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Research article

Vegetation Composition, Richness, and Diversity in Homegarden Agroforestry Systems, Jimma zone, Oromia regional state, southwest Ethiopia

Fanos Kebebe[1], Zerihun Kebebew[2], Dereje Bekele[2] and Yadesa Bato*[1]

[1]Ambo University, College of Agriculture and Veterinary Science, Forestry Department, Ambo, Ethiopia.
[2]Jima University, College of Agriculture and Veterinary Medicine, Natural Resource Management Department, Jima, Ethiopia.
Corresponding author: yadesabato2020@gmail.com

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Abstract

Homegarden agroforestry systems, consisting of multi-layered trees, shrubs, crops, and livestock around homesteads, serve both ecological and socio-economic functions. This study assessed plant species composition, richness, and diversity in homegardens across highland, mid-altitude, and lowland zones in the Jimma area of southwest Ethiopia. Data from 156 randomly selected households revealed 101 plant species (59 woody, 42 herbaceous) from 50 families, with Fabaceae**,** Myrtaceae**,** and Euphorbiaceae being the most diverse. Species were 52.5% exotic and 47.5% native, with trees, herbs, shrubs, and lianas making up 38.6%, 39.6%, 18.8%, and 3% respectively. Higher diversity was observed in mid-altitude zones (Shannon index: 1.93), attributed to favorable conditions and better management. Despite supporting biodiversity, homegardens were dominated by exotic species due to household preferences for productive, marketable plants.

Keywords: agroecology, agroforestry system, homegarden, Jimma zone, species composition

1. INTRODUCTION

Agroforestry is an integrated land management system of growing food crops, trees, and/or animals together for multiple benefits from the same land use parcel that is practiced by farmers throughout the world (Nair *et al*., 2021a). The agroforestry system is being practiced throughout the globe due to its multiple benefits in many aspects (socio-economic, ecological, and cultural). Agroforestry systems can be categorized into three based on the nature of components: agrisilviculture (combination of woody species and crops), silvopastoral (combination of woody species and animals and/ or pasture), and agrosilvopastoral (combination of woody species, crop, and/ or animals and/ or pasture) systems (FAO, 2015). In all agroforestry systems, the three

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fundamental sets of components that are managed by people are woody perennials, animal husbandry, and herbaceous plants (both wild and domesticated crops). The term homegarden is used to describe a type of horticulture that involves small landholdings around or adjacent to the home, and includes diverse combinations of various economically valuable plants such as trees, shrubs, vines, and herbaceous (Nair *et al*., 2021b, Kumar and Nair, 2006). Homegardens (HG) agroforestry system has been documented worldwide, mainly in the tropical regions where profound variability in size, frequency, and function of homegarden has been noted (Kumar and Nair, 2004).

A major portion of global agrobiodiversity thrives in complex agroecosystems such as homegardens, which are managed by smallholder farmers (Galluzzi *et al*., 2010). Homegardens are designed to meet household food consumption needs (Kehlenbeck *et al*., 2007; Kumar and Nair, 2004), and they are well adapted to the local ecological conditions and socio-economic systems (Altieri, 2002; Schneider, 2010). Agroforestry technologies maintained by rural farmers fulfill an important role in the ecological, social, and economic function of communities (Gebrahiwot, 2017). The cultivation of different crops is regarded as a strategy of farmers to diversify their subsistence and cash needs. Diversification also helps to stabilize yield or income in cases of incidences of disease and pests, and market price fluctuations (Nair, 2006). Homegardens are characterized as 'intimate multi-story' gardens around homesteads (Kumar and Nair, 2004). A variety of woody and non-woody crops, as well as wild plants, can be found in various systems (Kehlenbeck *et al*., 2007; Kumar and Nair, 2004), and is linked to the diversity of traditional knowledge (Huai & Hamilton 2009). This plant diversity represents the careful selection over generations for optimal food nutritional security and cultural value (Nair 2006).

The homegarden agroforestry system is a multispecies agro-ecosystem where different herbaceous and woody species are deliberately managed in integration by land users (Kumar and Nair, 2006). It provides numerous economic benefits to rural communities in the tropics and also serves as an intermediary for biodiversity conservation. Many homegardens in the tropics are economically more viable than other land use systems in the regions because of the high-value cash crops comprised in them. Agroforestry systems are common land use systems among small-holder farmers in southwest Ethiopia. Agroforestry is considered to improve agricultural

sustainability because of the close connection between various crops, trees, and livestock, which offer ecologically and economically valuable benefits (Shapiro and Frank, 2016).

Homegardens are variable with regard to species management practices and the diversity of plant species. Some scholars have described the homegardens agroforestry of the Jimma zone (Kebebew and Urgessa, 2011), but still, there is insufficient scientifically well-organized evidence of information concerning the composition, richness, diversity, and similarity index of plant species in homegarden agroforestry practices across different agro-ecological zones in Jimma zone, southwest Ethiopia. The lack of such basic information is one of the serious problems that hamper future agrobiodiversity conservation and management plans, and strategies developed by considering different agro-ecological zones in the study area. The objective of this study was to investigate the vegetation composition, richness, diversity, and similarity index of plant species grown in homegarden agroforestry practices across three separate agroecological zones in Jimma zone, southwest Ethiopia. The present study tried to address the following questions: Does the agroecological variation affect the vegetation composition, richness, and diversity of plant species grown in homegarden agroforestry practice in Jimma zone, southwest Ethiopia? What are the vegetation composition similarity indexes among three separate agroecological zones in the study area? Therefore, the findings of the present study generated well-scientifically organized information on the effect of different agroecological zones on agrobiodiversity of vegetation composition, richness, diversity, and similarity index in the study area. Moreover, the result of the study was provided basic information for further research, and extension works and notified better appropriate agrobiodiversity conservation and management planning.

2. MATERIAL AND METHODS

2.1. Description of the study area

2.1.1. Location of the study area

The study was carried out in Mana and Kersa districts, Jimma zone Oromia National Regional State, Southwest Ethiopia. Mana and Kersa districts are located 369 km and 328 km distance to Southwest of Addis Ababa, the capital city of Ethiopia respectively. The geographical location of Mana and Kersa districts are between 7° 37′ 55″ N to 7° 54′ 0″ N and 36° 37′ 15″ E to 36° 53′ 31″ E (Figure 1).

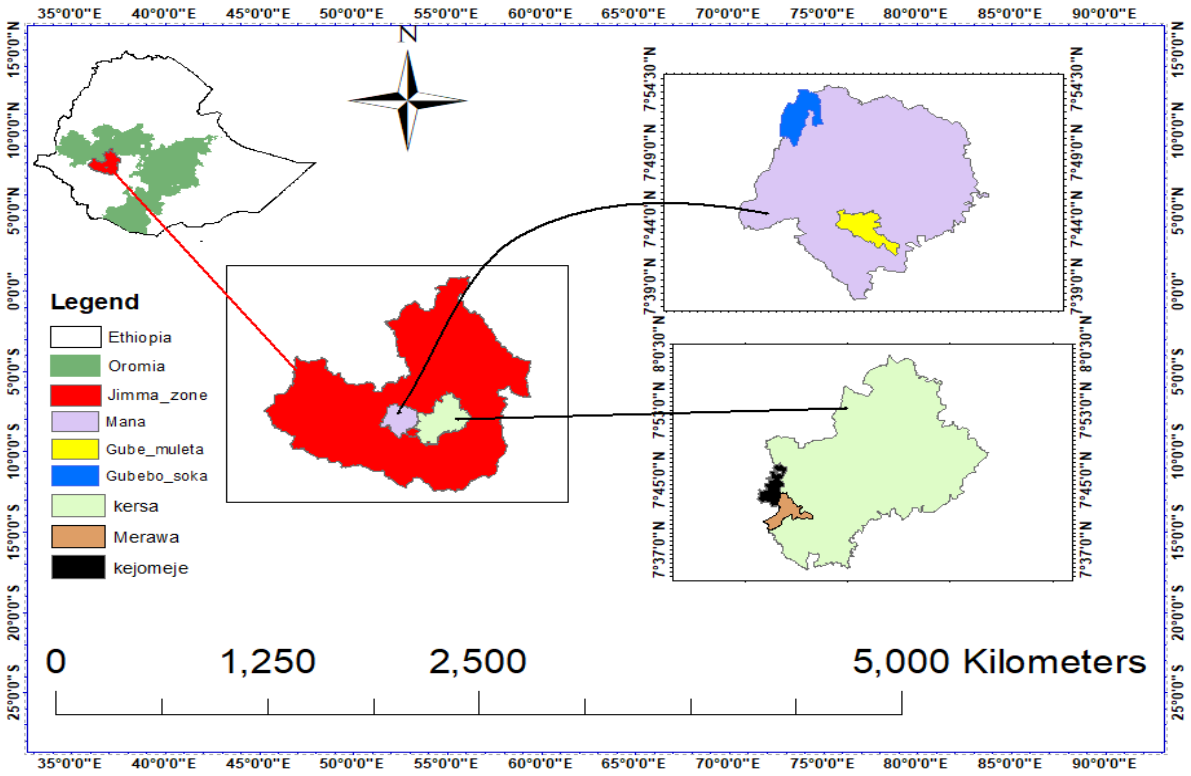


Figure 1. Map of the study area

2.1.2. Topography and Climate

The study area has diverse topography and agroecology. The study areas consist of three agroecologies, such as highlands (Dega), midlands (Woynadega), and lowlands (Kolla). Accordingly, the proportional distribution of the agro-ecological setting for Mana district highlands (12%), midlands (65%), and lowlands (23%), whereas for Kersa district highland (25%), midland (57%) and lowland (18%). The altitudinal range of the Mana and Kersa districts is found from 1,040 to 2980 meters above sea level (m a.s.l) (Samuel *et al*., 2016). The region experiences a bimodal rainfall distribution, with the highest precipitation from July to September and the lowest precipitation from March to May. An average annual rainfall ranges from 1138 to 1690 mm, whereas the temperature fluctuates between 6 and 31°C (National Metrological Service Agency, 2021).

2.1.3. Farming system

Smallholder farmers are supported by the mixed crop-livestock system on a subsistence level. Teff, maize, sorghum, coffee, fruit crops, vegetables, potato, pulse, and enset are the dominant crops grown in the study sites (Kechero *et al*., 2013). Maize is the most staple food crop in the study sites. Cows, oxen, goats, sheep, and poultry are livestock commonly known in the study

sites. Enset-coffee-based homegarden agroforestry land use practice is commonly known in the sites. Smallholder farmers have experience in the use of the homegarden, farmland, coffee farm, and woodlot land using agroforestry practices (Gemeda 2021, Kebebew and Urgessa, 2011). Among them, homegarden agroforestry practice is the main one in the sites. Smallholder farmers obtain their annual income from Enset crops, cereal crops, livestock, tree products, and vegetables. Based on figures from (CSA, 2020) the study area has an estimated population of 21,386, and of these 4,281 are households.

2.2. Reconnaissance Survey

A reconnaissance survey was conducted in Mana and Kersa districts to get a general impression of different land-use farming systems in the area, to collect information on the accessibility of the studies, to familiarize us with the study area, to get an insight into the homegarden agroforestry system, topography, and other environmental conditions, to determine the sampling method to be used for households survey, and vegetation data collection. During the reconnaissance survey in the study area, three different agroecologies, such as highlands (Dega), midlands (Woynadega), and lowlands (Kolla) were identified (Figure 2). A complete enumeration of the plant species was carried out in each selected household homegarden using the method used by (Tolera *et al*., 2008).



Figure 2. Homegarden agroforestry practice along the agro-ecology zone of the study

2.3. Sampling Design

Several research designs were used in this study: a) for selecting study sites, a combination of purposive and simple random sampling techniques were used, b) for the household survey, a descriptive survey research design was employed, which included a structured questionnaire with both closed and open-ended questions; c) for Focus Group Discussions (FGDs) participant households selection were conducted using purposive sampling, and, d) for assessing vegetation

composition and diversity in homegarden agroforestry systems across three agro-ecological zones, systematic sampling techniques were employed.

2.4. Sampling Procedure

Multistage sampling techniques were applied to select sample households because the study needs sampling in different stages. Jimma zone has 20 districts. In the 1st stage, out of those districts, two districts Mana and Kersa were selected purposively based on the potential they have in homegarden agroforestry practice. In 2nd stage, based on reconnaissance survey results, both districts' kebeles were classified into different agroecology. In the 3rd stage, out of 26 Kebeles of Mana district, two kebeles were selected, and out of 34 Kebeles of Kersa district, two kebeles were selected purposively based on the potential of homegarden agroforestry practice. In the 4th stage, stratified the wealth status of households living in each kebeles. These were categorized into three wealth classes rich, medium, and poor according to the set criteria by key informants and administrative district. Three types of agroecological zones are recognized in Ethiopia, based on altitude: highland (2300-3200m), mid-highland (1500- 2300m), and lowland (500-1500m) (MoA, 1998). In the Jimma zone, Mana and Kersa districts were considered as a unit, in which, three distinct agro-ecological situations were identified (Table 1).

Table 1. Agroecology of the study area

District	Kebeles	Agroecology	Altitude range
Mana	Gubebo soka	Lowland	(1100-1499) m.a.s.l
	Gube muleta	Mid-highland	(1600-2200) m.a.s.l
Kersa	Marewa	Mid-high land	
	Kejo meje	Highland	(2200-2833) m.a.s.l

Source: Household survey 2022

2.4.1. Sample size

The sample size was determined based on the formula given by (Yamane, 1967) as $n = \frac{N}{1+N(e^2)}$, to estimate an appropriate sample size based on the total size of a population and desired margin of error with concern for precision and practicality. Where n is the sample size, N is the size of the population and e is the desired level of precision. Accordingly, the formula is important to determine and calculate the sample size; at a 95% confidence level and precision level of ±7.

Hence, the total household heads in two districts of four kebeles were 156 (Gubebo soka (52), Marewa (28), Gube muleta (28) and Kejo meje (48)) selected by simple random sampling method among the wealth categories of the population.

2.4.2. Local Community criteria for households' wealth categories

Among the socio-economic factors that influence homegarden agroforestry practices is household wealth status such as rich, medium, and poor categories that exert a profound impact on the lives of individuals to interrelate with their economic access to adopt and practice (Table 2). Different workers also highlighted that the wealth status of households positively or negatively influences homegarden agroforestry practice in Ethiopia (Tega and Bojago, 2023; Tadesse *et al*., 2021; Ayichew, 2019).

Table 2. Local standard criteria for classifying households' wealth categories

Criteria variable	Wealth categories		
	Rich	Medium	Poor
Farm landholding size (ha)	1.5-2.5	0.75-1.5	<0.75
Access to purchase agricultural inputs	without credit	60 % credit	100% credit
Number of Ox	>3	2-3	1 or 0
Number of Cows	>6	3-5	0-2
Number of Ruminants (goat & sheep)	>8	4-8	0-3
Ability to send their children to school	100%	75%	<50%
Access to fulfill families' basic needs	>85%	50-75%	<50%
Access to technology information (TV, Radio, Mobile phone)	>75%	50-75%	<50%
Home furniture facilities holding	>80%	50-80%	<50%
Living House construction quality	high	medium	low

Source: Household survey 2022

For the present study, a total of 156 households were selected by simple random sampling techniques from each wealth category distribution (Table 3).

Table 3: Respondents sample size with wealth category for the present study

District	Kebeles	Total households per Kebele	Wealth category & sample size			Total samples
			Poor	Medium	Rich	
Mana	Gubebo soka	1427	15	25	12	52
	Gube muleta	768	8	14	6	28
Kersa	Marewa	769	11	11	6	28
	Kejo meje	1317	18	16	14	48
	Total	4281	52	66	38	156

Source: Household survey 2022

2.5. Data Collection Method

2.5.1. Sources of Data

The survey data were collected from primary and secondary sources. The primary data sources for this study were key informants, individual household heads of the selected study area, and the existing field vegetation species on individual homegardens. The secondary data were collected from the relevant literature, journals, internet, and governmental office (Woreda Agricultural and Rural Development Office and local DA Center).

2.5.2. Primary Data Collection

The primary data were collected through key informants, focus group discussion (FGD), direct field observation, household survey, and homegarden vegetation inventory. The primary data were collected from the selected representative household heads samples by using semi-structured questionnaire interviews that contained both closed and open-ended questions. The questionnaires primarily were prepared in English language and were translated into the local language (Afaan Oromo), to avoid ambiguity among respondents as the majority of the respondents are Oromo ethnic group and Afaan Oromo speakers.

2.5.3. Key informant interview

For primary data collection, first carry out informal interviews of key informants (individuals who are assumed to have good knowledge about the overall locality), and group discussion with them by forming one group of key informants per each selected sample Kebele to generate the overall information of the area. Key informants (KIs) are defined as persons who lived for a long time in the area, and with a better acquaintance with homegarden agroforestry. KIs were selected by snowball method (McKeganey *et al*., 2002). In each kebeles, selected five farmers were asked to give the name of the other five KIs depending on the above definition. Out of the mentioned total KIs, the most frequently mentioned five were selected at each kebele. Those selected KIs (20 individuals) were also used to classify farmers into wealthy categories. The records of Kebele offices were used to determine the wealth status of farmers: At the Kebele level, all resident farmers are categorized as poor, medium, and rich, based on the criteria of land holding, number of livestock owned the area of the farm occupied by cash crops, and the level of involvement in off-farm activities.

2.5.4. Vegetation data collection

In the selected homegarden agroforestry system samples, transect lines were placed to assess the vegetation species composition, richness, and diversity potential using systematic sampling techniques. To prevent biased sample selection, the transect lines were drawn and placed parallel to one another along the altitudinal gradient in the individual household farm of homegarden agroforestry system. The transect lines were delineated by using the 50-meter gap between two adjacent transect lines and between the consecutive intervals of quadrat sample plots on a transect line (Yadesa etal., 2021). A systematic sampling and transect line quadrat samples selection technique were employed separately on individual homegarden farms of selected households.

For vegetation data collection the sample quadrat size was established as the main quadrat of 20 m x 20 m (400 m^2) for matured trees, shrubs, and climbers. In each of the main quadrats, five subquadrats (2 m × 2 m) for the natural regeneration status of seedlings and saplings of woody species, and five subquadrats of 1 m × 1 m area for herbaceous data collection by arranging four (4) subquadrats at each corner and one (1) subquadrat at the center following the procedure described by Muller-Dombois and Ellenberg (1974). All sample quadrats on transect lines at starting and ending points were located at least 10 m from each homegarden agroforestry farm stand edge to avoid the edge effect (Muller-Dombois and Ellenberg, 1974). The data on vegetation composition, richness, and diversity in the study areas were collected from 156 household homegarden agroforestry farms. For the study of woody floristic, the data of woody species (trees, shrubs, climbers, seedlings, saplings) and structures (DBH, height, stem density) and herbaceous composition were collected for each perspective quadrat. In each quadrat, a complete list of vegetation present was identified, and measured the species name, stem density, diameter at breast height (DBH), height (H), and estimated the canopy cover of individual species. In this survey, woody species with DBH>5cm (at 1.3m height) were measured using diameter tape, and the height of the woody was measured by using a hypsometer, while herbaceous species were counted and recorded per sub-quadrat.

2.5.7. Plant identification

Owners of the farms, elders, and local botany experts were used to identify the local/vernacular names of plant species in Afan Oromo (AO). Various published volumes of Flora from Ethiopia

and Eritrea and Useful Trees and Shrubs of Ethiopia were used to identify the scientific names and families of plant species, (Edwards, 1995; Edwards *et al.*, 2000; Azene, 2007). Most of the species collected from each plot were identified in the field. To reliance on local names risks misidentification, the identified plant species in the field were verified by cross-checking specimens with Ethiopia and Eritrea flora book volumes 1-8. For those species that were difficult to identify in the field, their local names were recorded and herbarium specimen was collected, pressed, and dried properly using a plant presser and transported to Jima University herbarium for proper identification and nomenclature.

2.6. Data Analysis

2.6.1. Primary data of household interview

The household interview data were analyzed by using IBM (SPSS version 24) software. Inventory data were organized by using Microsoft Office Excel 2016. We used descriptive statistics to describe the qualitative and quantitative data collected for the study. The differences between group means were determined by an independent t-test (to compare two groups) of species diversity between males and females.

2.6.2. Homegarden inventory of vegetation data

For each three agroecological categories (highland, mid-highland, and lowland), species diversity; richness; and evenness of vegetation were calculated using Ecological Methodology software. Species richness, diversity, and evenness were measured using Shannon and Wiener's (1949) diversity index.

The species diversity index (H') - was calculated according to Shannon-Wiener (1949) by using the following formula:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \qquad \text{……(1)}$$

Where, H' = 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 total cover; and ln = log base $_n$ (natural logarithm).

Species richness (R) is measured to know how many numbers of different kinds of species are present in each plant community type or forest land-use system (Krebs 1999). The computational formula is as follows:

R = (*S*'-1)/LnN …….. (2)

Where R is species richness; S' is the number of species of that taxonomic group observed and N is the total number of individual species observed

Species evenness index (J') is a measure of how similar species are in their abundance. The Evenness of species was calculated by dividing H by Hmax as:

J*'*= *H'*/*H'*max or *J'*=*H'*/ln*S* ……..…… (3)

Where **J**' *is the Species e*venness index, ***H'*** is Shannon-Wiener Diversity Index; ***H'max*** is equal to the natural logarithm of richness in S**,** and ***ln*** = log base $_n$ (natural logarithm); **S** is the total number of species in the study area, Hmax = lnS.

2.6.3. Floristic Composition similarity indices

Sorensen's similarity index was used to determine the pattern of species turnover among successive three agroecological categories (highland, mid-highland, and lowland) of homegarden agroforestry system practice. The species similarity analysis among three agro-ecological categories of homegarden agroforestry system is described by using the following formula (Kent and Coker, 1992):

Ss = 2a/ (2a+b+c),

Where, **Ss** = Sorensen's similarity coefficient; **a** = Number of species common to both samples;**b** = Number of species in sample 1; **c** = Number of species in sample 2

3. RESULTS AND DISCUSSION

3.5. Socioeconomic characteristics of sampled household

The in-depth study was conducted on 156 households who have homegarden agroforestry farms. Out of 156 sample households surveyed, 81.41% (127) were male households and 18.59% (29) were female household-headed (Table 4). This indicated that male-headed households were dominated in homegarden agroforestry farmland holding in the area. The Age compositions of the households varied between 38 and 78 years old, with an average of 47 years old. Among the age composition, the majority 68.6% of households were found in a productive age group (≤ 64 years old), whereas, the rest 31.4 % of households found in the non-productive age group (> 64 years old). The most common family size ranged between 4 - 11 persons per household, with an average of six. In line with the present finding socioeconomic characteristics of households of

the study area, Tadesse et. al., (2021), and Tega and Bojago (2023) also indicated that the variation in socioeconomic nature exists within the community in south-central Ethiopia.

Table 4. Socioeconomic characteristics of the sampled household

Socio-economics Characteristics	Minimum	Maximum	Mean
Age	38	78	47
Education level	0	12	4.6
Family size	4	11	6
Farm holding size (ha)	0.56	4.25	1.25
Number of cattle	3	19	7
Number of ruminant animals	5	24	9

The study areas included households with varying educational statuses, from illiterate to full-time completion of high school. Regarding the educational status distribution at the first level (1-4 grade), those able to write and read accounted for 35%, second level (5-8 grade) shared 17%, high school (9-12 grade) 25%, and illiterate (non-read and write ability) accounted 23% among the household respondents. The household farmers owned different types of cattle, and ruminants to rear with an integrated to homegarden agroforestry system (Table 4). The overall farm size of households is varied between 0.56 and 4.25 ha, with an average of 1.25ha.

3.2. Characteristics and size of homegarden in the study area

Of the surveyed households, all (100%) were practicing homegarden to grow different types of plant species such as vegetables, fruits, spices, staple crops, medicinal plants, and coffee to fulfill various basic needs of household members. The size of homegardens agroforestry is generally less than that of the field cropland owned by the respondents. In the study area, the homegarden size varies ranging between 250 m^2 and 8750 m^2. The average homegarden sizes in the three wealth categories were 746.3 m^2, 2711.4 $m^{2,}$ and 4900.3 m^2 in poor, medium, and rich inventory homegardens respectively. In line with the present inventory Mattsson *et al.* (2018), and Kumar and Nair (2004) reported that the different homegarden farms vary in size, species types, species density, and structure.

Table 5. The size of homegarden in different wealth categories in Mana and Kersa districts

wealth category	Average area (m^2)	No of homegardens	Proportional distribution in Percent	
			Average area coverage (%)	No of homegardens (%)
Rich	4900.3	38	58.63	24.36
Medium	2711.4	66	32.44	42.31
Poor	746.3	52	8.93	33.33
Total	8358	156	100	100

Source: Household survey 2022

The homegarden age varies between 5 to 40 years, and the overall average age of homegarden is 23 years. The range of family members involved in homegardening in the study area was 1 to 8 and 100% of surveyed household heads owned the homegarden farmland managed by them. Homegarden, characterized by diverse plant species, livestock, and beekeeping is an essential part of the food production system in the study area in supplementing household field production (Table 5). Similarly, other workers stated that the variation of homegarden potential in their physical components, productive objective, and distribution from place to place (Mattsson *et al.,* 2018; Kumar and Nair 2004; Mitchell and Hanstad, 2004).

3.3. Floristic Composition of Homegarden Agroforestry

In general, in the study area, a total of 101 plant species belonging to 88 genera and 50 families were identified in the study areas of homegarden agroforestry. According to the results of the plant species composition assessment, 39 trees, 19 shrubs, 40 herbs, and 3 lianas were identified. The Fabaceae family contained 8 species (7.92%) of the woody species recorded in the study area, making it the dominant family. The reason that Fabaceae is the most dominant in the system is due to the fact most vegetables, spices, and medicinal plants belong to this family, which is found in the study site. In line with the present report, Getinet and Zerihun (2022), Regassa (2016), and Amberber *et al.* (2014) reported the dominance of the Fabaceae family in the homegarden agroforestry system.

Following the Fabaceae-dominated family, Myrtaceae and Euphorbiaceae are found in equal numbers in 6 species (5.94%), making them the most common family among woody species. The other frequent families are Solanaceae, Poaceae, and Moraceae, which are represented by 5 species (4.95%), Rutaceae, Rosaceae, and Asteraceae, which are represented equally by 4 species (3.96%), Zingiberaceae and Lamiaceae, which are represented equally in 3 species (2.97%), Oleaceae, Musaceae, Meliaceae, Cupressaceae, Brassicaceae, Bignoniaceae, Araceae, and Alliaceae are occurred equally in 2 species (1.98%), and other 30 families are occurred equally in 1 species (0.99%). The proportional of species composition variation among families might be attributed to individual species' ecological requirement variation, and farmers' species preference to conserve and manage by retaining the naturally regenerated species on their farmlands. The different authors of Mengistu and Fitamo (2015), Abebe (2013), and Mekonnen *et al.* (2014) found different families with different species proportions in different homegarden agroforestry at different locations in Ethiopia.

This research area includes both exotic and indigenous plant species in its homegarden agroforestry practice. Out of the 101 plants identified in this study, 53 (52.48%) are exotic plant species in the study area's homegarden agroforestry. Only 48 (47.52%) of the plant species are native. Fruit and vegetables, which directly contribute to species richness, are responsible for the dominance of exotic plant species in homegarden agroforestry. This finding corresponds with Regassa (2016), who reported that 32.17% of the plants identified in Hawassa's homegarden are native to Ethiopia, while 62.02% are exotic species. The study's findings are also consistent with Senbeta *et al.* (2013), who reported that trends in the frequency of use favor exotic and economically important species. This finding differs slightly from Mengistu and Asfaw (2016) previous finding in Southeast Ethiopia homegarden agroforestry practice, where farmers manage both exotic (46.7%) and native (53.3%) tree/shrub species.

3.4. Vegetation species growth habit distribution along altitudinal gradients

The plant species identified in this study belong to four growth habits: tree, shrub, herb, and liana. Of the total 101 identified plant species, the majority of the species in the homegarden agroforestry practice were herbaceous, and trees each equally accounting for about 39% of the identified species (Figure 3). This is because farmers prefer herbaceous crops, particularly vegetables, and fruit trees for home consumption and market purposes. This finding is consistent with Amberber *et al.* (2014), who found that herbaceous plants contributed more to Holeta homegardens. The result reported by Regassa (2016), showed that herbs were the most numerous species in the homegardens of Hawassa followed by shrubs 27.13% and trees 24.8%. However, shrubs and lianas contributed 19 % and 3%, respectively, to the homegardens of the Mana and Kersa districts of the Jimma zone.

Table 6. Vegetation species growth habit distribution along the altitudinal gradient

Plant growth habit	**Altitudinal gradient zone**		
	Low- altitude	Mid- altitude	High- altitude
Tree	24	33	27
Shrubs	12	15	13
Liana	3	2	1
Herbs	25	32	16
Total	64	82	57

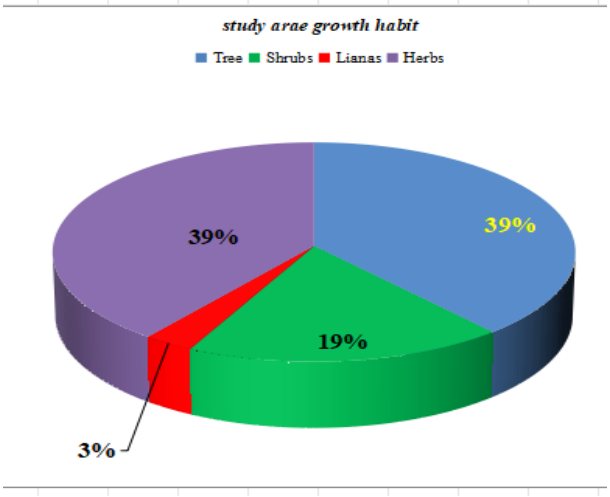


Figure 3. Vegetation growth habit distribution proportion in the study area

Generally, the results showed that the highest plant species 82 (40.4%) were recorded at mid-altitude homegarden agroforestry, followed by low-altitude homegardens with 64 (31.5%) plant species distribution. On the other hand, the least plant species 57 (28.1%) were recorded in the low-altitude of homegarden agroforestry farms (Table 6). This result is comparable to that of Castiñeiras *et al*., (2002), who found that fewer fruit tree species were grown in homegardens at higher elevations and that changes in crop species composition caused a decrease in structural complexity of gardens along the elevation gradient.

3.5. Vegetation species richness, and diversity of homegarden agroforestry

Households in the study area retain the naturally regenerated and plant various woody and herbaceous components based on space available horizontal and vertical and their compatibility with crops and household production objectives. The highest and lowest numbers of exotic and native plant species (woody and herbaceous) were recorded in Mana and Kersa districts, respectively. The extent of plant species richness distribution in agroecological perspective level comparison was mid-highland (82) > lowland (64) > highland (57) (Table 7).

The Shannon – Wiener diversity index (H') computed for the vegetation species diversity for the individual three agro-ecologies zone of the Mana and Kersa districts' homegarden agroforestry systems practicing at households. The overall Shannon-Wiener diversity index of vegetation species in homegarden agroforestry showed that the different values of species diversity (1.55 – 1.93), richness (57 – 82), and evenness (0.64 – 0.77) among three agro-ecologies zone. The possible reason for the variations of species diversity, richness, and evenness across agro-

ecologies zones of homegarden agroforestry may have occurred due to the influence of environmental factors such as micro-climate, elevation, slope, soil properties, and degree of individual household conservation and management practices, disturbance, and preference of farmers to retain and cultivate plant species on their agroforestry farmland. Similar to the present findings, other workers also reported variation values of species diversity, richness, and evenness among different households' homegarden agroforestry in Ethiopia (Molla et. al., 2023; Abebe et. al. 2010; Tolera *et al*., 2008)

Table 7: Species richness, evenness, and Shannon-Weiner diversity index of plants in homegarden agroforestry

Agro-ecology type	Altitudinal range (m.a.s.l)	Slope Range (%)	Species Richness	Species diversity (H')	Simpson diversity	Species evenness (J)
Highland	2200-2833	12-24	57	1.55	0.66	0.64
Mid-highland	1600-2200	7.5-16	82	1.93	0.75	0.77
Lowland	1100-1499	9-18	64	1.78	0.74	0.74
P value			0.01	0.001^{***}	0.001^{**}	0.05

Keys: *, **, ***, and ns = significant at $P < 0.05$, high significant at $P < 0.01$, very high significant at $P < 0.001$, and nonsignificant at $P > 0.05$, respectively.

The Shannon diversity index for plant species in this study is H'=1.93 in the mid-highland, H'=1.78 in the lowland, and H'=1.55 in the highland. Similarly, Simpson's index was found as 0.75 for mid-highland, 0.74 for lowland, and 0.66 for highland agroecology (Table 7). The statistical test showed that Shannon and Simpson diversity indices of plant species highly significantly differed ($p < 0.001$) across agroecological zones of homegarden agroforestry system. The Shannon and Simpson diversity indices showed that mid-highland agroecology has higher species diversity, richness, and evenness than lowland and highland. The possible reasons for high species diversity, richness, and evenness in mid-highland agro-ecology might be attributed to an intermediate wide variation of altitudinal range (1600-2000 m.a.s.l) of area because, an intermediate altitude could be associated with relatively favorable environmental circumstances like suitable rainfall, temperature ranges, which can facilitate the rapid acquisition of resources to support different plant species or ecologically diverse species that need to adapt to their changing environment. In line with the present findings, Molla *et al*., (2023), Legesse and Negash (2021), Bajigo and Tadesse, (2015), and Abebe *et al.* (2010) reported, the nature of plant diversity, richness, and evenness largely depends on the favorable ecological characteristics.

3.6. Plant species similarity among agroecology

Sorenson's coefficient of similarity was computed to evaluate the continuous or discontinuous of similar species composition among three agroecological zones homegarden agroforestry. Sorensen's similarity coefficient for the Mana and Kersa districts of the Jimma zone area ranges from (34 to 43) % among agroecological zones (Table 8). The highest species composition similarity was observed between the lowland and mid-highland agroecologies (43%).

Table 8. Sorensen's similarity coefficient (Sc) among three agro-ecology zones

Agro-ecology	Highland	Mid-highland	Lowland
Highland	1	__	__
Mid-highland	0.34	1	__
Lowland	0.38	0.43	1

The possible reason for the highest species composition similarity between lowland and mid-highland could be due to the geographical proximity, and the close similarity of altitude and slope ranges. Moreover, high similarity indices could be attributed to environmental homogeneity, which generally results in uniformity in weather conditions, resulting in good plant growth. The finding was in agreement with the study reported in different study areas by other workers (Daba, 2018; Tefera *et al.,* 2016).

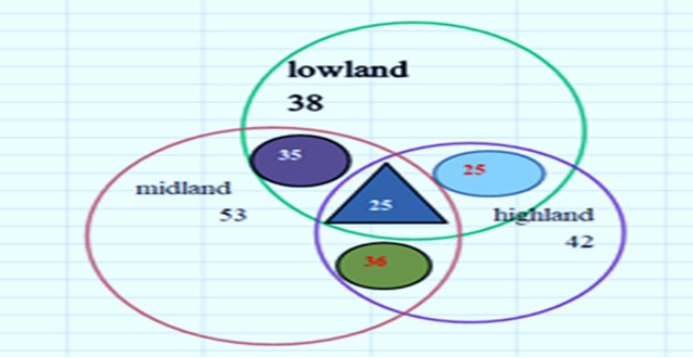


Figure 4. Species composition similarity among agro-ecological zone

According to Sorenson's coefficient of similarity index, the overall species similarities/ homogeneity among three agro-ecologies in the study area revealed less than 50%, this indicated that relatively high heterogeneity of homegarden agroforestry species composition leads to the creation of vegetation diversity or variety in the area (Yadesa, 2021). On the other hand, among three agroecologies, the minimum Sorenson's coefficient of similarity index value is exhibited

between midland and highland (34%) (Table 8 & Figure 4). This may happen due to the influence variation on understory native plant species, internal micro-climatic modification conditions variation, soil properties variation, species growth ecological requirement variation, and degree of human impact (anthropogenic) action variation in management practices. Moreover, due to species growth requirements, species adapted to mid-highland agroecology may not be adapted to highland agroecology and vice versa. Other workers also reported that low species similarity index between the same agroforestry systems due to agroecology's variation, and local environmental influence on the species' growth, and adaptation (Daba, 2018; Tefera *et al.,* 2016; Tadesse, 2002; Tesfaye, 2005).

4. CONCLUSION

Homegarden agroforestry system is widely practiced around homesteads in the Mana and Kersa districts of the Jimma zone. Homegarden agroforestry systems of the study area are characterized by high exotic and native plant species composition. In the Jimma zone, the households are commonly cultivated, retaining the natural regenerated species, and conserving the diversity of exotic and native plant species in homegarden agroforestry for a variety of social, economic, and ecological benefits. The size of homegardens agroforestry in the study area varied among the three wealth categories of poor, medium, and rich households.

The inventory of the vegetation data indicated the presence of different species which include trees, shrubs, herbs, and lianas observed in the area. In the study area, 101 plant species belong to 50 families, and 88 genera were identified. Fabaceae, Myrtaceae, and Euphorbiaceae were the most species-rich family in individual household homegarden farms. The identified plant species were classified into four habits, trees 39, shrubs 19, herbs 40, and Lianas 3 species. From the identified plant species, exotic species comprise a larger portion than native species. The highest species richness and diversity were recorded in mid-highland followed by lowland agro-ecologies. The species composition similarity among agroecologies' was shown to be less than 50%, which indicates high species heterogeneities, and species discontinuity between agroecologies. Homegarden agroforestry system provides multiple socio-economics and ecological benefits for small-holder households and plays an important role in plant biodiversity conservation, however, it is dominated by exotic plant species rather than native species, therefore, it needs more attention to encourage households to intensify native plant species in the homegarden agroforestry practice.

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