradual decline of soil fertility which was mainly infuenced by various factors in agro-biodiversity home-garden farming systems. Based on these overall backgrounds this study was conducted with the aim to identify the crops composion, species recness and diversity of the home-garden plants, to identify the major agroecosystem services of the agr-obiodiversity in home- gardens, to document the local management practices and peoples knowledge in managing agro-biodiversity in home –gardens and to identify the threats to the sustainable management of home-garden agro-biodoversity of Wondo District, West Arsi Zone, Oromia, Ethiopia.

1.2. Statement of the problem

Ethiopia had diverse climatic, altitudinal, and socio-cultural conditions that make the diversity and composition of plant species maintained in homegardens that could vary from one agro-ecology to another. In addition, people of different cultural groups believed to have their own traditional methods of maintenance and conservation of agro-biodiversity. Despite a wide

range of socioeconomic benefits, for the past several decades homegardens have been neglected and received little research attention for agricultural researches. More recently, however, they have begun to receive the attention of more researchers after the promotion of world food and agricultural organization (FAO,2021).

The advantages of having a garden at home extend beyond just getting food. In many instances, the selling of crops grown in backyard gardens greatly boosts the household's income (Saediman *et al.,* 2021). Households who are small-scale can better comprehend the discrepancy between global knowledge and local potential for food and nutrition security by concentrating on smallholder farming households (Timberlake *et al.,* 2022). For Smallholder farming households, the local agro-biodiversity can support increased economic prosperity and food security. People are more willing to conserve and protect their environment and resources where they can perceive benefits to their nutrition and income (Sahoo *et al*., 2021). Home-gardens have been shown to benefit the household in a variety of ways. Due to the variety of crops grown there, they enable the production of food virtually all year round, provide materials for building, fuel, and cosmetic goods, are significant sources of money for the home, are status symbols, and are key locations for the conservation of agro-biodiversity (Castañeda-Navarrete, 2021, Vinceti *et al.,* 2022).

Ethiopia's smallholder farmers' food and income security have not been fully researched. The studies on traditional home-gardens that have been done so far in Ethiopia (Tadesse *et al.,* 2019, Atiso & Fanjana, 2019, Sahle *et al.,* 2022) have mostly concentrated on traditional management and functions. Little attention has been paid to empirical data on the degree of agro-biodiversity in traditional home-gardens, management techniques, agro-ecosystem services, and in coping with climate change shocks. Such empirical investigations are also absent in the current research sites. Therefore, this study was designed to provide the basic data that enhance the traditional home- garden agro- biodiversity systems, agroecosystem services and managements practices with a particular emphasis on document plants composing home -garden agro biodiversity, plant species composition and diversity of the home gardens, the major agroecosystem services of the agrobiodiversity of plant, factors combine to determine home- garden agro- biodiversity and composition, management practices and existing threats on management and conservation plant resources.

1.3 Objectives

1.3.1 General objective

The general objective of the study was to assess the traditional home- garden agr-biodiversity systems, agroecosystem services and managements in Wondo District, West Arsi Zone, Oromia Region, Ethiopia

1.3.2 Specific objectives

The specific objectives were**:**

1. To identify the composition, speices richness, species diversity of homegarden plants in the study ara.

2. To identify the major agroecosystem services of the agr-obiodiversity in home- gardens

3.To document the local management practices and peoples knowledge in managing agro-biodiversity in home -gardens

4. To identify the threats to the sustainable management of home-garden agro-biodoversity

1.4 Research questions

The following research questions were used as guides in collection of data for the study.

1. What are the composition, species richness and species diversity of homegarden plants of the study area?

2. What are the major agroecosystem services of the agro- biodiversity home gardens?

3. What are traditional management practices and skills used to manage home- gardens agro-biodiversity?

4.What are the existing threats to the management home- gardens agro-biodiversity ?

1.5 Scope of the study

The present study was conducted in two representative *Kebeles* in Wondo District. It studed the traditional home- garden agro-biodiversity systems, agroecosystem services and managements in Wondo District, West Arsi Zone, Oromia Region, Ethiopia

1.6. Significance of the study

Home- garden agro- biodiversity plays a great role in diversifying food, income and changing the livelihood of the community. Therefore, this study provides valuable information regarding the level of home-garden agro-biodiversity, agroecystem services and management practices. The findings will also provide information on the major factors bottlenecking the sustainable

management of traditional home-garden agro-biodiversity for improving the livelihoods of the local communities and maintaining the genetic and species diversity of agro-biodiversity. The findings from this study will benefit policy makers, agricultural reseach institutions, local communities.

1.7 Limitation of the Research

Due to constraints related to budget, this study was limited to two agroecologies and kebeles. It collected a cross-section data. It moreover limited to collecting data related to traditional home-garden agrobiodiversity, agroecosystem services and traditional management systems.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Definition and Concept of Homegarden

Homegardens are variously named in English language as agroforestry homegardens, backyard gardens, farm-yard, roof top garden, homestead farms, gardens (Kumar and Nair, 2004). In Ethiopia, a very common Amharic vernacular name equivalent for the term homegarden is "Yeguaro-ersha", in Oromo vernacular language is "oddoo" means a land at a backyard of a house (Zemede Asefaw, 2001).

Homegarden is commonly defined as land use systems involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably, livestock within the compounds of individual houses, the whole tree-crop- animal unit being intensively managed by family labour (Christanty, 1990; Kumar and Nair, 2004).

In relation to this (Kumar and Nair, 2004; Tesfaye Abebe *et al.*, 2010), argues that deliberate management of multipurpose trees and shrubs are essentially man-made and reflect the wisdom of the traditional culture and ecological knowledge that have evolved over the years. Home garden is a small system of household plant production (Cherry and Di-Leonardo, 2010) and an unpopular aged-long food security strategy (Teitelbaum and Beckley, 2006) partly because of its wide variety of produce and its informal nature. Home gardening has become an important part of cultural heritage (Seaton, 1981) which denotes specific farming practices at different localities. It is therefore inappropriate to ascribe definite and effective cultural practices to the management, siting and ownership of home gardening because home gardening has been a way of life for centuries (Zerihun Kebebew, Weyessa Garedew and Adugna Debela, 2011)

2.2Agro-biodiversity

2.2.1 Definition and concepts agro- bio diversity

Agro-biodiversity is defined as the variety and variability of animals, plants, and microorganisms used directly or indirectly for food and agriculture crops, livestock, forestry and fisheries (CBDC, 2020). It comprises the diversity of genetic resources (varieties, breeds, etc.) and species. These are used for food, fuel, fodder, fiber, and pharmaceuticals and also farming and

production systems. In addition, it includes the local agricultural practices and knowledge, which all-together support the productivity of agro-ecological systems providing a range of options and values. Agro-biodiversity is the result of natural selection processes and the careful selection and inventive developments of farmers; the entire range of the domestic crops used in world agriculture is derived from wild species that have been modified through domestication, selective breeding and hybridization. Most remaining world centers of diversity contain populations of variable and adaptable landraces as well as wild and weedy relatives of crops, all of which provide valuable genetic resources for crop improvement (FAO,2023).

Biodiversity is essential to life on Earth; it provide resources such as food, medicine, fibers, fuel, and building materials, as well as intangible services, on which human kind relies. For people in developing countries, particularly in least developed contexts, biodiversity is vital for survival. Biodiversity also forms an important part of people's belief systems and their cultural and spiritual values (CBD, 2019).)described agro-biodiversity as 'a dynamic and constantly changing of relations between people, plants, animals, other organisms and the environment, always coping with new problems, always finding new ways. Ethiopia has a large natural and cultural diversity with a big range of climates which result from of its topography and latitudinal position (CBD, 2019).

2.2.2 Benefits of agro-biodiversity

Agro-biodiversity at the local scale has a range of benefits. Biodiversity can increase productivity, food security, economic returns, and leads to diversity of products and improve income opportunities, human nutrition and contribute to sustainable agricultural production. Plants contain bioactive compounds with antioxidant activities that may potentially be chemo-protective against many diseases (Thrupp, 2017). Agro-biodiversity in the homegarden can improve both continuous access to foods and the nutritional quality of households. Homegardens are often known for accommodating a particularly rich diversity of crops and usually managed by women and most of the production is directly used for cooking benefits to the entire family (Lossau *et al*., 2011).

2.2.3 Agro-biodiversity and agricultural intensification

The links between agriculture and biodiversity have changed over time and should be viewed n the context of global agricultural development trends. Agricultural intensification increased output per unit area of land have been shaped by demographic pressures (high population growth rates, the migration of people into frontier areas, and imbalances in population distribution), and the predominant paradigms of industrial agriculture and the Green Revolution (Thrupp, 2017).

These paradigms generally emphasize maximizing yield per unit of land, uniform varieties, reduction of multiple cropping, standardized farming systems (particularly generation and promotion of high-yielding varieties), and the standardized applications of agrochemicals. The widespread adoption of high yielding varieties and other technologies has led to reduction of biodiversity which in turn diminishes the ecosystem services provided by agro-biodiversity and, therefore, undermines ecosystem health (Thrupp, 2017).

2.2.4 Agro-biodiversity in Ethiopia

Ethiopia is centre of origin for crops such as: sorghum, tef, coffee and enset, and is centre of diversity for many others such as: wheat, barley, and Ethiopian Mustard, Chickpea, Lentils and Finger millet. Ethiopia is recognized as an important source of the public goods associated with crop genetic diversity conservation, as it is a primary or secondary centre of diversity for several crops. The tremendous variation in altitude, temperature, rainfall, soil type and ecological settings, as well as the diverse social and cultural conditions together with different levels of market integration are some of the possible explanations for the existence of remarkable genetic variation of crop varieties in the country (Tizazu Guire, 2015).

The number of crop accessions of Ethiopian origin that have been introduced to various international and foreign national crop improvement programs and seed companies is enormous: More than 1800 for wheat and more than 4500 for sorghum, around 2500 for barley and more than 900, large numbers are also reported for chickpea, lentil and finger millet (FAO.2023).

Crop genetic resources are the product of the interaction between human and natural selection of the environment, yielding a set of domesticated crops and varieties used in agricultural production. Crop genetic resources are embedded in seeds and they are an important determinant of the characteristics and attributes of the crop species, together with environmental and human management factors. Farmers choose crops and seeds to provide a set of attributes that meet

their specific production and consumption needs (Smale and Bellon, 2014). The resulting increased intensification, characterized by absence of fallowing, lack of technical change and total absence of conservation practices and furthermore complicated by frequent drought, is creating a high degree of land degradation and, the combination of, high population pressures, poor agricultural policy making, conflicts and environmental degradation have left Ethiopia a country with low agricultural productivity, high rates of food insecurity and high rates of dependency on external food sources. Recent estimates therefore, a decline of land and grain productivity (FAO, 2023).

2.3 Home-gardens and agro-biodiversity

2.3.1. Definition of home- gardens

Different countries call homegarden by different names. These include house- gardens, household gardens, or kitchen gardens by their defining criterion that they are adjacent to the house where their gardener(s) live. These can be urban home-gardens (private garden adjacent to a house in a town or city) or rural homegardens (garden adjacent to a house in a rural area). It is known as solar in Chiapas and Spanish; Gartl or Gorte in Eastern Tyrol and German; and kebun rumah in Kalimantan and Indonesian (Christian *et al.,* 2014).

Homegarden is locally known as *yeguaro-ersha, Yeguaro Masa, YeguaroIrsha, and Yeatikilt-Bota* (in Amharic language), *eddo, Hoddo, Boro, Mandubee* in Afan Oromo (in Oromo language) (BirukKefale, 2020). Common locations for gardens in relation to the house in Ethiopia are backyards (48%), front yards (26%), side yards (13%) and those that almost encircle the house (13%). Various combinations of these types exist as back and sides, back and one side, front and sides, etc. In many rural villages where homegardening is well developed, the space in front of the house iswith a clean green meadow as a family resting and socializing place. In some areas, fences confine gardens while in others they merge with crop fields and may be fenced together (Zemede Asfaw, 2016).

2.3,2 Importance of home-gardens for agrobiodiversity conservation and development

Home gardens, which are one of the traditional agro bio diversity systems, are defined by a variety of characteristics in accordance with the local physical environment, ecological and economic situation, and cultural characteristics, but they are generally defined as multi-species, multi-storied, and multi-purpose gardens located close to a home (Park *et al,* 2019).

Home-gardens are microenvironments containing high levels of species and genetic diversity which serves not only as sources of food, fodder, fuel, medicines, spices, construction materials and income in many countries around the world, but are also important for in situ conservation of a wide range of plant genetic resources.

Home-gardens are dynamic systems; their structure, composition, and species and cultivar diversity are influenced by changes in the socioeconomic circumstances and cultural values of the households that maintain these gardens. Understanding the factors and decision-making patterns that affect the management of home-gardens is crucial for including home-gardens as a strategic component of in situ conservation of agrobiodiversity. The conservation of agrobiodiversity is inseparable from the sustainable use of plant genetic resources in agriculture. Thus agro-biodiversityconservation is both a goal and a means to secure the livelihoods and wellbeing of farming communities in poorer regions of the developing world. Home-gardens are clear examples of diversity rich production systems that serve both a development and a conservation function (Eyzaguirre and Watson, 2015).

2.4 Agro- biodiversity of home-garden

2.4.1 Crops agro- biodiversity

Crop diversification is an intentional strategy of farmers to ensure subsistence and it has several advantages. These comprises 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). The species diversity of crops and trees in agricultural systems promote recycling of nutrients, increases efficiency in the use of moisture, nutrients, and sunlight, and reduces incidence of weeds, pests, and diseases (Tesfaye Abebe *et al.,* 2013)..

The number of species grown-up in a farm (species richness) is an important display of diversity. However, from the utility point of view, it is not only the richness that matters but also the heterogeneity in functions. It is very important to have appropriate mixtures of different functional groups of crops to meet balanced nutrition and cash needs of households. Huang *et al.,* (2017) identified three types of functional groups in agro forestry systems, namely ecological, conservational and livelihood functional group.Crop diversity, also referred to as plant genetic resources for food and agriculture and embraces the diversity within and among crops, their

semi-wild and wild edible plant species. This diversity has evolved over thousands of years in a dynamic interaction between nature and humans, as part of their agricultural activities. It provides the biological foundation for food production and food security and contributes to economic growth (FAO, 2019)

2.4.3 Tree and shrub form of plants agro- biodiversity

Trees and shrubs are very important components of homegardens, as they play multiple roles in the systems. They provide the households with wood products and cash, and play a role in maintaining and enhancing the physical environment needed to keep going crop production. Trees provide firewood, which is the major energy source in most developing countries (Tesfaye Abebe, 2013).

These functions help to maintain and improve soil fertility, regulate soil moisture and temperature, and improve the microclimate ultimately contributing to the stability and flexibility of the systems. Therefore, the presence in farms of diverse tree species that serve different socio-economic and ecological functions could contribute to sustainability of agricultural systems (Tesfaye Abebe, 2013).

2.5 Diversity of plant species

Tropical homegardens are renowned for their typically high levels of biological diversity. This species diversity is the result of gardeners' meticulous selection and management, which is aimed at providing products they consider to be important to subsistence and livelihoods (Kumar and Nair, 2019). Homegarden diversity partly depends on altitudinal gradients, climatic conditions, size and age of the garden, remoteness from urban centers, and village size, among other factors (Wezel and Ohl 2015).

Furthermore, socio-cultural and economic characteristics of gardeners are importantfor explaining plant diversity in homegardens. Biodiversity is the totality of genes, species and ecosystems of a region. Biological diversity is the variety and variability of animals, plants and microorganisms at the genetic, species and ecosystem levels and is necessary to sustain key functions of the ecosystem (Agbogidi, 2013).Ethiopian homegardens collectively maintain a larger proportion of the country's useful plants. This diversity can be seen under the following categories of food producing plants, spices, medicinal, live fence, shade, fodder, firewood, construction, furniture, cultural, spiritual, ornamental and multipurpose plants (Udofia *et al.*,

2012). They help to the avoidance of environmental deterioration of climate related hazards commonly associated with monoculture production systems and income generating site. Also the diversity of plants in the homegardenlinked with other organisms contribute to the formation and maintenance of soil structure, retention of moisture and nutrient levels and promotes the recycling of nutrients; which reduces ecosystem vulnerability to climate change (Girma Woldemichael *et al.,* 2018).

2,5,1 Food producing plants

Ethiopia is one of the major centers of basis for many crops. It is an important primary and secondary gene pool for many field crop species that are useful sources of germplasm for economic traits in general and sources of genes resistant to diseases and pests in particular (CBD, 2019).

In addition, Ethiopia is a primary gene center for eleven field crops including noug (*Guizotia abyssinica*), teff (*Eragrostis tef*), the Ethiopian mustard (*Brassica carinata*) and enset (*Ensete ventricosum*). Field crops such as barley, sorghum, durum wheat, finger millet, faba bean, linseed, sesame, safflower, chickpea, lentil, cowpea, fenugreek and grass pea have a large genetic diversity in Ethiopia. There has been an enormous contribution of Ethiopian crop plant genetic resources to the world and useful genetic variations of global significance have emanated from these genetic resources (Badgley *et al.*,2017).

According to Zemede Asfaw (2016), about 74% of the crops documented in homegardens were categorized as food crops while the remaining 26% were non-food crops, indicating the importance of homegardens in supplying food to the household. In addition, out of 112 species of crops found growing in southern and southwestern Ethiopia, 69 (62%) were recorded in homegardens only, 26 (23%) both in homegardens and crop fields and 17 (15%) in fields only. In most parts, about 85% of the cultivated species are encountered under cultivation in homegardens, about 50% constantly in homegardens and about 35% in homegardens and fields.Farmers plant a variety of crops in homegardens to make sure access to fresh produce throughout the year (Larios *et al.,* 2013)

2,5,2 Medicinal plant species

The use of traditional medicinal plants has been widely experienced in Ethiopia. Indigenous peoples of different localities in the country have developed their own specific knowledge to

use, handle and conserve plant resources (Melesse Maryo *et al.*, 2015), which gave traditional medicine its diverse nature. As result, wide use of traditional medicine in Ethiopia could be credited to efficiency against certain type of ailments, economic affordability, physical accessibility and cultural acceptability as compared to modern medicine (Pankhrust, 2018). Medicinal plants contain drugs used for suppressing, preventing or curing many forms of diseases, and more than 95% of conventional medical preparations are of plant origin in Ethiopia (Melese Maryo *et al.*, 2015).

Moreover, home-based medicinal plant use relies on plants of the homegarden crops, weeds and that grow wild around human habitation. The cultivated medicinal plants are mostly shaped in homegardens either for medicinal or other primary purposes. The community knows medicinal plants of homegardens, as the knowledge on them is open or public (Zemede Asfaw, 2016 and Mekonnen Amberber, 2019).Furthermore, medicinal plants have been widely stated for their various applications in treatment of a variety of ailments (Bajpai *et al*., 2013 and Temesgen Magule, *et al*., 2014).

2,5,3 Spices plant species

Ethiopia is a country with a long history of using spices. The country is believed to have recognized contacts with the Arab world and India probably since the dawn of history; and traded with them for centuries (Pankhurst, 2018). Spices were among the commodities refered to havebeen traded in those days. Some spices of South Asian origin are suggested to have been introduced into Ethiopia following the relationships recognized with Portugal by the early 16^{th} Century (Feleke Woldeyes, 2011).

A spice is a dried seed, fruit, root, bark or vegetative substance used in nutritionally unimportant quantities as a food additive for flavoring, and sometimes as a preservative by killing or preventing the growth of harmful bacteria. Many of these substances are also used for other purposes, such as medicine, religious rituals, cosmetics, perfumery or eating as vegetables. For example, turmeric (parts of ginger) is also used as a preservative; licorice (parts of *Glycyrrhiza glabra*) as a medicine; garlic as a vegetable and nutmeg as a recreational drug. The history of spices in Ethiopia is an ancient one and spices remain as basic food items of the Ethiopian people. Ethiopia is the homeland for many spices, for example Korarima (*Aframomum corrorima*),

long pepper (*Piper longum*), black cumin (*Nigella sativa*), Bishops weed (*Aegopodium podagraria*) and coriander(*Coriandrum sativum*) (Duns and Willems, 2013).

2,5,4 Construction, firewood, furniture and fodder plants species

In south and southeastern parts of Ethiopia, many trees and shrubs are grown in the homegardens and near to it. These are provided that firewood, which is the major energy source in most developing countries. Furthermore, trees offer wood for various local uses, such as housing construction, fencing, furniture, household utensils and farm tools. Trees also provide other products such as fodder, human and livestock medicine, food and they serve as bee forage. Furthermore, trees are increasingly becoming important income sources for many farmers in ruralareas, mainly because the wood can be sold as timber or as firewood (Tesfaye Abebe, 2015).

According to Subedi *et al*., (2004), fodder trees primarily for livestock purposes are planted in Nepal. The most common fodder species were species of *Ficus species, Melia azedarach* and *Anthocephaleus cadamba*. Fodder species like bamboo and broom grasses were planted in the home-garden to keep land from soil erosions and landslides. The twigs and branches of fodder trees left after the leaves have been eaten are used as firewood for household cooking. Homegarden trees are also usually used as support for trailing vines of a number of vegetables (beans, yams, chayote, gourds, pumpkin, etc) (Shrestha *et al*., 2016).

2,5,5 Ornamental, stimulant, spiritual and Cultural plants

Cultural diversity in a given country helps to conserve biodiversity in homegardens (Millat-e Mustafa, 2015). The composition of unique plants in homegardens varies with ethnicity, food culture, religion, and spirituality. Sometimes unique flowers and fruits desired for religious and spiritual purposes are distinctive cultural feature of home-gardens. Beside, homegarden plants are significant for their aesthetic value and cooling effect and are regarded as a symbol of wealth and social status. The beautiful trees, orchids and climbers, ferns, ornamental plants and flowers are important species in home-gardens (Sthapit *et al*., 2018). Moreover, the most important stimulant and beverage species are coffee (*Coffea arabica*), tea (*Camellia sinensis*), gesho (*Rhamnus prinoides*) and khat (*Chatha edulis*) (CBD, 2019).

2,5,6 Multipurpose plant species

Home-gardens are rigorously cultivated agro-biodiversity systems manage within the compounds of individual homes. They involve the deliberate management of multipurpose trees and shrubs (the woody component), grown in intimate association with herbaceous species (mainly annual, perennial, and seasonal agricultural crops), and livestock (Tesfaye Abebe, 2015). A variety of trees and shrubs are found integrated within a majority of the homegardens. These trees and shrubs usually have multiple uses and provide food, fodder, firewood and timber for household uses. This means that many species of home-garden crops have multiple uses. According to the survey conducted, it was observed that many herbs such as *Allium sativum* and *Ruta chalepensis* plantedfor their medicinal as well as food and spice (Matheos Agize *et al.*, 2013).

2.6 Benefits Commonly Attributed to Home- gardens

Home- gardens are believed to provide a number of benefits to families, regarding from improving nutrition and providing a source for additional household income, to improving the status of women in the household. and also play numerous roles as, nutritional supplements, food security in times of crisis, shade, fuel wood, cash income, experimentation, medicinal plants and small-animal raising (FAO, 2019).

Also it has a great role to *in situ* conservation of agro biodiversity or plant genetic resources (FAO, 2019; Eyzaguirre and Linares, 2015). Homegardens are one of the most diverse agrobiodiversity systems and make a vital contribution to meet up various household needs, especially for smallholder farmers in developing countries. Ofcourse, the uses of home-gardens vary, as some are used for subsistence agriculture and others for commercial production of food crops (Yirefu Tefera *et al*., 2019).

2.6.1. Socioeconomic contribution of home- garden agro - bio diversity

The high diversity of species in home garden have a wide socioeconomic and agro-ecological roles including production of food and a wide range of other products such as firewood, fodders, spices, medicinal plants and ornamentals and avoidance of environmental deterioration of climate related hazards commonly associated with monoculture production systems income generating site (Ewuketu Linger, 2014)).

The associated component diversity of Home garden agroforestry enhances the livelihood of the local people by providing socio-economic and agro-ecological service than non-tree based garden; important to adapt climate change or climate related stress (drought) (Ewuketu Linger, (2014)).

Cash crops and fruit trees play a vital role in cash income generation in addition to household consumption. Coffee, ginger, avocado and mango are major sources of income while satisfying household consumption. The income difference between households was may be wealth status difference, knowledge of desirable species integration and composition of economically important species and the size of home-garden and households preference for specific crops (Desta Hamore&Belayneh Lemage, 2019).

2.6.2. Home- garden contribution to the family health

Home gardens have been established that even moderate and mild energy malnutrition contributes to child mortality, and micronutrient deficiencies are associated with increased risk of child and maternal mortality. Home gardens are one strategy for addressing malnutrition and micronutrient deficiencies. Even though animal products are the best source of micronutrients, vegetables and fruits may be the only source of micronutrients that are reliably available to poor households. One of the most important vitamins supplied by homegardens is vitamin A, which is essential not only for healthy eyes but also for protection of infectious diseases such as measles (Mekonen Kebede, 2010).

2.6.3. Production benefits from trees

Home gardens tend to have some tree output that can be used for long-term production and sale for profit. Palms are traditionally of significant importance in small farm management as sources of edible fruits, oil, green vegetables, fiber, thatch, construction wood, fuel wood and other useful products are often found in home gardens (Soumya Mohan, 2014). The purposes of planting and retaining woody species in the homegardens were consistent with the findings of where they asserted that tree species were deliberately retained and/or planted on farmlands for the provision of fuel wood and wood supply, income generation and environmental services (Getahun Yakob *et al,* (2014)).

2.6.4. Nutrition and food availability

Nutrition and food supply are major aspects of home gardens. Food crops are not only widely prevalent, but they also provide a significant portion of the household nutritional requirement in many home gardens around the world (Soumya Mohan, 2014). The principal goal home gardens is not to optimize production, as it could be in the rest of the farm, but to guarantee a minimum supply of different food products at all times of the year functioning as a buffer in times of low income and food scarcity often, high value products from home garden can be sold to purchase staple food during period of scarcity. Since the diverse mixture of crops is harvested at different times, a constant supply of food in some or the other is available from these home gardens at all time or the year (Mekonen Kebede, 2010).

2.6.5. Improving the gender role in home garden

Home gardens contain possibilities of increasing family participation in the production and contribution toward family well-being. It attributes development of the home garden as a regular feature of the traditional farming system in parts of tropical Africa, in part to the division of labor between the sexes. The women who developed and maintained these systems used gardening as a way to express their autonomy and worth within the village setting (Soumya Mohan, 2014).Men are involved in livestock trading and whole sale and large scale trading of food crops such as potatoes, avocado and trading of items besides khat and eucalyptus in the market (Mersha Gebrehiwot, (2013)).

2.6.6. Aesthetics and ornamentation

The home garden is often a haven for the family members of rural communities to relax and gather together after a hard day's work. They are often focal community meeting points. The gardens sometimes have a variety of flowers and other ornamental decorations. Some villages use these home gardens as a way to gain recognition for the village as a whole. The villagers are proud of the way their gardening contributes to the beauty of the village. In several tropical cultures, these ornamental flowers and some other selected plants are used for ritualistic and cultural reasons (Soumya Mohan, 2014).

Aesthetic plants that are grown for the display of aesthetic features including the flower, leaves, scent, overall foliage texture, fruit, stem and bark and also prominent thorns of rose sericea and cacti. The cultivation of ornamental plants is called floriculture, which forms a major branch of horticulture (FAO, 2021).

2.6.7. Home gardens as a Source of Supply of Medicinal Plants

According to World Health Organization (WHO), medicinal plants form the bases of traditional or indigenous healthcare systems used by the majority of the population of most developing nations. Indeed, it is reported that more than 3.5 billion people rely on plants for the treatment of both human and livestock diseases. In south Asian countries, alone 500 million people are reported to seek health security from the leaves, roots and barks of trees. Home gardens can be used to grow certain traditional herbs and spices. Traditional medicine and medical properties of plants are fields that are currently generating much interest among researchers (Mekonen Kebede, 2010).

Plant based medicinal systems, although in practice for thousands of years, are now coming to the forefront and attempts are being made to recognize their medicinal properties (Soumya Mohan, 2014). Traditional healers in Ethiopia utilize the herbal resources available in nature for various disease treatments. As reported before, approximately 800 species of the medicinal plants grown in Ethiopia are used for treating about 300 medical conditions (Admasu Moges, 2020).

2.6.8 Multipurpose plant species in the home gardens

Home- gardens are intensively cultivated agro-forestry systems managed within the compounds of individual homes. They involve the deliberate management of multipurpose trees and shrubs (the woody component), grown in intimate association with herbaceous species (mainly annual, perennial, and seasonal agricultural crops), and livestock (Nair, 2019). Many species of home garden crops have multiple uses. According to the survey conducted it was observed that many herbs such as *Allium sativum* and *Ruta chalepensis* are planted for their medicinal as well as food and spice (Matheos Agize *et al.,* 2013).

2.7. Factors influencing the homegaren agro bio- diversity

2.7.1 Socioeconomic factor

The socioeconomic factor is one factor that affects households' decision to practice homegarden agro-biodiversity, including farmland size, education status, total annual income, and livestock. The study conducted by Habtewold Atiso and Fekadu Fanjana (2020) contribution of agroforestry home gardens to household income generation in Boloso Bombe District, Southern Ethiopia. The authors' result showed that shortage of land size and low income was one of the major factors in practicing home-garden agro-biodiversity. Similar studies done by

Nzilano (2013) contribution of homegarden agro-biodiversity to household food security and income generation among communities in Mbeya Rural District, Tanzania, indicated that land shortage and low income were the factors that influenced the contribution of homegarden agro-forestry to household food security and income generation.Another study was done by Namwata *et al.* (2012) productivity of the agroforestrysystems and its contribution to household income among farmers in Lushoto District, Tanzania using a Multiple linear regression modeSpecies diversity and composition of home gardens is influenced by ecological, socio-economic and cultural factors. Species composition, structure and function of home gardens may be influenced by ecological, socioeconomic and cultural factors, such as distance from urban markets, household size and composition, environmental degradation and family tradition. According (Megabit Beyene *et al,* 2018),

2.7.2 Demographic factor

Several studies indicated that age, sex, and family size are important demographic factors affecting homegarden agro-biodiversity practice decisions. Empirical evidence from Agena Anjulo and Amare Mezgebu (2016) conducted in Fogera District, Northwestern Ethiopia indicated that age was negatively related to agro-biodiversity practicing and the relation was not statistically significant Whereas sex and family size were found to have a positive effect on agro-biodiversity practicing but not statistically significant.

A study conducted by Endale *et al.* (2020) analysis of the socio-economic contribution of agro-biodiversity systems to smallholder farmers around Jimma town, Southwestern Ethiopia by using multiple linear regression models. The authors result revealed that sex, age, and family size were not statistically significant in the socio-economic contribution of agroforestry systems to smallholder farmers. A study confined by Alemayehu Asale and Taye Buke (2017) on determinants of income from agro-biodiversity practice in Boloso Bombe Woreda, Wolaita Zone, Ethiopia by using a Multiple linear regression model. The finding indicatesthat the sex and age of the households were statistically significant in practicing agro-biodiversity while the family size is no statistically significant

2.7.3. Physical environment

Altitude and climate are important ecological factors that influence species diversity. 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 as it is demonstrated for humid lowland tropical areas, which are very rich in species as compared to other ecological zones. Ethiopia is a center of diversity for cereals such as barley, wheat, sorghum, finger millet, and teff (Harlan 2017). But the highlands of northern Ethiopia are relatively less favored than other areas of the country in terms of both growing environment and market infrastructure, positively affect crop diversity decades (Melaku Worede *et al.*2017). Complex topography, cultural diversity and environmental heterogeneity offer suitable conditions for a wide range of crop species in Ethiopia (IBCR 2020). Ethiopia has very diverse climatic conditions varying from hot and dry deserts in the lowland areas to cold and humid alpine habitats in highlands. Such diverse climatic conditions and habitats contributed to the presence of high species diversity in plants and animals, making Ethiopia one of the 25 mega diversity countries of the world in biodiversity (WCMC, 2020).

2.7.4. Wealth Status

The resources of the household, mainly land, but also labor and capital could affect farm level species diversity and composition. As per capita land-holding increases, so does the diversity of the cropping pattern, although the planting density of each crop falls. On the other hand, farmers with little access to resources, particularly land, may focus on the production of few staple food crops or trade-off home production of crops with off-farm waged work, depending on their individual comparative advantage (Getahun Yakob *et al*, (2014)).

According to Tefera Jogora (2019), in Shashemene District, Oromia Region, Southern part of Ethiopia, wealth status was another factor that influences woody species diversity of homegarden agro forestry practice. According to wealth status classification, largest home garden sizes were recorded in garden of rich farmers than medium and poor farmers in all villages. Wealth status also influenced the wood production of homegardens (Getahun Yakob *et al.*, 2014), but the variation in conversion to cash crop between the three wealth categories (poor, medium and rich) was insignificant (Mersha Gebrehiwot, 2013).

2.7.5 Household Preference

In Nepal, many species are either already domesticated or are in the process of domestication in the homegardens. This indicates that farmers perceive homegardens as an experimenting site for their own research and also take them as the avenue for adopting/adapting new species/varieties (Gautam *et al.,* 2014), and for homegarden species diversity the change has been based on a conscious choice and decision made by individual farmers to meet their immediate financial income needs.(Mersha Gebrehiwot, 2013). In Sebeta town, oromia regional state, Ethiopia, households cultivate and protect a mixture of herbs, lianas, shrubs and trees depending on the need and decision of households (Zemede Asfaw, 2011).

2.7.6 Management Practices

According to Berhanu Abraha (2013), South-Western part of Ethiopia, particularly areas rich in Millettia ferruginea tree, the tree population is high in homegardens due to the effect of tree management practices by the society in order to improve the tree shading capacity for inter cropping of coffee and enset plantations. Beside, in Nepal, homegardens are generally managed under intensive and integrated production system a variety of plant species and varieties are planted together and their interactions managed accordingly (Shrestha *et al.,* 2016).

The management of multi-species agrosystem for fulfilling the subsistence and cash needs of households enhances homegarden sustainability and agro biodiversity conservation (Telemose Seta *et al.,* 2013). In addition to that in South-Western Ethiopia, Kafficho people are managing woody medicinal plants in their homegarden (Tesfaye Awas , 2007) and thus, the homegarden owners to get as high as possible diversity in their gardens, because it is a consequence of the way they manage their homegarden (Akinnifesi,2010).

2.8 Traditional Management of Home garden Plant Species

Even if both men and women are involved in the management activities of home gardens; women are more participants during cultivation, harvesting and marketing activities (Zemede Asfaw,2001). In Peoples use various way of home garden management which includes; weeding, watering during dry season, fencing, digging and making erosion canal. Home gardens not only house food plants, medicinal plants, spices, ornamental plants and construction materials; but also they are important locations for the cultivation of neglected, underutilized, threatened and rare species. They are also important centers of experimentation, plant introduction, and crop improvement as well as refuges for unique genetic diversity (Engels, 2018).

2.8.1 Hand Weeding

Hand weeding plays pivotal role in removing unimportant vegetation which compete for light, water, and many nutrients (Kunhamu, 2013). Weeding by hand is one of the most important management aspect of home garden species particularly at their early stages. Weeding of home garden species contributes much in delaying the competent species for water and other nutrients (Talemos Seta *et al.*, 2013). Weeding is one of the home garden management in which women have direct involvement (Reta Regassa, 2016). Women play critical roles in the management of home garden species since they stay at home for caring of family members (Zemede Asefa, 2001; Abiyot Birhanu and Zemede Asefa, 2016).

2.8.2 Fencing

Fencing of home garden is important to protect home garden species from damage by animal (Amare Getahun *et al.,* 2014). Fencing is important as wind breaker and shelter; as to protect home garden species from predators and to control the free movement of human and animals. Morgan (2005) also pointed out that tropical home garden management through fencing controls the human, animal and other wild animals attack which can damage the species growing stage. The communities across the tropical region prefer different species which can give service as fence. Trees which are best for fuel wood, shade, soil fertility improvement, medicine, fodder,construction and other purposes are more preferred (Zemede Asfaw, 2011).

2.8.3 Organic Fertilizer Application

Organic fertilizer in agricultural system is used to produce food and fiber in contrast to chemically based conventional farming systems. It is also called biological fertilizer because it improves soil biology, enhances soil's natural fertility, and promotes plant biodiversity (Kumar and Nair, 2019). Organic fertilization enhances soil fertility and promotes home garden species productivity (Talemos Seta *et al.,* 2013).

Cover crops, manure, residue mulch, and compost are among the alternative sources of nutrients used in organic farming to increase vegetation diversity. Organic fertilizer improves the cohesiveness of the soil, increases its water retention capacity and promotes a stable aggregate structure. Mulches are effective tool in reducing weedpopulations by inhibiting weed germination and cost-effective kind of fertilizer (Zemede Asfaw,2011).

2.8.4 Runoff Controlling

Soil erosion is the chronic problem mostly across the developing countries. Management and-conservation of soil are critical to human well-being. Their prudent use and management are more important to meet the high demands for food production and satisfy the needs of an in-creasing world population (Morgan, 2005). Establishment of micro basins, contour plough-ingand channels of overland flow and planting reduce soil erosion around the home (Yirefu Tesfaye and Desta Hamore, 2019).

2.8.5 Watering and Pruning

To be effectively grown and to give different socio-economic and ecological contributions home garden species need proper management systems (Mueller and Ellenberge, 2017). Prun-ing is important to remove the branches of tall tree species which blocks the sunlight fromthe home garden species.

2.9 Indigenous knowledge and home garden management in Ethiopia

The term “indigenous” knowledge or “local” knowledge is used to refer to that knowledge which is generated and transmitted by communities, over time, in an effort to cope with their own agro ecological and socioeconomic environments (Hodgkin, 2002).

Indigenous people often have detailed knowledge of the local agro-ecological conditions, char-acteristics of plants and animals, resources and ecological processes in the ecosystems and landscapes on which they depend for sustenance and life ways. This knowledge is accumulated over hundreds and sometimes thousands of years as it is passed from generation to generation, but is also constantly adjusted to changing conditions and new experiences (Kassam, 2019). Local knowledge owned by a community is valuable information for researchers, to understand ecological aspects in order to utilize the environment and biological resources. Preserving local knowledge can be done by documenting and studying a community with ethno ecology study (Sari, 2015).

Home- garden owners use various forms of plant management strategies in home gardening activities.. Exploring the conservation potential of the many diversified home garden systems discloses opportunities for interdisciplinary studies involving botanists, ecologists, geneticists, anthropologists and sociologists. An improved understanding of the factors which encourage or enable diversity within the domain of home gardens would allow conservation scientists and

communities to foster and maintain important knowledge and biological resources while also preserving the health of services these multifunctional, sustainable agro-ecosystems provide to nature and people (Agbogidi, 2013).

2.10 Agro- biodiversity conservation and development in home gardens

In Wondo (hereafter woreda) of West Arisi, it is obvious that farmers practice homegardens for economic, social and environmental benefits. However, management of plant species and their contribution is not well known by scientific communities. Hence, understanding on why and how farmers manage the homegardens: available knowledge on preference, arrangement, uses of woody species and other components is limited only to farmers.

In Ethiopia, information on home gardens and on farm trees is generated from limited studies and are more specific in terms of site, culture and socioeconomic (Getahun Yakob *et al*, (2014)). Farmers manage woody species mainly to reduce resource competition, enhance growth, and to achieve the aim of targeted production. These productions continued through the integration of multipurpose plant species, which are economically feasible and socially acceptable (Desta Hamore &Belayneh Lemage, (2019)).

2.10.1 Conservation value of home gardens

Home- gardens, one of the oldest forms of managed land-use systems, are considered to be the richest in species diversity per unit area. Several landraces and cultivars, and rare and endangered species have been preserved in the home gardens. home gardens as an ecosystem contain multiple levels of diversity, including cultural, genetic and agronomic diversity (Zemede Asfaw, 2011; Kumar and Nair, 2019).

This complex ecosystem close to the house where plants can closely be observed and managed makes it a convenient site for traditional plant experimentation and domestication. Some home garden species that exists both in cultivated and uncultivated forms are also income earners (Agbogidi, 2013).

2.10.2 Threats to home garden farming systems

The current threats facing biological diversity call for investigations on the aspects of conservation of the natural resources of an environment (FAO, 2021) and in this, agro biodiversity has a great significance. The term agro biodiversity specifies the variety and variability of

plants, animals and microorganisms that are indispensable for sustaining key functions of the agro ecosystem, comprising of its structure and processes for, and in support of food production and security (FAO, 2022). Although it has been sustainable for centuries, the home garden agro ecosystem is under threat due to environmental degradation, replacement of traditional crops or land races, change of garden design and architecture facilitated by population pressures and the monoculture 'syndrome' of modern agriculture as well as cultural dilution and shift (Zemede Asfaw, 2016). Recently introduced crops threaten the culturally and economically valued crops of homegardens in Ethiopia (Zemede Asfaw, 2011). Concern about biodiversity conservation and utilization will be delusive without proper attention to traditional systems (Altieri and Merrick, 2015).

CHAPTER THREE

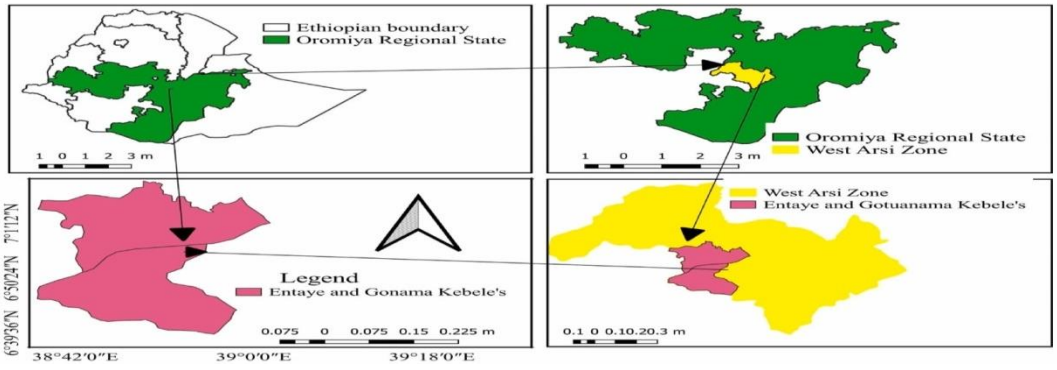
3. MATERIALS AND METHODS

3.1 DESCRIPTION OF THE STUDY AREA

3.1.1 Geographical location

The study was conducted in Wondo district, West Arisi Zone, Oromia Region, located on the western escarpment of the central rift valley of Ethiopia, located at about 267 km south of Addis Ababa (Fig.1).According to the Wondo District Agricultural Office, the landscape of the study area varies with an altitude ranging between 1500 and 3200 m.a.s.l (Wondo District Agricultural Office,2023). About 78% of the Wondo District lay in the Woina Dega (mid-land) agro-ecological zone, while 22% of the district lies in the Dega

Accordingly, the present study was carried out in the mid-land agro-ecological zones of the District. Thus, the agro-climatic zones of the area is characterized by a 'tropical highland monsoon (Mersha Gebrehiwot,2017). The area has a bimodal rainfall pattern in which the short rainy season is between March and May, whereas the long rainy season occurs from July to October, accounting for more than 80% of the total rainfall rain fall (Kebede Mamo,2018). The temperature of the area shows large diurnal but small seasonal changes, with an annual average of 20 ^{o}C (Wondo district office of agriculture,2023). (Wondo District Office of Agriculture,2023) .



Source Wondo District agricultural and rural development office

Figure.1:Location of the study sites

3.1.2 Geology and soils

Geology is defined as those large-scale geological and geomorphologic features defining the natural physical scenery of a site, for example volcanic edifices. According to MoWR (2002) the geomorphology of Ethiopia is variable and it is generally the result of repeated volcanic and tectonic events with the associated erosion of Mesozoic sedimentary and volcanic rocks, and deposition process. The three dominant textures in the area are clay soil (40%), sandy soil)10%) and loam soil (50%) (WARDO,2023).The underlying parent materials in the study area are of alkali trachytes and basalts, often overlain by volcanic ash deposits from the late tertiary period volcanics (Anonymous, 1973).

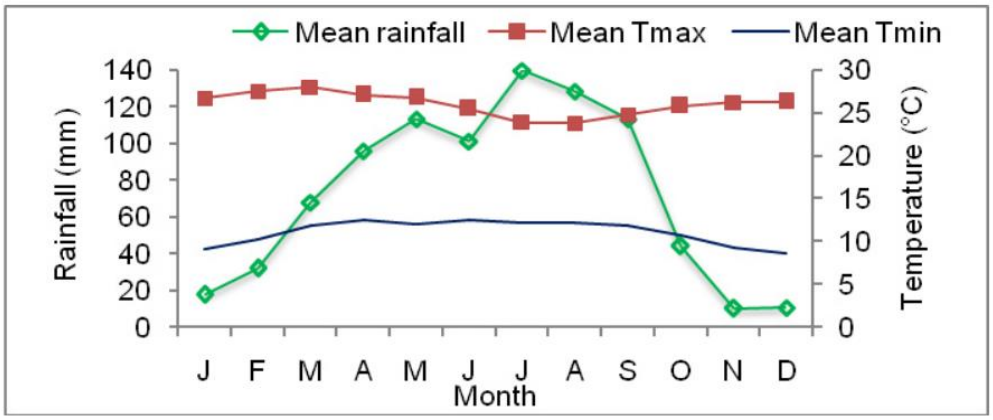
The highland areas bordering the rift valley are characterized by moderately weathered dark-reddish brown soils with a clay-loam texture (FAO, 2019). The soils at the lower elevation range of Wondo Genet are deep, loamy and relatively fertile Mollic Andosols (FAO, 2019). The soil of all smallholder farmers' fields was classified as Mollic Andosol with a sandy-loam texture (Yimer Fantahu, 2006). soil, water, forest and wildlife are some of the natural resources Wondo Districr bestowed with. The valley plain has fertile soil. The loamy sand textured soils, which contain most important nutrients, cover the area (FAO, 2019)

3.1.3 Agro-climatic conditions

The rainfall and the temperature condition of the area was describe based on the data collected from 2013-2023 by the National Station (Fig. 2).The minimum (coldest month) and maximum temperature (hottest month) were 5.2 ^{o}C and 29.1 ^{o}C respectively. The agroecology of the District receives 23% average annual rainfall during the short rainy season and receives about 73% during the long rain season. The annual rainfall ranges from 1000 to 1500 mm and mean annual temperature ranges from 15-22 °C. About 78 % and 22% of the District agro-ecological zones are midland and highland respectively.

The mid altitude (1500-2300 m.a.s.l.). receivies a meanannual rainfall ranging from 900-2000 mm and experiences a mean annual temperature that ranges from 18- 25 °C The highland (2300 to 3200 m.a.s.l.) receive mean annual rainfall and that ranges from 1500-2600 mm and temperature that ranges from 10.9°C to 21 °C .(Minitry of Agriculture ,2007 and Tadele Ferede *et al*., 2010). The total area of the District is 15,145 ha or 151.45 km2. Of this 6298.62 ha is used for agriculture, 556.11 ha for grazing, 1106.84 ha is covered by forest, 350

ha is used for fertile and 160.2 ha is infertile. The topography of the District has mountains and hills, which covere 43.5%, flat areas 36.25% and undulating parts 20.25%



Source: National Meteorological Agency Shashemene branch (2023)

Figure 2 Climadiagram showing rainfall distribution & temperature variation from 2013 – 2023, dry periods are dotted and wet periods are blackened

3.1.4 Natural Vegetation

The remnant forest vegetation of District can be categorized as 'Dry evergreen Afromontane' forests. Dry evergreen Afromontane forests have been defined as forests with a drought period of about half the year in one or two periods and an annual precipitation between 400-1700 mm. They occur in both the Northwest and Southeast Highlands of Ethiopia, at altitudes from 1500-2700 m, with average annual temperatures between 14-20 °C and annual rainfall between 700 and 1100 mm (Demel Teketay 2017).

According to the elderly local informants, most of the District area was covered with such forests until the 1920s. However, high deforestation rates through the years have left only highly disturbed remnant forests which are now confined to the mountain slopes. A limited area of plantation forests that belong to Wondo Genet college of Forestry (WGCF) and the former Munessa-Shashemene State Forest Development Project (established in 1969) also exist in similar locations as the natural forests. On the other hand, trees have been often maintained (and sometimes planted) on homesteads, farmlands and farm boundaries and give rise to, what could be described as a 'homestead' and/or 'scattered trees on crop lands' (parkland) type of agroforestry systems. While a variety of fruit trees and shrubs and cash tree crops (e.g. *Man-*

gifera indica, Coffea arabica, Persea americana, Prunus persica, Rhamnus prinoides, Catha edulis, etc.) dominate the homesteads, the dominant species in the forest include *Cordia africana, Albizia gummifera, Croton macrostachyus*, *Ficus* species, and *Millettia ferruginea.* Maize (*Zea mays*) sometimes followed by teff (Eragrostis tef) is the major grain crop grown on farms, while 'enset' (*Ensete ventricosum*), a staple food in the area and in most of southern Ethiopia, is grown in the homestead along with sugarcane (*Saccharum officinarum*), various root crops and vegetables.

3.1.5 Demographic and socio economic features

Based on the 2005 Census conducted by the CSA, this district has a total 11,995 households 9,338 males and 2,657 female headed's households. Agricultural production is the main means of livelihoods for the District, 14.85% of its population are urban dwellers (CSA,2005).. The dominant crops grown in the Wondo District are maize, teff, sorghum, beans and wheat. Besides, enset has a significant role for household's food security, whereas also on the other hand, trees have been often maintained (and sometimes planted) on homesteads, farmlands and farm boundaries and give rise to, what could be described as a 'homestead' and/or 'scattered trees on crop lands' (parkland) type of agroforestry systems. While a variety of fruit trees and shrubs and cash tree crops (e.g. *Mangifera indica, Coffea arabica, Persea americana, Prunus persica, Rhamnus prinoides, Catha edulis,* etc.) dominate the homesteads, the dominant species in the forest include *Cordia africana, Albizia gummifera, Croton macrostachyus*, Ficus species, and *Millettia ferruginea.* Maize (*Zea mays*) sometimes followed by teff (*Eragrostis tef*) is the major grain crop grown on farms, while 'enset' (*Ensete ventricosum*), a staple food in the area and in most of southern Ethiopia, is grown in the homestead along with sugarcane (*Saccharum officinarum*), various root crops and vegetables.

Livestock production is also the second major source of the household's economy in the two study districts. Cash crops, mainly coffee has also a significant contribution in the Wondo District. The production system are rain fed agriculture. Irrigation water is also available to households to produce cash crops such as sugarcane, coffee and chat. Enset is the major home garden crop, which also constitutes major subsistence food along with maize and potato. The staple food (kocho) for the majority of farmers is prepared from Enset, and almost every house-

hold grows it in the home garden. Cattle, sheep, goats, chicken and donkey dominate livestock husbandry (Wondo District Office of Agriculture,2023).

3.2. Reconnaissance survey

Reconnaissance survey of the study area was made betweenSeptember 01 to Oct 30, 2022. General information about the District was obtained during the survey. Data collection was done during two round field visits. A detailed inspection was first hold in order to get an overview of the cultural and socio-economic aspects of the communities in September 2022 to see if the prospective area is suitable to meet the objectives stated. Development agents (DAs) of the District and elders were contacted during the preliminary survey before the selection of the specific study sites. During the survey, study sites was selected, sampling methods were determined, accessibility of the home -garden was assessed, and altitudinal gradient and topography of the site was inspected.

3.3. Sampling technique

3.3.1 Study Site selection

The selection of the study sites was conducted between September 01 to October 30, 2022 during the general reconnaissance survey. Wondo District was selected purposively due to its high potential of traditional homegarden agro- bio diversity practices. A multistage sampling technique was employed to select the home-gardens for the study. A purposive sampling technique was used based on the altitudinal gradient mid altitude (1750-1900 m.a.s.l,) and highland (2300-2450 m.a.s.l,) for the study to collect agroecosystem services data in the homegarden farms.

To select representative study sites within each agro-ecological zone, administrative units were used. The smallest administrative unit in the district is locally called ganda or kebele, which means Peasant Associations (PAs). Two rural kebeles, namely, Entaye and Gutanama, were purposively selected from middle and highland agroecology respectively, to assess traditional home- garden biodiversity systems, agroecosystem services and the management practices. The reason for purposive selection of the two study kebeles, the main critera were fulfilling of altitude range, presence of homegarden woody species diversity practices in the area and proximity to road access to conduct the research. Once the kebeles were identified, the sample size

was determined using the formula used by Yamane Taro (1967) and a total of 351 households were calculated and proportionally allocated to kebeles in the midland and highland (Table 1).

The households were selected based on simple random sampling technique.The reason for purposive selection of the two study kebeles, the main critera was fulfilling of altitude range, presence of home garden agro biodiversity practices and proximity. Moreover the rate of agricultural expansion and population size, altitudinal difference and agro climatic zone Gotanama kebeles was selected representing the highland while Entaye kebele was chosen to respresent midland agroecological conditions.

3.3.2 Focus group discustions (FGDs) and households and selection

The focusn group discussants were selected using a purposive sampling technique. They include model farmers, local elders and developmental agents. Since these people were expected to provide detail information about the home- garden agro-biodiversity practices, agroecosystem services, and managements, as well as threatening factors. Systematic sampling technique was used to select household heads. There were a total 1475 households in the two kebeles

A total of 315 households were selected using the following equation developed by Yamane Taro (1967) sample size determination formula.

$$n = \frac{N}{1+N(e)2}$$

Where : n is the sample size,

N is the total number of households in the Sample kebele ,

e is the maximum variability of making error 5% (0.05), and

1 is the probability of an event occurring.

n =1475/1+1475 $(0.05)^2$ = 351 households

Of 1475 total households, 815 households belonged to Entaye *Kebele*, while 660 households are from Gutanama Kebele (WDAO, 2023)

Out of the 351 total sample sizes, 194 households were selecvted from Entaye Kebele and 157 households from Gutanama kebele were selected and were determined through proportioning technique to each Kebele (Table 1)

Table 1: The number of household heads and sample size of informants in the study area

No. of kebele	Name of Kebele	Total no, of house hold Heads	Sample size per kebele
1	Entaye	815	194
2	Gotanama	660	157
Total		1475	351

Source: Kebele Administration Office (2023)

In addition a total of 10 (4 elders, 2 development agents and 4 models farmers from the selected Kebeles) were selected as key informants through a purposive sampling technique. They were selected based on information taken from local farmers, community elders and developmental agents.

3.4. Types and sources of data

In order to achieve the intended objectives, the data for this study were collected from both primary and secondary data sources. Primary data was collected from primary sources using household survey, focus group discussions, field observation and plant inventory.The data were collected through face-to-face interviews using questionnaires. Secondary data were obtained from literatures, district and kebeles offices.wondo District Agricultural office and from wondo District Finance and Economic Department

3.5 Instruments/tools of data collection

3.5.1 Ethno botanical Data Collection

Ethnobotanical techniques were employed to collect data on knowledge and management of home-garden agro-biodiversity used by people in Wondo District as described in Martin (1995) and Cotton (1996). Techniques were group discussion, semi-structured interviews, field observations, preference ranking and direct matrix ranking.

3..5,2 Semi-structured interviews

Questionnaries was developed to collect the required data. Data related to the composition of agro- biodiversity in each home-garden were collected through inventory and interview. Semi-structured interviews with household heads were conducted on different aspects: conservation and management practices of useful plant species, to what extent conservation practices were undertaken by the people in homegarden farm system, for what purpose do people in the study

area use plants, the use categories of useful plant species (food supply like cereals, pulses, vegetables, root and tuber crops, fruit crops, oilseeds, other crops and trees, medicinal, ornamental, shade, timberproduction, spices, fuel wood production etc. Moreover, the question consisted closed and open ended and contained different aspects like household characteristics, income of the household, plant names, planting practices, relevant information about the role of agro-biodiversity in diversifying the livelihoods of the communities and challenges on home-garden agro- biodiversity.

3.5.3. Direct field observation

Plant observation in the home-garden farm system was made with farm owners in each site during ethnobotanical data collection. During the field visits, an attempt was made to let the informants discuss the cultural and ecological knowledge. Direct field observation and guided field walk targeted the crops in home-garden. In addition, a serious of observation related to diversity and composition of crop species along a range of altitude variation .

Figure 3: Home-garden field observation (Source; photo by Sori Alemayhu)

3.5.4. Focus Group Discussion

Focused group discussions were conducted in two selected kebeles with participants being selected among farmers who have been practicing traditional home- garden biodiversity systems, The data collected from focus group discussion, were used to supplement the findings of the

household survey. During the discussions, the points that were discussed included the most common home-garden food crops, medicinal plants, spice plants, ornamental plants, forage plants, multipurpose plants, traditional indigenous knowledge towards the management system of their home-garden crop plants and the factor that challenged their home-gardening practice.

Figure 4: Key informants group discussion session (Source; photo by Sori Alemayhu)

3.5.5. Preference ranking

A preference ranking technique was employed with informants to rank some selected homegarden species according to their value or desirability. preference ranking was made for nine fruits, four vegetables,six tubers and roots,five cerals, thirteen spices and nine shade trees commonly used in homegardens by ten informants. Each rank is given an integer value, 1, 2, 3, 4 and so on with the most important item given the highest value, while the least important assigned the smallest value, while the least important assigned the smallest value (1).This technique is to rank some selected homegarden plant species according to their significances

The respondents were given a list of these crops in home-gardens and asked to rank them from the highest to lowest (least) in decreasing order according to their perception following Martin (1995). The rank for the species was determined by adding up these values for all informants.

3.5.6 Direct matrix ranking

Direct matrix ranking was exercised for eleven commonly reported multipurpose trees and seven medicinal plants in order to assess their relative importance to local people according to Martin (1995). Based on their relative importance, ten selected informants were asked to assign use values for each plant (5 = best, 4 = very good, 3 = good, 2 = less used, 1 = least used and 0 = not used) to each use category. Medicinal plants were important to traditional healers for different categories of diseases (Abdominal and nasal and skin diseases, diabetes, anemia, blood pressure and hemorrhoid.The use categories in multipurpose trees comparison include; food, construction, fence, fire wood, shade, medicine and fence. Then the results of ten informants were summed up to generate a matrix that represents the entire community.

3.5.7 Plant Inventory

In the two study site, crop species was identified in different zoning nature in the homegardens. In District, also the home-garden was divided into four sections frontyard, upper-side-yard, back-yard *and* lowerside-yard, relative position to the house (Feleke Woldeyes, 2016; Matiwos Ageze *et al.,* 2013), in order to determine the diversity of crop species existing in home-garden agro-biodiversity practices, crop species inventory was made on home-gardens of purposively slected household's of the study sites. To sample plant species, a plot laided randomly across the homegarden to increase the probability of included all species (Woldemichael *et al.,* 2018). There after, sample plots of 10 m x 10 m ($100m^2$). were laid randomly along the homegarden and identity of woody plant species (local name and scientific name) and number of woody plants were recorded from each plot. To sample herbaceous species, 5 small plots (2mx2m) ($4m^2$) one from each corner and one from the center of the big plot were laid and the identity of the species with their number was recorded.

A complete enumeration of 60 home-gardens (30 from mid altitude and 30 from highland) were carried out. Each crop species in the home-garden were identified and recorded. Moreover complete inventory of crop species were carried out in the home-garden. After a vernacular name was known, scientific names were identified with the help of different publications of

Flora of Ethiopia and Eritrea (Hedberg *et al*., 2006). In addition, consultion of botanists was done for species that are difficult to identify through the above techniques. Supportive instruments were used such as, global positioning system (GPS) and digital camera. The geographical location of each homegarden plot (the reference point) was measured by a GPS.

3.6 Data management and Analysis

3.6.1 Socio-economic data analysis

Ethno botanical data were collected on home-garden plants regarding diversity, their use category and the associated indigenous management practices and were analyzed through percentages and descriptive statistical methods, In case of inferential analysis, person correlation wsa used for analyzing correlation of demographic and socio-economic variables plant species richness or diversityvariables and Chi-Square test P-value at 0.05 levels were used for data analyses. Statistical Package for Social Sciences (SPSS) Software Version 25 and Microsoft Office Excel 2010 were for the data analysis. Data collected through focus group discutions, guided garden tours and check list were narrated qualitatively

3.6.2 Plant species analysis

Complete inventory of home-garden was conducted to assess every crop species in the home-gardens. The plant inventory data were organized using (SPSS) Software Version 25 and Microsoft Office Excel 2010. Then, the floristic composition was analyzed for species diversity using equations of the parameters such as frequencies, relative frequencies, Shannon and Wiener, Simpson's and evenness indices, Species richness is simply the number of plant species present in the homegarden and Sorenson's similarity indices were computed for the rendomly selected 60 home-gardens of both agro- ecology (Nischalke,2017), (Shannon1949).

3.6.2.1. Species diversity within home- garden

Shannon's Index is the most appropriate index of diversity and accounts for both richness and evenness of the species present (Shannon and Wiener, 1949). Thus, species diversity is a number of species richness and evenness or equitability. Species diversity index provides information about species rarity and commonness. Measures of species diversity are usually seen to be key indicators for the well-being of ecological systems (Heywood, 1998).The Shannon Diversity Index (H') is calculated using the following formula;

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

Where, S = total number of species, Pi = is the proportion of each species in the sample. ln = log base n. Shannon's equitability (EH) or Evenness is calculated as follows:

EH = H/Hmax = H/lns. Equitability assumes a value between 0 and 1 with 1 being complete evenness (Whittaker, 1972). Following home garden plant species data collection described by Martin (1995), the home garden plant species data collected were organize and summarized

3.6.2.2. Similarity among home gardens

Sorenson`s Index of similarity was used to compare the degree to which species composition of study sites matches in the study area. It is the most common binary similarity coefficient because it relies on presence or absence of data. The similarity of species composition between the study two kebeles was calculated with the Sorensen coefficient of similarity with the formula

Sorensen`s Index: $Ss = \frac{2a}{2a+b+c}$

Where, Ss= Sorensen's similarity coefficient, a = Number of species common to both samples, b = Number of species in sample 1 only, c = Number of species in sample 2 only,Sorenson's similarity coefficient ranges in value from zero (no similarity) to one (complete, similarity). Often, the coefficient is multiplied by 100 to give a percentage similarity index.

Also, dissimilarity is then computed as: $Ds = \frac{b+c}{2a+b+c}$Or 1- Ss, Similarity and dissimilarity analysis among the two sampling sites of the homegardens in the study area were computed.

3.6.2.3 Frequency and relative frequency

Frequency is the number of times a species occurs within the sample plot (Van der Maarel, 2005). It was study by sampling the study area at several places at random and recorded the name of the species that occurred in each sampling units (Martin, 1995). Frequency classes were calculated to estimate the heterogeneity and homogeneity of species by following Lamprecht (1989). It is calculated by the equation:

$$F \text{ (Frequency)} = \frac{The\ number\ of\ plots\ where\ which\ that\ species\ occurs}{\text{Total number of quadrants in the sample}} x\ 100 \quad (1)$$

Relative Frequency It is the distribution of one species in a sample relative to the distribution of all, this calculate with the formula (Martin, 1995).

$$\text{(Rf) Relative frequency} = \frac{Frequency\ of\ species\ in\ the\ homegarden}{Total\ frequency\ of\ all\ species\ in\ sampled\ homegarden} \text{x}100 \quad (2)$$

3.6.2..4 Density and relative density

Density is a derivate variable, being the abundance per unit area (Van der Maarel, 2005). It is an expression of the numerical strength of a species where the total number of individuals of each species in all the quadrats is divided by the total number of quadrats studied. Density is the average number of individuals of a species on a unit area basis. It is closely related to abundance of but more useful in establishing the importance of a species (Martin, 1995). Density is calculated by the equation: (Martin, 1995).

$$\text{Density} = \frac{\text{No, of individuals of the species}}{\text{per unit area}} x100 \quad (3)$$

Relative density is the number of individual of species as a percentage of the total number of individual of all species in the area (Martin, 1995).

$$\text{Rd (Relative density)} = \frac{\text{Density of species}}{\text{Total density of all species}} \text{x}100) \quad (4)$$

3.7 , Ethical consideration

The researcher received official permit from Hawasa University College of Natural and Computational Science, Wondo Woreda Administration Bureau to conduct this study. Household survey respondents and (FGD) informants were provided detail explanation on the overall objective of the study ahead of time. Interviews were administered on free is of interviewees and assured confidentiality and anonymity of the information obtained from them to use only for the intended research objectives

CHAPTER FOUR

4 RESULTS AND DISCUSSION

This chapter presents the results of both quantitative and qualitative analysis of data in line with the specific objectives of the study. The data which were collected from, household survey, focus group discussions, field observation and plant inventory in the study area were were analyzed and interpreted in this this chapter. From the data obtained, inferences and deductions were made in relation to the research objectives. The findings presented in this chapter are discussed under thematic areas and sub-sections in line with the study objectives. The thematic areas include: study socio economic characteristics, the location and types of home-garden, plant biodiversity, major plant use categories in the home-gardens, factors affecting compostion and diversity of species in home-gardens, traditional knowledge of management and conservation of useful home-garden plants, threats to useful plant diversity and composition in home-gardens. The results are presented in form of tables and figures.

4.1 Demographic and Socioeconomic Characteristics of the households

Household's demographic and socio-economic features can influence home-garden agro- biodiversity and composition in home-garden. Out of the six demographic and socioeconomic variables considered, sex, age, educational background of the households, households' family size, farm size, agro-ecology home-garden size and wealth status showed a significant relationship with the level of agro- biodiversity in home- garden. Out of the total 351 households, most of them were predominantly male headed (74.6%). The chi-square test (X^2 =97,256, p=0.037) revealed that gender has a positive relation on the home-garden agro-biodiversity management and significant effect on the management of home-garden agro-biodiversity. About 27.9 % of the households found had age ranging between 20 and 35 years, 48.4% ranging between 36 and 51 years and (23.6%) were 52 and above 52 years old.

The chi-square test reveal that age had significantly (X^2 =85,347, p=0.032) influenced traditional home-garden agro-biodiversity. The Chi-square test that the educational status of household head is insignificant (X^2 = 78.162, p = 0.012) and was positively related to homegarden agro-biodiversity practicing. This result is similar with Katungi (2019) that, literate farmers had more information access and three was a significant difference between illiterate and literate household heads in home-garden agro-biodiversity management. The level of education

was expected to increase farmers‟ ability to obtain, process, and use information related to the home-garden agro-biodiversity manegement. It had a direct influence on improved way of managing plant species practices or in adoption of new technology.

This result is consistent with in Zambia, Jamala *et al*. (2013), literate households could adopt more improved farming technologies due to their enhanced ability to acquire technical knowledge and farmers who had some level of education responded readily to improved technology, such as application of fertilizers, use of pesticides and improved planting materials thus increasing their productivity. The chi-square test reveal that there is statistically insignificant proportional between home-garden agro-biodiversity and the marital status of the households at (X^2 =8,532, p=0.212).

According to Getu Alemayehu *et al.,* (2015), the ethno botanical knowledge and practice within any culture varied depending on age, sex, marital status and education level. Household size in the study areas ranged from 2 to 9 family size per individual households. The chi-square test revealed that there is statistically insignificant proportional between home-garden agro-biodiversity and the family size of the households at (X^2 =86.646 p=0.002).

The presence of high number of family size interrelated with farm size. This means that as the family size increases, the farm size decreased. This in turn affected or reduced the diversity of plant species. Out of the total 351 households, most of them were midland (55.3%). Agro-ecology is a major factor for home-garden agro-biodiversity. The chi-square test ($\chi 2$ = 79.170, p = 0.000) reveals that agro-ecology has a positive relation with the homegarden agro-bio diversity conservation. Agroecological differences are significant ecological factors that influence home-garden agrobiodiversity. Soemarwoto (2016) stated in their study on Javanese home-gardens have indicated that the home-garden agrobiodiversity decreased with increasing altitude. This is because of the drop in temperature that could affect the growth of some species. Out of the 351 surveyed home-gardens,32.5% had less than 0.5 hectare and 46.2% had 0,5 to 1 hectare Only 4.3% of the households had greater than 1.6 hectares, with the average of 1.05 hectare (Table 2.), This means that the majority householders had 0.5 to 1 hectare homegarden holding size. The chi-square test ($\chi 2$ = 97.461, p = 0.001) reveals that home-garden holding size has a positive relation with the home-garden agro-bio diversity conserva-

tion. This is greater than the mean home-garden size (0.185) reported by Euketu Linger (2014), for homegarden around Jabithenan District, Northwestern Ethiopia. About 48.2 % home-garden area was 0.19 hectare, while about 30.7% was less than 0.5 hectare. A similar study conducted in Sebeta-Awas District, southwest Ethiopia reported that with increasing size of home-gardens, more richness of species composition was observed (Mekonen Amberber *et al.*, 2019*).* Abreha Asefa (2021) also reported that, land holding size affected the management of home-garden agro- biodiversity. The households are grouped as poor, medium and rich on the basis of the resources they own.

Out of 351 respondents 17.7%, 44.2% and 38.2% were classified as rich, medium and poor, respectively (Table 2). As other variables, wealth status also affects positively or negatively the home-garden agro-biodiversity, it has highly significant positive effects on home-garden agro-biodiversity at chi-square ($\chi 2$ =77.67 , p = 0.014) reveals wealth status has a positive relation with the home-garden agro-bio diversity conservation. This variation is due to the fact that rich farmers have more resources than medium and poor farmers, and medium farmers have more resources than poor farmers.

Farmers who have more resources manage their plant species better than those who have less resource in their home - garden. Because farmers who have small resources focuses on the management or production of immediate consumption rather than considering sustainable management or production as they have fear for their subsistence. Most of the times, rich farmers have good awareness and took training on crop species diversity and others like crop production better than medium and poor farmers.

They get more information about agricultural technologies as they have more contact from development agents as they were model farmers in the area and also use mass media. According to Emtage and Suh (2005), households that intend to crop species on land own or manage higher levels of resources, more active in terms of crop species and have higher awareness of crop species regulations than households that do not intend to crop species in the future. All demographic and socio-economic variables except marital status had signifcantly and positively related to traditional home-garden agro-biodiversity conservation (Table 2).

Table 2: Relationship between socio-demographic variables and traditional home- garedn agro-biodiversity manegemnt

No,	Characteristic of household	Categories	Frequency	% of house-holds	X2	P- value
1	Sex	Male	262	74.6	97.256	0.037*
		Female	89	25.4		
2	Age	20-35	98	27.9	85.347	0.032*
		36-51	170	48.4		
		52 above	83	23.6		
3	Educational back-ground	Illiterate	121	34.5	78.162	0.012*
		Primary (grade 1-4)	88	25.1		
		Primary (grade 5-8)	81	23.1		
		Secondary (grade 9-12)	49	14.0		
		Diploma	7	2.0		
		University degree	5	1.4		
4	Family size	1-5	170	48.4	86.646	0.002*
		6-10	166	47.3		
		>10	15	4.3		
5	Home-garden size	< 0.5	114	32.5	97.461	0.001*
		0.5 – 1	162	46.2		
		1- 1.5	60	17.1		
		>1.6	15	4.3		
6	Marital status	Married	237	67.5	8.532	0.411
		Single	97	27.6		
		Divorced	9	2.6		
		Widow	8	2.3		
7	Agro-ecology	Midland	194	55.3	79.170	0.000*
		Highland	157	44.7		

8	Wealth status	Rich	62	17.7	77.67	0.014*
		Midum	155	44.2		
		Poor	134	38.2		

Source: Questionnaire Survey, 2023

* Significance level at 5%.

4.2. The location and types of Home-garden

The home-garden comprised of gardens with different sizes and shape. Out of the 351 home-gardens 35%, of them found in the backyard of the living houses ((“Dawwoo duubarraa”, the local name of back yard in Afan Oromo), *Enset ventricosum, Brassica carinata, Zea mays* and Persea americana were the prominent plant species cultivated in such home-gardens, Backyard was dominant in home-gardens in Loma and Gena Bosa districts of Ethiopia (Mathewos Agize, 2015). About 83% of home- garden were located in the backyard in Bulen district north westeren Ethiopa (Yirefu Tesfaye *et al.,* 2019). Mathewos Agize, (2015) reported that back-yard is the predominant size of homegarden in Dawro home-gardens were positioned in the backyard of an individual house (Zemede Asfaw and Abiyot Birhanu,2016) and Fentahu Mulugeta 2022).

The remaining 26.2 % ,24.2 % and 14.5 % were located at backyard &front yard, backyard & side yard and back yard side yard and front yard respectively. Traditionally, households allo-cated different parts of their home-gardens for different types of crops. For example, the front yard was used for growing crops having values for shade, cultural events and fuel. This portion had small open space left as play feld for children,

The front yard was used to cultivate trees such as *Olea europea ssp. cuspidata, Podocarpus falcatus, Cordia africana* and *Ficus vasta*. According to the households, these trees provided shade and served as places where cultural ceremonies and social gatherings beare held during religious holidays. Talemos Seta *et al.* (2013) that trees having social and cultural value were planted in front part of homegardens. . In this study, plants such as *Carica papaya, Ocimum lamiifolium, Ruta chalae pensis, Allium sativum, Allium cepa, Beta vulgaris, Brassica oleracea, Cucurbita pepo, Daucus carota, Mangifera indica, Coffea arabica, Catha edulis, Citrus sinensis, Phaseolus vulgaris and Collocasia esculenta* were most commonly grown in both sides of the home-garden use. Home-gardens consisted of different types of cultivated and

non-cultivated plant species. There are similar ndings from previous studies supporting this particular result (Hong & Zimmerer, 2022).

Table 3: The location of home-gardens

Kebeles	Agero-ecology	No of HHDs	Position of home- garden			
			BY	BY& FY	BY &SY	Circle yard
Intaye	Mid land	194	64	48	55	27
Gotana-ma	High land	157	59	44	30	24
Total		351	123	92	85	51
%		100	35	26.2	24.2	14.5

Source: Questionnaire Survey, 2023

Figure 5: Outside view of a typical structure of Wondo home-garden (Source; photo by Sori Alemayhu)

Figure 6: Inside view of a typical structure of Wondo home-garden

4.3 Plant biodiversity

4.3.1 Composition and distribution of home-garden plant species

Out of the surveyed 351 home-gardens, a total of 104 plant species were identified (App.I). The composition of crop species differed from one altitude to another. Out of these crops, 57 species were collected from midland agro-ecology while 29 species were collected from high-land agro-ecology. 18 home-garden plant species were common for both agro-ecology. The species richness was significantly different between the two agro-ecological zones (X^2 = 8.634, p = 0.001). Such a difference in the home-gardens attributed to as differences agro-ecological characteristics. socio-economic, culture and management strategy of farmers. This finding is similar with (Castiñeiras *et al*., 2012; Shrestha *et al*., 2016) who reported, structural complexity of homegardens decreased with increasing elevation.

The 104 plant species were taxonomically categorized under 54 genera and 41 families (App.II). This result is slightly higher than a finding of (Mathewos Agize *et al.*, 2013) who reported that a total of 94 plant species representing 41 families in homegardens, These variations could be due to individual difference in management practices, size of homegarden, socio-economic backgrounds, altitude, soil fertility status, proximity to the market and road and religious factors (Mathewos Agize *et al.*, 2013). Species richness was complicated by the difference in altitude, amount of rainfall, type of soil, and other factors such as differences in social, environmental, and economic conditions that influenced species distribution and provenances (Tadesse Kappie,2002). Out of these plant species, family *Poaceae* ranked first (26.82%) species followed by *Fabaceae* (24.39%) species, Rutaceae (14.63%) species, Eu-

phorbiaceae and Solanaceae each (14.63%) species, Lamiaceae and Rosaceae (each (12.19%) species. Asteraceae , Moraceae and Myrtaceae each with 4 (9.75%) species, Brassicaceae 3(9.75) species. The remaining Acanthaceae, Alliaceae, Anacardiaceae, Araceae, Boraginaceae, Cupressaceae, D oscoreaceae, Musaceae, Proteaceae, Verbenaceae each with 2 (4.87%) species and Agavaceae, Aloaceae, Annonaceae, Apiaceae, Balanitaceae, Bignoniaceae, Cactaceae, Caric ceae,Celastraceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Cyperac ae,Flacourtiaceae, Meliaceae, Moringaceae, Oliaceae , Phytolaccaceae, Podocarpaceae, Rha naceae, Rubiaceae each with (2.43%) species. *In the* present study Fabaceae and Poaceae were the dominant families. This result is similar with Tigist Wondimu *et al*. (2018) who reported that Poaceae was the largest family around 'Dheeraa' home-garden, Arsi, Ethiopia. Alfred (2019) reported that members of Poaceae were dominating large portion of family found in the home-gardens of Zimbabwe. This may indicate that home-gardeners mostly cultivated Poaceace for food security purposes. Sthapit *et al*. (2018) showed that the composition of unique plants in home gardens varied with ethnicity, food culture, religion and spirituality.

Unlike this result, in case of in case of Holeta, Solanaceae ranked third (Mekonnen Amberber, 2015), in case of Wolayta Solanaceae ranked fourth (Talemos Seta *et al.*, 2013). There was a significant difference ($p < 0.05$) between the agroecological conditions in terms of level of agro-biodiversity in home-gardens. Such difference attributed to differences in agro-biodiversity could exist as agro-ecological characteristics, socio-economic and traditional management strategy of households.

Table 4: Families, number of species and their percentage

No	Family	No of species under these family	%
1	Poaceae	11 species	26.82
2	Fabaceae	10 species	24.39
3	Rutaceae	6 species	14.63
4	Euphorbiaceae, Solanaceae	6 species each	14.63
5	Lamiaceae, Rosaceae	5 species each	12.19
6	Asteraceae, Moraceae, Myrtaceae	4 species each	9.75
7	Brassicaceae	4 species	9.75
8	Acanthaceae, Alliaceae, Anacardiaceae, Araceae,	2 species each	4.87

	Boraginaceae, Cupressaceae, Cyperaceae, Dioscoreaceae, Musaceae, Proteaceae, Verbenaceae		
9	Agavaceae, Aloaceae, Annonaceae, Apiaceae, Balanitaceae, Bignoniaceae, Cactaceae, Caricaceae,Celastraceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae,Flacourtiaceae, Meliaceae, Moringaceae, Oliaceae , Phytolaccaceae, Podocarpaceae, Rhamnaceae, Rubiaceae	1 species each	2.43

4.3.2 Growth form of traditional home-garden agro-biodiversity

A total of 104 species were recorded in the traditional home-gardens. There were four life forms: trees, shrubs, herbs, and climbers (Table. 5). Among the recorded plant species, 38 were herbs, 17 were shrubs, 47 were trees and 2 were climbers. This shows that trees are predominant life form in home-gardens. Among total plant species identified in the study area; trees were the highest growth habits 27.8%), followed by herbs (19.2%) shrubs (5.76%) and climbers (1.19 %) were in mid land where as herb were the highest growth habit (11.5%), followed by trees (9.6%) whereas shrubs (4.8%) in the highland and where as climbers were (1.19%), in mid land and were no in the highland (Table 5).

Growth habit of home- garden plant species showed a significant difference $p<0.05$ between midlands and highlands. This means that trees are the most numerous species in the study areas. The result of getting more number of tree species agreed with that of Mulugeta Kebebew (2018) more tree species recorded in the sites. This is no agree with kandari *et al. (*2015) in Hararghe Eastern Ethiopia that 49 % were herbs, 36 % were trees and 5 % were shrubs. Mekonen Amberber *et al.* (2015) reported that from the total species studied, 39.8 % were herbs, 30.1% were trees, and 23.0% were shrubs home-gardens in Sebeta-Awas district of the Oromia Regionof Ethiopia.

Table 5: Comparision of the composition of different plant growth forms (habits) of both altitudes

Growth habits	Midland(%)	Highland(%)	Common to both(%)	P-value
Herb	19.2	11.5	6.7	0.043
Sherub	5.76	4.8	5.7	0.032
Tree	27.8	9.6	5.7	0.023
Climber	1.19	0	0	0.002

Homegarden plant habit assessment, Wondo district, 2023

4.3.3 Species richness, diversity and evenness

The plant species richness per home-garden was higher the midland compare to highland. The plant species richness value at midland and highland were 57 and 29, respectively. Plant species richness value higher in the midland. This shows the plant was higher which was significantly different (P value =0.045) (Table 6). Plant species richness varied across altitudinal variation. The present finding is also similar with the work done by Bajigo and Tadesse Kappie (2002 that the middle elevation was highest in plant species richness Tesfaye Abebe (2010) reported that altitude and slope of farms affected heterogeneity of crop species. Similarly, elevation negativelyinfluenced plant species richness in Indonesian home-gardens (Kehlenbeck *et al.,* 2019).

The midland had better soil and water conditions road access for marketing home-garden products. Soemarwoto and Conway (2016) also reported a decrease in plant species diversity of homegardens with increasing altitude. Hodel *et al*. (2019) reported that species richness decreased with increase in elevation Kebede Mamo *et al*. (2018) reported that elevation and slope was significantly correlated negatively with species richness.

The Shannon diversity index result shows a value of 2.87 and 2.35 for the midland and highland respectively and evenness value of 0.6 and 0.7 for the mid altitude and highland respectively (Table 6). Likewise, comparison of Shannon-Weiner diversity index showed that there was significant difference (X^2 =12.732, p= 0.002). the highland and midland in terms of species eveness and richness. As shown in table 6, the highest species diversity was recorded at midland and this is due to the highest species richness in the study sites. Shannon diversity in-

dex is usually associated with an increase in species richness (Tesfay Jogora *et al.* 2019) reported high plant species diversity index of 2.32 in homegarden of Northern Ethiopia midland home- garden .Home-garden owners reported that home-garden species diversity could be related to factors such as access to water, size of homegarden and infestation of plants by pests and weeds. Elsewhere, it was reported that low species diversity could be a result of the shifting from polycultural gardening practices to cultivatingfew income generating food crops (Habtamu Hailu ,2019).

The evenness index reveal that the species in midland (E = 0.73) was more abundant and equally distributed as compared to highland (E =0.65) (Table 6). Also, comparison of evenness index showed that there was significant difference (X^2 =8.375 , p= 0.004).. This shows that more species richness per home-garden was recorded under the mid altitude than the highland. Statically, the result showed that plant richness was significantly different (P value =0.026) between mid land and highland. The average species per home-garden was 20.4 and 17.7 in mid altitude and highland respectively (Table 6).

High species diversity and evenness in midland could be attributed to the presence of optimum environmental factors such as altitude, slope, adequate nutrient and moisture, and proximity to the market and road Plant species richness varied across altitudinal variation. Tesfaye Abebe (2019) reported that altitude and slope of the farms affected heterogeneity of crop species. In the low altitude sites where temperatures are suitable, the number of crops increased because of their good adaptability to the climatic conditions. However, this was also associated with road access, because most of the low altitude sites also had better access to the roads that facilitate marketing. Soemarwoto and Conway (2016) also reported a decrease in plant species diversity of home-gardens with increasing altitude. Hodel *et al*. (2019) reported that species richness decreased with increase elevation due to decreased mean temperature. The possible difference in species diversity and evenness could be due to the variation in the farm household landholding size, species preference, management, and the opportunity that affords the farmer to maintain the plant species on their home garden (Abayiness Legesse, 2021)

Table 6: Diversity indices and species richness of crop species in the home- garden agro- biodiversity practices at the two agro-ecological zones

Agroecological altitude	No of Plot	Species richness	Diversity index value

			Evenness	Shannon diversity
Mid land	30	57	0.7	2.86
Highland	30	29	0.6	2.35
Chi squre		9.543	8.375	12.732
P value		0.045*	0.004*	0.002*

Home-garden plant diversity assessment, Wondo district, 2023

* significance level at 5%.

4.3.4 Similarity and dissimilarity among plant species

The similarity and dissimilarity of plant species were different from one site to others. A similarity in plant species composition between the two agro-ecological traditional home-grden biodivertiy was 29%. The low similarity could be due to the differences in agro-ecology and species requirements. Plant species adapted to midland agro-ecology may not adapt to highland agro-ecology and vise-versa. The similarities in homegarden plant species composition were compared between the two study sites. In the midland 57 plant species and in Highland 29 plant species were recorded, where there were 18 common both sites. The Sorenson similarity coefficient index between the two studies sites is 0.29 (29%), indicating that the numbers of species in common between to the two study sites is low. This result indicated that there was less similar type of plant species between the two study site homegardens. The reason for less similarity between the two agro ecological study sites indicated that there was the effect of altitude variation on plan species similarity.

The distribution of species among the sites showed significant dissimilarity (71%). between the study sites. The reason for the less similarity between the two agro- ecological study sites indicated that there was attributes to the effect of altitude variation in the the study sites According to YirefuTesfaye (2019) report there was low plant species diversity and low number of species richness in home-garden located near roads and access market. Also, as aforementioned agroecological or site characteristics, socio-cultural and farmer‟s management strategy could be the cause for the variation of plant species between the two agro-ecological zones.

Table 7: Sorenson`s Index of similarity of overall species in two selected sites of the **study area**

Study sites	Midland	Highland
Entaye	1.00	0.29
Gutanama	0.29	1.00

Source field data, 2023

4.3.5 Frequency of plant species

The percentage frequency, relative frequency and frequency of each species were analyzed because they give approximate indications of the homogeneity and heterogeneity of species. From the total number of the species recorded in the study area, *Ensete ventricosum* was the most frequently recorded species. Belachew Wassihun (2003) reported that *E. ventricosum* has high frequency of occurrence as useful plants in home-gardens in Southern Ethiopia, supporting the present finding. Tesfaye Abebe (2018) also reported that Ensete ventricosum has key position as a dominant species in Southern home-gardens. Mekonnen Amberber *et al.* (2015) reported that *Ensete ventricosum* (93.75%) was the most frequent species in Holeta homegardens. In addition, the occurance of plant species in each homegarden were calculated (App.III).

Out of the 104 plant species, *Ensete ventricosum* took the first ranks with frequency (100%) and relative frequency 2.63 followed by *Zea mays L.* with the frequency 98.33 % and relative frequency (2.59) and *Coffea arabica L.* with frequency 96.6% and relative frequency 2.54. These plant species occurred frequently. This higher occurance indicated their adaptability to different altitude gradient or variations and accessablity to the farmers.

Similarly, Mekonnen Amberber (2015) reported that *Ensete ventricosum* was the most frequent species occurring in almost all of the sampled home-gardens (93.75%), followed by *Eucalyptus camaldulensis* (90.63%) of the total sampled home-gardens. Unlikely to this finding in homegarden of Sebeta Hawas district, Oromia region (Tefera, Jogora 2019) reported *Catha edulis, Rosmarinus officinalis*, and *Rhamnus prinoides* had the highest frequency. The most ten densest species are *Ensete ventricosum, Zea mays L. Coffea arabica L. , Phaseolus vulgaris L. Persea americana Mill , Eucalyptus camaldulensis , Eucalyptus globulus Labill. , Catha edulis (Vahl) Forssk. , Musa x paradisiacal L. Eleusine floccifolia (Forssk).* Because of staple food

use and economic value in the study area *Zea mays L.*was had high frequency next to *Enset venticosum*

Table 8; Lists of plant species with the highest frequencies and relative frequencies of occurrences

Scientific name	no,of hgs spe- ciesoccurs	total no of quadrants	frequency (%)	reltive fre- quency	rank
Musa x paradisiacal L.	47	60	78.33	2.06	10
Phaseolus vulgaris L.	54	60	90	2.37	5
Persea americana Mill	57	60	90	2.50	4
Ensete ventricosum (Welw.)	60	60	100	2.635	1
Eucalyptus camaldulensis Dehnh.	50	60	83.33	2.195	8
Coffea arabica L.	58	60	96.6	2.547	3
Eucalyptus globulus Labill.	53	60	88.33	2.327	6
Mangifera indica L.	35	60	58.33	1.53	11
Zea mays L.	59	60	98.33	2.59	2
Rhamnus prinoides L	53	60	51.66	2.36	6
Catha edulis (Vahl) Forssk.	48	60	80	2.108	9

Source field data, 2023

4.3.6 Density of home-grden plant species

Plant species density is expressed as the number of plant per unit area and it is a crucial parameter to know homegarden plant species status and for the sustainable homegarden plant species management. From the total number of individual plant species some species found have to the largest density in the study area. For example, six individual plant species i.e *Coffea arabica* (16.4%), *Eucalyptus spp*. (10%), Zea mays L. (19%), *Persea americana* (10%) and *Catha edulis* (8.9%) were relatively hveing the largest density in midland site (Table 9). This result as compared to other previous finding, The total plant species abundance per ha (1020) were recorded in home-garden agroforestry in Shashemenne District (Tefera Jogora, 2019)..The plant species density variation in the two study sites indicated that the role of altitude, accessibility and management variation.

Table 9: Plant species with the highest number of individuals, densities, and relative densities **of occurrences**

No,	Botanical name	Number	Densities	Relative densities
1	*Coffea arabica L*	9897	1.64	11.40
2	*Ensete ventricosum(Welw.)*	5469	0.91	6.34
3	*Eucalyptus globulus Labill.*	6479	1.00	7.50
4	*Persea americana Mill*	6543	1.01	7.50
5	*Zea mays L.*	11421	1.90	13.24
6	*Catha edulis (Vahl) Forssk.*	5379	0.89	6.24

Source field data, 2023

4.4 Major agro-ecosystem services of home-garden agro-biodiversity

Farmers cultivate diverse plant species in their home-garden to satisfy their subsistence needs. Simultaneously, those plants, which grow themselves, are either tolerated or protected for their known or perceived use (Feleke Weldeyes, 2016). Home-gardens in the study sites provided a number of services to the local people. The local people used them to get balanced diet, to treat the day to day illness of their health and their domestic animals, firewood, construction, income generation, for soil fertility (to prevent the degradation of soil, to protect wind and others), and for social aspects. The major agro-ecosystem services delivered by home-gardens were food supply, medicinal, were spices multipropse and other several services. There were 11 main agro-ecological services in home gardens.

The households heavily relied on home-gardens for their agro-ecosystem services: 37.5 %, were food, 14.42 % were medicinal, 7.69% were spices and 6.73% multipropse (Table 10).

These results higher than Melese Mereyo (2013) who found eight differenr agro-ecosystem services: which were identified In Gedeo home-garden, Melese Mereyo and Daniel Fetamo (2015) have recorded 10 major plant use categories and 10 functional groups of crops were recognized in Sidama home-garden (Tesfaye Abebe, 2019). These imply that most of the home-garden plant species were food and make significant contributions to the nutritional well-being. Similarly, this finding is consistent with the findings of Van and Bongers stating (2013), that people that manage home-gardens for multiple goods to satisfy their social, cultural and economic needs, mainly food. This result is similar to the findings of Reta Regassa

(2016), in southern Ethiopia around Hawassa stating that the largest food crops as fruit, accounting for about 23%. Also, this result is agreed with the findings of Pulido *et al*. (2018) that reported people that manage home-gardens get multiple goods to satisfy their social, cultural and economic needs, mainly food

Table 10: The agro-ecological services and their frequencies in the homegardens

Major agro-ecological services	Number of plants	Percent
Medicine	19	14.2
Food	101	28.8
Spice	11	11.1
Multipropse	8	8.8

4.4.1. Home-garden agro-biodiversity as food and nutrition supplement

The magnitude and rate of output of products, as well as the ease and food plants are cultivated in the study area and are available in different seasons. However, significant amounts of nutrient supplying home-garden products are more available during the main rainy season between June and September (Zemede Asfaw, 2011). Farmers have a long tradition of using vegetables, pulses, roots/tubers and fruits in their traditional food culture Out of the recorded (37.5 %) food plant species, fruits comprises (13.46 %), tubers and roots (7.6 %) of plants, vegetables accounts (3.84%), and oils (2.88 %), cereals holds (6.73 %) and pulses (2.88 %) . (Figure 7). Result showed that food crops has significant difference ($p < 0.05$) othrs crops between mid land and the highland.

Similarly, this finding is consistent with the findings of Van and Bongers stating (2013), that People that manage home-gardens for multiple goods to satisfy their social, cultural and economic needs, mainly food. This result is similar to the findings of Reta Regassa (2016), in southern Ethiopia around Hawassa stating that the largest food crops as fruit, accounting for about 23%. Also, this result is agreed with the findings of (Zemede Asfaw & Yohanis Zergaw, 2022, Fernandez & Méndez, 2018). Relatively, resource-poor households often depended more on home-gardens for their food staples than wealthy ones, which used home-garden plants as supplements and secondary staples to food and income generation. Home-gardens offered a cheap source of nutritive foods for poor and marginalized households (Dissanayake, 2020).

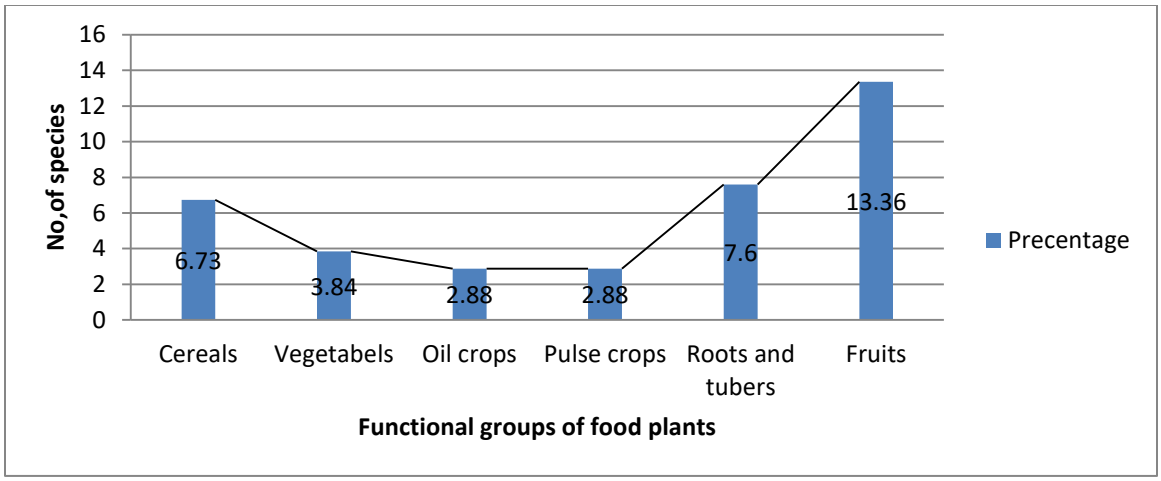


Figure 7. Percentages of functional groups of food plants

The most useful plant species in the home gardens of the District were food plants. Food crops has significant difference ($p < 0.05$) othrs crops between mid land and the highland. This shows that most households in the study area largely depend on home gardens for food. Thus they grow plants which can meet their basic needs; this can help to reduce on the daily food expenses since it can simply be produced in the home compound, and this promotes home gardening in the District.

These results were agreed with the report of Mulugeta Kebebew (2018) who presents food crops as the most cultivated plants in home-gardens, Zemede Asfaw and Ayele Nigatu (2016), farmers have successfully integrated food crops like potato, leafy vegetables and pepper into their original dishes, often creating new ones and Fernandes and Nair (2019); the important role of food production in home-gardens is the maintenance of almost continuous production throughout the year from the unit and can provide a safeguard against failure and a security for the interval between the harvests of other agricultural crops of the home gardens.

4.4.1.1. Fruits

Local people tend to grow various types of fruits not only used to fulfill the nutritional requirement but also to their economic and social purpose. In addition to these, residents who have houses in the sloping area tend to grow fruits in that area to hold and strengthen the soil. In total 15 kinds of fruits were recorded among which simple preference ranking was done for the most important fruits frequently mentioned, in two agro climatic zones .Accordingly *Per-*

sia americana and *Carica papaya* followed by *Citrus sinensis (L.) Osheck* the most important fruits cultivated in the study area.

Table 11 the preference ranking of most important homegarden fruit crops in the homegardens of the study area and their total score and preference ranks (1-9)

Fruit crops	Scores given by key informants(I)								Total	Rank
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8		
Annona senegalensis Per	*3*	*4*	5	2	4	5	2	9	34	6
Carica papaya L.	*7*	*9*	7	8	6	8	7	4	56	2
Casimiroa edulis L	*1*	*2*	3	1	2	4	1	1	15	9
Citrus sinensis (L.) Osheck	*6*	*7*	6	7	5	7	3	7	48	3
Citrus medica L.	*2*	*1*	8	4	3	2	4	5	29	8
Mangifera indica L	*5*	*5*	4	3	7	6	5	3	38	5
Musa x paradisiacal L.	*4*	*3*	1	6	8	3	9	6	40	4
Persea americana Mill.	*9*	*8*	9	9	9	9	6	8	67	1
Psidium guajava L	*8*	*6*	2	5	1	1	8	2	33	7

Source field data, 2023

The finding indicated that *Persia americanal* ranked first as the most useful home garden fruit plant species. *Carica papaya and Citrus sinensis (L.) Osheck* ranked second and third as the most preferable fruits plants used as source of food. *Casimiroa edulis ranked* 9^{th} the least preferred.

Fiure 8: Papaya planted in a homegarden (Source; photo by Sori Alemayhu)

4.4.1.2. Vegetables

Major vegetable crops include *Solanum tuberosum* L.. Ipomoea batatas (L.)Lam.), *Ensete ventric osu0m(Welw.)*, cabbage (*Brassica oleracea* var. *capitate*), brocc (*Brassica oleracea* var. *italica*), Vegetable crops has difference between mid altitude and the highland. Because mid altitude farmers grow high potential vegetable crops in their home-garden for income generation such as *Daucus carota, Brassica oleracea, Beta vulagaris, Lycopersicon esculentum, Solanum tuberosum* and *Brassica carinata* these species farmer adapted to sale urban market. In the highland *Capsicum annum, Solanum tuberosum* and *Brassica carinata* are dominated rural market vegetable crops.

According to Zemede Asfaw and Ayele Nigatu (2016), farmers have successfully integrated food crops like potato, leafy vegetables and pepper into their original dishes, often creating new ones. Vegetables contribute to a balanced diet by providing not only energy-rich food but also supply of vital protective nutrients like vitamins and minerals (Soumya Mohan, 2014). Fresh vegetables provide us carbohydrate, vitamins, mineral, which are essential to our body. Hence, home garden can provide nutritious and balanced diet to the family that makes the farm

families healthy and strong. Along with nutrition supply and food security, home garden is a source of income. In the rural and remote areas where other employment opportunities are meager,

Table 12. Simple Preference ranking of frequently encountered vegetables species (1-3): 3-most valuable, 1- least valuable

Scientific name	Key informant											
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	Socre	Rank
Solanum tuberosum L.	1	2	1	1	1	2	1	2	1	1	13	3th
Brassica carinata A.Braun	3	3	3	2	3	3	2	3	3	3	28	1st
Ipomoea batatas (L.)Lam.)	2	1	2	3	2	1	2	1	2	2	18	2nd

Source field data, 2023

The findings indicated that Brassica carinata A.Braun ranked first and is the most used vegetable *Solanum tuberosum L.* A.Braun and *Ipomoea batatas* ranked second and third most preferable vegetable plants used in the area. Third ranked vegetable plants *Solanum tuberosum* are the least used vegetables when compared with the others.

4.4.1.3. Tubers and roots

Major tubers and roots crops include Daucus carota L. Dioscorea alata L, Ensete ventric osu0m(Welw.), Ipomoea batatas (L.)Lam.),Manihot esculenta Crantz and Xanthosoma sagittifolium (L.). Enset is one of the most important food crops that ensure food security in the country (Habtamu and Zemede, 2011; Tesfaye, 2005). Ensete ventric osu0m(Welw.) play a central role in providing household food needs in the country (Tadesse, 2002) . The other root crops of the home- garden areas including *Daucus carota L. Dioscorea alata L,, Ipomoea batatas (L.)Lam.),Manihot esculenta Crantz and Xanthosoma sagittifolium (L.). dominantly produced by the communities to improve their livelihoods. Similar conclusions were also given by Mekonnen et al, (2014) and Reta, (2016) based on the research they conducted on the contributions of home-gardens in the Holeta and Hawassa towns respectively.*

The findings indicated that *Ensete ventric osu0m(Welw.)* ranked first and is the most used *tubers and roots Ipomoea batatas (L.)Lam and Manihot esculenta Crantz* ranked second and third most preferable *tubers and roots* plants used in the area. *Xanthosoma sagittifolium (L.)* fourth ranked *tubers and roots* plants, *Dioscorea alata L and Daucus carota L.* are the least used *tubers and roots* when compared with the others..

Table 13: simple preference ranking for commanly mentioned tubers and roots in homegardens (1-6):6- for most valuable, 1- for least valuable

Tubers and roots	Key informant											
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	Score	Rank
Daucus carota L.	*1*	*2*	*1*	*1*	*2*	1	6	2	3	1	20	6
Dioscorea alata L	*2*	*1*	*2*	*2*	*1*	5	1	3	2	2	21	5
Ensete ventric osu0m(Welw.)	*6*	*5*	*6*	*3*	*4*	6	4	6	5	5	50	1
Ipomoea batatas (L.)Lam.)	*5*	*6*	*4*	*6*	*5*	4	5	4	6	4	49	2
Manihot esculenta Crantz	3	4	5	4	6	3	2	5	4	6	42	3
Xanthosoma sagittifolium (L.)	*4*	*3*	*3*	*5*	*3*	2	3	1	1	3	28	4

Source: Questionnaire survey, 2023

4.4.1.4. Cereal crops

Local people cultivate various types of cereal crops for changing their livelihood by using as source food, source of income, fodder, mulching, , medicine as well as cover of their home during home construction .*Zea mays* and *Phaseolus vulgaris* cultivation are dominant in in two agro climatic zone of the District than the other crop (Table 14), Key informants asserted that the five widely cereal crops that were selected based on their consensus and telling the most frequented species. The scores given to each species as per informant preference were added and ranked. Consequently, *Zea mays L.* ranked first and *Phaseolus vulgaris L.* was the least preferred creal crop (Table 8).

Table 14: simple preference ranking for five cereal crops in homegardens (1-5):5- for most valuable, 1- for least valuable

Scientific name	Key informant											
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}	Score	Rank
Zea mays L.	*5*	*4*	5	3	5	5	4	3	5	5	44	1st
Eragrostis tef (Zucc.)	*2*	*1*	3	2	2	1	5	1	2	1	20	5th
Phaseolus vulgaris L.	*4*	*5*	4	4	3	4	3	4	3	2	36	2nd
Sorghum bicolor (L.)	*1*	*2*	1	1	1	3	2	5	1	4	21	4th
Hordeum vulgare L.	*3*	*2*	2	5	4	2	1	2	4	3	28	3rd

Source field data, 2023

Zea *mays* and *Pharsalus vulgaris were* the most used cereal crops because these crops are the major source of food and income in the District. *Eragrostis tef*, *Sorghum bicolor* and Hordeum vulgares were also cereal crop in the study area which used sources of food and income simlar to *Zea mays* and *Phaseolus vulgaris*.

4.4.2 Home-garden agro-biodiversity as sources of medicines

The communities are partly dependent on medicinal plants cultivated in their home garden to fulfill their day-to-day remedies for the treatment of human ailments and curing livestock diseases. From the total of 19 species of medicinal plants, 36.9% species were herbs, 15.7% were shrubs, 15.7% were climbers and 31.6% were trees (App.I). This means that the species richness of medicinal plant higher than that reported by Reta Regassa (2016) in Hawassa City and Regassa Bekele (2014) in Bishoftu town.

This change may be because of altitude variations and specific locations but the above result obtained from different altitudinal gradient and geographical locations. This result indicates that Asteraceae is the most distributed plant family among medicinal plant species followed by *solanaceae* in the study area. Similarly, this result agreed with Reta Regassa (2016) reported that among medicinal plants *Asteraceae* and *Solanaceae* were the most used for remedies.

Mohammed Adefa and Berhanu Abraha (2013), reported that preference ranking in Tehuledere district, Ethiopia for 8 selected plant species showed that *Allium sativum* was the most preferred one followed by *Negella sativa*.This finding agrees with the findings of Tizazu Gebre (2015), Debela Hundie (2001) and Endalew Amenu (2017) that herbs were the mostly harvested forms for medicinal purposes. However, the finding of Fisseha Mesfin *et al*. (2019) indicated that shrubs were the most harvested forms for medicinal purpose

A given plant species is used in the treatment of different diseases. People show direct preference towards plant species having healing potential of various ailments. Preference ranking performed by ten key informants for 7 selected plant species (Table 15) showed that *Allium sativum* to be the ranked first followed by *Lepidium sativum*. Mohammed Adefa and Berhanu Abraha (2013), reported that Direct matrix ranking in Tehuledere district for 8 selected plant species showed that *Allium sativum* was ranked first followed by *Negella sativa*

Table 15: Direct matrix ranking of seven medicinal plants widely used in in Wondo district homegardens as per ten key informants' group discussion

Ailment Treated	Medicinal plants and collective scores						
	Lepidium sativum	*Eucalyptus globulus*	*Vernonia amygdalina*	*Moringa stenopetala*	*Allium sativum*	*Ocimum lamiifolium*	*Ensete ventri-cosum*
Abdominal and nasal Diseases	*65*	57	34	32	67	54	73
Skin diseases	*60*	46	63	23	79	65	48
Diabetes	*50*	89	23	44	53	23	45
Blood Pressure	*78*	67	54	37	95	43	54
Anemia	*58*	59	65	27	89	23	23
Hemorrhoid	*96*	87	44	67	98	55	34
Total score	*407*	405	283	230	481	263	277
Rank	*2*	3	4	7	1	6	5

Source field data, 2023

4.4.3. Home-garden agro-biodiversity as sources of spices

Fourten plant species were recorded as spice Plant in the Homegarden of the study area. In the study area; spices were being widely used for flavors in vegetables, meat, Wott, tebis etc.and also used as a medicine and an appetizer. Spices were either used for household purpose or some are used as income generating and are purposely planted in gardens. Even if the species richness of the recorded Spice plants. The results of preference rankings showed that the most widely used spices were, *Allium sativum L*, *Artemisia absinthium* L, *Ruta chalepensis L.* which takes 1^{st} ,2^{nd} and3^{rd} *ranks respectively*. Species in the study area were more than results noticed by Tesfaye Abebe *et al*, (2010) reported that ten spices were recorded in Sidama garden A high number of spices belonged to Lamiaceae (4 species), Alliaceae, Apiaceae, Solanaceae and Verbenaceae (2 species each), and Rutaceae and Brassicaceae (1 species each). This finding is also agreement with Feleke Woldeyes (2016) reported that historically Spices Plant Species have food related benefits and can be viewed from different perspectives; flavoring, nutrition, preservation and other additional use. This demonstrates the abundance of plants used as spices

in home-gardens, which are used for various purposes at a household-level (Bistaa *et al.*, 2022). Their growth for is shown in (Table 16).

Table 16: Preference ranking for 13 selected spices and condiments plants (larger value (13) for a species most used and (1) for a least used spices and condiments plants based on the ten key informants perceptions

List of spices and condiments widely used in food preparation	Family name	Habit	Scores given by key informants(I)										Total	Rank
			I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8	I_9	I_{10}		
Allium sativum L	Alliaceae	H	13	12	13	10	13	13	12	13	11	13	123	1
Allium cepa L	Alliaceae	H	9	7	2	5	8	3	6	4	3	9	56	7
Artemisia absinthium L	Solanaceae	S	12	13	11	13	12	12	10	12	9	11	115	2
Capsicum annuum L	Solanaceae	H	5	11	5	7	9	10	8	10	5	10	80	5
Capsicum frutescens L	Apiaceae	H	8	5	6	8	6	9	4	5	10	8	69	6
Coriandrum sativum L.	Apiaceae	H	1	3	3	2	1	5	3	11	2	1	32	12
Rosmarinus officinlls L	Lamiaceae	S	2	1	4	3	3	2	1	3	1	7	27	13
Lippia adoensis Hochst	Verbenaceae	S	3	4	7	1	7	4	5	6	8	5	50	9
Hordeum vulgare L.	Pobacae	H	6	2	8	6	5	1	2	2	7	3	42	11
Ocimum basilicum L	Lamiaceae	H	7	9	9	11	11	8	13	8	12	12	100	4
Ocimum basilicum var.	Lamiaceae	H	4	3	2	9	2	7	7	7	4	6	51	8
Rosmarinus offcinalis L.	Lamiaceae	S	10	6	1	1	4	6	9	1	6	4	49	10
Ruta chalepensis L.	Rutaceae	H	11	11	12	12	10	11	11	9	13	2	102	3

Source field data, 2023

4.4.4. Home-garden agro-biodiversity as sources of stimulants

According to household informants in the study area three tree plant species were identified as stimulantsplants. In this category *Coffea arabica*., Nicotiana tabacum, *Catha edulis* and *Rhamnus prinoides* were recorded homegardens in the study area. *Coffea arabica* is the most widely used and cultivated dominant species recorded in all the selected kebeles.

The least species number which was only four was recorded under this category. According to informants, they are trying to adapt grown mainly for fetching high cash income plants in their

homegardens. This means that the species richness of stimulant plant species higher than that stated by Reta Regassa (2016) out of 258 useful plant species, 3 stimulant species documented in the Hawassa city. This difference may be because of altitude variations..

Table 17: List of stimulant plants growing in Wondo District home-gardens with the parts used

No,	Species name	Parts used	Application
1	*Coffea arabica L.*	Seed	Used as hot beverage
2	*Catha edulis (Vahl.) Fors*	Young leaves	Chewing young leaves
3	*Nicotiana tabacum L.*	Leaves & shoots	Used for smoking, chewing
4	*Rhamnus prinoides L 'H*	Leaves & sicks	used in the preparation of locale beer (Tella)

Source field data, 2023 .

4.4.5. Home-garden agro-biodiversity as sources of shade services

Local people used plants as a shade for different purpose like for cultural ceremonies, social meetings, recreational value and help as shade one to other plants (*Coffea arabica, Catha edulis, Ensete ventricosum, Cordia africana, Persea americana* and others) are intercropped plants in homegardens. This result similarly reported by homegardening practice of Wolayta by Girma Woldemichael *et al.*, (2018) in misha woreda. Shade plants consist of 14 (13.46%) species of total plant species that identified in the study area (App.I). The recorded plants have not only as a shade plant species but also have different functions.This means that tree plants are mostly handled for other purpose like construction material, furniture, income source, beauty aids, firewood, food but also used for shade value. This is similarly stated by Zemede Asfaw (2016) and this is non-destructive use of plants where no parts of plant removed from the mother tree and hence, it needs further encouregment and intensification. Furthermore, the most frequently distributed plants more than 50% of the homegardens were *Ensete ventricosum,, Cupressus lustanica, Cordia africana, Persea americana,, Croton macrostachyus, Mangifera indica, Grevillea robusta,* and *Podocarpus falcatus* (Table 18). This result nearly similar that reported by Solomon Tamirat (2015) in kochere woreda.

Table 18:. The most frequented shade value plants

No,	Scientific name	No of Hg a species occur	Total No Of Quadrants	Frequency in-which the spe-cies occur%	%Of Relative Frequency	Rank
1	*Cupressus lusitanica Mill*	323	60	46.6	1.2	3
2	*Ensete ventric osu0m(Welw.)*	5469	60	100	2.6	2
3	*Podocarpus falcatus (Thunb.)*	87	60	78	2	8
4	*Grevillea robusta R. Br.*	111	60	58	1.53	7
5	*Eucalyptus globulus L*	6475	60	88.3	2.1	4
7	*Cordia africana Lam*	288	60	50	1.31	5
8	*Mangifera indica L*	123	60	25	0.65	6
9	*Persea americana Mill.*	6543	60	95	2.5	1

Source field data, 2023

4.4.6 Home-garden agro-biodiversity as sources of domestic energy services

Since the area was had no electrification, the local peoples were dependent on fire wood. Most of these plant species were obtained from wild or semi-wild state and some are purposely planted in gardens for different purpose and indirectly used for fire wood. The important plants used as fire wood to the local people in the study area were trees and shrubs in their growth forms. Accordingly trees are the main source of fuel wood than herbs in the site surveyed. As reported by household informants.the most important ones were *Acacaia albida, Croton macrostachyus, Cupressus lusitanica, Eucalyptus camaldulensis, Juniperus procera, Millettia ferruginea, Olea europaea , Syzygium guineense, Lantana camara, Zea mays, Schinus molle , Ficus elastca, and Ficus* suri. There are similar findings (Tesfay Abebe & Zebene Asfaw, 2023, Tefera Jegora *et al*., 2019 that home-garden agro-biodiversity are alsoversatile sources of domestic energy such as ¦rewood and charcoal besides other agro ecological services.

4.6.7 Home-garden agro-biodiversity as sources of live fence and dry fence

Live fences were grown around houses and home gardens. The cost of live fencing is low, and sometimes the fence will continue to grow on its own, Home garden fences almost always contained live plants which provide additional benefits to families as food, medicine, material for construction, farm and household implements and cordage (Zemede Asfaw 2001).

The communities were cultivated live fence home garden plant species to provide additional benefits such as source of construction material, source of fruits, corridor, resting sites and ornamental at the gate of the homes common. Live fence plants of the study area includes trees, herbs, shrubs and climbers in their growth forms and they can grew by themselves or planted by household owners with specific useful purposes that is an important management practice observed in the area mainly to protect their home garden components,

The most important live fence home garden plants recorded in the study area were *Acacia albida, Euphorbia ampliphylla Acacia mellifera ,Calpurnia aurea, Dovyalis caffra, Erythrina brucei, Justicia schimperiana,Lantana camara, Pycnostachys abyssinica, Solanum incanum and Vernonia theophrastifoli*. This means that fences are very important to obtain multiple functions. There are similar ¦ndings from previous studies (Tefera Jorga et al., 2019, Tesfaye Abebe, 2023) that home-gardens also integrate into their landscape diverse plants species serving for live and dry fences.

Figure 9 Live fence home garden plant species

4.4.8 Home-garden agro-biodiversity as sources of forage and fodder

The importance of currently documented fodder and forage plants considered as one of the use categories. Out of the total plant species identified in the study sites, about 6 plant species accounting 5.76% of the total plant species (App. I). Considering their growth forms, 3(50%) species were herbs,1(16.6%) were shrubs and 1(16.6%) were climbers This result

is lower than that of reported by Abebeyehu Fanta (2014) in Sinan woreda and Reta Regassa (2016) in Hawassa city. These variations of result may be coming from geographical locations, altitudinal ranges and sample size.Livestock are an integral part of farming systems and are generally kept within homestead, and fodder trees have special place in home gardens (Shrestha *et al*., 2018).

The most common fodder species were species of *Zea mays, Musa acuminate, Ensete ventricosum* and *Anthocephaleus cadamba*. Fodder species like bamboo and broom grasses were planted in the home garden to protect land from soil. As reported by informants the most important fodder plants were *Cynodon dactylon* and Sesbania sesban in addition, the byproducts of crop plants Zea mayes,*Vicia faba, Ensete ventricosum, Phaseolus vulgaris, Saccharum officinarum, Xanthosoma sagittifolium Sorghum bicolor,* and *Hordeum vulgare* were served as forage for livestock. All these fodder and forage species are perennials that the study community used in successive harvesting to feed their animals throughout the year with no need for replanting. Similarly Alemtsehay Teka (2019) reported for Wonago woreda in Gedeo and Eza woreda in Gurage zone about the mode of feeding of cattle among homegardens and surroundings of their respective indigenous people

4.6.9 Home-garden agro-biodiversity as sources of ornamentals

Local people in the study area managed different types of ornamental plants in home-gardens. These plants give beauty aids and attractions for people. As reported by informants in the study area ornamental plants were used during festivities, holly days and cultural ceremonies to decorate their house and give pleasure for the family they also provided as live fences, shade trees and others and most of them are found at the front yard and on the side yards of the house.Documented ornamental plants in the study area according to household informant, were *Rosa x richardii, Cupressus lusitanica, Cymbopogon citratus, Santolina chamaecy, Podocarpus falcatus,Pelargonium whytei ,Rosmarinus offcinalis* and *Aloe otallensi.* Most of the ornamental plants located in front yard and side yard of houses.

Specially, near to house. But some are managed either in back yard or far to home infront yard. Most of the time, the ornamental plants grown near to house are herbs and shrubs with beautful flowers or inflourescence In addition, considering growth habits of the ornamental plants were tree 6.73% species, herbs 42% species, shrubs 14% species and tree 42% spe-

cies (App. I). This result unveiled that home-gardens integrate plants species mainly for enhancing the aesthetic bene¦ts as well as for environmental, economic, and social services of household wellbeing (Balasha *et al*., 2019, Pushpakumara *et al.*, 2020, Patel *et al.*, 2022).

4.4.10 Home-garden agro-biodiversity as sources of multipurpose plant species

Plant species with various functional categories such as construction, furniture and equipment, fire wood, charcoal, shade tree, and others were grouped under multipurpose functions. Under this category, a total of 24 species were recorded from the study area. Direct matrix ranking was made for elven frequently occurring multipurpose tree species against their six different uses such as food, medicine, construction, fire wood, and charcoal by ten indigenous knowledgeable persons.

The results indicated that *Ensete ventricosum, Persia Americana, C. macrostachyus* and *Cordia Africana*, with scores of 156, 115, 110, and 100 ranked first, second and third, respectively (Table 19).According to Zemede Asfaw (2011), plant species are utilized for multiple purposes apart from their single value The indigenous people of the study area practiced growing multipurpose trees, shrubs and grasses on the front or either sides of their houses, which provide a number of functions.

This result to be in agreement with Matheos Agize *et al*., (2013) reported the most frequently encountered multipurpose plants in the order of importance in Loma and Gena bosa districts of Dawuro zone were *Ensete ventricosum, Ficus vasta, Cordia africana, Croton macrostachyus, Arundo donax, Jatropha curcas, Maerua oblongifolia, Moringa stenopetala, Tamarindus indica* and *Terminalia brownie.* There are similar ¦ndings (Ivanova *et al.*, 2021, Hong & Zimmerer, 2022, Naigaga *et al.*, 2021, Khanal *et al.*, 2019) that home-gardens contain versatile plants, ranging from herbs to woody trees, with multi-functions for households.

Table 19:. Direct matrix ranking of elven multipurpose tree species from Wondo District homegardens based on five use types

plants Scientific name	Attributes, score and ranks						
	Food	Medicinal	Construction	Fire-wood	shade	Fence	Total
Cordia africana Lam	0	15	25	22	22	16	100
Croton macrostachyus Del.	0	24	25	25	20	16	110

Cupressus lusitanica Mill	0	0	24	23	25	20	92
Eucalyptus camaldulensis	0	0	25	25	24	23	96
Grevillea robusta R. Br.	0	0	21	22	23	21	87
Juniperus procera Hochst.	0	0	25	16	24	18	83
Mangifera indica L	25	12	0	16	20	12	85
Olea europaea L. subsp.cuspidata	0	0	22	22	24	12	80
Persea americana Mill.	25	25	21	12	22	10	115
Podocarpus falcatus (Thunb.)	0	0	25	16	24	14	79
Ensete ventric osu0m(Welw.)	80	21	23	0	32	0	156

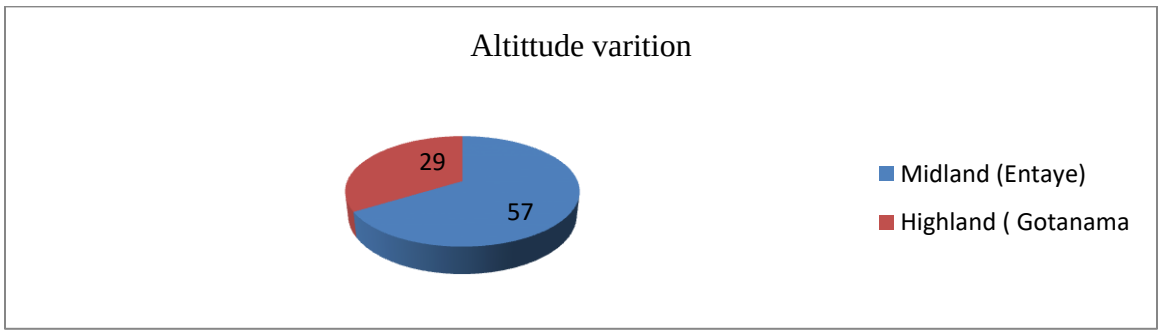
Source field data, 2023

4.5 Factors Affecting plant Species Diversity

4.5.1 Altitude variation

Altitude is a major factor for plant species diversity in home-gardens. The two specific study areas are laid in different altitude ranges.The highland altitude ranges from 2300 to 3200 m.a.s.l, whereas midland study sites ranges from 1500 to 2300 m.a.s.l, As a result, the plant species were recorded in the home-garden 29 and 57, respectively (Figure 10).

This might be due to diferences in agroecological conditions among Kebeles, as evidenced by (Ertiro *et al.*, 2017) who demonstrated that agroecology has an impact on variation. The difference in species diversity in two study sites is driven by the fact that the type of home-garden crops cultivated by the local people varies leading to the variation in the management and retention of plant species in their homegardens. This result is similar to Tesfaye Abebe (2005) in Sidama Zone, Southern Ethiopia where the altitude is above 2300 m.a.s.l the temperature is low and plant diversity is generally low.



Source field data, 2023

Figure 10: The homegarden plant species diversity in the two altitude range of the study site

4.5.2 Land use type

In the two study areas, the local people introduced plant species in their homegardens, including exotic species, different fruit trees, and cash crops. This led to plant species richness or diversity in the homegardens. There were different land use types in the two study sites. For example, the land use type of midland is dominated by coffee with shade tree (35.6) and scattered tree with annual crops (44.5%), where the high land is dominated by grazing grazing land with tree (23.8%), and plant with annual crops (52.5%) (Table,20).

Generally, this study showed that species richness, diversity and evenness varied with land use type/a. Lalisa and Herbert (2010) also reported that species richness, abundance and diversity of homegarden plant species are different among different land use practices. The result of the land use type variation played a significant role in plant species diversity variation between the two study sites. Motuma Tolera (2006) Arisi Negelle District, Ethiopia and Meresha Gebrehiwot (2013) in Gemmeto Galle, Southern Ethiopia indicated land use change in the homegardens over time.

Table 20: Land use type of two study sites (From n=351 respondent)

Land use	Entaye (midland)		Gutanama (highland)		X^2	P-value
	No.of HH	%	No. of HH	%		
Coffee with shade tree	68	35.6	31	18.4	12.173	0.000*****
Tree with annual crop	85	44.5	84	52.5		
Grazing land with tree	30	17.7	38	23.8		
Only plant grown land	8	4.2	7	4.4		
Total	191	100	160	100		

Source field data, 2023

4.5.3 Wealth status of the households

Wealth status also influenced the plant species composition in homegardens. The wealth status of the household was medium 38.2 % and 51.3 %, the poor 41.9 % and 33.8 %, the remaining

19.9 % and 15.0% are rich with better living condition in midland and the highland respectively The land holding size of household ranged from <0.5 to 2 ha and 0.3 to 1,5 ha in midland and highland respectively.

In the midland, the average species richness ranged from 8.6 to 5.4 specie. It showed a declining trend from rich to poor wealth class. In the highland, the average species richness ranged from 7.23 to 3.81ha. It showed declining trend from rich to poor wealth class. In the two agro ecological zones, the Chi-Square test result indicated that land sizes are significantly dependent on wealth category and traditional home garden agro- biodiversity and composition significantly dependent on wealth category Significant at P, 0.05 level. In this study, rich farmers had significantly higher number of species than poor farmers (Table 21).

This is because a poor tends to focus on few selected species to satisfy immediate needs. This is in line with research in homegardens of Arisi Negele, Ethiopia by Motuma Tolera *et al*. (2018) that reported poor farmers experience income constrain to focus on few selected species which generate money to satisfy their immediate needs.The wealth status significantly influenced land holding system between wealth categories, poor farmers hold small land size as compare to rich farmers. Nevertheles the wealth categories did not significantly influence the three weath categories (poor, medium and rich) in the two study sites. The reason is poor households intensively grow in their small sized garden. This result agreed with the earlier report of Meresha Gebrehiwot (2013) and diffent from the previous study report of Reshad (2006).

Table 21: Wealth Status of the Households in both sites

	Mid altitude (Entaye)			Highland (Gutanama)			P-value
Wealth status	Wealth status (%)	Species richness(no)	Average HGarea(ha)	Wealth status(%)	Species richness(no)	Average HGarea(ha)	
Rich	19.9	8.6	2.5	15.0	7.23	2	0.001*****
Midium	38.2	7.8	2	51.3	6	1.5	0.004*****
Poor	41.9	5.4	1.5	33.8	3.8	0.5	0.007*****

Source field data, 2023

*. Significant at the 0.05 level.

4.5.4 Stakeholder intervention

In any where homegarden plant species management may support by different stakeholders. During homegarden the study on plant species, the households (farmers) interview result 45(28.8%) of respondent were from (highland) only government institution and 59(30.9%) respondent from midland GOV were involved in homegarden plant species management. Nevertheless, 41(21.5%) of respondent of household and key informants like Elder and kebele development agents were informed that in Entaye study site nongovernmental organization like sustainable land management project that supported by World Bank Fund was involving on homegarden plant species management practites.

In addition, the household respondent interview result indicated that, stakeholder intervention in Entaye (midland), 38(19.9%) awareness creation and training, 10(5.2%) awareness creation and improved seed, and 12 (6.2%) of respondents say improved seed and seedling provision and 4 (2%) of respondents say awareness creation- improved seed and seedling provision were assessed (Table 22) and whereas Gutanama(Highland), 95(59.4%) of respondents 38(23.8%) awareness creation and training, 40(25.0%) improved seed provision, 6(3.75%) improved seed and seedling provision, 2(1.25%) awareness creation and improved seed, and seedling provision (Table 22) were assessed from household interview.

Table 22: Type of stakeholder intervention

	Type of stakeholder intervention							
Kebele	CRD	AWT	IPS	SDL	AWT+IPS	IPS+SDL	AWT+IPS+SDL	Sum
Entaye	-	38	54	10	10	12	4	128
%	-	19.9	28.3	5.2	5.2	6.2	2	66.8
Gutanama	-	38	40	9	-	6	2	95
%		23.8	25.0	5.6	-	3.75	1.25	59.4

Source field data, 2023

Key: AWT; awareness creation training, IPS ; improved seed and seedling, SDL, Seedling, CRD, Credit

4.5.5 Opportunities for plant species diversity

Different opportunities influence the diversity of plant species of homegardens. In two the study areas, midland site had access to, market (10.5%); seedling (15.7%) only extension services (14.7%); market and extension (18.6%); and market, price, seedling access and extension services opportunities (9.9%) (Table 23),

whereas the highland) site had access to, proximity to market (10 %); only price (6.9%); seedling access (13.1%); only extension services (16.3%); proximity to market and extension (21.3%); and market, price, seedling access and extension services opportunities (12.5%) (Table 23). These factors affected plant species diversity in the homegarden. The chi-square test revealed that there is statistically significant between the opportunities for home garden agrobiodiversity and composition (, $p < 0.05$). In both study site

The result agreed with earlier report of (Tefera Jogora, 2019). These opportunities contributed to species richness in the midland site but unaffectednot species diversity. They however contributed to low species diversity, whereas in the highland site low species diversity, which attribute to low level of the opportunities compared to the midland agroecology. The reason was there were less of the above mentioned opportunities in the Gutanama (highland) site. This demonstrates that, the presence or absence of opportunities affect plant species diversity in the homegardens.

Table 23: Opportunities for plant species growing in homegardens midland and highland agroecologies

Kebele	Opportunities for plant species growing in homegardens HG									
	MARK	PRI	SDL	CRD	EXS	MARK+EXS	MARK+PRI+SDL+CRD+EXS	Total	X^2	p-value
Entaye	20	23	30	35	28	36	19	194	12.134	0.001
%	10.5	12	15.7	18.3	14.7	18.8	9.9	100	6.321	0.034
Gutanama	16	11	21	32	26	34	20	157		
%	10.0	6.9	13.1	20	16.3	21.3	12.5	100		

Source field data, 2023

Key: MRK, Market; PRI, Price; SDL, Seedling; CRD, Credit; & EXS, Extension

4.5.6 Plant species preference of household

To assess plant species preference trends in the two agro-climatic study areas, respondents were asked to rank the three most important plant species among the species they retain or plant on their homegardens.

Accordingly, in highland area, *Millettia ferruginea, Bersama abyssinica and Vernonia auriculifera* ranked first, second and third corresponding to 20,15 and 13 respectively for fuel wood consumption purpose; *Bersoma abyssinica, Eucalyptus spp*. and Prunus africana ranked first, second and third corresponding to 25,17 and 13 respectively for construction purpose; Eucalyptus spp., *Millettia ferruginea and Coffee arabica* ranked first, second and third corresponding to 11,9 and 7 respectively for sale purpose; *Vernonia auriculifera, Croton macrostachyus and Hagenia abyssinica* ranked of first, second and third corresponding to 9,8 and 6 for medicine purpose; *Hagenia abyssinica, Eucalyptus spp. and Prunus africana* ranked first, second and third corresponding to 20,15 and 10 respectively for farm implement purpose; and *Millettia ferruginea, Eyrthina brucei and Vernonia auriculifera* ranked first, second and third corresponding to 25,24 and 23 respectively for shade purpose.

More over, *Croton macrostachyus, Vernonia amygdalina and Schefferrela abyssinica* ranked first, second and third corresponding to 18,10 and 8 respectively for bee keeping forage purpose; *Vernonia auriculifera, Millettia ferruginea and Eyrthina bruce*i ranked first, second and third corresponding to 25,15 and 11 respectively for soil fertility purpose; *Vernonia auriculifera, Millettia ferruginea and Eyrthina brucei* ranked first, second and third corresponding to 10,15 and 12 respectively preferred for soil fertility purpose; *Cupressus lusitanica, Hagenia abyssinica and Jacaranda mimosifola* ranked first, second and third corresponding to 9,7 and 2 respectively were preferred for aesthetic value purpose.

The result agreed with previous study report of Getahun Yakob *et al.* (2014). Basically, household plant species preferences were depended on its use or purpose of plant species and varied with due to altitude and socio cultural factors. In the highland site, most household preferr mainly indigenous multipurpose trees species which were incorporated into the homegardens, commonly nitrogen fixers or soil fertility improvement species were preferred in this study area. This result agreed with GetahunYakob *et al*. (2014) , but in the midland area, households mainly preferred cash and fruit species. The reason for plant species preference

was depending on altitude and socio economic culture of local communities. Therefore, household plant species preference is the factor forin fluenced plant species diversity and richness, in addition to the agro ecological suitability.

4.6 Traditional knowledge and home-garden agro-biodiversity management

4.6.1 Management of plant species diversity and composition

Traditional management practices or indigenous knowledge was used to handle different types of plant population in and around homegardens. Local people named homegardens as Eddo, Hoddo, or Boro, Mandubee in Afan Oromo. In the study area, local people developed a general homegarden plants with considerable diversity and composition that facilitates productions of the major livelihood necessities.

They have managed to select crops that co-adapt and give multiple values. In current study, about 104 useful homegarden plant species were identified based on different use categories. Local people managed well these plants to obtain multiple benefits like nutrition value, medicinal value, ornamentals, constructional materials, furniture, income source, firewood, fences, shade, multipurpose and tool making value. This shows the significance of home-garden agro-biodiversity to households. This result was consistent with earlier findings Zemede Asfaw (2001) and Tefera Mekonnen (2011).

4.6.2. Sources of seed, seedling production and planting materials management

Growing planting materials at nursery sites substantially benefited the management of agrobiodiversity in home-gardens. Households managed a variety of important home-garden agrobiodiversity in their small-scale nursery sites. *Ensete ventricosum, Persea americana*, and other important species were among those that were raised and planted. These planting materials selections practices were performed by the local people using different criteria. These are yield quality and quantity, times of length from planting to harvesting, resistant to diseases, pests, and drought. In addition, the local farmers performed practices of propagagtion, thinning, transplanting, seedling and harvesting.

Tradtionally farmers have accumulated knowledge to produce and plant seedlings in their home-garden. The farmer got plant seedlings and plant materials from different sources (Table 24). In the midland home-gardens, self raised homegarden (32.5%), relatives (15.7%), market (35.6%) and from agricultural office nursery site (16.2%). All households (100%) planted plant

species in their homegarden (Table 24), whereas in the highlands, sources of seedling from self raised (25.0%), relative (15.6%), market (26.9%) and from agricultural nursery site (32.5%).

.This result similarly stated by Tadesse Kippie (2002) about selection and storage of planting materials for farmers of Gedeo people as an important management component of the well-developed agroforestry systems; Solomon Tamirat (2015) stated in Kochere woreda and Regassa Bekele (2014) reported in Bishfitu town.

The result is also similar to earlier report of Getahun Yakob *et al*., (2014) in Gimbo District. Nursery site contribute much in growth and continuity of homegarden species acquired for planting material (Solomon Tamirat,2015). During the dry season of the year, some essential homegarden species were selectively planted and grown in their small-scale nursery site through care and effective protection. Some of the dominant species which were planted and grown in the nursery area were; *Coffea arabica*, *Enset ventricosum*, *Sesbania sesban*. *Millettia ferruginea*, *Cupressus lusitanica* and *Persea americana*

Table 24: No. of respondent for plant seedlings planting of plant species planted in homegardens and sources of seedlings

	Planting of seedlings in home-garden		Sources of seedlings				
Kebele	Yes	No	Sum	SLR	Relative	Market	AGD
Entaye	191	-	191	61	30	68	31
%	100	-	100	32.5	15.9	35.6	16.2
Gutanama	160	-	160	40	26	43	52
%	100	-	100	25.0	15.6	26.9	32.5

Key: SLR, Self raise; AGD; Agricultural Development/ From government nursery

Figur 11 Seedling preparation by local peole *(Source*; photo by Sori Alemayhu)

4.6.3 Seedling management practices

Farmers traditionally managed plant seedlings in their homegarden to get multiple benefits. Thinning, composting and weeding were the most commonly used management practices in the site (Table 25). Thinning and weeding (7.5%), weeding and hoeing (22%), thinning, weeding and hoeing (23.9%) and only weeding(30.2%) were the traditional management practices in the home-gardens by households in the highlands (Table 25) whereas, weeding and hoeing(7.4%), thinning, weeding and hoeing (2.7%), only compositing(8.9%),,only puring (4.7%) and only weeding (31.6%) were the traditional management practices implemented by households in the midlands (Table 25).

Table 25: Traditional seedling management practices in homegardens (n=351)

Site	Type of management practices

Kebele	TH	PR	CMP	WDG	HOG	TH+WDG	WDG+HOG	TH+WDG+HOG	CMP+WDE+HOG
Entaye	-	9	17	60	-	11	37	53	-
%	-	4.7	8.9	31.6	-	7.4	19.5	27.9	-
Gutanama	-	9	17	48		12	35	38	-
%	-	5.7	10,7	30.2		7.5	22	23.9	-

Source field data, 2023

Key: TH, Thinning; PR, pruning; CMP, composting; WDG, Weeding; & HOG, Hoeing

4 .6 .4 Securing (fencing) home garden plants

The close relationship between house, garden and family is the role the home garden plays in terms of security. The most common plant species that used for live fences were *Cupressus lusitanica, Dovyalis caffra , Euphorbia ampliphylla, Justicia schimperiana, Vernonia amygdalina* and *Sesbania sesban.* Similarly, reported by Abebeyehu Fanta (2014) in Sinan woreda and Solomon Tamirat (2015) in kochere woreda. Although, the plant species that local people frequently used for dry fences were *Eucalyptus camldensis, Arundinaria alpina, Arundo donax, Balanites aegyptiaca, Sorghum bicolor* and *Zea mays*. As reported by Zemede Asfew (2001) one or the other part of gardens might be free of fencing.

In view of that, most of the time the local people used fences infront of houses or front yard, side yard (near to house), back yard (near to house), at the end of the farms and sometimes at boundry side. This result indicated that the importance of fences to care of homegarden and surroundings from different barriers. Similar result reported by Solomon Tamirat (2015) in kochere woreda.

4.6.5 Traditional home-garden agro-biodiversity and soil fertility management

Both organic and inorganic fertilizers were used for the management of soil fertility of homegardens. As a result, the soil become black, moist, fertile and suitable for cropping diverse plants. Similarly, the response of key informants implied that the users of organic fertilizers occupied the highest portions with the percentages of 75%. This means that the majority of people in the study rea used inorganic fertilizer. This result supports the outcomes of interviewer's reports. In general, the highest percentages of local people in the study area used inorganic fertilizer for adjoining crop fields.

This result to be in greement by Telamo Seta (2013) in wolayita, Tefera Mekonnen (2010) in sebeta-hawas woreda and Solomon Tamirat (2015) in kochere woreda. In addition, Kembata people kept the soil fertility by using various traditional management practices. These techniques are intercropping legumes plants with other crops, which have ability to fix nitrogen in the soil that ensures its fertility. Specially, *Fabaceae* family species that known to keep the soil fertility.

Besides, the local people of the study area, added plant residues, straws of crops, some older parts of the leaves and by-product of different plants to increase the soil organic matter which enhances the fertility. Furthermore, the study area people used crop rotation to rehabilition of the soil fertility. For instance, *Phaseolus vulgaris* replaced by *Eragostis tef*, *Triticum aestivum* and *Hordeum vulgare*, and *Vicia faba* substitute by *Solanum tubersum* and *Colocasia esculenta*. This result also reported by Solomon (2015) about Gedeos' soil management practices involves the appliction of plant residues, planting of legumes trees and shrubs, and growth of herbaceous undergrowth in homegarden and crop fields.

Figure 12: The importance of animal dung and enset residue for soil fertility

4 .6.6 Traditional practices to increase the productivity of home-garden agro-biodiversity

Management practices like intercropping were observed among people of the area in which *Zea mayes* was intercropped with *Canavalia ensiformis, Ipomoea batatas, Capsicum annuum, Cucurbita pepo* and *Brassica species*, to collect more amount of product per unit area to optimize with shortage of land and to fulfill the diverse household needs. This is a common case of home garden management practice observed in south Ethiopia (Tadesse Kappie, 2002; Tesfaye Abebe, 2005 and Talemos Seta, 2013).

Figure 13: The tradition of diversifying plants in the study area (Source ;photo by Sori Alemayhu)

4 .6.7 Disease and pest control

Garden pests like termites that damage tuber crops such as *Solanum tuberosum and Ensete ventricosum* were controlled by the application of wood ash to the soil according to garden owners. Sprinkling a wood ash around the base of young plants, and also lightly on new leaf growth is known to deter insects and fungi (FAO, 2019). The burrowing of diseased insects by digging the soil to prevent transmission of bacterial and viral disease were another indication of local management strategy practiced by people .This observation is in line with anti-pest properties used by the Chagga people in Tanzania (FAO., 2022) showed that they were used as a first step protection, indicating potential uses of indigenous knowledge

4.6.8 Traditional ploughing method

Local people in the study area used various method to plough their farms. These various methods are ploughing by oxen and manual (Table 26). According to household interviewers' and key informants, 42.7% of household informants and 30% of key informants reported that ploughing by oxen and 57.3% of household owners ploughing by manual method (Table 26). The manual method users have small farm sizes near to house. However, none of the farmers

used tractor because of small farm size. This result showed that highest portions of the local people in the study area used manual for adjoining agricultural fields.

Table 26. Sources of planting materials, fertilizer and ploughing method

Fertilizer user	Informants (n= 351 HH)	Percent (%)	Rank	Keyinformants (n=10	Percent (%)	Rank
Organic (Compost and manure)	82	23.4	3	3	20	3
Inorganic (DAP & Urea)	165	47	1	5	50	1
both users	104	28.6	2	2	30	2
Traditional ploughing plow						
Method						
Using ox	150	42.7	2	3	30	2
Manual	201	57.3	1	7	70	1
Tractor	0	0		0	0	

Source field data, 2023

4.6.9 Responsible for plant species management

Household interview surveys revealed that households managed their home-gardens' agro-biodiversity by using their traditional and indigenous knowledge. Despite the fact that both men and women managed their own home-gardens, women were more involved a variety of jobs, including planting, growing, watering, fertilization, weeding, harvesting, storing, transporting, and marketing fruits and vegetables. Among the family member, men are the main managers of the homegardens practicing ploughing plow, preparations, sowing, planting and maintenance.

Women are responsible for trading their products and making compost. Men also participate in activities such as fencing, weeding, watering and harvesting of products, mainly those of fruit producing shrubs. Both men and women cultivated and managed root and tuber, vegetable crops, spices, and medicinal plants. However, taking of fresh products of these plants to the market was carried out mainly by women and children.

Besides, young children are not only participating on farming activities but also keep ornamental plants near to house. This activity specially done by young females. This result showed that the highest management practice taken by males in the family For example, in Gotanama (highland) study area, 40.6%, 19.4%), 22.5%, and 17.56% of respondents were agreed on men, men and boy, all family members (men, women, boy and girls) were respectively responsible for

homegarden plant species management (Table 27), whereas in midland study area, 42.9%, 19.4%, 24.1%, 13.6 %, of respondents agreed on men, women, girl and all family members (men, women, boy and girls), were respectively responsibile for plant species management (Table 27). Women worked mostly in home-gardens where subsistence crops were grown,

however, women's engagement was relatively minimal in home-gardens where cash fruit crops and trees predominated (Konyak *et al.*, 2022, Khan *et al*., 2021, Pradhan *et al.*, 2021). Women played significant roles in planting, protecting, managing, harvesting and utilizing home-garden agrobiodiversity. Male farmers or house-headers believed that women are effective managers of the home-garden species in Ethiopia

Table 27: Responsible for plant species managemen

gero-ecology of the study area	esponsible for plant species management			
	Men	women	Girl	All family
Midland	42.9	19.4	24.1	13.6
Hghland	40.6	19.4	22.5	17.5
otal	83.5	38.8	46.6	31.1

Source field data, 2023

4.7 Threats to the management of traditional home-garden agro-biodiversity

During interviews, the Focus group discustions listed more than 10 major threats of home garden agro- biodiversity in the study areas.(Table 28). According to respondants, 16% of household informants and 40% of key informants reported that disease and pests are the mian and the top factors incase of affecting plant diversity and composition followed by the effect of farm size with the 16% of gardener informants and 20% of key informants, and Lack of awerness with 12.8 % of household. Besides, in the case of Lack of economic status, 11.1% of household owners and 63% of Focus group discustions replied as the fourth major threat to the plant diversity and composition in the study which ranked 1st – 4^{th} respectively.

This means that the most home-garden and its surroundings management and conservation of plant resources affected by disease and pests. This result is in agreement with Solomon Tamirat (2015) in kochere woreda and Tesfay Abebe (2005) stated that altitude had an effect on on the evenness or distribution of plant species and area share of cropsin the study area. With regard to farm size, 39% of household informants and 37% of key informants reported that the size of farms reduced the species richness and the area share of major crops. For instance, in the midland (1500-

2300) meter above sea level and highland (900- 2000) meter above sea level the largest area covered by cash crops like zingiber officinale and colocasia esculenta. As a result, the area shares of Ensete ventricosum and others reduced.

This result similarly stated by TesfayeAbebe (2005) farm size had significant effects on the area share of crops. In addition, lack of agricultural inputs like seeds, seedlings and fertilizers are one of the obstacles to the managements of plant in the study area. In the same manner, there is a lack of agricultural office support to create awareness to the farmers. On the other hand, climate conditions like warm/hot air conditions affected some crops like *Ipomoea batatas* was rare or no longer grow around study area, and lack of regular rainfall distribution. Inaddition, lack of water availability or access to used instead of rainfall during winter season or shortage of rain.

Besides, plants destructed by different animals like Echidna, which affected *Ipomoea batatas and* young *Ensete ventricosum* corms, ape that affected *Zea mays* and birds' feds on *Zea mays* and *Sorghum bicolor.*Indeed, lack of economic status more related to buy seed, seedlings and fertilizer, and also to keep livestock specially ox which used to plough their farms. As whole, these all factors are the major constraints and challenges to the managements and conservations of plants around home-gardens and adjoining agricultural fields. This result similarly reported by different studies carried out, the results of FAO (2023) and Rahman *et al*. (2017) and Tefera Jorga., *et al*. (2019) revealed that differences in climate, edaphic and socioeconomic factors brought change in composition and biological diversity of plants.

Table 28: Major threats of the management of traditional home-garden agro-biodiversity

No,	Major threats of home garden agro- biodiversity	Respondant (n= 351)	Percent (%)	Rank	Key yinformants (n=10)	Percent (%)	Rank
1	Altitude	18	5.1	9	2	20	2
2	Climate condition	24	6.8	8	-	-	
3	Farm size	56	16	2	1	10	4
4	Lack of awerness	49	12.8	3	1	10	4
5	Lack of market access	34	9.7	5	-	-	
6	Drought (water shortage).	18	5.1	9	-		

7	Disease and Pests	59	16.8	1	4	40	1
8	Distruction by animals	33	9.4	6	-	-	
9	Lack of economic status	39	11.1	4	2	20	2
10	Floods	25	7.1	7	-	-	

Source: Questionnaire survey, 2023

The top five factors affecting home-garden agro-biodiversity management were home-garden size; disease and pest; illegal trading and lack of access to market places, transportation and infrastructure facilities; and unstable price of fruits, vegetables and other crops that eventually caused §uctuations in household income. Generally, poor economic background related to buying good quality seeds, and seedlings; declining landraces; diseases and pests; inadequate support from extension services; poor market value chain; shortage of traction power; and poor management of wild animals were the major bottlenecks to managing home-garden agro-biodiversity.

Therefore, trainings, incentives for tree plantings and seedling distribution, pest and disease management, marketing, etc. need attention by all stakeholders. There are similar ¦ndings from previous studies in Ethiopia (Zebene Asfaw & Yohannes Zergaw, 2022) that similar challenges predominantly constrainedthe sustainable management of traditional home-garden agro-biodiversity and similar recommendations such as promoting researches on home-gardens agro-biodiversity and agro-ecological services, creating awareness of stakeholders, scaling-up of appropriate home-garden components, provide quality seeds and seedlings, and reinforce policies and strategies that encourage farmers and key stakeholders to make home-gardens an alternative to improve their welfares**.**

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5. Conclusion and Recommendations

5.1 Conclusions

- The traditional home-garden agro-biodiversity is an integral component of local agri-food – agroforestry system in rural settings, which provides multiple agro-ecological services.
- A total of 104 plant species distributed in 41 families grouped in to 11 functional groups were documented in the study area. *Poaceae* was the most frequently observed family containing eliven species, followed by *Poaceae* containing ten species, Rutaceae seven species.
- In the study area the species diversity of homegarden plants were ranged between 2.35 to 2.87 and the species richness was ranged between 29 to 57 plant species. Species diversity index indicated that there is alittle significance difference across the district and had less species richness when compared with other study sites.
- The result of this study indicate that homegarden crop plant produced in Wondo District has many use-values like: source live fence, fodder, firewood, food, medicinal, shade, spices, furniture, ornamentals, construction, aromatic and stimulants.
- Results of the study showed that people of the study area practice home- gardening with minimum and maximum hone garden sizes of 0.25 and 2.5 ha.
- In the study area the composition of home-garden crop plants were located backyard containing (35%) and considered as the wider parts of home-garden containing most food crops, income source homegarden plants and some multipurpose plant species.
- The states of homegarden is at alarming rate, are at the verge of extinction in most of the areas the homegarden are turning to be mono-cropping, chat dominated homegardens .
- Although households manage the soil fertility and productivity of their home-gardens using both organic and inorganic fertilizers, the majority of them preferred organic fertilizers over inorganic fertilizer due to their accessibility, ease of production, environmental friendliness, and long-lasting effects on soil fertility and productivity, among other factors.

- Farmers in the study area obtained seed and seedling of homegarden components from different sources. The purchased seed contributed the first source of planting materials.

- Self-saved seeds, sharing between and among homegarden owners, and seeds or seedlings obtained from agriculture bureau were also sources of planting materils.

- This has increased the genetic diversity of the district. But there are factors affecting the diversity and productivity of homegarden plants.

- These include lack of access to water, Socio-economic status, soil fertility, garden size, cultural and personal preferences variation of seasons and the knowledge gap in the cultivation, agricultural input support, animals and birds, crop pests and occurrence of plant diseases.

- The frequently distributed plant species varied along each site or one altitude to others. The *Ensete ventricosum* occurred through all homegardens frequently. This shows that the necessity of plants for food value and income sources.

- The local people in the sudy area have traditional indigenous knowledge for managing their homegarden crop plants by watering, fencing, fertilizing, isolating infected plants, storing products by drying, smoking and hunging surrounding their house frame work

5.2 Recommendations

Based on the results of the study, the following suggestion are recommended

- Maintenance of Mandubee (Wondo'traditional homegarden) is a strategy for complementarities between in-situ and ex-situ conservation of agrobiodiversty, and thus it should be considered as priority area of conservation
- Roads should be built to address transportation towards the produced homegarden products to make farmers gain good markets and motivate them
- Encourage home-gardening for agro- biodiversity conservation and management as well as for cultivation of spices, food plants, medicinal plants and other multipurpose species
- Further studies are required to fill the gap of this work such as analysis of soil sampling, and land use management system in the area. Because the present study was limited to assess the status of home-garden agro- biodiversity along with their traditional

management practices and uses, and to generate and make available information on their roles for in situ conservation of agro-biodiversity

- ❖ Indgienous knowledge and experience of homegardeners is very impotant to conserve species diversity and genetic resources. This need to support by scientific knowledge to increase its consistency for future generation
- ❖ Governments, NGO and private sectors should support by giving planting materials or facilitates the way to propagates on their homegardens and encourages use of composts in modern way instead of using chemical fertilizer.
- ❖ Agricultural research center and university research centers should give attention to encourages and interconnect the indigenous knowledge with scientific knowledge, specially incase of uses of traditional ways to treat plants like planting *Pycnostachys abyssinica* around diseased *Ensete ventricosum*, and used for other animals and human ailments.

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Appendic:

Appendix 1: Plant species inventoried in Wondo District homegardens, Scientific name, Family name, Local name, Amharic name, Habit, use and Agro-ecology (N=351).

No,	Scientifc name	Family name	Local name Affan Oromo	Amharic name	Habit	Use	Agroecology
1	*Acacia albida Del*	Fabaceae	Laftto	Grar	T	LF,CS,SH,FW	High
2	*Acacia mellifera (Vahl) Benth*	Fabaceae	Harangama	Kontir	T	LF,FW	Mid
3	*Agave sisalana Perrine*	Agavaceae	Argissa	Kacha	H	LF,OR	Mid
4	*Allium cepa L.*	Alliaceae	Qullubii-diimaa	key shinkurt	H	SP,MD	MH
5	*Allium sativum L*	Alliaceae	Quu lubii-adii	nech shikurt	H	MD	High
6	*Aloe monticola Reynol*	*Aloaceae*	Hargiissa	Erret	H	MP,LF	Mid
7	*Annona senegalensis Per*	Annonaceae	Gishta	Gishita	T	FR	Mid
8	*Artemisia absinthium L*	*Asteraceae*	Arta	Harti	H	MD	Mid
9	*Arundinaria alpina K. S*	Poaceae	Lemen	Kerkha	H	LF,OR	High
10	*Arundo donax L.*	Poaceae	Shambako	Shambako	H	LF.OR	High
11	*Beta vulgaris L.*	Chenopodiaceae	Hundee diimaa	Qosta	H	VG	Mid
12	*Brassica carinataL.*	Brassicacea	Yeguragiegomen	Bedeno	H	FW,SH	MH
13	*Brassicaintegrifolia (West)*	Brassicaceae	Shana marama	Tikilgomen	H	VG	Mid
14	*Calpurnia aurea (Ait.)*	*Fabaceae*	Ceekaa	Digeta	T	LF,MD	Mid
15	*Canavalia* ensiformis (L)	Fabaceae	**x**	Adenguare	H	CR	Mid
16	*Capsicum annuum L*	*Solanaceae*	Brbare	Kariya	S	SP	Mid
17	*Capsicum frutescens L*	Solanaceae	Barbaree	Mitimeta	S	SP	Mid
18	*Carica papaya L.*	*Caricaceae*	Paappayyaa	Papyia	H	FR	Mid
19	*Carthamus tinctorius L.*	Asteraceae	Suff	Suf	H	OL	Mid
20	*Casimiroa edulis L*	*Rutaceae*	Shasho	Kasmir	T	FR	Mid
21	*Catha edulis (Vahl.) Fors*	*Celastraceae*	Jimaa	Chat	T	ST	Mid
22	*Citrus sinensis (L.) Osheck*	*Rutaceae*	Lomii	Lomi	T	FR	Mid

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No,	Scientifc name	Family name	Local name Affan Oromo	Amharic name	Habit	**Use**	Agro-ecology
23	*Citrus medica L.*	*Rutaceae*	Turungoo	*Tirengo*	T	FR	Mid
24	*Coffea arabica L.*	Rubiaceae	Buna	Buna	T	ST	MH
25	*Collocasia esculenta (L.) Schott*	Araceae	Godarree	*Godare*	H	AT	High
26	*Cordia africana Lam*	Boraginaceae	Wadeecha	Waniza	T	,SH,Mp	Mid
27	*Coriandrum sativum L.*	Apiaceae	shucar	Demblal	H	SP,CS,SH	High
28	*Croton macrostachyus Del.*	Euphorbiaceae	Bakkanisa	Bisana	T	CO,MP	MH
29	*Cucurbita pepo L.*	Cucurbitaceae	Buqqee	Duba	Cl	FR,Fd	Mid
30	*Cyperus cyperus*	Cyperaceae	x	Engcha	H	Fd. OR	High
31	*Cymbopogon citrates (DC.)*	Poaceae	Tegisara	Tej sar	H	SP,MD	High
32	*Cupressus lusitanica Mill*	Cupressaceae	Gatira faranji	Yeferenji tid	T	FW,CS,MP,	High
33	*Cytisus proliferus L. F.*	Poaceae		Menozaf	S	Fd	High
34	*Eleusine floccifolia (Forssk.)*	Poaceae	Coqo sa	Serdo	H	Fd	Mid
35	*Daucus carota L.*	Apiaceae	Carorot	Karrot	H	AT	High
36	*Dioscorea alata L*	Dioscoreaceae	X	Ochone	H	AT	Mid
37	*Dioscorea bulbifera L*	*Dioscoreaceae*	Boyena	Boyena	H	AT	High
38	*Dovyalis caffra(Hook.f &Harv.*	Flacourtiaceae	Koshomii	Koshim	T	LF	Mid
39	*Echinops kebericho Mesfin*	Asteraceae	Kabaricho	Kebricho	H	MD	High
40	*Ehretia cymosa L*	Boraginaceae	Uraaga	Game	T	Oi	Mid
41	*Ensete ventricosum (Welw.)*	Musaceae	Qoccoo	Enset	H	AT,MD,SH	MH
42	*Eragrostis tef (Zucc.)*	Poaceae	Xaafit	Teff	H	CR	Mid

Appendix 1: Plant species inventoried in Wondo District homegardens, Scientific name, Family name, Local name, Amharic name, Habit, use and Agro-ecology (N=351).

No,	Scientifc name	Family name	Vernacular Name Affan Oromo	Amharic name	Habit	Use	Agro-ecology
43	*Erythrina brucei Schweinf*	Fabaceae	Korchii	Korch	T	LF,SH.OR	High
44	*Euphorbia ampliphylla Pax*	Euphorbiaceae	Adaamii	Kulkuwal	T	CS,FW	Mid
45	*Eucalyptus globulus Labill.*	*Myrtaceae*	Bargamo-adii	*Nech bahir zaf*	T	LF	High
46	*Eucalyptus camaldulensis*	Myrtaceae	Bargamo-diimaa	Key bahirzaf	T	MD,Co,MP	High
47	*Euphorbia trucalli L.*	Euphorbiaceae	Chada	Kinchib	T	MD,FD	Mid
48	*Ficus elastca Roxb. ex*	Moraceae	Yegoma zaf	Yegoma zaf	T	LF	Mid
49	*Ficus sur Forssk.*	Moraceae	Harbuu	Shola	T	SH,	Mid
50	*Ficus vasta Forssk.*	Moraceae	Qilxaa	Warka	T	FW.CS	MH
51	*Glycine max (L.) Merr*	Fabacea	X	Akuriater	H	Pu,Fd	High
52	*Grevillea robusta R. Br.*	Proteaceae	Giraaviiliyaa	Gravil	T	CS,SH	Mid
53	*Hagenia abyssinica (Bruce)*	Rosaceae	Heto	Kosso	T	FW,MD	High
54	*Hordeum vulgare L.*	Poaceae	Garbuu	Gebs	H	CS	High
55	*Ipomoea batatas (L.)Lam.)*	Convolvulaceae	Maxaxasha	Sukar dinch	H	AT	Mid
56	*Jacaranda mimosifolia D*	Bignoniaceae	Muka kewie	Jacaranda	T	SH ,FW	Mid
57	*Jatropha curcas L.*	Euphorbiaceae	Ayderke	Yeferenji kobo	T	SH,FW	Mid
58	*Juniperus procera Hochst.*	Cupressaceae	Gatira Habasha	Yehabesh tid	T	SH,FW,MP	Mid
59	*Justicia schimperiana (Hochst.ex Nees) T.Anders*	Acanthaceae	Dhummugaa	Sensel	T	SH	High
60	*Lantana camara L.*	Verbenaceae	Ye- wof kolo	Yewof kolo	S	SP,LF	Mid
61	*Lepidium sativum*	Brassicaceae	Fetto	Fetto	T	FW	MH
62	*Lippia adoensis Hochst*	Verbenaceae	Kusaaye	Kasseret	S	SP	High
63	*Lycopersicon esculentum*	Solanaceae	Timatimi	Timatim	H	FR	Mld
64	*Lagenaria siceraria (Molina) Standl.*	Cucurbitaceae	Bukke	Kil	Cl	0R	Mid

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No,	Scientifc name	Family name	Local name Affan Oromo	Amharic name	Habit	Use	Agroecology
65	*Mangifera indica L*	Anacardiaceae	Maangoo	Mango	T	.FR, SH	Mid
66	*Manihot esculenta Crantz*	Euphorbiaceae	Cassava	Kassava	T	AT,MD	Mid
67	*Melia azedarach L.*	Meliaceae	Milia	Milia	T	MD	Mid
68	*Millettia ferruginea Hochst.*	Fabaceae	Birbirraa	Birbira	T	,SH,FW	Mid
69	*Moringa stenopetala (Bak.)*	Moringaceae	Shifera	Moringa	T	MD,VG	Mid
70	*Morus alba L.*	Moraceae	Enjorie	Enjori	T	,FR	High
71	*Musa x paradisiacal L.*	Musaceae	Muzii	Muz	H	FR,Fd	Mid
72	*Nicotiana tabacum L.*	Solanaceae	Timboo	Timibaho	H	ST	Mid
73	*Ocimum basilicum L.*	Lamiaceae	Siqaqime	Besobila	H	SP	Mid
74	*Ocimum lamiifolium H*	Lamiaceae	Qoricha-michii	Damakese	S	MD	High
75	*Ocimum urticifolium*	Lamiaceae	Koricha-alkani	Dema Kassie	H	SP	MH
76	*Olea europaea L. subsp. cuspidata*	Oliaceae	Ejeersa	woyra	T	OR,SH,MP,CO	MH
77	*Opuntia cylindrica (La*	Cactaceae	Adami	Qulqal	H	Lf	Mid
78	*Pennisetumviolaceum (Lam.)L. Rich.*	Poaceae	Marga harba	zihone sar	H	Fd	Mid
79	*Persea americana Mill.*	Rutaceae	Abukado	Abokado	T	FR,MP	Mid
80	*Phaseolus vulgaris L.*	Fabaceae	Boloqqie	Adenguware	H	CR	MH
81	*Phytolacca dodecandra L'*	Phytolaccaceae	Andodee	Endod	S	MD.SH	High
82	*Podocarpus falcatus (Thunb.)*	Podocarpaceae	Birbirsa	Zigiba	T	Fw,SH,MP	MH
83	*Prunus africana (Hook. f.*	Rutaceae	Hoomii	Tikur enchet	T	Fw,SH	Mid
84	*Psidium guajava L*	Myrtaceae	Zeytunaa	Zytone	T	FR	Mid
85	*Prunus persica L.*	Rosaceae	Kokkii/Kok	Kok	S	FR	Mid
86	*Rhamnus prinoides L 'H*	Rhamnaceae	Geeeshoo	Gesho	T	SP	MH
87	*Ricinus communis L.*	Euphorbiaceae	Qobboo	Gulo	T	OL	Mid

Appendix 1: Plant species inventoried in Wondo District homegardens, Scientific name, Family name, Local name, Amharic name, Habit, use and Agro-ecology (N=351).

No,	Scientifc name	Family name	Local name Affan Oromo	Amharic name	Habit	Use	Agro-ecology
88	*Rosa abyssinica Lindley*	Rosaceae	Qega	Qega	S	FW	Mid
89	*Rosa hybrida Hort.*	Rosaceae	Sgie-rada	Tsigereda	S	OR	Mid
90	*Rosmarinus offcinalis L.*	Lamiaceae	Siga-metibesha	Sigametibesha	S	SP,OR	MH
91	*Ruta chalepensis L.*	Rutaceae	Chiracot	Tenadam	S	SP,MD	MH
92	*Saccharum offcinarum L.*	Poaceae	Shenkor-ageda	Shenkora	H	FR,FO	Mid
93	*Schinus molle* ***L.***	Anacardiaceae	Alaaltu	Turimanturi	T	FW,SH	Mid
94	*Sesbania sesban (L.) Merr.*	Fabaceae	Sasbaaniyaa	Sesbania	T	Fd	High
95	*Solanum incanum L*	Solanaceae	Hidi	Embay	S	LF	Mid
96	*Solanum tuberosum L*	Solanaceae	Dinicha	Dinich	H	AT	MH
97	*Sorghum bicolor (L.) Moench*	Poaceae	Mashela	Mashila	H	CR	Mid
98	*Syzygium guineense. Subsp guineense*	Myrtaceae	Baddessa	Dokma	T	Fw,FR,LF	Mid
99	*hymus schimperi Ronninger*	Lamiaceae	Tossign	Tossign	H	SP,MD	High
100	*Vernonia amygdalina Del*	Asteraceae	Dhebicha	Grawa	T	MD	MH
101	*Vernonia auriculfera Heirn.*	Asteraceae	Reejjii	Gengerita	T	LF	High
102	*Vicia faba L.*	Fabaceae	Baqeella	Bakela	H	CR	High
	Withania somnifera (L.)	Solanaceae	Gizaawaa	Gizewa	S	MD	High
103	*Xanthosoma sagittifolium (L.)*	Araceae	Bonaan diimtuu	Godare	H	AT	Mid
104	*Zea mays L.*	Poaceae	Boqqolloo	Bokolo	H	CR	MH

Growth habits- T= Tree, S=Shrub, H=Herb, Cl=Climber

Agro-ecosystem services : F=Food plants, ; MD: Medicnal;FR, CR = cereal, fruit,VG;vegitabel; AT;aerial tuber; CO: Construction of houses; FW: Firewood; OR: Ornamental; Lf: Live fence; Fd: Fodder; Fu: Furniture; SH: Shade; Mp=Multipurpose species, Sp= spices, St= Stimulant,

Agro- ecology : Mid: Midland; High: Highland ; MH: ; Midland and Highland

Appendix II: Number of families and their number of species in the study area.

No,	Family	No.of spp	% total	No,	Family	No.of spp	% total
1	Acanthaceae	2	4.87	22	Euphorbiaceae	6	14.63
2	Agavaceae	1	2.43	23	Fabacea	10	23.80
3	Alliaceae	2	4.87	24	Flacourtiaceae	1	2.43
4	Aloaceae	1	2.43	25	Lamiaceae	5	12.19
5	Anacardiaceae	2	4.87	26	Meliaceae	1	2.43
6	Annonaceae	1	2.43	27	Moraceae	4	9.75
7	Apiaceae	1	2.43	28	Moringaceae	1	2.43
8	Araceae	2	4.87	29	Musaceae	2	4.87
9	Asteraceae	4	9.75	30	Myrtaceae	4	9.75
10	Bignoniaceae	1	2.43	31	Oliaceae	1	2.43
11	Boraginaceae	2	4.87	32	Phytolaccaceae	1	2.43
12	Brassicacea	4	9.75	33	Poaceae	11	26.19
13	Cactaceae	1	2.43	34	Podocarpaceae	1	2.43
14	Caricaceae	1	2.43	35	Proteaceae	2	4.87
15	Celastraceae	1	2.43	35	Rhamnaceae	1	2.43
16	Chenopodiaceae	1	2.43	37	Rosaceae	5	12.19
17	Convolvulaceae	1	2.43	38	Rubiaceae	1	2.43
18	Cucurbitaceae	1	2.34	39	Rutaceae	6	14.63
19	Cupressaceae	2	4.87	40	Solanaceae	6	14.63
20	Cyperaceae	2	4.87	41	Verbenaceae	2	4.87
21	Dioscoreaceae	2	4.87				

Appendix, III The Shannoon Index Diversity of the two study area

	Scientifc name	Abun-dace/numer	Midland				Highland			
			n	pi	lnpi	pi*lnpi	n	Pi	lnpi	pi*lnpi
1	*Allium cepa*	278	177	0.002828	-5.8682	-0.0165	101	0.004	-5.459	-0.0232
2	*Allium sativu.*	165	-	-	-		165	0.006	-4.9681	-0.0345
3	*Aloe monticola* Reynolds*	88	88	0.001406	-6.5670	-0.0092	-	-	-	-
4	*Annona senegalensis Per*	90	90	0.001438	-6.5445	-0.0094	-	-	-	-
5	*Artemisia absinthium*	158	158	0.002524	-5.9817	-0.0151	-	-	-	-
6	*Arundinaria alpina K. S*	186	-	-	-	-	186	0.007	-4.8483	-0.0380
7	*Arundo donax L.*	158	-	-	-	-	158	0.006	-5.0115	-0.0333
8	*Beta vulgaris L.*	179	179	0.00286	-5.8569	-0.0167	-	-	-	-
9	*Brassica carinata*	567	270	0.004314	-5.4459	-0.0234	297	0.012	-4.3803	-0.0548
10	*Brassica oleracea*	486	486	0.007765	-4.8581	-0.0377		-		
11	*Balanites aegyptiaca*	356	200	0.003195	-5.7460	-0.0183	156	0.006	-5.0242	-0.0330
12	*Calpurnia aurea*	162	162	0.002588	-5.9567	-0.0154	-	-	-	-
13	*Canavalia ensiformis*	103	103	0.001646	-6.4096	-0.0105	-	-	-	-
14	*Capsicum annuum*	108	108	0.001726	-6.3622	-0.0109	-	-	-	-
15	*Capsicum frutescens*	148	148	0.002365	-6.0471	-0.0143	-	-	-	-
16	*Carica papaya*	289	289	0.004617	-5.3779	-0.0248	-	-	-	-
17	*Casimiroa edulis*	442	442	0.007062	-4.9530	-0.0349	-	-	-	-
18	*Catha edulis*	5379	5379	0.08594	-2.4541	-0.2109	-	-	-	-
19	*Citrus aurantifolia*	387	387	0.006183	-5.0859	-0.0314	-	-	-	-
20	*Citrus sinensis*	512	512	0.00818	-4.8060	-0.0393	-	-	-	-

21	*Citrus medica L.*	311	311	0.004969	-5.3045	-0.0263	-	-	-	-
22	*Coffea arabica L.*	9897	8568	0.136891	-1.9885	-0.2722	1329	0.056	-2.8819	-0.1614
23	*Collocasia esculenta (L.)*	621	288	0.004601	-5.3814	-0.0247	-	-	-	-
24	*Cordia africana Lam*	288	141	0.002253	-6.0956	-0.0137	93	0.003	-5.5415	-0.0217

Appendix, III Shannon's diversity index for the data obtained from sample sites (Quadrats)

	Scientifc name	Abun-	Midland				Highland			
		dace/numer	n	Pi	lnpi	pi*lnpi	N	Pi	lnpi	pi*lnpi
25	Cucurbita pepo L.	234	141	0.00225	-6.09	-0.0137	93	0.003	-5.54	-0.0217
26	*Cucurbita pepo L.*	98					98	0.004	-5.48	-0.0226
27	*Cymbopogon citrates (DC.)*	98					98	0.004	-5.48	-0.02268
28	Cyperus alternifolius L.	323					323	0.013	-4.29	-0.0585
29	Cytisus proliferus L. F.	333					333	0.014	-4.26	-0.0598
30	Eleusine floccifolia (Forssk.	4785	4785	0.07645	-2.57	-0.1965		0		0
31	*Daucus carota L.*	105		0			105	0.004	-5.42	-0.0239
32	*Dioscorea alata L*	65	65	0.00103	-6.86	-0.0071		0		0
33	*Dioscorea bulbifera*	79		0			79	0.003	-5.70	-0.019
34	*Dovyalis caffra(Hook*	123	123	0.00196	-6.23	-0.01225		0		0
35	*Echinops hoehnelii*	230		0			230	0.009	-4.63	-0.0449
36	*Ehretia cymosa*	145	145	0.00231	-6.06	-0.0140		0		0
37	*Ensete ventric osu0m(Wel*	5469	4532	0.07240	-2.62	-0.190	939	0.039	-3.22	-0.1278
38	*Eucalyptus globulus Labill.*	6479		0			647	0.273	-1.29	-0.3544
39	*Eucalyptus Camaldulensis*	2131		0			2131	0.089	-2.40	-0.2164
40	*Euphorbia trucalli L.*	87	87	0.00139	-6.57	-0.0091		0		0
41	*Ficus elastca Roxb. ex*	108	108	0.00172	-6.36	-0.0109		0		0
42	*Ficus sur Forssk.*	09	9	0.00014	-8.84	-0.0012		0		0
43	*Ficus vasta Forssk.*	53	13	0.00020	-8.47	-0.0017	40	0.001	-6.38	-0.0107
44	*Glycine max*	1237		0			123	0.052	-2.95	-0.1540

45	*Grevillea robusta R. Br.*	111	111	0.00177	-6.33	-0.0112		0		0
46	*Hagenia abyssinica (Bruce)*	216	216	0.00345	-5.669	-0.019		0		0
47	*Ipomoea batatas (L.)Lam.)*	65		0			65	0.002	-5.89	-0.0161

Appendix, III Shannon's diversity index for the data obtained from sample sites (Quadrats)

	Scientifc name	Abun-dace/numer	Midland				Highland			
			n	Pi	Lnpi	pi*lnpi	n	Pi	lnpi	pi*lnpi
48	*Lantana camara L.*	129	129	0.002	-6.1845	-0.012	37	0.00156	-6.4632	-0.010
49	*Lepidium sativum*	77	40	0.0006	-7.3554	-0.004		0		0
50	*Lippia adoensis Hochst*	89		0			89	0.0037	-5.58548	-0.020
51	*Lycopersicon esculen-tum*	123		0			123	0.0051	-5.26193	-0.027
52	*Mangifera indica L*	1131	1131	0.018	-4.0135	-0.072		0		0
53	*Musa x paradisiacal L.*	4569	4569	0.072	-2.6173	-0.191		0		0
54	*Nicotiana tabacum L.*	2189	2189	0.034	-3.3531	-0.117		0		0
55	*Ocimum basilicum L.*	87	87	0.001	-6.5784	-0.009		0		0
56	*Persea americana Mill.*	6543	6543	0.104	-2.2582	-0.236		0		0
57	*Phaseolus vulgaris L.*	3754	2341	0.037	-3.2860	-0.122	1413	0.0595	2.82065	-0.168
58	*Podocarpus falcatus*	87	50	0.0007	-7.1323	-0.005	37	0.0015	-6.4632	-0.010
59	*Prunusafricana (Hook. f.*	151	151	0.002	-6.0270	-0.014		0		0
60	*Psidium guajava*	321	321	0.005	-5.2729	-0.027		0		0
61	*Prunus persica L.*	96	96	0.001	-6.480	-0.009		0		0
62	*Rhamnus prinoides L 'H*	5129	3242	0.051	-2.9604	-0.15334	1887	0.0795	2.53137	-0.20137
63	*Ricinus communis L.*	2845	2845	0.0454	-3.0910	-0.1405		0		0
64	*Ruta chalepensis L.*	123	87	0.0013	-6.578	-0.00914	46	0.0019	6.24547	-0.01211
65	*Saccharum offcinarum L.*	315	315	0.00503	-5.2919	-0.02663		0		0
66	*Solanum tuberosum*	678	432	0.00690	-4.9759	-0.03434	216	0.0091	-4.69884	-0.04279
67	*Sorghum bicolor (L.) Moench*	479	479	0.00765	-4.8726	-0.03729		0		0

68	*Vernonia amygdalina*	542	95	0.00151	-6.4904	-0.00985	447	0.0188	-3.97156	-0.07484
69	*Vernonia rueppellii*	612	0				612	0.0258	-3.65738	-0.09436
70	*Vicia faba L.*	798	0				798	0.0336	-3.39201	-0.11411
71	*Zea mays L.*	11421	8768	0.14008	-1.9655	-0.27534	2753	0.1160	-2.1536	-0.24995
Total		86229	62590	**H'= -2.8606**			23721	**H' = - 2.65303**		

Appendix IV. Frequency (FR), relative frequency (RF), density (D) and relative density (RD), of homegarden plant species in Wond District

	Scientifc name	No,ofHGs species occurs	Total No Of Quadrants	Frequency inwhich the speciesoccur%	%Of RelativeFrequency	No of individuals	Density	Relative density
1	*Allium cepa*	36	60	60	1.581	278	0.046	0.322
2	*Allium sativu.*	26	60	43.33	1.141	165	0.027	0.191
3	*Aloe monticola* Reynolds*	18	60	30	0.790	88	0.014	0.102
4	*Annona senegalensis Per*	47	60	78.33	2.064	90	0.015	0.104
5	*Artemisia absinthium*	31	60	51.66	1.361	158	0.026	0.183
6	*Arundinaria alpina K. S*	18	60	30	0.790	186	0.031	0.215
7	*Arundo donax L.*	15	60	25	0.658	158	0.026	0.183
8	*Beta vulgaris L.*	19	60	31.66	0.834	179	0.029	0.207
9	*Brassica carinata*	40	60	66.66	1.756	567	0.094	0.657
10	*Brassica oleracea*	30	60	50	1.317	486	0.081	0.563
11	*Balanites aegyptiaca*	36	60	60	1.581	356	0.059	0.412
12	*Calpurnia aurea*	32	60	53.33	1.405	162	0.027	0.187
13	*Canavalia ensiformis*	31	60	51.66	1.361	103	0.017	0.119
14	*Capsicum annuum*	40	60	66.66	1.756	108	0.018	0.125
15	*Capsicum frutescens*	27	60	45	1.185	148	0.024	0.171
16	*Carica papaya*	31	60	51.66	1.361	289	0.048	0.335
17	*Casimiroa edulis*	52	60	86.66	2.283	442	0.073	0.512
18	*Catha edulis*	48	60	80	2.108	5379	0.896	6.238
19	*Citrus aurantifolia*	51	60	85	2.239	387	0.064	0.448

20	*Citrus sinensis*	34	60	56.66	1.493	512	0.085	0.593
21	*Citrus medica L.*	32	60	53.33	1.405	311	0.051	0.360
22	*Coffea arabica L.*	58	60	96.6	2.547	9897	1.649	11.477
23	*Collocasia esculenta (L.)*	34	60	56.66	1.493	621	0.103	0.720
24	*Cordia africana Lam*	30	60	50	1.317	288		0.333

Appendix IV. Frequency (FR), relative frequency (RF), density (D) and relative density (RD), of home species in Wond District.

	Scientifc name	No,of HGs spe-ciesoccurs	Total No Of Quadrants	Frequency inwhich the spe-ciesoccur%	%Of Rela-tive-Frequency	No of in-dividuals	Density	Relative density
25	Cucurbita pepo L.	15	60	25	0.658	234	0.03	0.27
26	*Cucurbita pepo L.*	22	60	36.66	0.966	98	0.01	0.11
27	*Cymbopogon citrates (DC.)*	25	60	41.66	1.097	98	0.01	0.11
28	*Cupressus lusitanica*	28	60	46.66	1.229	323	0.05	0.37
29	Cytisus proliferus L. F.	31	60	51.66	1.36	333	0.05	0.38
30	Eleusine floccifolia (Forssk.	42	60	70	1.844	4785	0.79	5.54
31	*Daucus carota L.*	15	60	25	0.658	105	0.01	0.12
32	*Dioscorea alata L*	14	60	23.33	0.614	65	0.01	0.07
33	*Dioscorea bulbifera*	10	60	16.66	0.439	79	0.01	0.09
34	*Dovyalis caffra(Hook*	24	60	40	1.054	123	0.02	0.14
35	*Echinops hoehnelii*	18	60	30	0.790	230	0.03	0.26
36	*Ehretia cymosa*	14	60	23.33	0.614	145	0.02	0.16
37	*Ensete ventric osu0m(Welw.)*	60	60	100	2.635	5469	0.91	6.34
38	*Eucalyptus globulus Labill.*	53	60	88.33	2.327	6479	1.07	7.51
39	*Eucalyptus Camaldulensis*	50	60	83.33	2.195	2131	0.35	2.47
40	*Euphorbia trucalli L.*	7	60	11.66	0.307	87	0.01	0.10
41	*Ficus elastca Roxb. ex*	16	60	26.66	0.702	108	0.018	0.12
42	*Ficus sur Forssk.*	11	60	18.33	0.483	09	0.001	0.01
43	*Ficus vasta Forssk.*	28	60	46.66	1.229	53	0.008	0.06

44	*Glycine max*	31	60	51.66	1.36	1237	0.20	1.43
45	*Grevillea robusta R. Br.*	35	60	58.33	1.537	111	0.01	0.128
46	*Hagenia abyssinica (Bruce)*	43	60	71.66	1.888	216	0.036	0.25
47	*Ipomoea batatas (L.)Lam.)*	32		53.33	1.405	65	0.01	0.075

Appendix IV. Frequency (FR), relative frequency (RF), density (D) and relative density (RD), of home species in Wond District.

	Scientifc name	No,of HGs spe-ciesoccurs	Total No Of Quadrants	Frequency inwhich the spe-ciesoccur%	%Of Rela-tiveFrequen-cy	No of in-dividuals	Density	Relative density
48	*Lantana camara L.*	28	60	46.66	1.22	129	0.021	0.149
49	*Lepidium sativum*	19	60	31.66	0.83	77	0.012	0.089
50	*Lippia adoensis Hochst*	25	60	41.66	1.09	89	0.014	0.103
51	*Lycopersicon esculentum*	15	60	25	0.65	123	0.0205	0.142
52	*Mangifera indica L*	35	60	58.33	1.53	1131	0.188	1.311
53	*Musa x paradisiacal L.*	47	60	78.33	2.06	4569	0.761	5.298
54	*Nicotiana tabacum L.*	26	60	43.33	1.14	2189	0.364	2.538
55	*Ocimum basilicum L.*	18	60	30	0.79	87	0.014	0.100
56	*Persea americana Mill.*	57	60	95	2.50	6543	1.090	7.587
57	*Phaseolus vulgaris L.*	54	60	90	2.37	3754	0.625	4.353
58	*Podocarpus falcatus (Thunb.)*	47	60	78.33	2.06	87	0.014	0.100
59	*Prunusafricana (Hook. f.*	36	60	60	1.58	151	0.025	0.175
60	*Psidium guajava*	56	60	93.33	2.45	321	0.053	0.372
61	*Prunus persica L.*	41	60	68.33	1.80	96	0.016	0.111
62	*Rhamnus prinoides L 'H*	53	60	88.33	2.32	5129	0.85	5.948
63	*Ricinus communis L.*	31	60	51.66	1.36	2845	0.47	3.299
64	*Ruta chalepensis L.*	14	60	23.33	0.61	123	0.020	0.142
65	*Saccharum offcinarum L.*	56	60	93.33	2.45	315	0.052	0.365
66	*Solanum tuberosum*	15	60	25	0.65	678	0.113	0.786
67	*Sorghum bicolor (L.) Moench*	27	60	45	1.18	479	0.079	0.555

68	*Vernonia amygdalina*	19	60	31.66	0.83	542	0.090	0.628
69	*Vernonia rueppellii*	21	60	35	0.92	612	0.102	0.709
70	*Vicia faba L.*	38	60	63.33	1.66	798	0.133	0.925
71	*Zea mays L.*	59	60	98.33	2.59	11421	1.903	13.244
	Total			**3795**	**100**		14.371	100

Appendix V ; Participant Consent form

You are invited to participate in the study entitled "Traditional Home- Garden Agr-biodiversity Systems, Agroecosystem services and Managements in Wondo District, West Arsi Zone, Oromia Region, Ethiopia'. The purpose of this study is to evaluate the level of Home garden agro biodiversity and management in the community. Your participation will involve completing an anonymous questionnaire that will take about 10 to 15 minutes.

Potential Risks: There are no anticipated risks to participating in this thesis.

Potential Benefit: You will not benefit directly from participating in this study. However, you will be providing information on Home garden agro biodiversity conservation the results of this thesis will provide valuable information regarding traditional home- garden agr-biodiversity systems, agroecosystem services and managements in Wondo District, West Arsi Zone, Oromia Region, Ethiopia

Storage of completed questionnaire: For the sake of confidentiality, the completed questionnaire sheets will be stored in a locked filing cabinet for which only the student researcher and the supervisor will have access.

Anonymity: The information you provide will be used as part of the researcher's written master's thesis. However, to ensure that participants are anonymous, your name is not required on any page of this document.

Rights to Withdraw: Your participation is voluntary and you can withdraw from this study at any time without any penalty. You can also choose to skip over any question you do not wish to answer. If you wish to withdraw from the study after you have started the questionnaire, you simply have to write a large "X" on the first page of the questionnaire and your questionnaire will be destroyed. If you hand in the questionnaire and then decide to withdraw from the study,

it will not be possible to remove your answers because there will be no way to link any answers to a specific person.

Questions: If you have questions or concerns about this study, please free to ask at any point. You can contact the researcher Sori Alemayehu (0942489742)

Consent to Participate: I have had the opportunity to read this cover page, discuss the research purpose and what my participation means with the researcher. I hereby consent to participate in the research by completing this questionnaire

Confidentiality of your **Information**: Information you are going to give for us will be used only for the purpose of the study. You will not be personally identified in the study report. Confirmation of agreement: I have read the consent form or the interviewer has read the consent form. I have understood the aim of the study and the things that I have to do if I agreed to participate in the study. I know that my participation is based on my will and have right to do or not to participate.

Would you willing to answer?

- If yes, proceed to the next page.
- If No, please stop here.

THANK YOU

HAWASSA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE DEPARTMENT OF BIOLOGY POSTGRAGUATE PROGRAM

Dear Respondent, I am Sori Alemayehu , now learning Masters in general biology from Hawssa University Collage of Natural and computionion science Department of Biology I would like done research on the "Traditional Home- Garden Agr-biodiversity Systems, Agroecosystem services and Managements in Wondo District, West Arsi Zone, Oromia Region, Ethiopia' as a partial fulfillment for Msc. So that are highly request to fill gently this question as your respond have a great asset to done this research.Exactly the information you will provide for the education purpose and feel free to express your idea freely.

Thank you in advance for your much willing participation and for taking the time to provide me with this important information.

Appendix VI : Questionnaire Format Sheet for Interview

Date…../…. /……

Household code number_____ Name of interviewer_____ sign _____

Date of interviewee day _____ month _____ year _____

Name of supervisor _____signature _____date _____

Part II. Background information of household characteristics

1. Agro ecology of the your kebele 1) Midland 2) Highland

2 Age group 1) 20-35 □ 2)36-51 □ 3) 52 above □

3. Gender (Sex) 1) Male □ 2) Female □

4. Marital status 1) Single □ 2) Married□

5. Household/family size 1)1-5 □ 2)6-10 □ 3)>10 □

6. What is your highest level of completed education?

1) No formal education □ 2) Adult education □

3) Primary education □ 4) Secondary education or above □

7.For how long have you been farming (in years)--------- 1)1-5 □ 2)6-15 □ 3)>16

8. On which type of farm Activity your participation is active? 1) On field crops/field farm 2) Animal Husbandry 3) Home garden 4) All

9. Wealth category: 1) Rich 2) Medium 3) Poor

10.What is the total size of your homegarden in hectare ? 1) < 0.5 2) 0.5 – 1 3) 1- 2 4) > 2

Part III :. Homegarden agro- biodiversity

1) What type of crops duo you cultivate on your homegarden? A) Cereals B) vegetables C) fruit D) Pulse crops E) Oil crops F other /specify/
2) Do you know the homegarden agro bio- diversity? A/yes B/No
3) If yes select the type of homegarden agro bio- diversity that you are used?

No,	Home garden crop species	Select	Number of plant species currently available	Purpose/Uses
A	**Cereal crops**			
1	Wheat			
2	Barley			
3	Oat			
4	Teff			

5	Maize			
6	Sorghum			
	If other specify			
B	**Pulse crop**			
1	Field pea			
2	Feb. been			
3	Lentil			
4	Chickpea			
5	Soybean			
	If other, specify			
C	**Oil crops**			
1	Lin seed			
2	Sesam/selit			
3	Ethiopian mustered			
4	Sun flower			
5	Guzatia			
6	Ground nut			
	If other, specify			

No,	Home garden crop species	Select	Number of plant species currently available	Purpose/Uses
D	**Fruit crops**			
1	Banana			
2	Mango			
3	Papaya			
4	Apple			
5	Orange			

6	Gishta			
7	Avocado			
8	Lemon			
9	Tinkish			
10	Sugar cane			
	If other, specify			
E	**Vegetable crops**			
1	Onion			
2	Cab-bage/tekurgomen			
3	White cabbage			
4	Garlic			
5	Carrot			
6	Potato			
7	Tomato			
8	Beetroot			
9	Flower cabbage			
	If other, specify			

No,	Home garden crop species	Select	Number of plant species currently available	Purpose/Uses
F	**Spice Crops**			
	Zinger			
	Kurunfud			
	Cinnamon /Kenefa			
	Chill			
	Tekur Azmud			
	Pepper			

	Fenugreek			
G	**Stimulants**			
1	Coffee			
2	Chatt			
3	Tobacco			
4	Rahummans			
	If anther			
H	**Type of tree used**			
1	*Eucalyptus*			
2	*Hyginia Absinca*			
3	*Juniperus proccera*			
	If anther			

4) Can home agro biodiversity have value A/ Yes B/ No

5) if yes select and take example on the role of home agro biodiversity that you know.

No,	The value home agro biodiversity	Select and take example
1	Contribute to increase productivity and food security.	
2	Reduce the pressure of agriculture on fragile areas, forests and endangered species.	
3	Conserve soil and increase natural soil fertility and health.	
4	Contribute to the increase of diversity over the area.	
5	Diversify products and income opportunities	
6	Help maximize effective use of resources and the environment.	
7	Improve human nutrition and provide sources of medicines and vitamins.	
8	Conserve ecosystem structure and stability	

Part VI plant species in homegarden

1) Have you ever plant species on your home garden? 1) Yes 2) No

a) If yes, indicate the species name, the preference with its rank?

Species type	Ranking score and use diversity	
	Reasons for preference	Rank

Reasons for preference: r1=firewood; r2= construction; r3= sale; r4=fruits; r5= medicine; r6=farm implements; r7=shade; r8= bee keeping; r9= soil fertility improvement; r10=fodder; r11= amenity; r12=lumber; r13 = fumigation;r14 =washing household materials ;r15=charcoal; r16 =others/specify/

2) For what purpose do you need plant species in your home garden most?

No	Plant species	Purposes										
		1	2	3	4	5	6	7	8	9	10	11

Key for purposes: 1- Fuel 2- Construction 3- Household tools 4- Fodders 5- Shade 6- Fencing 7- Soil fertility 8- Fruit 9- Timber 10- cultural value 11-Other

3. List names of plants in your home garden used as multi-purpose

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-

4. Where do you get the seedlings? 1) Self raised 2) Self regenerate 3) Wildling 4) AR-DO nursery 5) Others

5) What are the factors that affectuseful plant diversity and composition in your surrounds?

1) Pests, plant disease and weeds 2) Farm size 3) Altitude 4) Lack of government support 5) Lack of awareness6) Lack of economic status 7) Lack of water accessability 8) climate & rain-fall conditions 9) Home garden size 10) Wild animals influence

6. Is there different stakeholder intervention on homegarden plant species development and management? 1) Yes 2) No

7.If yes describe Stake holder and type of intervention.

No,	Name of stakeholder	Type of Intervention	Remark
1	Government office		
2	University		
3	Religious institution		
4	NGO		
5	Others		

Type intervention, by providing: 1) Development fund 2) Awareness and technical training 3) Seed 4) Seedling 5) Experience sharing visit 6). Management Material 7).Others

4. What type of management practices do you use for homegarden plant species?

No,	Types of plant Species	Management	Reason
1			
2			
3			
4			
5			

Key for management: 1=Thinning, 2= Pruning, 3= Composting, 4=, Weeding 5= irrigating, 6= hoeing, 7= Others

Key for reason: 1= for growth, 2= To reduce competition, 3= To reduce shade, 4= For fuel wood, 5= For fodder, 6= Others ……

8.What are good opportunities in your managing plant species practices?

No,	Woody Species	Opportunities	Rank
1			
2			
3			
4			
5			

Key: Opportunities: o1= market; o2=price; o3=water harvesting; o4= seedlings; o5=credi

5. What problems did you encounter in managing plant species and how did you solve them?

No,	Plant Species	Problem	Solution
1			
2			
3			
4			
5			

Key for problems: 1- Animal, 2- Insect-pest, 3- Disease, 4- Thieves, 5- Others

Key for solutions: 1- Fence, 2- Insecticides, 3- Guarding, 4- Others

How do you describe the plan growing practices in homegarden the last ten years? 1) Yes 2) No

Increase		Decerase		Remark
Plant species	Resoan	Plant species	Resoan	

Key: Reasons for increase: r1= increased market value; r2= increased fuel wood demand; r3=increased fodder demand; r4=Decreased market value; r5=decreased demand for construction wood; r6=increased demand for Lumber; r7= increased demand for handles of tools; 8=other /specify/

Reasons for decrease: d1= increased market value; d2= increased fuel wood demand d3=increased fodder demand; d4=Decreased market value; d5=decreased demand for construction wood; d6=increased demand for Lumber; d7= increased demand for handles of tools; 8=other /specify

If trees on your homegarden are used to improve soil fertility, indicate the species and parts of the tree used?

Plant species name	Plant part	Criteria	Rank	Remak

Key: Trees in order of importance to soil fertility improvement

Tree part Code: t1= root; t2=bark; t3= leaves; t4= new shoot; t5=flower; t6=pod/fruits Criteria to use tree species to soil fertility improvement Code: f1=fast Decomposition; f2=competition; f3=Deciduous; f4=Vigorous Growth; f5=availability of soil animals; f6= other /specif

Which method do you use to plow ploughing to homegardens and adjoining fields? a) Ox b) Manual c) Tractor d) Others

9. Who take plant management practices at household level?

Preferred plant species	Niche	Management practice	Who manages/division of labor/	ho makes decision	Reasons for managing

Key: Who manages: w1=Men; w2=Women; w3=Boys; w4=Girls; w5=men and women; w6=other /specify

Who makes decision: d1=men; d2=women; d3=both

1) What is your perception/Interest on homegarden agro bio-diversity? 1) Positive 2) Negative

Thank you for giving your time and willingness to participate in respond or filling this interview !!

HAWASSA UNIVERSITY

COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCE DEPARTMENT OF BIOLOGY POSTGRAGUATE PROGRAM

Appendix VII: Key informant interview Guide Lines

Introduction:

The KI**s** is for the aim of the MSc thesis work to study " study status of homegarden agro- biodiversity in Wondo District, West Arsi Zone, Oromia Regional State, Ethiopia " I would like to assure you that any ideas raised here are used only for this research. Your contribution has a vital role in the success of the study. Any of your opinions that will be included in this thesis report will not mention your name. Thank you very much for your active participation essential ideas!

Instruction:

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

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

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

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

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

I. Background information of

1. Interviewee name----------

2. What is the agro-ecology of your kebele ? ----------

3. Occupation type ----------

II. Guideline questioners for Key informant interview (KIs)

1) Please briefly tell us about your experience homegarden management and its contributions to the plant biodiversity conservation.

3) What was the main reason for agro bio- diversity and domestication in homegarden?

4) What are the government and non government intervention in homegarden agro bio- diversity production?

5) What are the main constraints for homegarden agro bio- diversity production?

6) What are the great challenges of natural resources degradation in your kebele?

7) What types of intervention needs to sustain the homegarden agro bio- diversity and benefits from it?

9) What are the local levels of conservation practices to conserve these scarce useful plants

10), Mention taboos, myths, or rituals and other concepts linked to plant use and conservation

12) Is there any professional expertise, who is responsible and advice you how to manage your homegarden?

13) Who is responsible for the proper management of homegarden in the household?

14) What are names of locally scarce useful plants in your kebele, mention the causes of scarcity for each species.

15) What factors influence agro biodiversity of home garden?

16) How is the current status of its home garden agro biodiversity when compared with the past 5 years (High /low)

17) What are the major determinant factors that affect agro bio diversity in your home garden ? 18)what are the existing threats to decline the status or level of diversity and composition of each kind of your home garden agro biodiversity ?

19) Do you think that is homegarden in your area effective enough for plant biodiversity conservation? If not why?

21 What options do you suggest in bringing sustainable plant biodiversity conservation in the area?

22.Which method do you use to plow ploughing to homegardens and adjoining fields?

23.Which fertilizers do you used in your surroundings?

Thank you for giving your time and willingness to participate in respond this FGDs !!

Appendix VIII: Observation checklist

Number of participant ----------

1. Do you know importance of home garden agricultural diversity?

2. Mention the types of home garden agrobiodiversity /Crops, livestock/ in species that used by the community

3. Mention the effect of home garden agrobiodiversity on livelihood of the habitat in the Environmental----------

Economical ----------

Cultural value ----------

Social benefit in increasing productivity

8. What types of Agricultural diversity used by the community at farm land and Home garden. This include:

Crop ----------

Animal_____

Appendix VIIII; Plant species inventory Format

Homegarden owner's name---------- Agro-ecology----------

Kebeles----------

Home garden size---------- (ha) Plot No_____ Altitudinal range--------

m.a.s.l

Homegarden Species Diversity Assessment Data Collection sheet

No of spp	Plant Spiece			Plant growth habit	Use of plant	Remark
	Code no.	local name	scientific name			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						