ASSESSMENT OF WOODY SPECIES DIVERSITY IN HOME GARDEN AGROFORESTRY AND THEIR INDGENIOUS MANAGEMENT PRACTICES ACROSS ALTITUDINAL GRADIENT: A CASE OF DALE WABERA DISTRICT, WESTERN ETHIOPIA

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Assessment of Woody Species Diversity in Home Garden Agroforestry and Their Traditional Management Practices across Altitudinal Gradient: In Case of Dale Wabera District, Western Ethiopia

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I declare that the thesis research works has not been done in study area else before or is not part of an on-going work.

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DEDICATION

I dedicate the thesis to my wife, Zenabu Shanko and my children, Yerosat and Umeran Solomon, for all their contribution.

STATEMENT OF THE AUTHOR

With my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis, and compilation of this thesis. Any scholarly material used in the preparation of the thesis has been recognized through citation. This thesis is submitted in partial fulfillment of the requirements for MSc degree in Natural Resource Management (specialization in Forest and Nature Management) at Jimma University.

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BIOGRAPHICAL SKETCH

Solomon Zeru was born in Kelem Wollega Zone, Dale Wabera District, on July 10, 1970. He attended elementary school at Kara Waddesa Primary School from 1978–1986, his secondary education at Kelem Comprehensive Secondary School from 1989–1992, Bekoji ATVET College in Natural Resources in September 2003–July 2005, and his BSc program at Jimma University College of Agriculture and Veterinary Medicine. He graduated with a Bachelor of Science in Natural Resource Management in 2014. Then, he was employed by the Oromia Agricultural Office in Dale Wabera District Agricultural Office. He served as an agriculture extension supervisor, soil and water conservation expert, and soil fertility management process owner after receiving his BSc until he joined Jimma University's College of Agriculture and Veterinary Medicine in October 2022 to pursue an MSc program in the field of natural resource management (Forest and Natural Management).

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LIST OF ABBREVIATIONS

AF	Agro forestry
AFS	Agro forestry system
ANOVA	Analysis of Variance
BA	Basal area
CSA	Central Statistics Agency
DBH	Diameter at breast height
FAO	Food and Agricultural organization
GPS	Global Positioning System
Ha	Hectare
HG	Home garden
HGAF	Home garden Agro forestry
HHHs	Household heads
HHs	Households
HSD	Honest significant difference
IVI	Importance Value Index
Km	Kilometer
LA	Lower altitude
LSD	Least Significance Difference
M	Meter
MA	Middle altitude
Masl	Meter above Sea Level
Rel.	Relative
SPSS	Statistical Package for Social Science
UA	Upper altitude
WPS	Woody Plant Species

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ABSTRACT

Agroforestry is used in home gardens to maintain a wide variety of woody species. Traditionally, woody plant species have been managed by farmers in their home gardens in order to support their livelihood. This study was conducted to investigate the woody species diversity of home garden agroforestry and their traditional management practices across the altitudinal gradient in Dale Wabera district, Kellem Wollega Zone, Western Ethiopia. *The study site was stratified into three elevations: lower, middle, and upper. And one kebele was selected purposefully from each elevation category. From each kebele, fifteen home gardens were selected randomly. 45 home gardens were sampled in total. And home gardens were taken as sample plots. A complete enumeration of woody species inventories was conducted in Home Garden. Analysis was done on the important value index, evenness, frequency, richness, and diversity of species across altitude categories. The findings of the study showed that from these three altitude groups, a total of 53 woody species from 32 families were identified. Fabaceae was the most dominant family with 6 species, followed by Moraceae with 5 species. The result of a one-way ANOVA showed that the diversity of woody species significantly varied across the altitudinal gradient (P<0.001). The highest species diversity was recorded in lower altitude categories. Woody species richness and altitude have a high negative correlation. Woody plant species preferred in the home garden agroforestry of the study area, in descending order, were: Coffea arabica, Catha edulis, Cordia africana, and Mangifera indica. Persea americana, Eucalyptus camaldulensis. The farmers use organic fertilizers, watering, prescribed burning, coppicing, mulching crop residue, thinning, pruning, pollarding, and fencing in all parts of the study area. Generally, home garden agroforestry practices conserve several woody species diversity in their systems, but woody species richness and diversity vary significantly along the altitudinal gradient in the study area. Therefore, the farmers in the study area should be aware of selecting woody species that are appropriate to the altitude gradient and diversifying woody plant species to maximize the use of home gardens.*

Key words/phrases: Altitude, Home Garden, Indigenous Knowledge, Management, Preferences

1. INTRODUCTION

1.1 Background

Agroforestry is a dynamic, ecologically based system for managing natural resources that involves integrating trees into farmland and rangeland to diversify and maintain production for the rising socio-economic and environmental benefits (Yusuf *et al*., 2020). Agroforestry includes a very broad range of activities, from agricultural management to sophisticated forest development (Ogunwusi, 2013).The link between agriculture and forestry has evolved into agroforestry. The primary elements are trees and shrubs, crops, pasture, and cattle, as well as environmental aspects such as climate, soil, and landform (Mohamed *et al*.,2023).

In Africa, there are many different types of agroforestry systems (Wani *et al*., 2021). Agroforestry systems and techniques used in Eastern Africa include improved fallows, rotational farming, woodlots, contour hedgerows, enclosure, boundary planting, home gardens, and farm forestry (Chirwa *et al*., 2015).

It is renowned for its variety, ecosystem balance, sustainability, home food security, and rural development (Fikre, 2019). In agricultural systems, a variety of woody plants supply goods and ecological services (Girmay *et al*., 2015). According to Asefa & Worku, (2014) trees provide a shelter belt, food, income, and soil fertility. It holds potential as an alternative to traditional land management for preserving soil fertility and productivity (Reyes, 2008).They are also noted for their ecological sustainability and ability to diversify local communities' livelihoods (Kumar, 2006).

Agroforestry techniques may be appropriate for many agro-ecological zones and numerous systems with a variety of diverse compositions that can serve essentially the same roles for livelihoods and landscapes (Mbow *et al*., 2014). In reality, there are numerous indigenous and agroforestry techniques, as well as different types of tree planting (Oino & Mugure, 2013). It is an ancient practice and also the farmers are too much familiarized with it in Ethiopia. It is the basic extension package in Ethiopia and contributes incredible benefits via socio-economic and environment (Kumar & Agarwal, 2021). Moreover, various regions of Ethiopia have different traditional agroforestry techniques. These activities are present on degraded areas, farm boundaries, home gardens, fences, grazing grounds, and crop lands (Fikre, 2019; Asefa & Worku, 2014).

Home garden is an integrated system that 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 (Agbogidi and Adolor, 2013). According to Galhena *et al*.(2013), home gardens are bright examples of production systems with rich diversity that serve both development and conservation functions (Hailu and Asfaw, 2011). It is also a significant source of both daily food and revenue (Kefale, 2020; Fikre, 2019).

The traditional practices where woody perennial species, annual crops, and invariably livestock are closely integrated around farmers' homesteads and managed mainly by family labor to stabilize their sustenance (Kebebew, 2018 ; Jegora *et al*.,2019).High plant diversity in home gardens can produce a large range of goods with numerous uses for little to no work, money, or other inputs (Abebe *et al*., 2019). A significant self-sustaining agro ecosystem with the dual purposes of productivity and on-farm conservation of the bio diversity is attained in home gardens (Kefale, 2020).

In Ethiopia, the home garden area, which has variable shapes and sizes, includes the living house, animal houses, grain stores, drying places, and plots of garden species. It is usually fenced and the fence is frequently reinforced by multipurpose live tree and shrub species (Kefale, 2020). According to Asfaw (2001b) report, the Common garden sizes range from about $500m^2$ to more than a quarter of a hectare. But in extreme cases, gardens as small as $20m^2$ and as large as one hectare have been recorded. Larger gardens approaching the upper limit are more frequent in households where the home garden is the only cultivated land available. When crop composition is considered, the gardens are typically of the mixed type and Common locations, in relation to the house are back yards, front yards, side yards and those that almost encircle the house (Ewuketu, 2014). In some areas, fences confine gardens while in others they merge with crop fields and may be fenced together (Asfaw, 2001b).

Woody plants are a crucial component of home gardens that support the diversification of livelihoods (Fikre, 2019). Due to tree–based agroforestry practice, home garden is more profitable than mono-cropping (Ewuketu, 2014). Home garden woody plants are managed to: i) provide shade for coffee, a variety of commercially valuable spices, and livestock, ii) supply rural communities with fuel wood and timber; iii) provide other products such as fodder, human and livestock medicine, food, and they serve as bee forage; and iv) play important ecological roles which could contribute to the sustainability of agricultural systems (Yakob *et al*., 2014). The common managements in tropical agroforestry system are pruning, prescribed burning, thinning, pollarding, grass mulch, watering, and coppicing (Fikir *et al*., 2018). The presence of woody species from home gardens to agricultural landscapes favors the survival of native woody species, and play an important role in conserving biodiversity (Yakob *et al*., 2014).

Agroforestry in different home gardens may vary in tree density for a variety of reasons, including ecological, cultural, and economical factors (Woldu *et al*., 2020).Natural topographic factors such as elevation, slope and aspect exhibit heterogeneity over time and space, and this also naturally influences plant distribution and diversity patterns (Malik *et al*., 2014 and Angessa *et al*., 2020). Home gardening has evolved into a generalized culture with significant diversity and adaptability, enabling owners to cultivate species of their choice (preference) (Gebremedhin & Mulubrhan, 2007).

Ecological, cultural, and elevation gradients have an impact on the woody species density, diversity, of agroforestry along altitudinal gradient and most of the study are under taken at the southern and northern parts of Ethiopia (Tefera *et al*., 2016 ; Fikir *et al*., 2018; Gebrewahid & Abrehe, 2019; Tesfay *et al*., 2022; and Chemeda *et al*., 2022). Even though information on woody species diversity in different land use types and their traditional management systems are crucial for conservation intervention in agro ecosystem. The focus mainly on trees in different land use types than woody species in home garden along elevational categories. The focus of this issue is very limited in Dale Wabera Woreda Kelem Wollega Zone. As result, there is no information about woody species diversity in home garden agroforestry in different altitude gradient, woody species choice and indigenous management practices. Therefor this study was conducted to contribute to fill the existing gap in the study area.

1.2. Statement of the problem

Woody plant species diversity is typically conserved and managed by Ethiopian farmers for multiple purposes surrounding their home garden as fence, shade, household consumption and agricultural integration (Yakob *et al*., 2014). However, the purpose of combining woody plants with crops is not to increase output and productivity (Sanchez, 1995).These needs identification of species type that have a good connection with crops and in managing woody plant species appropriately within current agroforestry systems. Farmers' preference for tree species is a basic criterion to select a tree and advise appropriate management in home garden agroforestry. Farmers require planned and technical assistance for this (Jegora *et al*., 2019).

There are several traditional agroforestry practices in different agro-ecological regions of the Dale Wabera district, but there are not well studied and documented. But Some scholars like (Yakob *et al*., 2014; Molla & Kewessa, 2015; Tefera *et al*., 2016; Tadesse *et al*., 2019; Wari *et al*., 2019; Hordofa *et al*., 2020), conducted the study on the diversity of woody species, carbon stock production, and comparing the value of home gardens and park land in southern and south western parts of Ethiopia without separation of elevation. But plant community properties may vary with a biotic factor along latitude and elevation gradients (Rosenzweig, 1995).

Due to this, there is no published data (research done) in the current study area on woody plant diversity and their traditional management system in home garden agro forestry along altitudinal gradient in general. Therefore this study would fill the information gap on diversity of woody plant species in different elevational categories and farmers woody species choices and indigenous management practices in Dale Wabera District.

1.3. Significance of the study

The results of this study on the diversity of woody plant species and indigenous management practices of home gardens agroforestry along an altitudinal gradient will offer fundamental knowledge about the selection of woody plant species that yield high woody production at the proper altitude in home garden agroforestry techniques and biodiversity preservation. This will be helpful for conducting additional research as well as for re focusing, strengthening, and expanding today's tree coverage, introducing new agroforestry systems, and other purposes. The management of woody plant species in in home garden agroforestry is thus supported by national policies and strategies in a sustainable manner.

1.4. Objectives of the Study

1.4.1. General objective

To investigate woody species diversity of home garden agroforestry and their traditional management practices across altitudinal gradient: in Dale wabera district, Kellem Wollega Zone, Western Ethiopia

1.4.2. Specific objectives

To assess wood species diversity of home garden agroforestry across altitudinal gradient of the study area;

To identify farmer's woody species preferences in home garden agroforestry along an altitudinal gradient in the Dale Wabera district;

To assess traditional woody species management practices in home garden agroforestry practices in the study area.

1.5. Research questions

Does the diversity of woody species vary in home-garden agroforestry across different altitudinal gradient?

What type of woody species do farmers prefer in home garden along different altitudinal gradient in dale wabera district?

What are the traditional woody species management practices in home garden agroforestry of the study area?

1.6. Scope of the study

The study mainly concentrated on biophysical assessment, spatially on woody species, and their traditional management along altitudinal gradient, which include woody species diversity, evenness, frequency, and DBH of the tree as well as local knowledge in management. Biophysical data were obtained through inventory, and management practices were gathered from households. The inventory data was used to compare species diversity and richness at various altitudes. Geographically, the study was carried out in the Dale Wabera District, west Ethiopia.

2. LITERATURE REVIEW

2.1 Concept and definition of agroforestry

According to World Agroforestry Center, agroforestry is a dynamic, ecological based natural resources management system through integration of trees into rangeland and farmland to diversify and sustain production for the increasing socio-economic and environmental benefits for all land users at all levels (Gebrehiwot Sahilu, 2017)(Gebrehiwot Sahilu, 2017)(Gebrehiwot Sahilu, 2017). Agroforestry has been a traditional agricultural practice sustainable for thousands of years and an important element of the cultural rural landscape in tropical and temperate regions around the world (Kumar, 2006; Kalaba, *et al*.,2010 and Alam & Sarker, 2011).

Agroforestry systems that combine trees and crops on the same land, including silvopastoral systems, the combination of trees and pastures/cattle in the same production unit, can increase productivity in the short and long term. They are also biodiversity friendly and bring social and economic advantages to the farmer (Murgueitio *et al*.,2010). In addition, AFS can serve an important role in climate change mitigation, due to carbon sequestration in woody components of the systems, as well as in soils (Roshetko *et al*., 2007). The most frequent AFS are annual and perennial crops under shade, multi strata systems such as home gardens and successional AFS, silvopastoral systems, live fences, and windbreaks (Krishnamurthy & Rajagopal, 2019; Montagnini, 2020 and Dhyani *et al*.,2021).

The specific characteristics of each of the systems vary strongly according to system design, objectives and species involved (Montagnini & Metzel, 2017). There are strong differences in AFS design and practices within ecological regions. Countries and locations can influence these practices, along with their productivity, sustainability, and environmental services provided, all depending on the interaction of economic, social, and political factors predominant in each (Montagnini & Metzel, 2017). Improved fallows, taungya (growing annual crops while establishing a forestry plantation), home gardens, alley cropping, planting multipurpose trees and shrubs on farmland, boundary planting, farm woodlots, orchards, or tree gardens, plantation/crop combinations, shelterbelts, windbreaks, conservation hedges, fodder banks, live fences, trees on pasture, and tree-based apiculture are among the main agroforestry practice s(Alao & Shuaibu, 2013).

2.2 Agroforestry practices in Ethiopia

Ethiopia is a tropical country with varied macro and micro-climatic conditions with diverse cultural and farming practices that have contributed to the formation of diverse ecosystems inhabited with a great diversity of life forms of both plants and animals(Wassie, 2020). Agroforestry is the production of trees and of non-tree crops or animals on the same piece of land (Legesse & Negash, 2021). In Ethiopia, smallholders practice various agroforestry practices depending on the socioeconomic and biophysical conditions which have livelihood implications (Abiyu *et al*.,2016). Among the agroforestry systems used by farmers, home gardens, parklands and live fences are the most dominant practices in Ethiopia (Tadesse *et al*., 2019). On agricultural lands, home gardens, farm boundaries, fencing, grazing lands, and degraded lands, traditional agroforestry approaches are used (Asefa & Worku, 2014).

2.3 Home garden agroforestry

Home garden agroforestry can be defined as land use system involving deliberate management of multipurpose trees and/shrubs in intimate association with agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop-animal unit being intensively managed by family labor and It is found in most ecological regions of the tropics and subtropics, but a majority of them are in the lowland humid tropics (Hamore & Lemage, 2019) In home garden agroforestry trees and crops provide numerous benefits to households, such as the production of building materials, food and firewood; generate family income and protect against soil erosion (Salam *et al*., 2000). Woody species are very important components of home garden that contribute to the livelihoods diversification, in Southern Nation's Nationalities and Peoples' Regional State is the most commonly known example of perennial-crop based home garden; In Ethiopian high land (Fikre, 2019).In Ethiopia, home garden is widely practiced as a major source of daily food and income generation (Fikre, 2019 ; Kefale, 2020).

2.3.1. Importance of home garden agroforestry

In Ethiopia, majority of the farmers practices home garden agroforestry around their homestead for several purposes. Woody components of the system provide several benefits to households, such as the production of building materials, fuel wood, income generation, food; generate and protect against soil erosion and improve soil fertility and adjust microclimate of the environment (Yakob *et al*., 2014 ; Hamore & Lemage, 2019).

Different regions of Ethiopia employ home garden agroforestry techniques (Asefa & Worku, 2014; Tefera *et al*., 2016). According to Kewessa, (2020) HGAF is classified as backyards, front yards, side yards, and enclosing yards in central, eastern, western, and southern Ethiopia. According to Krishnal and Weerahewa, (2014), the distribution of species in the home garden results in a multistory structure that resembles a forest. It is made up of a mixture of almost-multipurpose trees, shrubs, and herbs, as well as some climbers along the border (Akinnifesi *et al*., 2010).

2.3.2 Woody species diversity in home garden agroforestry

Home gardens are identified by their high diversity of species with many life forms varying from herbs to trees. These create multistory canopy structure, which makes home garden multi strata system (Birhane et al., 2020). Numerous academics noted that the number and species richness of woody species varied in diverse study areas and types of land use. (Belay & Ruelle 2014) found 40 woody species in home gardens of Debark District, northern Ethiopia. The majority of other land use groups don't have as many woody plant species as home gardens do (Molla & Kewessa, 2015 and Bikila & Zebene 2016) discovered 15 and 64 woody species in home gardens in Dello Mena, South-East Ethiopia. In home gardens in the south-western region of Ethiopia, 93 different species of trees and shrubs are grown with numerous permanent and annual crops (Fikre, 2019) identified 55 woody species in Gibe District, SNNPR, and 28 woody species in Abreha we Atsebeha (Guyassa & Raj, 2013). There are 29 woody species in the South Omo Zone of Southern Ethiopia (Terefe *et al*., 2010), 45 woody species in the Bale Zone of Southeast Ethiopia (Bogale *et al*., 2017).

According to Fikre (2019), the Shannon index of variety ranges from 0.86 to 1.88 in traditional agroforestry in Southern Ethiopia, 2.22 in crop fields, and 1.98 in home gardens in South-central Ethiopia (Motuma & Zebene 2008). According to Ewuketu *et al*., (2014) the Shannon index of woody species with home gardens in the Jebithenan district of Northwestern Ethiopia ranges from 2.26 to 2.43, and 1.31 in home gardens, 1.12 in cropland, and 2.04 in grazing land in the Tigray region, (Etefa and Raj 2013). Accordingly 2.59 LA, 2.81 MA, 2.16 UA Along altitudinal gradients in Jallo muktar dry evergreen Afromontane forest, west Hararghe zone,(Gebremedhin Jabo, A. and Sintayehu, 2020) .

In Gibe District, SNNPR, Woody species evenness of Home garden agroforestry ranges from 2.68 to 2.79 in three kebele (Fikre, 2019) and 0.39 to 0.48 in home garden agroforestry of the Tigray Region, Ethiopia (Etefa and Raj , 2013), from 0.65 to 0.73 in Jebithenan district, northwest Ethiopia (Ewuketu *et al*., 2014), from 0.5 to 0.6 in Home Garden Agroforestry of three Agro ecological Zones of Dilla Zuria District, Gedeo Zone, Southern Ethiopia (Tefera *et al*., 2016). According to (Mekonnen *et al*., 2022), species with the highest IVI are the most prevalent in a certain vegetation, and it combines data from three parameters which include RF, RD, and RDO. Also it is crucial to compare the ecological significance of species. the variation in IVI among agroforestry practices is connected to differences in farmers' preferred species, differences in the growth performance of species, the number/existence of individuals/dominance per plot, basal area, and agroforestry plot area (Bajigo and Tadesse, 2015).

In Akure Forest Reserve, Ondo State, Nigeria, the numbers of plants per hectare that are woody species are 210 (Akinbisoye *et al*., 2014). Debark District in northern Ethiopia has 246 individuals/ha of total woody plant density (Belay *et al*., 2014). According to Narahari *et al*.(2015), the average tree stand density in home garden agroforestry systems is 475 stems per hectare. Other species had far lower densities than the Eucalyptus species, which had the maximum density (192 individuals/ha) (Tefera et al., 2014). The average number of stems per hectare of trees in crop field ranged from 21 to 127(Narahari *et al*., 2015). In West Africa, 1401 unique trees (shade) were counted across all sites (Dawoe *et al*., 2016), with the average density of coffee trees in Yayu forest being roughly 3,600 stems/ha (Deribe, 2018). On woodlots, the average tree stand density is 5000 stems per hectare (Narahari *et al*.,2015).

Generally, the majority of the woody plant species in the Home gardens agro forestry were. *Mangifera indica, Citrus aurantifolia, Phoenix dactylifera, Psidium guajava, and Citrus paradise, Persea americana, Cordia africana, Coffea arabica, Millettia ferruginea, Catha edulis, and Ficus vasta, Rhamnus prinoides, Citrus aurantifolia, and Citrus sinensis , Ensete ventricosum, -Croton macrostachyus, Eucalyptus camaldulensi, Albizia gummifera, Melia azedarach and Musa species* are most often grown plants in home gardens.(Zerihun and Kaba , 2011; Asefa & Worku, 2014 ; Ewuketu *et al*., 2014).

2.4 Farmers woody plant species preferences in home garden agroforestry

Agricultural landscapes with heterogeneous species traits and environmental variables can benefit from the diversity of woody species in terms of ecosystem productivity and sustainability (Rotich et al.,2017). However, decisions made by farmers to plant trees or maintain existing trees as part of an agro forestry practice (AFP) (Mulu, 2009).Despite the fact that farmers cultivate woody plants to meet their household's needs for various wood products and services, it is equally important to determine which species are grown on the farms (species diversity), at what scale (relative density), and how frequently (relative frequency) (Duguma and Hager,2010). Communities throughout the tropical region favor various species that can serve as fences. More preference is given to trees that can be used for construction, medicine, feed, soil fertility improvement, shade, and other uses (Kefale, 2020).

Farmers' preferences for woody species should be acknowledged and communicated with because such preferences are reflected in the wood resources that are available on their holdings (Mulugeta and Admassu, 2014). Home gardening has evolved into a generalized culture with significant diversity and adaptability, enabling owners to cultivate species of their choice (preference) (Gebremedhin and Mulubrehan, 2007). The value of trees in addressing production and service function challenges has, however, long been recognized by farmers. That is well acknowledged. Men may choose timber or woodlots away from the homestead, while women may prefer fruit and fodder trees close to the homestead. Rich households may favor monocultures, while poor households may prefer multi-strata gardens to retain diversity (Mulugeta and Admassu, 2014).

2.5 Traditional Woody Species Management Practices of Home Garden Agroforestry

Indigenous knowledge, also known as local knowledge, is the information that people have created and passed down over time in an effort to adapt to their unique socioeconomic and agro ecological contexts (Hodgkin, 2002). Indigenous people frequently have in-depth knowledge of the local agro-ecological conditions, traits of plants and animals, resources, and ecological processes in the ecosystems and landscapes on which they rely for subsistence and ways of life (Tekken *et al*.,2017).To manage biodiversity in agricultural environments, farmers use a variety of management techniques (Hodgkin, 2002). By preserving the distinctive agricultural elements, crops, and crop combinations on the farm, the home garden maintains indigenous knowledge and cultural heritage. By preserving the distinctive agricultural elements, crops, and crop combinations on the farm, the home garden maintains indigenous knowledge and cultural heritage. (Asfaw, 2001b; Parra *et al*.,2012). South-western Ethiopia is one of the tropical African nations where home garden agroforestry is prevalent and has long dominated land use practices (Mersha and Kelbessa, 2016).

Traditional methods of home garden management include hand weeding, nursery preparation, organic fertilizer application, fencing, and runoff control (Asfaw, 2001b). Most home gardens are held by individual families, with the family head in charge of overall administration. The family head is typically in charge of creating the structure, choosing suitable places for positioning the main crops, and closely observing and significantly affecting the structure and direction of home garden development in order to manage the garden area and the plants (Agize *et al*., 2013). In large gardens, where more strenuous work is required, men's contributions are more significant (Kefale, 2020).

In many parts of the country, farmers need to manage woody species in home garden agroforestry for multiple purposes including household consumption and improving their household economy(Yakob *et al*., 2014; Tefera *et al*., 2016). Farmers' preference for tree species is a basic criterion to select tree and devise appropriate management in home garden agroforestry (Madalcho 2019). Farmers apply different management techniques while establishing and growing woody species in home garden agroforestry. The common management practices are pruning, thinning, and composting, weeding, mulching, digging, prescribe burning watering, and application of insecticides, protection, Pollarding, Coppicing (Kunhamu, 2013; Talemos *et al*., 2013; Reta, 2016; and Fikir *et al*., 2018).

Pollarding is practiced to optimize the height of live fences, to harvest fuel wood, to obtain construction wood, to reduce shade effects on crops and Coppicing is to obtain planting material. Protection was done through fencing to protect from damage by animals (Yakob *et al*., 2014; Tefera *et al*., 2016). Fencing is also serves as a wind breaker and Pruning to reduce shade effects on crops and collecting wood to be used for fencing, constructing houses, firewood and also for sales (Asfaw, 2001b; Getahun *et al*., 2014; Abiyot, and Zemede, 2016; Jegora *et al*.,2019 and Tadesse *et al*., 2019). Mulch and compost, Organic fertilizer enhances the soil's cohesion, boosts its capacity to retain water, and encourages a soil aggregate structure. Mulches are a cost-effective type of fertilizer and an efficient strategy for lowering weed populations because they prevent weed germination (Asfaw, 2001b).

2.6 Factors Affect Woody Species Diversity

Three categories can be used to categorize the factors that affect the species composition and diversity of plants in a home garden. (a) Elements of the natural environment, including topography, soil type, temperature, altitude, and relative humidity (Kumar, 2009). (b) The household's socioeconomic characteristics (Kehlenbeck and Maass, 2004); and (c) the features of home gardens, such as the kind of tree crops they grow, where they are located (factors, such as elevation, slope, and aspect, show heterogeneity over time and space, which naturally affects patterns of plant distribution and diversity(Malik *et al.*, 2014). Especially, due to its influence on solar radiation, air temperature and wind speed, aspect has major control on vegetation growth, species composition and structure (Yang *et al*.,2006). For instance, near the equator, east-west aspect can have a significant effect on floristic composition, diversity, and structure, in contrast to north-south facing aspect in the Northern Hemisphere and Southern Hemisphere (Yirdaw *et al*., 2015). Richness of woody species exhibited a monotonic decline with elevation (Angessa *et al*., 2020).

2.6.1 Environmental Variation

Natural conditions result in interactions or changes between biological elements, geographical constraints, and environmental elements (Verberk *et al*., 2013). The survival and rate of growth of recently planted trees until they reach maturity are significantly influenced by the meteorological conditions. Plant species richness and diversity are thought to decrease away from the equator and at higher latitudes and elevations (Salazar *et al.,* 2015). The author claims that compared to tree communities at higher elevations, those at lower elevations have higher species richness; lower stem density, and a higher basal area. Additionally, tree communities at closer proximity to the equator have higher species richness; closer stem density, and higher basal area (Malizia *et al*., 2020). However, a decrease in the abundance of one plant species may result in an increase in the abundance of another, so reducing competition (Li *et al.,* 2020).Thus, according to Victorero *et al*.(2018), internal factors (biological qualities, such as life history and functional attributes) are equally important in controlling the variety of plant communities. External factors include location, land cover, and environmental conditions (Soininen *et al*., 2007).

2.6.2 Agro-Climatic Condition

The local climate and soil conditions, which in turn have various effects on the structure of the vegetation, can be influenced by topographic elements including slope, aspect, and elevation (Zhang *et al*., 2013; Zhang *et al*.,2016). Because of the consequent variations in the amount of water available for growth, the relative distance from a water source can potentially be a threat to the type and distribution of woody vegetation (Asanok,*et al*., 2016).Vegetation patterns on a local scale can be influenced by the physical and chemical characteristics of the soil (Zhao *et al.*, 2015).In drought-prone places, soil moisture also dramatically alters the growth patterns of trees (Asanok *et al.*, 2016).

The occurrence of various vegetation types and floristic variety in Ethiopian environments has been influenced by topographic and altitudinal variance (Angessa *et al*., 2020). An influence of an altitudinal gradient on plant species diversity leads to variations in climate patterns and soil differentiation (Meragiaw *et al*., 2018). According to studies, variables including radiation, precipitation, and temperature that affect species composition are distributed in space and time differently depending on elevation, slope, and aspect and Long recognized as a potential important factor in producing variations in ecosystem characteristics (Méndez-Toribio *et al*.,2016).Additionally, it has been discovered that in the southern Ethiopian highlands, the physical and chemical characteristics of the soil have an impact on the types of plant communities that exist (Yimer , 2006).

2.6.3 Land Size

Zubair and Garforth,(2006) performed on-farm tree growing, and the availability of land was a crucially encouraging component in their success. The resources of the household, mainly land have an impact on woody plant species diversity (Nöldeke *et al*., 2021). For instance, farmers with small land holding cannot have a large stock of woody plants since the available land is primarily used to produce crops for consumption. Large land holders, on the other hand, could produce a large volume of wood (Nöldeke *et al*., 2021). The study conducted by (Abebe , 2005). Also shows that size of the home garden affect woody plant species richness. In general, a farmer's knowledge of trees, interest in them, and the size of their field all influence the species of trees they choose to plant (Lengkeek *et al*.,2005).

2.6.4 Wealth Status

The diversity of tree species on farmlands is influenced by a number of factors, including wealth. According to a study by Tesfaye Abebe(2005), wealth level is not a factor in the diversity of tree species. However, if the size of a farm is substantially connected with a farmer's wealth status, farm size can be used to explain differences in wealth groupings. Wealth may also have an impact on how different tree species are used for diverse purposes. Despite being present on their farm and being used by other farmers for that specific purpose, some households do not use a species for a particular good or service. According to Kindt, *et al*.(2004), richer families had less medicinal species, this could mean that the richer households choose to buy medicine from sources other than their farms and are not interested in growing medicinal trees on their farms.

2.6.5 Effect of altitude on woody species diversity.

Natural topographic factors, such as elevation, slope, and aspect exhibit heterogeneity over time and space. And this also naturally influences plant distribution and diversity patterns (Malik et al., 2014). Angessa et al (2019) stated that the study at Lake Wanchi watershed, Aspect and elevation had significant effects on woody plant species distribution, woody plant species composition and richness and have a monotonic decline with increasing elevation. Numbers of woody taxa and stem density showed a statistically significant reduction along the altitudinal gradient (muche et al., 2021). Elevation, slope and aspect significantly correlated negatively with species richness, whereas only elevation and slope related significantly (Mamo et al., 2013).

A complex of factors determines the composition of AF systems (Reang et al., 2021). Among other factors, topographic gradients (slopes, elevation, and aspects), plantation niches, land use management, cultural diversity, and varying-rainfall pattern have been found to affect the functional composition of on-farm tree species (Pandey et al., 2016). Notably, elevation and tree plantation niches, such as home gardens, parklands, coffee shade tree systems, scattered trees on farmland, and boundary plantations are the principal factors that considerably affect the distribution of plant species (Legesse and Negash, 2021). An increasing elevation is usually related to a lower temperature and higher humidity, and hence this climatic variability strongly shapes the composition of vegetation in general and trees used for AF purposes in particular (Solefack et al., 2018)

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1 Location:

The study was conducted in the Dale Wabera district, Kelem Wollega Zone, Oromia National Regional State, western Ethiopia. It is located at about 593 km in the western direction from Finfine, the capital city of Ethiopia. Seventy two km from zonal capital city, Dembi Dollo and altitudinal range of the study site is between 1400 and 2200m.a.s.l. geographically, it is located between latitude 8°50’0’’-- 09°10’00’’N and longitude of 34°50’30’’-- 35°18’0’’E. The total area of the District is about 455.28073 km^2 (Gadisa & Hailu, 2020; Katebu *et al*., 2023).

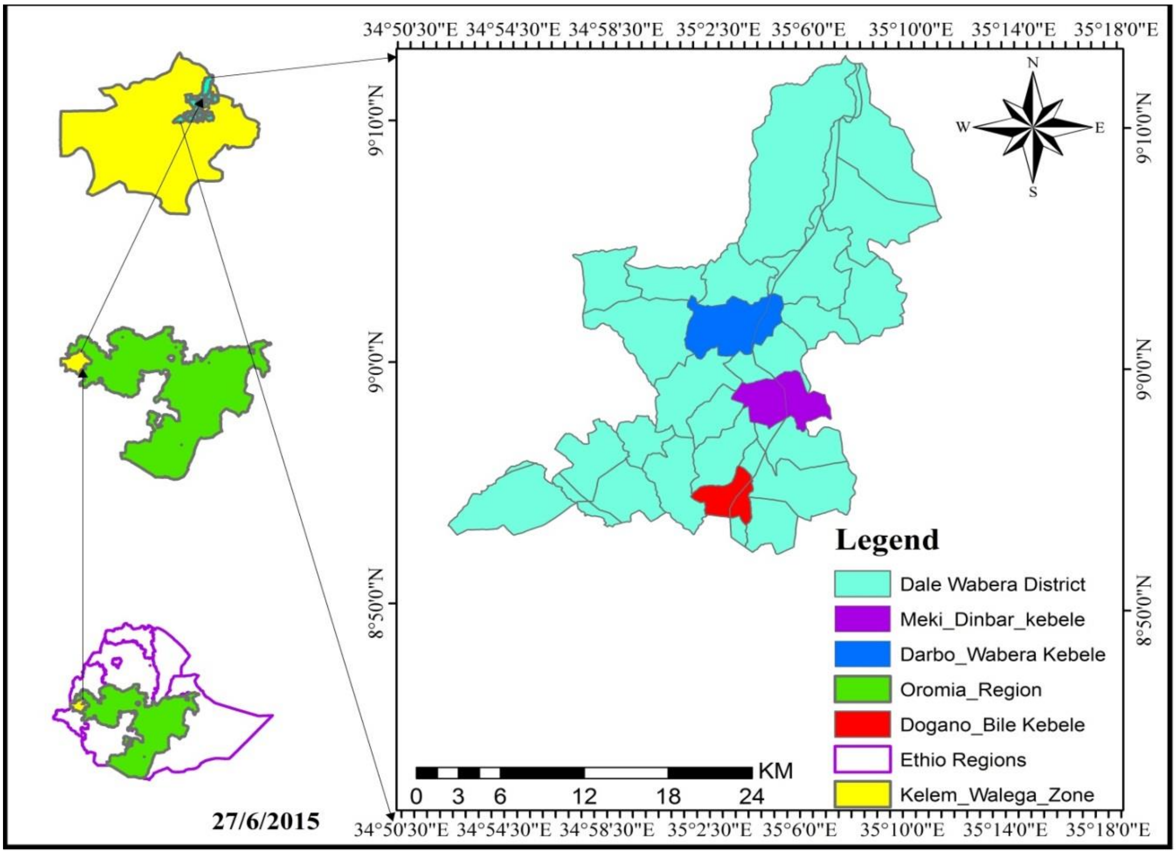

Figure 1: Map of study area

3.1.2 Population

According to the 2007 national census report a total population of the district was 106,885, of whom 53,247 were males and 53,638 were female.

3.1.3 Agro-Ecology and Soil

The major soil of the district is Nitisols (80%) and vertisols (17%) and others (3%)(Gadisa & Hailu, 2020 and Katebu *et al*., 2023),which is dominant soil type of the area with the characteristics of harden when dry, sticky when wet. Topographically, deep river valleys (korma, dhiba and Walensu Rivers), gorges, escarpments, ridges and rolling sceneries and hills characterized the study site. The major part of the area consists of rising and falling plateau.in area there is no deeply increased valleys it is rolling with pattern of small rounded hills and ridges.

3.1.4 Climate and Vegetation

Dominant climate of agro-climatic zone of the area is characterized to be wet wayina dega 98% moist kola2% with the mean annual rainfall of the study area is 1500 mm, ranges from 1200 mm to 1800 mm and temperature varies from 21°C to 29°C with an average daily temperature of 25°C (Katebu *et al*., 2023). Different species of high-value trees, such as *Mangifera indica, Musa accuminata*, and *Carica papaya*, are incorporated primarily around homesteads to provide food sources as well as generate income for the farmers. *Croton macrostachyus, Ficus thonningii, Ficus sur, Ficus vasta, Cordia africana, Albizia gummifera,* and *Acacia species* are among the tree species commonly found as scattered vegetation in agricultural land. *Eucalyptus* species, *Grevillea robusta*, and *Cupressus lusitanica* are grown as woody species. *Premna schimperiana, Markhamia lutea*, *Croton macrostachyus*, *Millettia ferruginea*, *Cordia africana*, *Albizia gummifera*, *Ficus sur, Ficus vasta, Sapium ellipticum, Albizia shempriana*, and various *Acacia species* are dominant trees in the degraded natural forest. Additionally, in the district's agricultural landscapes, these species are dispersed across various land use types (field observation).

3.1.5. Farming system

In the Dale Wabera, mixed farming systems, cattle, and subsistence farming are the most common types of farming. Agroforestry systems are commonly used in crop production farming and entail planting or retaining trees in the system due to their diversity of uses, such as *Cordia africana, Albizia gummifera,* and *Eucalyptus camaldulensis*, the most prevalent type of land use. Crop fields, coffee plantations, Home gardens, grazing grounds, and wooded lots are where farmers in the area typically grow woody tree plants. Due to the potential for output diversification on small plots of land, these agroforestry technologies in particular provide farmers with a variety of products. It does, in fact, lessen the district's land deficit. Various components make up the system of these agroforestry approaches. Farmers also plant fruit and fodder trees, spices, animals, and woody species in their backyard gardens in addition to crops.

3.1.6. Economic Activity

The district's primary economic sector is agriculture, which is rain-fed and characterized by low productivity. The agro climatic environment is ideal for cultivating a variety of crops, including annual and perennial ones. The main grains farmed by the farmers are finger millet, barley, teff, sorghum, maize, etc. Some farmers raise fruits and vegetables for both food and profit. Few farmers practice minor irrigation agriculture, cultivating maize and vegetables for domestic consumption and the local market using streams and springs. In the district, livestock is an essential component of the farming system. Oxen and horses for transporting are a greater source of power for land cultivation. Caws, oxen, sheep, goats, and calves are the main animals raised in the region.

3.2 Methods

3.2.1 Study Site Selection

After the reconnaissance survey, the study site was stratified into three elevation categories based on altitudinal gradients (Bekele,1993): lower (1400–1670), middle (1671–1940), and upper (1941–2200) to obtain homogenous units (Birhane *et al*., 2020 and Chemeda *et al*., 2022). After stratification, all kebele in each elevation category were recorded, and one kebele was selected purposively from each elevation category based on the extensive presence of home garden agroforestry. Specifically, *Dogano Bile* (low altitude), *Meki Dinbar* (middle altitude) and *Darbo Wabera* (upper altitude) were selected. And also, three Villages (a small administrative unit) were selected randomly from each kebeles (Abebe *et al*., 2019; Tefera *et al*.,2019). And also, from the interviewed household five home gardens were selected randomly from each village (because the villages are small in size and are grouped by 15 households to administer); therefore five home gardens can represent the Villages. Totally 45 home gardens were sampled, following (Birhane *et al*. (2020). and home gardens were taken as a sample plots. A complete enumeration of woody species inventories were conducted in HG (Tolera *et al.*, 2008)(as Tolera et al.,2008 stated that because of the average home garden size is 900m^2 a home garden can be taken as complete inventory). Therefore the numbers of plots are 45.

3.2.2 Households Sample Size Determination.

Households were selected from kebeles administration registration lists of households with farm land and home garden based on population size using the following formula proposed by (Kothari, 2004).

$$n = \frac{z^2 pqN}{e^2(N-1) + pqz^2}$$

Where

N=total number of house holds

p=level of precision which is 5%=0.05

e=allowed error which is 5%=0.05

q=1-p=1-0.05=0.95, the probability of getting failure in one trail.

Z=confident interval 95%, 1.95 from z-table

n=Sample size

The sample size was selected from the total household of the selected kebele, namely; Dogano Bile, Meki Dinbar and Darbo Wabera. Therefore, the total number of house hold sample size was 184. Further, the sample size was proportional.

SSK = NHHK * TNR/TNHH. (Table 1)

SSK=Sample size of kebele

NHHK=Number of households of the kebele

TNR=Total number of respondent

TNHH=Total number of house holds

Eg=for Dgano bile

SSK=401*184/1188=62

Table 1 Total number of household and sample sizes

No	Name of Kebeles	Total number of Household			Total number of sample size
		Male	Female	Total	
1	Darbo Wabera	384	11	395	61
2	Meki Dinbar	370	22	392	61
3	Dogeno bile	380	21	401	62
*	Total	1134	54	1188	184

These sampled households were selected at regular intervals using random sampling from a list. A list of target population elements is available, arranged and numbered in the order

1-N. accordingly; the appropriate sample interval for each kebele was obtained through the application of the(Singh and Masuku, 2014) formula, Who claimed that R = N/n (the R is known as the sampling interval) if there are N units in the population and n units are to be selected. Out of the remaining R (sampling interval) for the previously chosen number, the first number is chosen at random.

$$R = \frac{N}{n}$$

Where, R=sampling interval

N=total house hold

n=sample size

For instance sample interval for Dogeno Bile will be, $R = \frac{425}{62}$ = 6.8 ~ 6

Then the first sample households were selected by choosing a random number between 1 and 6 from the registration list. Eg., if the selected household was 5 for this kebele during sample size determination, the subsequent household were selected at every "6^{th}" person by adding the interval; that means the sample households next to the 5^{th} person are 5 + 6 = 11 and continued like this to get the total sample households (62). The remaining two kebeles were completed in the same manner to determine the total number of representative sample households, which are 184.

3.3 Methods of Data Collection

3.3.1 Woody Species Inventory

In each sampled home garden along the altitudinal gradients classification, the parameters: local name and number of woody specie per sampled home garden were recorded. Other primary data including diameter at breast height (DBH) and tree height was collected. Diameter at breast height and height of woody plant were measured by using diameter tape and clinometer respectively. The data was collected from woody species with DBH greater than or equal to five centimeters (≥5 cm) diameter at breast height (DBH at 1.3 m) (Tolera *et al.,* 2008 ;Yakob *et al*., 2014 and Giday *et al.*, 2019) and shrubs, saplings (height ≥ 1.3m and DBH 2.5–5cm), following Lamprecht's classification (Lamprecht, 1989, and Gebremedhin and Sintayehu, 2020).

Woody species data include tree species abundance, diversity, richness, basal area, frequency, dominance, importance value index; traditional management practices in home gardens were identified. Plant identification was mostly done at the field level by the help of key informants (KI) for local name. During plant identification at the field, there was no un common species encountered due to woody species grown in home garden mostly common to community of the study area, they were familiar to tree grown in their home garden with its use and local name that no difficult in species identification at field level. Even though specimen was not collected, image of some species were collected to use for more confirmation of identification. And identification of scientific names of species was done using useful trees and shrubs for Ethiopia (Hedberg *et al*., 2006; Bekele, 2007). Environmental attributes such as altitude, location, etc. were recorded during the expedition using GPS (Global Positioning System) (Appendix Table 16).

3.3.2. Socio-Economic Data Collection

Following Tekle and Maryo (2022) the study was used only primary data. First the questioner was translated to local language (Afan Oromo). The qualitative data were collected by assessing the history of study area regarding the diversity of woody plant species along altitude, farmers' woody species preference in home garden and traditional management practices using community's indigenous knowledge. The data were gathered from primary data source through household survey using semi-structured questionnaire (house hold interview) (Appendix 1).

Beside household interview, focus group discussion and field observation were also use to collect woody species diversity and traditional management practices. Three focus groups were conducted. One focus Group Discussion (FGD) in each kebele (with member of ten(10) individuals consisting of elders, kebele leaders, development agents (DA) and women to supplement the household data, to obtain critical reflections and to triangulate data gathered through formal interviews. This member includes individual having deep knowledge about their local community's tree management practices and home garden. Key informants (KI) or Community elders were selected to conduct discussion. Five individual farmers were selected randomly to identify key informants with Kebele leader members and development agents. They were asked to give the names of four key informants from each kebele and a total of 12 KIs were selected from the three Kebeles. They were selected based on their knowledge and experience regarding to local name of woody species identification.

3.4. Data Analysis

3.4.1 Vegetation Data Analysis

Data from the inventory were entered and summarized by Microsoft Excel, and utilized to calculate population structures such as basal area, height, diameter at breast height (DBH), important value index (IVI), and frequency of woody species (Kent and Coker, 1992 and Dibaba *et al*., 2014).The status of woody species in household's farmers of the study area was examined by calculating the diversity, species richness, and evenness values. Accordingly, the followings are details of methods and steps used for analyzing the vegetation data.

Diversity was calculated by using the equation: $H' = -\sum_{i=1}^{S} pilnpi$

Where: H'= the Shannon diversity index,

S= the number of species

Pi= the proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total, pi=ni/N,

ni = number of individuals of species "i"

N = total number of individuals of all species,

Ln = log base

A higher value of H' indicates high diversity in the sample (Magurran, 2005)

Shannon's evenness was calculated as: (Kent, 2011; Solow, and Polasky, 1994) :

$$J' = \frac{H'}{Hmax} = \frac{H'}{lnS} with\ H' = Hmax = lnS$$

While, H' is Shannon index,

J'= evenness

S= species richness

Equitability assumes a value between 0 and 1 with 1 being complete evenness (Magurran, 2005).

The frequency was calculated as follows:

$$Frequency = \frac{Number\ of\ plots\ in\ which\ species\ occur}{total\ number\ of\ plots} \times 100$$

For each woody species, the basal area was calculated according to Newton,(2007).

$$BA = \frac{(\pi(DBH^2)}{4}$$

Where, $\pi = 3.14$

BA=basal area (m^2)

DBH = diameter at breast area (cm)

The similarity of woody species composition in the three altitudinal gradients was computed by using the Jaccard's similarity coefficient (Magurran, 2005).

$$\mathrm{SJ} = \frac{a}{a + b + c}$$

Where SJ = Jaccard's Similarity Coefficient;

a = number of tree species common to sites A and B,

b = number of tree species recorded only the site A and

c = number of tree species recorded only in site B.

The values of SJ range between 0 and 1, 0 indicates complete dissimilarity and 1 indicates complete similarity in species composition.

The important value index was calculated according to **Kent (2011)**.

IVI (%) =Relative abundance + relative dominance + relative frequency

$$\text{Relative abundance} = \frac{\text{Number fo individuals of woody species}}{Total\ \text{Number fo woody individuals}} \times 100$$

$$\text{Relative dominance} = \frac{\text{Dominance of woody species}}{Total\ \text{domonance fo all woody species}} \times 100$$

$$\text{Relative frequency} = \frac{\text{frequency of woody species}}{\text{frequency fo all woody species}} \times 100$$

3.4.2 Qualitative Data

The qualitative data collected through house hold interview on traditional management practices of woody species, woody species and choice were narrated based on the existing condition and knowledge on the literature after entered to computer. It was computed using Microsoft excel to summarize and analyze using descriptive statics such as frequency and percentage. The information was mostly used to describe management practices and other on obtained results from inventory.

3.4.3 Statistical Analysis

The altitudinal gradient was an independent variable, while density, species richness, species evenness, and species diversity are considered as dependent variables. Variables were compared using one-way analysis of variance was used using R software versions 3.4.3. Significant difference detected through (ANOVA) with ($P < 0.05$) were investigated by comparisons of means using Tukey's HSD test. During analysis woody species inventoried in each plots were converted to hectare to manage the variation in plot size of the home gardens.

4. RESULTS AND DISCUSSIONS

4.1. Woody species composition and diversity along the altitudinal gradient.

4.1.1 Woody species composition

In the study area, 53 woody species were identified, classified into 47 genera and 32 families (Table 2). Among the identified species, *Coffea arabica*, *Catha edulis*, *Cordia africana*, *Musax paradsiaca*, *Eucalyptus camaldulensis*, *Mangifera indica*, *Grevillea robusta*, *Justicia schimperiana*, *Vernonia auriculifera*, *Persea americana*, and *Sesbania sesban* were the most dominant species in the study site. The highest number of species, 6 (11.32%), was recorded in Fabaceae., followed by Moraceae 5 (9.43%) in the family Rutaceae, Euphorbiaceae, Asteraceae, and Rosaceae are *3 (5.66%)* each; Bignoniaceae,Rubiaceae, Myrtaceae, and Musaceae *are* 2 (3.77%) each; the family Acanthaceae, Anacardiaceae, Annonaceae, Araliceae, Arecaceae, Buddleiaceae, Caricaceae, Boraginaceae, Casuarinaceae, Cupressaceae, Lauraceae, Malvaceae, Melianthaceae, Meliaceae, Mimosoideae, Moringaceae, Oleaceae, Poaceae, Proteaceae, Punicaceae, Celastraceae, and Verbenaceae (1.89%) are recorded by one species.

This outcome was consistent with research conducted in the Sub-Humid Lowlands of Ethiopia (Tadesse *et al*., 2019), the diversity and composition of useful plant species along altitudinal gradient in selected Home Gardens of Kembata Tembaro Zone, SNNPr of Ethiopia (Samuel, 2020) and a study conducted in the Hawassa Zuria District in Sidama Zone, Southern Nations (Birhane *et al*., 2020) who reported that the dominant family of woody species recorded in home garden agroforestry is the Fabaceae family and also Chamada et al. (2022),stated in the study conducted on Tree diversity and biomass carbon stock analysis along altitudinal gradients in coffee based agroforestry system of Western Ethiopia the Fabaceae family was the dominant family in the study area.

Additionally, the findings indicate that 23 (43.4%) of these species were exotic (e.g., *Persea americana Mill, Musax paradsiaca, Eucalyptus camaldulensis*, *Mangifera indica L*., and *Grevillea robusta have* a high relative dominance) and 30 (56.6%) (e.g., *Cordia africana Lam., Coffea arabica* L., *Catha edulis, and Croton macrostachyus Del.*), were native. This result is dissimilar to that of Molla and Kewessa (2015), who found that in the Dello Menna district of southeast Ethiopia, traditional agroforestry practices had a higher percentage of exotic species among indigenous. The species diversity and richness are significantly varied across the altitudinal gradient. There were 25 woody species found at the upper altitude, 39 at the middle altitude, and 41 at the low altitude, and diversity of woody species at low altitude gradient (H' = 2.5), middle altitude gradient (H' = 1.75) and the upper altitude (H =1.60). And the evenness indices at the upper, middle and lower altitudes were J = (0.671, 0.641 and 0.676) respectively. this study is comparable to that of the study conducted in Dandi District, Central Ethiopia (Humnessa, 2020) which identified 52 woody species based on the diversity and composition of home garden agroforestry practices. And greater than the 39 woody species found in home gardens in the woody plant species diversity of home garden agroforestry in three agro ecological zones of Dilla Zuria District, Gedeo Zone, Southern Ethiopia (Tefera *et aL*., 2016) and the 49 woody species found in the Woody Species Diversity of Home Garden Agroforestry along an elevation gradient in Southern Ethiopia (Birhane *et al*., 2020).

This suggests that, out of all the elevation types in the study sites, the home garden's at the lower altitude has the highest richness of woody plant species. The highest concentration of woody plant species in low altitudes can be attributed to factors such as variations in altitude, more fertile soil than in other areas, and ideal environmental conditions for the growth of woody species. According to Birhane et al. (2020), site characteristics, management strategies, socioeconomic issues, and farmers' preferences for tree species could all contribute to variations in the richness of woody species between different locations. This is consistent with the findings of a study conducted in northeastern Ethiopia on tree and shrub species along altitudinal gradients (Muche *et al*., 2022). The outcome demonstrated that, in comparison to mid- and high-elevation plots, tree species richness was highest in the lower-elevation plots.

Table 2 Total number of woody plant families, genera, and species recorded in home garden agroforestry

Altitudinal Gradient (mas)	Species	Family	Genera
1941–2200(UA)	25	19	24
1671–1940(MA)	39	24	36
1400–1670(LA)	41	27	38
Over all	53	32	47

4.1.2 Similarity indices

The Jaccard similarity for the UA, MA, and LA was 0.48 (48%); this indicates that the three elevations have low woody species similarity. Generally, 53 woody species were identified in the study area; of these, 41 were located in LA and 9 were unique to this altitude category; the remaining 17 species were shared with all, 2 with the UA, and 13 with MA. Parallel to this, of the 39 species identified in MA, only 7 were unique to the gradient and 2 were shared by the UA. Of the total number of species, only four were unique to the UA; the other 21 species were shared by MA&LA (Appendix Table 14&15) and Fig. 2. Between low and middle altitudes, there was the greatest similarity in woody species compositions (61%) and the lowest (40%) between low and upper altitudes (Table 3). Comparable to the findings of Birhane et al. (2020), who found that the estimated Jaccards coefficients of similarity for middle and low elevations are higher than those for other elevations. The high number of common species found in both elevations compared to other elevations may be the cause of the relatively high similarity in the composition of woody species between middle and low elevations. Which is (30); the other two are, in turn, (19) low to high and (19) high to middle elevation (Appendix Table 14&15) and Fig. 2. And I agree with Birhane et al. (2020) that altitudinal variation and the extent of human impacts may have contributed to the lowest species similarity between LA and UA. Haider *et al*. (2018) also reported that Jaccard dissimilarity in species composition increased with increasing elevation distance.

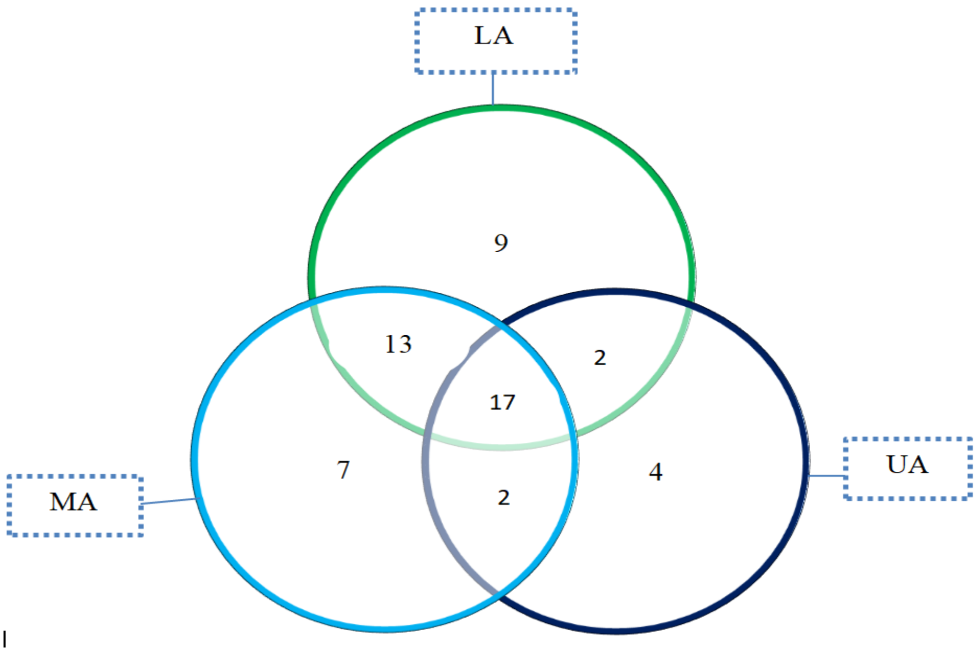

Figure 2: Common and unique species of the altitude categories

Table 3 Jaccard's Similarity Index (%) of Woody Species among Altitudinal Gradients in Dale Wabera Wareda

Altitudinal gradient	Upper altitude	Low altitude
Low altitude	0.40	-
Middle altitude	0.44	0.61

4.1.3 Woody species diversity, richness, and evenness

The Shannon index was used to identify and compare diversity between altitude categories. Accordingly, species diversity was estimated by using species richness, Shannon diversity, and evenness index. Based on this, the current study results show that the Shannon diversity index, species richness, and species evenness varied across the altitudinal gradient (Table 5). The result of the one-way ANOVA showed that the diversity of woody species significantly varied across the altitudinal gradient ($F(2, 42) = 52.8$, $P < 0.001$, Fig. 3). The low altitude gradient ($H' = 2.5$) had the highest species diversity, followed by the middle altitude gradient ($H' = 1.75$) and the upper altitude ($H = 1.60$). These findings are consistent with a study conducted at Hawassa Zuria District in Sidama Zone by Birhane *et al. (2020),* who found that there were significant differences in the diversity index, Shannon, and evenness among the three elevation gradients and that the lower elevation had significantly higher diversity and evenness index values than the other two studied elevation gradients.

Table 4 Woody Species Diversity, Richness and Evenness Value in HGAF of Dale Wabera Woreda

Altitudinal gradient(m asl)	Shannon Diversity Index (H')	Species richens (S)	Evenness Index (E)
LA (1400-1670)	2.51	14	0.676
MA (1671-1940)	1.75	11	0.641
UA (1941-2200)	1.60	8	0.671
P-value	< 0.001	< 0.001	< 0.05

Statistically significant difference P< 0.01between the three altitude

Table 5 ANOVA Table of Species Diversity in Different Altitude Categories

Factor	DF	Sum Sq.	Mean sq.	F Value	P value
Altitude	2	2.3931	1.1966	52.8	0.001
Residual	42	0.9518	0.0227		

The evenness indices at the upper and lower altitudes were slightly high (J = 0.671 and 0.676, respectively) (Table. 4). It was noted that more species are found in the home garden agroforestry at the lower altitude gradient than in the middle and upper altitudes. It was interesting to note that however the lower altitude have high number of species, it is evenly distributed throughout its ecosystem. In the case of upper altitude, it was interesting to note that, despite having a lower number of species than lower altitude, it hosts evenly distributed species throughout its ecosystem. This contributed to the slightly high evenness index in the home garden agroforestry of lower and higher altitude gradient of Dale Wabera District.

The reason for the high diversity at lower elevations could be attributed to factors such as improved soil fertility, the preference of farmers for woody species, and favorable ecological condition that promotes the growth of wood species in the area as compared to middle and upper altitudes. The result is consistent with Körner (2007), who reported that climate variations were the cause of differences in diversity. Harsh climate conditions, like high winds, intense solar radiation, and poor soil fertility, may make it difficult for some species to occur at high altitudes.

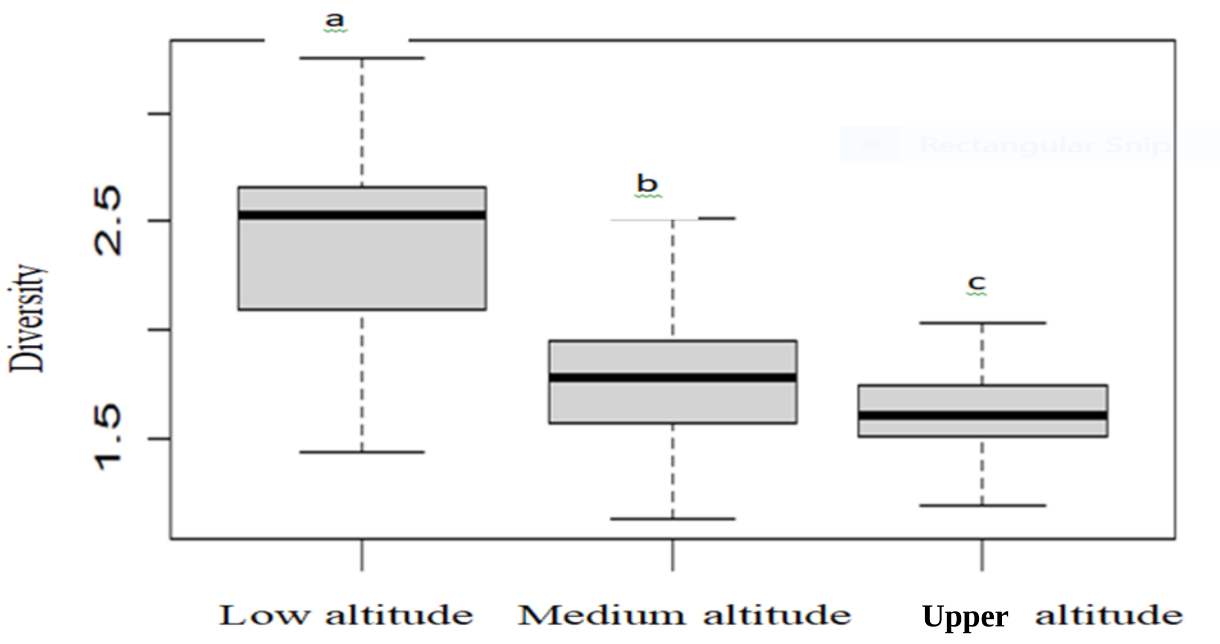

Figure 3: A boxplot showing the woody species diversity across the altitudinal gradient.

The different small letters on the boxplot indicate the significant differences in diversity among the altitudinal gradients.

Comparing different home gardens along an elevation gradient in terms of Shannon diversity indices, there was no statistically significant difference between the upper and middle altitude categories in the study area. The current study identified that variation was observed when comparing Middle Altitude and Lower Altitude and Upper Altitude and Lower Altitude, which was statistically significant ($P<0.001$). (Table 6)

Table 6 Comparisons of means using Tukey's HSD after ANOVA foe species diversity

Variables	Mean difference (standard error)	Lower Limit	Uppr limit	P-value
Middle Alt-Lower Alt	-0.4314667	-0.5650137	-0.29791962	0.0000000***
Upper Alt- Lower Alt	-0.5314667	-0.6650137	-0.39791962	0.0000000***
Upper Alt - Middle	-0.1000000	-0.2335471	0.03354705	0.1757276NS

Where,*P<0.05; ***P<0.001; NS-non significant

During comparisons, similar patterns of variation were also found for evenness values across different altitudinal gradients (Table 7). When comparing the evenness indices of

MA with LA and UA, it was lowest in that altitude gradient and high at the LA and UA gradients. These differences were statistically significant (p<0.001).

Table 7 Comparisons of means Using Tukey's HSD after ANO for species evenness

Variables	Mean difference (standard error)	Lower Limit	Uppr limit	P-value
Middle Alt-Lower	-0.3915333	-0.5367502	-0.24631642	0.0000002***
Upper Alt- Lower	-0.5203333	-0.6655502	-0.37511642	0.0000000***
Upper Alt - Middle	-0.1288000	-0.2740169	0.01641692	0.0910951NS

Where,*P<0.05; ***P<0.001; NS-non significant

When comparing the current study results at three altitudinal gradients, the Shannon diversity index result reveals that in the home garden agroforestry of study sites, low altitude was more diversified, followed by middle altitude, where species diversity ranges between 2.5 and 1.60 and species evenness ranges between 0.676 and 0.641 (Table 5). The results showed lower diversity and evenness indices than studies on the diversity and composition of useful plant species along an altitudinal gradient in selected home gardens of Kembata Tembaro Zone, SNNPr, Ethiopia (H = 2.98, j = 0.69) (Samuel, 2020). but higher results in both species diversity and evenness than studies conducted on carbon stock and woody species diversity in home garden agroforestry along an elevation gradient in southern Ethiopia (H = 1.8, j = 0.081) (Birhane *et al.*, 2020).

Generally, this study showed that woody species diversity and richness vary across different altitudinal gradients. This could be due to differences in topography, species functions, nutrient and moisture availability, management activity, and factors related to the socioeconomic status of the farmers. According to Meressa (2020), Variations in topographic factors, moisture, and nutrient availability are the causes of the differences in species diversity between various areas. The study conducted in southern Ethiopia revealed that tree diversity declines with increasing altitude and that altitude has a significant impact on overall species richness, composition, and diversity (Desalegn & Beierkuhnlein, 2010). Plant growth is restricted as altitude rises due to high rainfall and a minimum temperature (Tefera *et al.*,2016).

4.1.5 Important value index

The relative ecological significance of a species within the forest ecosystem was expressed by its index of variation (IVI). It was computed by adding together the species' relative frequencies, densities, and dominance. According to Molla & Kewessa (2015), the importance value index (IVI) measures a species' overall significance and provides information about its ecological success in a given area. High IVI species are linked to land uses and farmers' preferences for particular species, which are connected to the market demand and service value of particular species. Higher IVI species are associated with both product value and preference for framer species, particularly in agroforestry practices (Mengistu & Asfaw, 2016).

In this study, because of their relatively high relative abundance (29.55%, 25.54%, 8.11%, and 5.79%), *Coffea arabica, Catha edulis, Justicia schimperiana*, and *Musax paradsiaca*, respectively, all have high IVIs. Cordia *africana (15.88%), Musax paradsiaca (12.5%) Eucalyptus camaldulensis (8.82%), Catha edulis (8.56%) Grevillea robusta (8.1)* has a high relative dominance and hence contributed the highest IVI value in the study area. The important value index indicates the degree of a species' dominance, occurrence, and abundance in relation to other related species in a given area (Kent, & Coker, 1992). According to Mekonnen *et al*.(2014), The dominance of these species could be attributed to their more significant economic roles in the system and species that have multiple uses have a higher IVI. The most important woody species in this study area's three-altitude category with the highest IVIs were presented in (Table 8). Of all species, Coffea arabica (52.60%), (48.4%), and (41.73%) were the top ranking in high altitude, middle altitude, and low altitude. followed by Eucalyptus camaldulensis (34.17%), Catha edulis (36.33%), and Mangifera indica (36.5%) at high, mid, and low altitudes, respectively.

As the current study indicated, the species with a higher IVI were the most important woody species in the home garden of the study area. For the upper altitude category, the highest IVI value is covered by species that provide construction tools, fuel wood, and higher income for the farmers, while in the case of middle altitude, the highest IVI value is covered by species that provide higher income for the farmers. And also at low altitude, the species with the highest IVI is covered by species that provide food and higher income for the farmers. Mengistu & Asfaw, (2016), state that fruit trees and other high-market-value species are the woody species with the highest IVI in home-garden agroforestry practices.**Table 8 The top five woody species with the highest IVI values three altitude category**

Altitude Category	***Scientific name***	**Family Name**	**IVI%**
Upper Altitude	*Coffea arabica L.*	Rubiaceae	*52.60*
	Eucalyptus camaldulensis Dehnh	Myrtace ae	*34.17*
	Catha edulis (Vahl)	Celastraceae	*23.95*
	Musax paradsiaca L.	Musaceae	*23.70*
	Cordia africana Lam.	Boraginaceae	*20.15*
Middil Altitude	*Coffea arabica L.*	Rubiace ae	*41.73*
	Catha edulis (Vahl)	Celastraceae	*36.33*
	Cordia africana Lam.	Boraginaceae	*34.75*
	Eucalyptus camaldulensis Dehnh	Myrtace ae	*21.29*
	Musax paradsiaca L.	Musacea e	*18.30*
Low Altitude	*Coffea arabica L.*	Rubiace ae	48.3
	Mangifera indica L.	Anacardiaceae	36.5
	Jatropha curcas	Euphorbiaceae	25
	Musax paradsiaca L.	Musacea e	20.8
	Catha edulis (Vahl)	Celastraceae	22

In this study area *Coffea arabica*, *Eucalyptus camaldulensis*, *Catha edulis*, *Musax paradsiaca, Cordia africana* were the most important woody species recorded in this area. The current study identified that some of species were exotic, timber wood, fruit trees and cash crops which have mostly economic value. This finding was in line with the result of Tolera *et al*.(2008), who reported, species occurred in home garden were mostly exotic trees such as *Eucalyptus and Cupressus* spp and fruit trees and cash crops such as chat (C. edulis), which are all species of economic or nutritional importance for farmers.

4.2 .Woody species preference

Certain woody species are kept around the house for reasons related to the practical benefits and services they provide (Jiregna et al.,2005)The primary justifications provided by the respondents for keeping woody species in the study area were enumerated in order of significance: income resource > food> construction material >fuel wood > shade > fence and boundary > agricultural tools. The outcome agrees with Mulugeta &Admassu

(2014) findings that the selection of a tree species depends upon the potential benefits of maintaining the tree on a farm. After asking respondents to rank the five most important woody species, a total relative score was computed to assess farmers' preferences for different species. Accordingly, *Coffea arabica, Catha edulis, Cordia africana, and Mangifera indica Persea americana, Eucalyptus camaldulensis, and Grevillea robusta, Musax paradsiaca, Azadirachta indica Citrus sinensis Cupressus lusitanica Jatropha curcas are ranked in descending order* (Table 9*)*. Mulugeta &Admassu (2014) also stated that the trees that farmers preferred were *Eucalyptus camaldulensis* > *Rhamnus prinoides* > *Catha edulis* > *Cordia africana*, and so forth.

Table 9 The five most significant woody species preferred by respondents in each altitude gradient

Altitude Category	Species	Respondent	%	Rank
	Coffea arabica,	55	90.16	1
	Cordia africana	52	85.25	2
	Catha edulis	51	83.61	3
	Eucalyptus camaldulensis	39	63.93	4
Upper Altitude	*Musax paradsiaca,*	32	52.46	5
	Coffea arabica	57	93.44	1
	Catha edulis	55	90.16	2
	Mangifera indica	47	77.05	3
	Eucalyptus camaldulensis	41	67.21	4
Middle Altitude	*Cordia africana*	34	55.74	5
	Coffea arabica	52	83.87	1
	Catha edulis	51	82.26	2
	Persea americana	43	69.35	3
	Cordia africana	43	69.35	3
Low Altitude	*Grevillea robusta*	43	69.35	3

The overall outcome shows that the farmers' preferred woody species at Dale Wabera Woreda were, in order of, Coffea Arabica > Catha edulis > Cordia africana > Mangifera indica, and so on (Table 10). Mulugeta &Admassu (2014) also stated that the selection of tree species depends on the advantages that can be gained from maintaining the tree on the farm. Traditional tree-based agricultural farming and land-use systems are excellent examples of how farmers have understood the value of trees in resolving these issues for centuries (Katebu *et al*., 2023).

Table 10 Woody species preference of respondents per study area

No	Species	Respondent	%	Rank
1	*Coffea arabica,*	164	89.13	1
2	*Catha edulis,*	157	85.33	2
3	*Cordia africana,*	129	70.11	3
4	*Mangifera indica,*	111	60.33	4
5	*Persea americana,*	77	48.37	5
6	*Eucalyptus camaldulensis,*	85	46.20	6
7	*Grevillea robusta*	89	44.57	7
8	*Musax paradsiaca,*	82	41.85	8
9	*Azadirachta indica*	9	13.04	9
10	*Citrus sinensis*	18	9.78	10
11	*Cupressus lusitanica*	24	4.89	11
12	*Jatropha curcas*	2	1.09	12
		184	100.00	

Important tree or shrub species that farmers prefer have been planted or retained (Table 10). As a result, the majority of farmers retained *Croton macrostachyus, Cordia africana, Ficus sycomorus, Sapium ellipticum,* and *Ficus vasta* among those listed. 88% (15) of the woody species that are commonly found in all three altitude gradients and are typically ranked in the top ten are preferred by the farmers in Dale Wabera. These species include, depending on their multiple uses, *Coffee arabica, Catha edulis, Cordia africana, Mangifera indica, Persea americana, Eucalyptus camaldulensis, Grevillea robusta, Musax paradsiaca,* and *Azadirachta indica.* The present study agrees with the findings of Jiregna *et al.* (2005), which suggest that the selection of tree species should be based on the potential benefits of maintaining the tree on the farm.

4.3. Woody species management

The community in the study area uses various management strategies, either traditionally or with their indigenous knowledge, to establish and grow woody species in home gardens, practice agroforestry, and safeguard multipurpose woody plant species. Retaining remnant or naturally regenerating plants and/or engaging in plantation activities allowed for the promising tradition of including woody plants in home gardens (Yakob *et al*. 2014). for example during interview 83.69% (154) of respondent respond that they carried out planting and 53.26 % (98) retaining indigenous woody plant in their home garden and 44%(81) of the respondent were practice planting of exotic woody species

in their home garden. Additionally, 32% of the species are native to the area, including *Ficus sycomorus, Sapium ellipticum, Croton macrostachyus,* and *Ficus vasta.* The present investigation aligned with the findings of Fikir *et al*.(2018) and Yakob *et al*. (2014), which documented that home garden land use types tend to favor the planting of exotic species and the retention of native species.

Farmers understood the significance of various woody species management activities for maximizing the interaction between woody crops and generating advantages from these activities, including improved soil fertility, fuel wood, and fodder (Yakob *et al*..2014). Respondents stated that the primary goals of these activities are to minimize negative interactions and optimize the system's overall performance in the home garden. For the woody species they owned, the respondents practiced a variety of management practices. This type of management involved coppicing, mulching crop residue, thinning, pruning, pollarding, applying organic fertilizers, watering, prescribed burning, and using fencing (Figure 5). This outcome was consistent with Madalcho and Tefera,(2016) findings. Also, the respondent stated that the primary goals of pruning and pollarding in a home garden were to lessen the impact on crops underneath and to gather wood for building, firewood, fencing, and animal feed. The outcome is consistent with the findings of Yakob *et al*. (2014), who stated that pruning the shade tree species kept in the home garden was done to lessen the shade for the production of coffee and to gather wood for sales, fencing, building homes, and firewood.

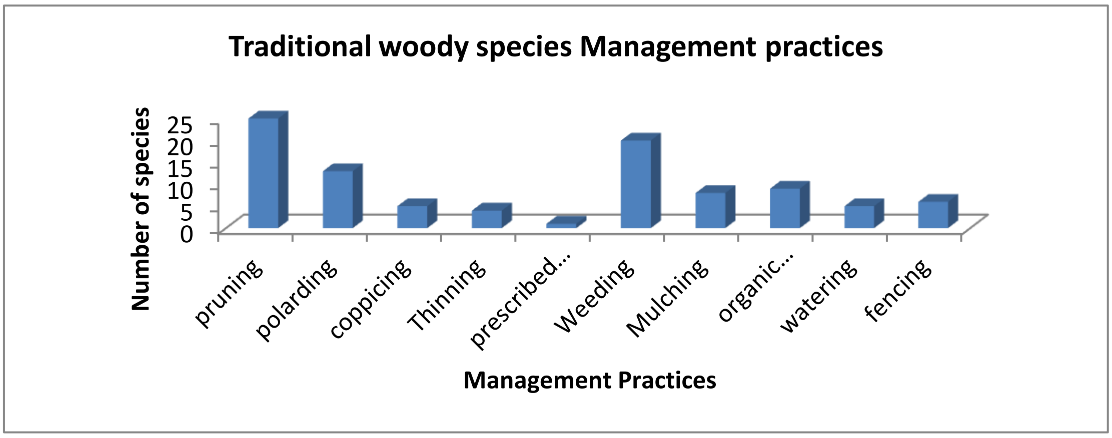

Figure 4: The type of management practiced by respondents in the study area

According to Yakob *et al.* (2014), to protect home garden species from damage by animals, protection was done through fencing. In group discussions, farmers explain that when multipurpose trees like *Cordia africana* and fruit tree species regenerate in their home gardens, they leave them behind and maintain them in the system. This explanation was evident when, during vegetation inventory, it was observed that farmers planted and built barriers around them as a protection against grazing animals and keeping people away (Figure 6).

Figure 5**:** The farmer keeps and safeguards *Persea americana* in is home garden by building barriers to keep animals and people from it.

Most farmers said that the only fertilizers they used in their home gardens were animal dung and organic waste from the house. Watering was done to ensure the early survival of seedlings planted, and coppicing and prescribed burning were only carried out to make it easier for *Eucalyptus* tree species to germinate and be harvested. And the result agreed with(Yakob *et al.*,2014).

5 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Home garden agroforestry practices are conserving several woody species diversity in their systems, which reduce the natural forest degradation. These findings revealed that woody species richness and diversity are varied significantly along altitudinal gradient in the study area. Woody species diversity and richness decreased with increasing altitude. Lower altitudinal gradient had comparatively higher woody species diversity than middle and upper altitudinal gradient.

Assessment of the importance of individual tree or shrub species in home garden indicated that high income generation woody species was ranked first followed by construction material and those are used for food. Farmers' tree/shrub preference was in order of *Coffea arabica> Catha edulis> Cordia africana >Mangifera indica >Persea americana>Eucalyptus camaldulensis > Grevillea robusta >Musax paradsiaca >Azadirachta indica >Citrus sinensis >Cupressus lusitanica > Jatropha curcas are ranked from high to low* based on the benefits derived from woody species.

The present study's findings verify that home garden agroforestry techniques can be very helpful in conserving the diversity of woody species. This is more essential to enhancing traditional agroforestry methods that incorporate multipurpose tree species to produce a variety of forest products, reducing the pressure on the current forest, and conserving biodiversity. These findings could be very helpful in developing development plans that can be applied to the study area's various elevation categories.

5.2 Recommendations

1. The residents of the study area have a tradition of keeping woody plants in their home gardens. Additionally, in order to make the most of their home gardens, they should be aware of the importance of diversifying woody plant species and choosing woody species that are suitable for the altitude gradient.
2. More tangible conservation efforts and interventions are needed to plant and retain woody plant species in home gardens, thereby increasing diversity, and managing woody plant species there while also maintaining the ones that are already there.
3. Applying manure and spreading organic matter were the main management techniques used in the home garden to raise the soil's fertility. But the farmers in the study area had very little experience of preparing compost. Thus, raising awareness and providing training are essential for enhancing soil fertility in home gardens.
4. Farmers should practice producing seedlings of woody plant species that are productive for the appropriate altitude gradient of the study area in order to obtain high-quality woody species products for their livelihood consumption and lessen their reliance on natural forests.
5. The Dale wabera agricultural office, NGOs, should bring woody species seedlings for the farmers.
6. Also further studies should be conducted to understand which woody species make a higher contribution to good wood production at different parts of the elevational gradient.

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7. APPENDIX

Appendix Table 1 : Semi Structured Interview questionnaire for householders

The researcher, Solomon Zaru is one of postgraduate students of Natural resource Management/forest and nature at JUCAVM . He is currently conducting a study on "Assessment of Woody plant species diversity and traditional management of home garden agro forestry along altitudinal gradient" as a partial fulfillment for the requirement of his master's degree. The main purpose of this survey interview questionnaire is to collect relevant data on the study's topic. The response that you are going to give for all the questions will anonymously be included in the analysis of the study; and the findings of the study will be used for academic purposes. Hence feel free while responding to the questions as your genuine response will subsequently determine the overall quality and reliability of the study. Finally, this questionnaire paper has two major parts. The first part includes questions on the socioeconomic and demographic characteristics of the sample households while the second part includes the main questions of the study.

The objectives of this question are to find out the effect of altitude on woody plant species diversity and traditional management of home garden agro forestry.

Instruction

Questionnaire to be filling by HHHs

Questions for assessment of woody plant species diversity, in agro forestry system of home garden in Dale Wabera District, Kellem Wollega Zone, Western Ethiopia

Personal information;

Name of interviewer_______________________ Date_______ Time___ Kebele________ Ditrict_______

1. Marital status: Married not married Divorced Widowed
2. Age: a) 25-50 b) 51-65 c) >65
3. Sex: a) Male b) Female
4. Family size 1)0-2 2) 3-5 3) 6-8 4)>8
5. Educational level: a) Illiterate b) Literate c) grade 1-4 d) grade 5-8 e) grade 9-12

Part I Main questions of the study

1. What are method (practice) used for including woody plant in your home garden agroforestry?

   A. Retaining B, Planting C, Both practices

1.1Depending on question number 1, which species you include more?

   -Exotic -indigenous

1.2 What is the reason for selecting species in your home gardens?

Exotic: ____

Indigenous: ____

2. What type of woody plant used commonly for agro forestry system?

2.1 Pleas indicate local Name, Habitat, local use and their uses in habitat on the following data sheet.

NO	Local Name	Scientific Name	Origin	Habitat	Their uses in habitat (Ecological use)	Local uses	Status

6. The woody plant populations are:

Increased Decreased the same

7. If your answer is decreasing. What is the reason?

____

____

8. Mention importance of woody plant species for different purposes?

____

____

9. What is the indigenous knowledge being available to manage woody species in your locality home garden?

no	Scientific Name	Habitat	Management practices	reason for management

Do you think That conserving woody species in home garden can create synergy between Natural forest and socio economic activities of local community?

A) yes B) no

If your answer is yes, how?

If your answer is no, why?

So what is the solution to be proposed?

From local community?

From government?

Appendix Table 2: Table Of Woody Species Rel.Frequency, Rel.Abandency, Rel.Domimance And IVI In HGAF Of Dale Wabera At Upper Altitude

No	*Scientific name*	Family Name	Rel. dety	Rel.freq.%	Rel.Dom	IVI%
1	*Buddleia polystachya*	Loganiaceae	0.00	*0.79*	*0.01*	*0.91*
2	*Manls sylvestris*	Rosaceae	0.00	*0.79*	*0.04*	*1.15*
3	*Persea americana Mill*	Laurace ae	1.00	*3.17*	*1.27*	*5.38*
4	*Eucalyptus camaldulensis Dehnh*	Myrtace ae	6.00	*8.73*	*19.21*	*34.17*
5	*Citrus sinensis (L.*	Rutacea e	0.00	*0.79*	*0.04*	*1.04*
6	*Ficus thonningii Blume*	Moraceae	0.00	*0.79*	*0.09*	*0.99*
7	*Justicia schimperiana (Hochst. ex*	Acanthaceae	11	*5.56*	*0.58*	*17.14*
8	*Vernonia amygdalina Del.*	Asteraceae	4.00	*9.52*	*0.41*	*14.11*
9	*Grevillea robusta R. Br.*	Proteace ae	0.00	*0.79*	*2.26*	*3.47*
10	*Bersama abyssinica subsp. abyssinica*	Melianthaceae	0.00	*0.79*	*0.01*	*0.91*
11	*Croton macrostachyus Del.*	Euphorb iaceae	1.00	*4.76*	*1.36*	*6.75*
12	*Mangifera indica L.*	Anacardiaceae	1.00	*5.56*	*1.86*	*8.36*
13	*Ricinus communis L.*	Euphorbiaceae	1.00	*1.59*	*0.29*	*2.40*
14	*Vernonia auriculifera Hiern*	Asteraceae	4.00	*8.73*	*0.56*	*13.58*
15	*Arundinaria alpina K. Schum.*	Poaceae	1.00	*0.79*	*0.08*	*1.92*
16	*Premna schimperi Engl.*	Verbenaceae	0.00	*0.79*	*0.03*	*0.93*
17	*Cordia africana Lam.*	Boraginaceae	2.00	*6.35*	*12.24*	*20.15*
18	*Morus alba L.*	Moraceae	1.00	*3.97*	*0.13*	*4.93*
19	*Coffea arabica L.*	Rubiaceae	38	*10.32*	*4.77*	*52.60*
20	*Ensete ventricosum (Welw.)*	Musaceae	0.00	*0.79*	*0.46*	*1.46*
21	*Musax paradsiaca L.*	Musaceae	7.00	*5.56*	*10.83*	*23.70*
22	*Millettia ferruginea(Hochst.) Bak.*	Fabaceae	0.00	*0.79*	*0.09*	*0.99*
23	*Sesbania sesban (L.) Mer*	Fabaceae	3.00	*9.52*	*0.61*	*13.48*
24	*Catha edulis (Vahl)*	Celastraceae	14	*7.14*	*2.60*	*23.95*
25	*Casuarina cunninghamiana Miq.*	Casuarinacea	0.00	*0.79*	*3.47*	*4.68*
26	Helichrysumformosissimum var.guilemi (engl.)	Asteraceae	5.00	*0.79*	*0.36*	*5.75*
			100	*100*	*100*	*300*

Appendix Table 3 woody species Rel.Frequency,Rel. abundance,rel. dominance and IVI in HGAFof dale wabera at middle altitude

No	Scientific name	Family Name	Rel. dety%	Rel.freq. %	Rel.Dom %	IV%I
1	*Persea americana Mill*	Laurace ae	*1.20*	*4.17*	*2.20*	*7.57*
2	*Eucalyptus camaldulensis*	Myrtace ae	*3.30*	*4.63*	*13.36*	*21.29*
3	*Citrus sinensis (L.*	Rutaceae	*0.70*	*3.70*	*0.12*	*4.52*
4	*Ficus sycomorus*	Moraceae	*0.00*	*1.85*	*2.40*	*4.25*
5	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Acanthaceae	*1.70*	*1.85*	*0.00*	*3.55*
6	*Vernonia amygdalina Del.*	Asteraceae	*1.50*	*4.17*	*0.28*	*5.95*
7	*Grevillea robusta R. Br.*	Proteaceae	*2.20*	*3.24*	*0.00*	*5.44*

8	Artocarpus heterophyllus	Moraceae	*0.00*	*0.93*	*0.15*	*1.08*
9	*Gossypium hirsutum L.*	Malvaceae	*0.00*	*1.39*	*2.45*	*3.84*
10	*Casimiroa edulis La liave*	Rutaceae	*0.00*	*0.46*	*0.12*	*0.58*
11	*Prunus persica (L.) Batsch.*	Rosaceae	*0.00*	*0.93*	*0.45*	*1.38*
12	*Citrus aurantifolia*	Rutaceae	*0.00*	*2.30*	*0.03*	*2.33*
13	*Croton macrostachyus Del.*	Euphorbiaceae	*0.00*	*2.30*	*2.46*	*4.76*
14	*Mangifera indica L.*	Anacardiaceae	*0.00*	*3.24*	*1.84*	*5.08*
15	*Carica papaya L*	Caricaceae	*0.80*	*1.39*	*0.78*	*2.97*
16	*Ficus vasta Frssk.*	Moraceae	*0.00*	*0.93*	*7.69*	*8.62*
17	*Ricinus communis L.*	Euphorbiaceae	*2.20*	*4.17*	*0.28*	*6.65*
18	*Vernonia auriculifera Hiern*	Asteraceae	*3.00*	*3.70*	*0.70*	*7.40*
19	*Annona senegalensis*	Annonaceae	*0.00*	*0.93*	*0.08*	*1.01*
20	*Arundinaria alpina K. Schum.*	Poaceae	*2.20*	*1.39*	*0.19*	*3.78*
21	*Premna schimperi Engl.*	Verbenaceae	*0.00*	*2.78*	*0.24*	*3.02*
22	*Cordia africana Lam.*	Boraginaceae	*7.80*	*6.02*	*20.93*	*34.75*
23	*Psidium guajava L.*	Myrtaceae	*0.00*	*1.85*	*0.12*	*1.97*
24	*Morus alba L.*	Moracea e	*6.00*	*5.10*	*2.19*	*13.29*
25	*Coffea arabica L.*	Rubiace ae	*30.90*	*6.02*	*4.81*	*41.73*
26	*Ensete ventricosum (Welw.)*	Musacea e	*1.20*	*2.78*	*3.69*	*7.67*
27	*Musax paradsiaca L.*	Musacea e	*4.80*	*4.17*	*9.33*	*18.30*
28	*Azadirachta indica A. Jus*	Meliaceae	*0.60*	*3.70*	*1.88*	*6.18*
29	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Fabaceae	*0.00*	*1.39*	*0.55*	*1.94*
30	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Oleacea e	*0.00*	*2.31*	*0.18*	*2.49*
31	*Cupressus lusitanica Mill.*	Cupressaceae	*1.50*	*3.24*	*5.89*	*10.63*
32	*Jacaranda mimosifolia D.Don*	Bignoniaceae	*0.00*	*0.46*	*0.23*	*0.69*
33	*Sesbania sesban (L.) Mer*	Fabaceae	*0.00*	*1.39*	*0.21*	*1.60*
34	*Calpurnia aurea (Ait.) Benth.*	Fabaceae	*0.00*	*0.93*	*0.03*	*0.96*
35	*Cussonia holstii Harms ex Engl.*	Araliceae	*0.00*	*1.85*	*0.90*	*2.75*
36	*Catha edulis (Vahl)*	Celastraceae	*27.00*	*4.17*	*5.16*	*36.33*
37	*Soyyama*	Asteraceae	*1.40*	*1.85*	*0.11*	*3.36*
38	*Galiniera saxifraga (G. coffeoides)*	Rubiaceae	*0.00*	*1.39*	*0.03*	*1.42*
39	*Acacia abyssinica Hochst.ex*	Fabacea e	*0.00*	*0.93*	*0.58*	*1.51*
			100	*100*	*100*	*300*

Appendix Table 4: woody species Rel. Frequency,Rel. abundance,rel. dominance and IVI in HGAFof dale wabera at low altitude

No	Scientific name	Family	density %	Rel.freq. %	Rel.Dom %	IVI %
1	*Buddleia polystachya*	Loganiaceae	0.3	0.5	0.1	1.1
2	*Persea americana Mill*	Laurace ae	2.4	6.4	4.4	13.2
3	*Eucalyptus camaldulensis Dehnh*	Myrtace ae	1.6	2.7	0.9	5.2
4	*Citrus sinensis (L.*	Rutacea e	1.6	4.3	0.6	6.5

5	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Acanthaceae	3.2	1.6	0.4	5.2
6	*Vernonia amygdalina Del.*	Asteraceae	1.1	3.2	0.2	4.5
7	*Grevillea robusta R. Br.*	Proteace ae	1.9	2.1	7	11.3
8	*Ficus sur Forssk.*	Moraceae	0.1	0.5	0.1	0.7
9	*Artocarpus heterophyllus*	Moraceae	0.1	0.5	0.1	0.7
10	*Casimiroa edulis La liave*	Rutaceae	0.6	2.7	0.6	3.9
11	*Prunus persica (L.) Batsch.*	Rosaceae	0.1	1.1	0.2	1.4
12	*Citrus aurantifolia*	Rutaceae	0.2	1.1	0.05	1.3
13	*Croton macrostachyus Del.*	Euphorbiaceae	0.6	3.7	2.9	7.2
14	*Mangifera indica L.*	Anacardiaceae	2.1	6.4	27.9	36.5
15	*Phoenix reclinata Jacq.*	Arecaceae	0.2	1.1	0.03	1.3
16	*Prunus africana (Hook.f.) Kalkm.*	Rosaceae	0.1	0.5	1.3	1.9
17	*Carica papaya L*	Caricaceae	1.2	3.2	3.3	7.6
18	*Jatropha curcas*	Euphorbiaceae	15.2	6.4	3.4	25
19	*Ricinus communis L.*	Euphorbiaceae	0.1	0.5	0.03	0.7
20	*Vernonia auriculifera Hiern*	Asteraceae	2.1	3.7	0.5	6.3
21	*Annona senegalensis*	Annonaceae	0.1	0.5	0.01	0.6
22	*Cordia africana Lam.*	Boraginaceae	1.2	4.3	5.7	11.1
23	*Psidium guajava L.*	Myrtaceae	0.4	1.6	0.6	2.6
24	*Morus alba L.*	Moracea e	0.8	2.1	0.2	3.2
25	*Coffea arabica L.*	Rubiace ae	34.6	8	6.3	48.3
26	*Ensete ventricosum (Welw.)*	Musacea e	1	3.2	2.44	6.6
27	*Musax paradsiaca L.*	Musacea e	6.9	4.8	9	20.8
28	*Punica granatum L.*	Punicac eae	0.1	0.5	0	0.6
29	*Azadirachta indica A. Jus*	Meliaceae	1.1	3.2	6.3	10.6
30	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Fabaceae	0.5	2.1	0.9	3.5
31	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Oleacea e	0.2	1.6	0.1	1.9
32	*Cupressus lusitanica Mill.*	Cupressaceae	0.2	1.1	2	1.3
33	*Millettia ferruginea(Hochst.) Bak.*	Fabaceae	0.1	1.1	0.14	1.4
34	*Leucaena leucocephala(Lam.)deWit*	Mimosoideae	0.6	2.7	0.1	3.4
35	*Jacaranda mimosifolia D.Don*	Bignoniaceae	0.1	0.5	0.9	1.5
36	*Sesbania sesban (L.) Mer*	Fabaceae	0.5	2.1	0.2	2.8
37	*Moringa oleifera*	Moringaceae	0.5	3.2	1.7	5.4
38	*Spathodea campanulata*	Bignoniaceae	0.7	1.1	3.2	5
39	*Calpurnia aurea (Ait.) Benth.*	Fabaceae	0.4	1.1	0.1	1.6
40	*Catha edulis (Vahl)*	Celastraceae	14.7	1.6	5.7	22
41	*Casuarina cunninghamiana Miq.*	Casuarinacea	0.5	1.4	2.2	4.3
			100	100	100	300

Appendix Table 5 : woody species Rel.Frequency, relative abundance Rel.Dominace and Important value index of study area

No	Scintific Name	Family	Rel. dety%	Rel.freq. %	Rel. Dom%	IVI%
1	Buddleia polystachya	Loganiaceae	0.10	0.38	0.03	0.51
2	*Cussonia holstii Harms ex Engl.*	Araliceae	0.08	0.77	0.43	1.27
3	*Manls sylvestris*	Rosaceae	0.06	0.19	0.01	0.26
4	*Persea americana Mill*	Laurace ae	1.17	4.80	2.68	8.65(10)
5	*Eucalyptus camaldulensis Dehnh*	Myrtace ae	2.55	4.99	8.82	16.36(5)
6	*Azadirachta indica A. Jus*	Meliaceae	0.69	2.69	3.69	7.07
7	*Coffea arabica L.*	Rubiace ae	29.55	7.68	6.27	43.50(1)
8	*Citrus sinensis (L.*	Rutacea e	0.71	3.26	0.22	4.19
9	*Catha edulis (Vahl)*	Celastraceae	25.54	4.03	8.56	38.14(2)
10	*Calpurnia aurea (Ait.) Benth.*	Fabaceae	0.40	0.77	0.14	1.31
11	*Ficus sycomorus*	Moraceae	0.08	0.77	1.14	1.98
12	*Ficus thonningii Blume*	Moraceae	0.02	0.19	0.03	0.24
13	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Acanthaceae	8.11	2.69	0.86	11.65(8)
14	*Vernonia amygdalina Del.*	Asteraceae	2.24	5.18	0.46	7.88
15	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Oleacea e	0.15	1.54	0.10	1.79
16	*Grevillea robusta R. Br.*	Proteace ae	1.40	2.30	8.10	11.80(7)
17	*Morus alba L.*	Moraceae	2.55	3.84	0.88	7.27
18	*Ficus sur Forssk.*	Moraceae	0.04	0.19	0.06	0.30
19	*Jacaranda mimosifolia D.Don*	Bignoniaceae	0.25	0.38	2.35	2.98
20	*Artocarpus heterophyllus*	Moraceae	0.06	0.58	0.08	0.71
21	*Gossypium hirsutum L.*	Malvaceae	0.06	0.58	1.16	1.79
22	*Casimiroa edulis La liave*	Rutaceae	0.19	1.15	0.22	1.57
23	*Prunus persica (L.) Batsch.*	Rosaceae	0.06	0.77	0.25	1.07
24	*Acacia abyssinica Hochst.ex*	Fabacea e	0.04	0.38	0.27	0.70
25	*Bersama abyssinica subsp. abyssinica*	Melianthaceae	0.02	0.19	0.00	0.21(53)
26	*Citrus aurantifolia*	Rutaceae	0.13	1.34	0.03	1.51
27	*Leucaena leucocephala(Lam.)deWit*	Mimosoideae	0.27	0.96	0.06	1.29
28	*Croton macrostachyus Del.*	Euphorb iaceae	0.42	3.45	2.30	6.17
29	*Mangifera indica L.*	Anacardiaceae	0.92	4.99	5.97	11.88(6)
30	*Phoenix reclinata Jacq.*	Arecaceae	0.04	0.38	0.01	0.43
31	*Galiniera saxifraga (G. coffeoides)*	Rubiaceae	0.15	0.58	0.02	0.74
32	*Moringa oleifera*	Moringaceae	0.12	1.15	0.51	1.78
33	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Fabaceae	0.19	1.34	0.53	2.07
34	*Musax paradsiaca L.*	Musacea e	5.79	3.45	12.50	21.75(4)

35	*Prunus africana (Hook.f.) Kalkm.*	Rosaceae	*0.02*	*0.19*	*0.39*	*0.60*
36	*Carica papaya L*	Caricaceae	*0.59*	*1.73*	*1.30*	*3.62*
37	*Ensete ventricosum (Welw.)*	Musacea e	*0.73*	*2.50*	*2.55*	*5.77*
38	*Ficus vasta Frssk.*	Moraceae	*0.04*	*0.38*	*3.64*	*4.06*
39	*Jatropha curcas*	Euphorbiaceae	*2.88*	*2.30*	*0.81*	*5.99*
40	*Ricinus communis L.*	Euphorbiaceae	*1.07*	*2.30*	*0.81*	*4.18*
41	*Vernonia auriculifera Hiern*	Asteraceae	*2.97*	*4.99*	*0.77*	*8.73(9)*
42	*Punica granatum L.*	Punicac eae	*0.10*	*0.19*	*0.01*	*0.29*
43	*Sesbania sesban (L.) Mer*	Fabaceae	*1.51*	*3.65*	*0.59*	*5.75*
44	*Annona senegalensis*	Annonaceae	*0.25*	*0.58*	*0.09*	*0.91*
45	*Casuarina cunninghamiana Miq.*	Casuarinacea	*0.12*	*0.58*	*1.05*	*1.74*
46	*Arundinaria alpina K. Schum.*	Poaceae	*1.02*	*0.77*	*0.12*	*1.90*
47	*Millettia ferruginea(Hochst.) Bak.*	Fabaceae	*0.25*	*0.58*	*0.30*	*1.12*
48	*Helichrysumformosissimum var.guilemi(engl.)*	Asteraceae	*1.38*	*0.96*	*0.16*	*2.50*
49	*Spathodea campanulata*	Bignoniaceae	*0.17*	*0.38*	*0.94*	*1.50*
50	*Premna schimperi Engl.*	Verbenaceae	*0.17*	*1.34*	*0.11*	*1.62*
51	*Cordia africana Lam.*	Boraginaceae	*1.48*	*5.57*	*15.88*	*22.92*
52	*Cupressus lusitanica Mill.*	Cupress aceae	*0.84*	*1.73*	*1.48*	*4.06*
53	*Psidium guajava L.*	Myrtaceae	*0.27*	*1.34*	*0.30*	*1.91*
			100.00	*100.00*	*100.01*	*300.01*

Appendix Table 6 : List of Woody Plant Species Collected From Home Gardens In The Upper Altitude**.**

NO	Vernacular Name	Scientific Name	Family Name	Origin	habit
1	Anfare	*Buddleia polystachya*	Loganiaceae	I	S
2	Appilii	*Manls sylvestris*	Rosaceae	E	S
3	Avokaadoo	*Persea americana Mill*	Laurace ae	E	T
4	Bargamoo	*Eucalyptus camaldulensis Dehnh*	Myrtace ae	E	T
5	Burtukaanii	*Citrus sinensis (L.*	Rutacea e	E	S
6	Dambii Jabbii	*Ficus thonningii Blume*	Moraceae	I	T
7	Dhummuugaa	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Acanthaceae	I	S
8	Ebicha	*Vernonia amygdalina Del.*	Asteraceae	I	S
9	Giraviliyaa	*Grevillea robusta R. Br.*	Proteace ae	E	T
10	Lolchiisaa	*Bersama abyssinica subsp. abyssinica*	Melianthaceae	I	S
11	Makkanniisa	*Croton macrostachyus Del.*	Euphorb iaceae	I	T
12	Mangoo	*Mangifera indica L.*	Anacardiaceae	E	T
13	Qobboo	*Ricinus communis L.*	Euphorbiaceae	I	S

14	Reejjii	*Vernonia auriculifera Hiern*	Asteraceae	I	S
15	Somboqqoo	*Arundinaria alpina K. Schum.*	Poaceae	I	S
16	Urgeessaa	*Premna schimperi Engl.*	Verbenaceae	I	S
17	Waddeessa	*Cordia africana Lam.*	Boraginaceae	I	T
18	Gora faranjii	*Morus alba L.*	Moraceae	E	S
19	Buna	*Coffea arabica L.*	Rubiaceae	I	S
20	Qaachoo	*Ensete ventricosum (Welw.)*	Musaceae	I	S
21	Muuzii	*Musax paradsiaca L.*	Musaceae	E	S
22	Sotalloo	*Millettia ferruginea(Hochst.) Bak.*	Fabaceae	I	T
23	Saspaniyaa	*Sesbania sesban (L.) Mer*	Fabaceae	E	S
24	Caatii	*Catha edulis (Vahl)*	Celastraceae	I	S
25	Soyyama	*Helichrysumformosissimum var.guilemi(engl.)mesfin*	Asteraceae	I	S

Appendix Table 7: Lists of woody plant species collected from home gardens at middle altitude.

NO	Scientific name	Vernacular Name	Family	Origin	Habitat
1	*Persea americana Mill*	Avokaadoo	Laurace ae	E	T
2	*Eucalyptus camaldulensis Dehnh*	Bargamoo	Myrtace ae	E	T
3	*Citrus sinensis (L.*	Burtukaanii	Rutacea e	E	S
4	*Ficus sycomorus*	Odaa	Moraceae	I	T
5	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Dhummuugaa	Acanthaceae	I	S
6	*Vernonia amygdalina Del.*	Ebicha	Asteraceae	I	S
7	*Grevillea robusta R. Br.*	Giraviliyaa	Proteace ae	E	T
8	*Artocarpus heterophyllus*	Jakfruutii	Moraceae	E	T
9	*Gossypium hirsutum L.*	Jirbii	Malvaceae	I	T
10	*Casimiroa edulis La liave*	Kasimirii	Rutaceae	E	S
11	*Prunus persica (L.) Batsch.*	Kookii	Rosaceae	E	T
12	*Citrus limonia Obs.*	Loomii	Rutaceae	E	S
13	*Croton macrostachyus Del.*	Makkanniisa	Euphorbiaceae	I	T
14	*Mangifera indica L.*	Mangoo	Anacardiaceae	E	T
15	*Carica papaya L*	Pappayyaa	Caricaceae	E	S
16	*Ficus vasta Frssk.*	Qilxuu	Moraceae	I	T
17	*Ricinus communis L.*	Qobboo	Euphorbiaceae	I	S
18	*Vernonia auriculifera Hiern*	Reejjii	Asteraceae	I	S
19	*Annona senegalensis*	Shukkaaroo	Annonaceae	E	S

20	*Arundinaria alpina K. Schum.*	Somboqqoo	Poaceae	I	S
21	*Premna schimperi Engl.*	Urgeessaa	Verbenaceae	I	S
22	*Cordia africana Lam.*	Waddeessa	Boraginaceae	I	T
23	*Psidium guajava L.*	Zayituunii	Myrtaceae	E	S
24	*Morus alba L.*	Gora faranjii	Moraceae	E	S
25	*Coffea arabica L.*	Buna	Rubiaceae	I	S
26	*Ensete ventricosum (Welw.)*	Qaachoo	Musaceae	I	S
27	*Musax paradsiaca L.*	Muuzii	Musaceae	E	S
28	*Azadirachta indica A. Jus*	Baybayee	Punicaceae	E	S
29	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Mukarbaa	Meliaceae	I	T
30	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Ejersa	Oleaceae	I	T
31	*Cupressus lusitanica Mill.*	Xidii Faranjii	Cupressaceae	E	T
32	*Jacaranda mimosifolia D.Don*	Jakarandaa	Bignoniaceae	E	T
33	*Sesbania sesban (L.) Mer*	Saspaniyaa	Fabaceae	E	S
34	*Calpurnia aurea (Ait.) Benth.*	Ceekaa	Fabaceae	I	S
35	*Cussonia holstii Harms ex Engl.*	Afarfatu	Araliceae	I	S
36	*Catha edulis (Vahl)*	Caatii	Celastraceae	I	S
37	*Helichrysumformosissimum var.guilemi(engl.)mesfin*	Soyyama	Asteraceae	I	S
38	*Galiniera saxifraga (G. coffeoides)*	Mixoo	Rubiaceae	I	S
39	*Acacia abyssinica Hochst.ex*	laaftoo	Fabaceae	I	T

Appendix Table 8: list of woody plant species collected from home gardens at low altitude

NO	Scientific name	Varnacular name	Family	Origin	Habitat
1	*Buddleia polystachya*	Anfare	Loganiaceae	I	S
2	*Persea americana Mill*	Avokaadoo	Laurace ae	E	T
3	*Eucalyptus camaldulensis Dehnh*	Bargamoo	Myrtaceae	E	T
4	*Citrus sinensis (L.*	Burtukaanii	Rutaceae	E	S
5	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Dhummuugaa	Acanthaceae	I	S
6	*Vernonia amygdalina Del.*	Ebicha	Asteraceae	I	S
7	*Grevillea robusta R. Br.*	Giraviliyaa	Proteaceae	E	T

8	*Ficus sur Forssk.*	Harbuu	Moraceae	I	T
9	*Artocarpus heterophyllus*	Jakfruutii	Moraceae	E	T
10	*Casimiroa edulis La liave*	Kasimirii	Rutaceae	E	S
11	*Prunus persica (L.) Batsch.*	Kookii	Rosaceae	E	T
12	*Citrus limonia Obs.*	Loomii	Rutaceae	E	S
13	*Croton macrostachyus Del.*	Makkanniisa	Euphorbiaceae	I	T
14	*Mangifera indica L.*	Mangoo	Anacardiaceae	E	T
15	*Phoenix reclinata Jacq.*	Meexxii	Arecaceae	I	T
16	*Citrus limonia Obs.*	Oomii	Rosaceae	I	T
17	*Carica papaya L*	Pappayyaa	Caricaceae	I	T
18	*Jatrova*	Qobboo faranji	Euphorb iaceae	E	S
19	*Ricinus communis L.*	Qobboo	Euphorb iaceae	I	S
20	*Vernonia auriculifera Hiern*	Reejjii	Asteraceae	I	S
21	*Annona senegalensis*	Shukkaaroo	Annonaceae	E	S
22	*Cordia africana Lam.*	Waddeessa	Boraginaceae	I	T
23	*Psidium guajava L.*	Zayituunii	Myrtaceae	E	S
24	*Morus alba L.*	Gora faranjii	Moracea e	E	S
25	*Coffea arabica L.*	Buna	Rubiaceae	I	S
26	*Ensete ventricosum (Welw.)*	Qaachoo	Musaceae	I	S
27	*Musax paradsiaca L.*	Muuzii	Musaceae	E	S
28	*Punica granatum L.*	rumanii	Punicaceae	E	S
29	*Azadirachta indica A. Jus*	Baybayee	Meliaceae	E	T
30	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Mukarbaa	Fabaceae	I	T
31	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Ejersa	Oleaceae	I	T
32	*Cupressus lusitanica Mill.*	Xidii Faranjii	Cupressaceae	E	T
33	*Millettia ferruginea(Hochst.) Bak.*	Sotalloo	Fabaceae	I	T
34	*Leucaena leucocephala(Lam.)deWit*	Lusiniyaa	Mimosoideae	E	S
35	*Jacaranda mimosifolia D.Don*	Jakarandaa	Bignoniaceae	E	T
36	*Sesbania sesban (L.) Mer*	Saspaniyaa	Fabaceae	E	S
37	*Moringa oleifera*	Moringa	Moringaceae	E	T
38	*Spathodea campanulata*	Spatoda	Bignoniaceae	E	T
39	*Calpurnia aurea (Ait.) Benth.*	Ceekaa	Fabaceae	I	S
40	*Catha edulis (Vahl)*	Caatii	Celastraceae	I	S
41	*Casuarina cunninghamiana Miq.*	Shuwashuwee	Casuarinacea	E	T

Appendix Table 9: List Of woody plant species collected from home gardens in study area.

NO	Scintific Name	Varnacular	Family	Orig	Habitat
1	*Buddleia polystachya*	Anfaaree	Loganiaceae	I	S
2	*Cussonia holstii Harms ex Engl.*	Afarfatu	Araliceae	I	S
3	*Manls sylvestris*	Appilii	Rosaceae	E	S
4	*Persea americana Mill*	Avokaadoo	Laurace ae	E	S
5	*Eucalyptus camaldulensis Dehnh*	Bargamoo	Myrtace ae	E	T
6	*Azadirachta indica A. Jus*	Baybayee	Meliaceae	E	S
7	*Coffea arabica L.*	Buna	Rubiace ae	I	S
8	*Citrus sinensis (L.*	Burtukaanii	Rutacea e	E	S
9	*Catha edulis (Vahl)*	Caatii	Celastraceae	I	S
10	*Calpurniaaurea (Ait.) Benth.*	Ceekaa	Fabaceae	I	S
11	*Ficus sycomorus*	Odaa	Moraceae	I	T
12	*Ficus thonningii Blume*	Dambii Jabbii	Moraceae	I	T
13	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Dhummuugaa	Acanthaceae	I	S
14	*Vernonia amygdalina Del.*	Ebicha	Asteraceae	I	S
15	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Ejersa	Oleaceae	I	T
16	*Grevillea robusta R. Br.*	Giraviliyaa	Proteaceae	E	T
17	*Morus alba L.*	Gora faranjii	Moraceae	E	S
18	*Ficus sur Forssk.*	Harbuu	Moraceae	I	T
19	*Jacaranda mimosifolia D.Don*	Jakarandaa	Bignoniaceae	E	T
20	*Artocarpus heterophyllus*	Jakfruutii	Moraceae	E	T
21	*Gossypium hirsutum L.*	Jirbii	Malvaceae	I	T
22	*Casimiroa edulis La liave*	Kasimirii	Rutaceae	E	S
23	*Prunus persica (L.) Batsch.*	Kookii	Rosaceae	E	T
24	*Acacia abyssinica Hochst.ex*	laaftoo	Fabaceae	I	T
25	*Bersama abyssinica subsp. abyssinica*	Lolchiisaa	Melianthaceae	I	S
26	*Citrus aurantifolia*	Loomii	Rutaceae	E	S
27	*Leucaena leucocephala(Lam.)deWit*	Lusiniyaa	Mimosoideae	E	S
28	*Croton macrostachyus Del.*	Makkanniisa	Euphorbiaceae	I	T
29	*Mangifera indica L.*	Mangoo	Anacardiaceae	E	T
30	*Phoenix reclinata Jacq.*	Meexxii	Arecaceae	I	T
31	*Galiniera saxifraga (G. coffeoides)*	Mixoo	Rubiaceae	I	S

32	*Moringa oleifera*	Moringa	Moringaceae	E	T
33	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Mukarbaa	Fabaceae	I	T
34	*Musax paradsiaca L.*	Muuzii	Musaceae	I	S
35	*Prunus africana (Hook.f.) Kalkm.*	Oomii	Rosaceae	I	T
36	*Carica papaya L*	Pappayyaa	Caricaceae	I	S
37	*Ensete ventricosum (Welw.)*	Qaachoo	Musaceae	I	S
39	*Ficus vasta Frssk.*	Qilxuu	Moraceae	I	T
39	*Jatropha curcas*	Qobbo faranjii	Euphorbiaceae	E	S
40	*Ricinus communis L.*	Qobboo	Euphorbiaceae	I	S
41	*Vernonia auriculifera Hiern*	Reejjii	Asteraceae	I	S
42	*Punica granatum L.*	rumanii	Punicaceae	E	S
43	*Sesbania sesban (L.) Mer*	Saspaniyaa	Fabaceae	E	S
44	*Annona senegalensis*	Shukkaaroo	Annonaceae	E	S
45	*Casuarina cunninghamiana Miq.*	Shuwashuwee	Casuarinacea	E	T
46	*Arundinaria alpina K. Schum.*	Somboqqoo	Poaceae	I	S
47	*Millettia ferruginea(Hochst.) Bak.*	Sotalloo	Fabaceae	I	T
48	*Helichrysumformosissimum var.guilemi(engl.)mesfin*	Soyyama	Asteraceae	I	S
49	*Spathodea campanulata*	Spatoda	Bignoniaceae	E	T
50	*Premna schimperi Engl.*	Urgeessaa	Verbenaceae	I	S
51	*Cordia africana Lam.*	Waddeessa	Boraginaceae	I	T
52	*Cupressus lusitanica Mill.*	Xidii Faranjii	Cupress aceae	E	S
53	*Psidium guajava L.*	Zayituunii	Myrtaceae	E	S

Key: T=Tree, S=Shrub, I=indigenous, E=exogenous

Appendix Table 10: Preference of Woody Species at Upper Altitude

	High Altitude			
No	Species	Respondent	%	Rank
1	*Coffea Arabica,*	55	90.16	1
2	*Cordia Africana*	52	85.25	2
3	*Catha edulis,*	51	83.61	3
4	*Eucalyptuscamaldulensis*	39	63.93	4
5	*Musax paradsiaca,*	32	52.46	5
6	*Grevillearobusta*	32	52.46	6
7	*Mangiferaindica,*	28	45.90	7
8	*Cupressus lusitanica*	23	37.70	8
9	*Citrus sinensis*	12	19.67	9
10	*Perseaamericana,*	8	13.11	10
		61	100.00	

Appendix Table 11: Preference of Woody Species at Middle Altitude

	Middle Altitude			
No	species	Respndnt	%	Rank
1	*Coffea Arabica,*	57	93.44	1
2	*Catha edulis,*	55	90.16	2
3	*Mangiferaindica,*	47	77.05	3
4	*Eucalyptuscamaldulensis,*	41	67.21	4
5	*Cordia Africana,*	34	55.74	5
6	*Musax paradsiaca,*	29	47.54	6
7	*Perseaamericana,*	26	42.62	7
8	*Grevillearobusta*	14	22.95	8
9	*Azadirachta indica*	1	1.64	9
10	*Cupressus lusitanica*	1	1.64	10
		61	100.00	

Appendix Table 12 : Preference of Woody Species at Lower Altitude

	Low Altitude			
No	Species	Resdnt	Rank	%
1	Coffea Arabica,	52	1	83.87
2	Catha edulis,	51	2	82.26
3	Persea americana,	43	3	69.35
4	Cordia Africana,	43	3	69.35
5	Grevillearobusta	43	3	69.35
6	Mangiferaindica,	36	6	58.06
7	Musax paradsiaca,	21	7	33.87
8	Azadirachta indica	8	8	12.90
9	Citrus sinensis	6	9	9.68
10	Eucalyptuscamaldulensis,	5	10	8.06
11	Jatropha curcas	2	11	3.23
		62		100.00

Appendix Table 13 : Woody Species Preference of Respondents per Study Area

Respondent woody species preference				
No	Species	Respondent	%	Rank
1	*Coffea Arabica,*	164	89.13	1
2	*Catha edulis,*	157	85.33	2
3	*Cordia Africana,*	129	70.11	3
4	*Mangiferaindica,*	111	60.33	4
5	*Perseaamericana,*	77	48.37	5
6	*Eucalyptuscamaldulensis,*	85	46.20	6
7	*Grevillearobusta*	89	44.57	7
8	*Musax paradsiaca,*	82	41.85	8
9	*Azadirachta indica*	9	13.04	9
10	*Citrus sinensis*	18	9.78	10
11	*Cupressus lusitanica*	24	4.89	11
12	*Jatropha curcas*	2	1.09	12
		184	100.00	

Appendix Table 14: Absence or presence of woody species with local name, scientific name, family, and genera in the altitudinal gradient of dale wabera woreda.

Local name	Scientific name	Family	Alt. gradient
Anfaaree	*Buddleia polystachya*	Loganiaceae	LH
Appilii	*Manls sylvestris*	Rosaceae	H
Avokaadoo	*Persea americana Mill*	Lauraceae	LMH
Bargamoo	*Eucalyptus camaldulensis Dehnh*	Myrtaceae	LMH
Burtukaanii	*Citrus sinensis (L.*	Rutaceae	LMH
Odaa	*Ficus sycomorus*	Moraceae	M
Dambii Jabbii	*Ficus thonningii Blume*	Moraceae	H
Dhummuugaa	*Justicia schimperiana (Hochst. ex Nees) T. Anders.*	Acanthaceae	LMH
Ebicha	*Vernonia amygdalina Del.*	Asteraceae	LMH
Giraviliyaa	*Grevillea robusta R. Br.*	Proteaceae	LMH
Harbuu	*Ficus sur Forssk.*	Moraceae	L
Jakfruutii	*Artocarpus heterophyllus*	Moraceae	LM
Jirbii	*Gossypium hirsutum L.*	Malvaceae	M
Kasimirii	*Casimiroa edulis La liave*	Rutaceae	LM
Kookii	*Prunus persica (L.) Batsch.*	Rosaceae	LM
Lolchiisaa	*Bersama abyssinica subsp. abyssinica*	Melianthaceae	H
Loomii	*Citrus aurantifolia*	Rutaceae	LM
Makkanniisa	*Croton macrostachyus Del.*	Euphorbiaceae	LMH
Mangoo	*Mangifera indica L.*	Anacardiaceae	LMH
Meexxii	*Phoenix reclinata Jacq.*	Arecaceae	L
Oomii	*Prunus africana (Hook.f.) Kalkm.*	Rosaceae	L
Pappayyaa	*Carica papaya L*	Caricaceae	LM
Qilxuu	*Ficus vasta Frssk.*	Moraceae	M
Qobboo Faranjii	*Jatropha curcas*	Euphorbiaceae	L
Qobboo	*Ricinus communis L.*	Euphorbiaceae	LMH
Reejjii	*Vernonia auriculifera Hiern*	Asteraceae	LMH
Shukkaaroo	*Annona senegalensis*	Annonaceae	LM
Somboqqoo	*Arundinaria alpina K. Schum.*	Poaceae	MH
Urgeessaa	*Premna schimperi Engl.*	Verbenaceae	MH
Waddeessa	*Cordia africana Lam.*	Boraginaceae	LMH
Zayituunii	*Psidium guajava L.*	Myrtaceae	LM
Gora faranjii	*Morus alba L.*	Moraceae	LMH
Buna	*Coffea arabica L.*	Rubiaceae	LMH
Qaachoo	*Ensete ventricosum (Welw.)*	Musaceae	LMH
Muuzii	*Musax paradsiaca L.*	Musaceae	LMH
rumanii	*Punica granatum L.*	Punicaceae	L
Baybayee	*Azadirachta indica A. Jus*	Meliaceae	LM
Mukarbaa	*Albizia gummifera (J.F.Gmel.) C. A. Sim*	Fabaceae	LM
Ejersa	*Olea europea subsp cuspidate (Wall.ex. DC.)*	Oleaceae	LM
Xidii Faranjii	*Cupressus lusitanica Mill.*	Cupress aceae	LM

Sotalloo	*Millettia ferruginea(Hochst.) Bak.*	Fabaceae	LH
Lusiniyaa	*Leucaena leucocephala(Lam.)deWit*	Mimosoideae	L
Jakarandaa	*Jacaranda mimosifolia D.Don*	Bignoniaceae	LM
Saspaniyaa	*Sesbania sesban (L.) Mer*	Fabaceae	LMH
Moringa	*Moringa oleifera*	Moringaceae	L
Spatoda	*Spathodea campanulata*	Bignoniaceae	L
Ceekaa	*Calpurnia aurea (Ait.) Benth.*	Fabaceae	LM
Afarfatu	*Cussonia holstii Harms ex Engl.*	Araliceae	M
Caatii	*Catha edulis (Vahl)*	Celastraceae	LMH
Shuwashuwee	*Casuarina cunninghamiana Miq.*	Casuarinacea	L
Soyyama	*Helichrysumformosissimum var.guilemi(engl.)*	Asteraceae	H
Mixoo	*Galiniera saxifraga (G. coffeoides)*	Rubiaceae	M
laaftoo	*Acacia abyssinica Hochst.ex*	Fabaceae	M

Appendix Table 15 : Common and Unique Woody Species to the Altitude Categories

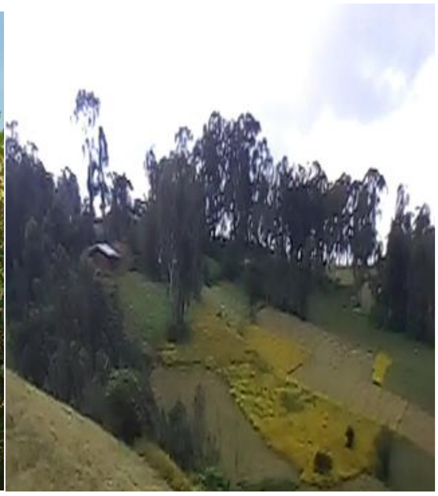
Common specieas for				Unique species for					
LA&MA	MA&UA	LA&UA	all	LA&MA	MA&UA	LA&UA	LA	MA	UA
30	19	19	17	13	2	2	9	7	4

Appendix Table 16: Location of the Specific Study Site

No	Altitudinal gradient	Kebele	Villages	Location		Altitude
				X	Y	
1	Upper Alt	Darbo Wabera	Wabera	0728915	0997805	2005
			Karra	0726448	0998584	1943
			Agalo ongoram	0727104	0999234	1945
2	Midle Alt	Meki Dimbar	Dimbar	0726756	0992741	1934
			Wara wale	0730010	0996429	1822
			Agalo Dinbar	0730345	0992843	1720
3	Lower Alt	Dogano Bile	Shuwee	0726748	0986381	1559
			Saqoo	0726385	0985070	1549
			Gaboo	0725780	0984010	1531

Appendix Figure 1: photo from field Survey

House hold interview DBH measurement Tree high measurement



Lower altitude Middle altitude Upper Altitude