Research Article *http://dx.doi.org/10.4314/mejs.v16i1.6*

Socio-ecological Benefit of Homegarden Agroforestry and Their Indigenous Management System: A Case Study in Digelu Tijo District, Oromia, Ethiopia

Kasim Edo[1], Leul Kidane[2]* and Tadesse Beyene[2]
[1]Sagure Secondary High School, Sagure town, Oromia, Ethiopia (ekasimedao@gmail.com).
[2]Department of Biology, College of Natural and Computational Sciences, Mekelle University, Mekelle, Ethiopia (*leul.kidane@mu.edu.et, leulkw@gmail.com).

ABSTRACT

Home gardens (HGs) are thriving traditional food systems safeguarding a rich agrobiodiversity. They supply basic needs as well as ceremonial and religious benefits to households (HHs). However, documentation of HGs in Ethiopia is inadequate and patchy. This ethnobotanical study was carried out in Digelu Tijo District Oromia National Regional State, Ethiopia to identify and document plant species diversity in HGs and the associated indigenous ecological knowledge of the local people. Four kebeles were selected based on their worthy traditional HG practice and detailed indigenous knowledge of the community. From these sites, 130 respondents (HG owners) were selected based on their good HG practice and management. Data were collected using semi-structured interviews, guided garden tours, group discussions, and market surveys. Data were analyzed by preference ranking, direct matrix ranking, descriptive and inferential statistics, Sørensen's similarity index, Shannon-Wiener diversity index, and Pearson correlation coefficients. HG areas range from 0.04 ha to 0.25 ha with a mean of 0.12 ha. A total of 72 useful plant species were documented. Fabaceae was the most frequently observed family containing ten species, followed by Solanaceae. The plant species comprised, 33% trees, 23% shrubs, 42% herbs, and 3% climbers. Eight social use categories were identified: edible plants (26%), medicinal plants (24%), forage plants (11%), plants for construction (10%), for income generation (9%), ornamentals (8%), spices (7%) and for shading (5%). The Shannon-Wiener indices of plant diversity (H') ranged between sites from 2.53 to 3.33. Ecological values of the HGs in the study area include maintenance of soil fertility, habitat provision to many organisms, enhancement of water quality, prevention of soil erosion**,** carbon sequestration, and improving soil moisture by providing shade. HGs are important for food security and restoring ecosystem services, particularly in ruined regions. The HGs are highly diversified with different plant species providing multiple uses and several ecological goods and services, but their potential is beyond this. They are threatened by various factors like lack of water, lack of access to quality seed/seedlings, disease and pests, poor access to markets, and insufficient technical support by agricultural experts. Therefore, for enhanced and integrated conservation of these rich resources and to ensure food security, joint efforts by all concerned stakeholders are required.

Keywords: Agrobiodiversity, Agroforestry, Ecological services, Food plants, Indigenous knowledge.

1. INTRODUCTION

Natural plant diversity in a system plays an invaluable role in maintaining ecosystem

Submitted on: 3rd June 2023 ***Revised and Accepted on: 15th March 2024***

equilibrium. The internal regulation of functions in natural ecosystems such as flows of energy and nutrient cycle are major services of plant biodiversity (Sutrisno et al., 2020, Yinebeb et al., 2022b). Worldwide, tens of thousands of species of higher plants, and several hundred lower plants, are currently used by humans for a wide diversity of purposes including food, fuel, fiber, herbs, spices, forage, and fodder for domesticated animals (Krupnick and Kress, 2005; Kidane et al., 2023).

Agroforestry systems and practices, which are more valuable than mono-cropping systems from a biodiversity perspective, play a pivotal role to meet the current diverse socio-ecological needs of people with fixed land in many parts of the world, including Ethiopia (Mcneely and Schroth, 2006; Shumi et al., 2019; Meragiaw et al., 2022). Land with trees around the houses of farmers is an agroforestry practice known to be ecologically sustainable and diversifies livelihood for the farmers. HG is commonly defined as a land use system involving careful management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, being intensively managed through family labour (Yinebeb et al., 2022b; Kumar and Nair, 2006; Eyasu et al., 2020). A well-designed structure of HG agroforestry can give desired benefits through efficient resource utilization.

The structure of HGs in the tropics is both horizontal and vertical. The horizontal structure is determined by localization of each HG species within the garden using the farmer's house as a reference. The vertical structure reflects the degree of species specialization and complexity (Kumar and Nair, 2006). To maintain agro-ecosystem resilience and to meet the HG products for requirements of the people during hassle of climatic hazard, like drought and flood shortage, scientific information is required. Lack of such scientific knowledge of HG agroforestry may lead to loss of HG structure and species diversity.

Species composition, structure, and function of HGs are influenced by ecological, socio-economic, and cultural factors, such as distance from urban markets, household size and composition, environmental degradation, and family tradition (Lamont and Eshabugh, 1999; Thangjam et al., 2022). Whether found in rural or urban areas, HGs are characterized by a structural complexity and multi-functionality, which enables the provision of different benefits to ecosystems and people (Galluzzi et al., 2010). The introduction of cash crops in HGs may be accompanied by reduced species diversity (Abdoellah et al., 2002), but the opposite may also be the case (Trinh et al., 2002).

In Ethiopia agriculture is hazardous due to several factors. Among these are climate change and unpredictability, land degradation in the form of soil erosion, reduced soil fertility and severe soil moisture stress, partly the result of loss of trees as well as reduced organic matter (Abdoellah et al., 2020; Mellisse et al., 2018). Ethiopia is a drought prone country, which leads to challenges in food production, especially because 95% of the agricultural activity is dependent on rainfall. Drought has been the major cause of food shortage and famine in Ethiopia (Shanka, 2022).

The effect of the above problems is loss of biodiversity, food insecurity and subsequent increase in rates of malnutrition, which are becoming the major tribulations of human well-being (Kidane et al., 2023). Adaptation to these serious challenges is necessary. One of the solutions to meet people's requirements is through the application of HGs which are more advantageous than monocropping (Mcneely and Schroth, 2006).

Studies and documentation on HGs in Ethiopia are still limited to some parts of the country and not representative (Berhanu and Asfaw, 2014; Yinebeb et al., 2022a; Birhane et al., 2020; Getachew et al., 2022; Tesemma, 2017). This includes various aspects as plant diversity, composition, socio-ecological values, including the traditional local knowledge towards management system of HG plants and the challenges related to HG practices. This contribution extends the documentation to Digelu Tijo District in Oromia Regional State, Ethiopia.

The following research questions were considered: i) What are the plant species composition, richness, and diversity of the HGs of the study area? What are the growth forms and, taxonomic categories of plants in the HGs? ii) What types of social and ecological values are obtained? iii) What practices do farmers apply to conserve and manage their HG plants? iv) What are the main challenges that affect the diversity, social and ecological values, and practice of conservation of HG plants? v) What actions ought to be taken to safeguard traditional knowledge and plant diversity of the district?

2. MATERIALS AND METHODS

2.1. Description of the Sudy Area

The study was conducted in Digelu Tijo District, East Arsi Zone, Oromia National Regional state, located at latitude 7˚ 35'57"- 7˚ 55'43" N and longitude of 38˚ 59'40" – 39˚ 24'31"E (Fig

1). The altitude of the study sites ranges from 2,680 to 3,164 m a.s.l. (Table 1).

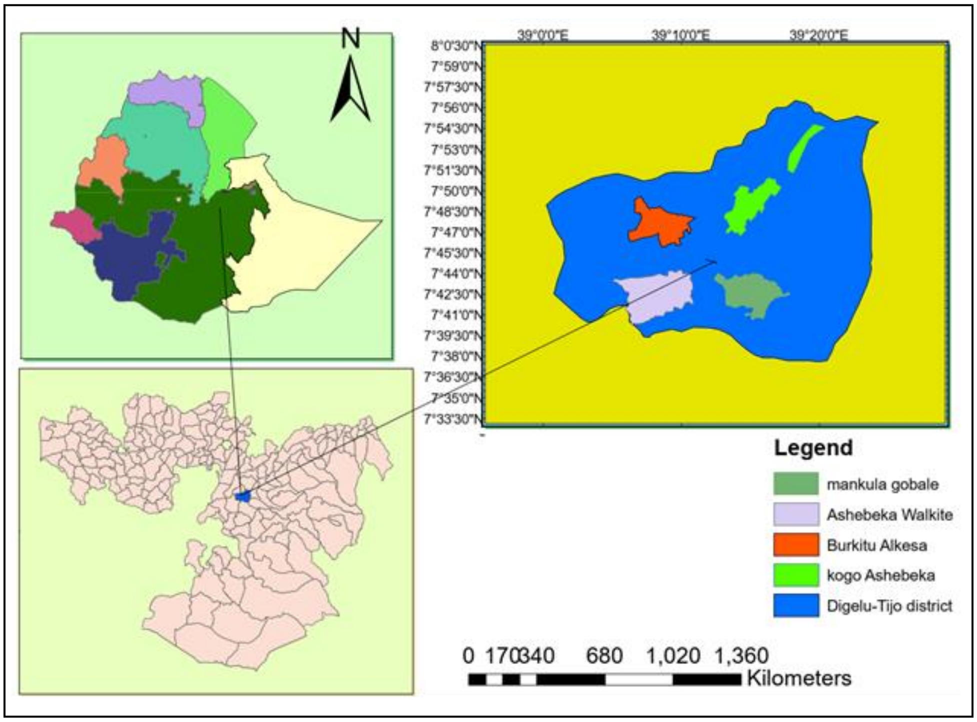

Figure 1. Map of the study area.

Table1. The geographical location and altitude of the selected study sites.

Kebeles	***Geographical location***		***Altitude***
	Latitude	***Longitude***	
Ashebaka walkite	7°63'07.96''N	39°29'27.87''E	2680 m
Burkitu alkesa	7°81'99.89''N	39°31'85.36''E	2896 m
Mankula gobele	7°74'18.34''N	39°34'94.45''E	3138 m
Kogo ashebeka	7°71'10.07''N	39°25'09.54''E	3164 m

The study sites receive an annual rainfall of 1,500 to 2,600 mm and the mean annual temperatures range from 14 to 24 °C. It is within the Dega agricultural zone with wet, cool temperate climate. Dega is found at 2,300–3,200 m a.s.l., with a mean annual rainfall 1,500–2,600 mm and a mean temperature of 10.9–21°C (Digelu Tijo District Agricultural Office Annual Report, 2015). The total population of the district is 140,466 of which 69,503 are men and 70,963 women. Among them 14,080 are urban dwellers (CSA, 2010). The area is characterized by highlands and flat- topped plateaus. Agriculture plays an important role in the district's economy, livelihood, and socio-cultural system. Commercial farming is limited; Mixed farming of smallholders and pastoral livestock keeping dominate (Digelu Tijo District Agricultural Office Annual Report, 2015).

2.2. Data Collection Method

2.2.1. Reconnaissance Survey and Site Selection

A reconnaissance survey of the study area was conducted during August 2018 to cognize the general impression of the area. The actual study was conducted in September 2018 and October 2019. This is the time of the year when fruits and plants mature, making it easy to get all parts of them. After the survey, focus group discussions were carried out with four agricultural experts of the woreda to obtain basic information about the handling and management system of the HGs. With the information gathered, the four kebeles in Table 1 were selected based on the availability of traditional HG practices.

2.2.2. Sample Size Determination

There are 2,132 identified total household in the four selected kebeles (CSA, 2010). Among these, the sample size (n) determination for the study was carried out using the following formula (Kothari, 2004):

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

Where, n = the desired sample size.

N= number of households in the four sampled kebeles (2,132).
Z = the critical value containing the area under the normal curve =1.96.
e = the desired precision level (5% precision = 0.05).
p = an estimated proportion attribute present in the population (0.1).
q = 1- p (1 – 0.1 = 0.9).

Thus, n becomes,

$$n = \frac{(1.96)^2(0.1)\,(0.9)\,(2132)}{(0.05)^2(2132-1) + (1.96)^2(0.1)\,(0.9)} = 130 \text{ household respondents}$$

Then the 130 respondents were allocated to four kebeles in relation to their population. Rendering on this formula the total number of the selected HHs is summarized in table 2.

The 130 HHs (115 men and 15 women) were purposely selected based on information obtained from the district agricultural experts and administrative bodies. As pointed out by Martin (1995), when recording indigenous knowledge, the choice of key informants is usually systematic, Accordingly, from the total of 130 respondents 16 household representatives (four from each site) were purposively selected for detailed observation and discussion based on their good HG practices. These selected good practitioners were asked to list and designate local indigenous edible plants and multipurpose tree plants by preference ranking and direct matrix ranking. In addition, three types of HGs were identified based on their size: small (<0.08 ha), medium (0.08-0.15 ha) and large (>0.15 ha).

Table 2. Total number of HHs and the sample size from the kebeles under study.

Selected Kebeles	***Total HHs (N)***	***Selected HHs (n)***
Kogo Ashebeka	625	40
Mankula Gobale	540	32
Ashebeka walkite	465	28
Burkitu alkesa	502	30
Total	**2,132**	**130**

2.2.3. Collection of Ethnobotanical Data

Ethnobotanical data were collected through semi-structured interviews, field observations, focus group discussions and market surveys, following (Tesemma, 2017; Martin, 1995; Cotton, 1996). The interviews and discussions were made using the local language (Afan Oromo) and later converted into English. During the semi-structured interviews, all interviewees were asked the same standard questions in the local language using open and close-ended questions.

2.2.4. Homegarden Surveys and Interviews

The HH investigations involved different data collection methods, including field observations, semi-structured interviews, and informal discussions. During the assessment and interviews, the species diversity, composition, socio-ecological values, HGs management practice, and factors that hinder the HG plant diversity were recorded. In addition, information on HH characteristics, plant growth form and purpose of HG practices were recorded. Socio-economic characteristics, like age, gender and educational background of the selected HG owners were also documented.

During the field survey, all HG plants were recorded according to their social use category values. Secondary data about the general information of the HGs were obtained from the agricultural office of the district.

2.2.5. Focus Group Discussions

According to Martin (1995), focus group discussions are mainly suitable when the objective is to understand better how people consider an experience, idea, or event. Four group discussions were conducted, one group from each site. There were eight key informants in each group, recommended by the agricultural experts and local administrators based on their exemplary HG performance and rich plant diversity. During the discussion, respondents were asked to list and describe their HG plants and the associated indigenous knowledge towards the management system of these, their socio-ecological values and the factors that challenge their HG practice.

2.2.6. Market Survey

The market is a place where traditional plant values and agricultural achievements as well as plant resources are shared among people. Hence, they supplement the ethnobotanical studies and are vital components for ethnobotanical data collecting. Thus, market surveys were undertaken to record various HG plant products in three nearby marketplaces (Sagure Gebeya Kamsa, Digelu Kidame Gebeya and Tijo-Sembeta gudda Gebeya) by interacting with sellers and buyers.

2.2.7. Plant Diversity

During the survey, all the selected HGs were visited, and all HG plant species were recorded. The area of the homegardens were recorded. In addition to the local names of plant species, socio-ecological values and growth forms were also recorded by asking the owners and through repeated observations. Voucher specimens were collected. Identification of specimens was done both in the field and later at Mekelle University using Flora of Ethiopia and Eritrea (Edwards et al., 1995, 1997, 2000; Hedberg and Edwards, 1989, 1995; Hedberg et al., 2003, 2004, 2006) and by comparison with already identified specimens and asking with experts from Mekelle University botany team.

2.3. Data Analysis

The collected data were analyzed and summarized using methods described by Martin (1995), including preference ranking and direct matrix ranking. Descriptive statistical methods used include Sørensen’s similarity index and Shannon-Wiener (1949) diversity index. Pearson correlation coefficient was computed using SPSS version 20 (Pandey et al., 2006). An assessment of the level of agreement with a series of statements about the importance of the 19 HG ecosystem services identified by Calvet-Mir et al. (2012) was executed. Specifically, informants were asked to tell how much they disagreed or agree with each of the statements in a scale ranging from one (“1 completely disagree”) to five (“5 completely agree”) (Table 10).

2.3.1. Preference Ranking

Preference ranking was carried out for five commonly used edible plants by sixteen informants, following Martin (1995), ranging from 5 (most preferred) to 1 (least preferred). Scores were summed for all informants, giving an overall ranking for the food plants by sample group of the informants.

2.3.2. Direct Matrix Ranking

Direct matrix ranking was performed following the method of Martin (1995) to five commonly reported multipurpose trees to assess their relative importance. Eight key informants were asked to assign social and ecological values for each plant. The values of each use diversity for a species were taken, and it was summed and ranked.

2.3.3. Shannon-Wiener Diversity Indices

For the diversity of homegarden plants in the four study sites the Shannon-Wiener index was used (Shannon and Wiener, 1949):

$$H = -\sum_{i=1}^{s} \text{Pi} \ \ln\ (\text{Pi})$$

Where, H' = Shannon-Wiener diversity index of the species,
s = number of species recorded in each homegarden, and
pi = proportion of the abundance of each species from the total abundance of plant species recorded in each homegarden.

Evenness was calculated as the ratio of observed diversity to maximum diversity using the equation: $E = H'/H\text{max}$

Where, $H\text{max}=\ln S$;
*H*max is the maximum level of diversity possible within a given population,
S = species richness (total number of species).

2.3.4. Similarity Among Homegardens

Sørensen's index of similarity was used to determine similarity between HGs: $S = \frac{2C}{A+B}$

Where, S is Sørensen's similarity index.
C is the number of species common to both sites.
A is the number of species present in one of the sites to be compared.
B is the number of species present in the other site.

The coefficient values range from 0 (complete dissimilarity) to 1 (total similarity) (Kent and Coker, 1992).

3. RESULTS

3.1. Socio-demographic Characteristics of the Respondents

Various demographic characteristics can be found in table 3. Most respondents were men.

Table 3. Demographic characteristics of the respondents.

Items	***Alternatives***	***No of Respondents***	***Percentage***
Sex	Male	115	88%
	Female	15	12%
	Total	**130**	**100%**
Age in year	25-35	20	15.4%
	36-45	55	42.3%
	46-55	30	23%
	56 and above	25	19..3%
	Total	**130**	**100%**
Educational background	Illiterate	32	24.6%
	Elementary (1-4)	45	34.6%
	Junior (5-8)	28	21.5%
	High School (9-12)	25	19.3%
	Total	**130**	**100%**
Household size	1-5	40	30.8%
	6-7	62	47.7%
	8 and above	28	21.5%
	Total	**130**	**100%**
Farming experience	5-10 years	10	7.7%
	11-15 years	18	13.8%
	16-20 years	25	19.2%
	21-25 years	35	27%
	> 26 years	42	32.3%
	Total	**130**	**100%**

3.2. Design and Setting of Home Gardens

In the present study, all the surveyed houses had HGs which vary in position, the front yard covered (8.5%) containing most attractive plant species, the side yards covered (9.6%) with medicinal, spice and multipurpose trees. The back yard accounts (63.9%) and contains food plants and the mixed yard accounts (17.7%) with fence plants and shade trees to use as quiescent place (Table 4).

3.3. Relationship between HG Size and Species Diversity

Three types of HGs were identified in the study kebeles based on their size. Their size ranges between 0.04 and 0.25 ha with an average of 0.12 ha. Seventy nine percent of the HHs were small (0.04 - 0.08 ha) to medium (0.09 - 0.15 ha) sized (Table 5). Number of species in HGs of different size is shown in table 6. There is a strong significant positive correlation between the garden size and plant species diversity (r =0.809, P=0.000) (Fig 2).

Table 4. Position of HGs in the surveyed compounds.

Kebele	***Sampled houses with garden***	***Front yard***	***Side yard***	***Back yard***	***Mixed yard***
Kogo ashebeka	40	-	5	27	8
Mankula Gobale	32	4	3	21	4
Ashebeka walkite	28	5	-	20	3
Burkite alkesa	30	2	5	15	8
Total	130	11	13	83	23
Percent (%)	100	8.5	10	63.9	17.7

Table 5. The size categories of HGs in the study area.

Homegarden Type	***Size range***	***No of HGs***	***Percent***
Large	0.160 – 0.250 ha	27	20.8
Medium	0.090 – 0.150 ha	45	34.6
Small	0.040 – 0.080 ha	58	44.6
Total		130	100

Table 6. Relation between HG size and species diversity.

Homegarden type	***No of Species***	***No of Family***	***Percentage***
Small	31	16	40.3
Medium	51	25	66.2
Large	63	31	80.5
Overall	72	38	

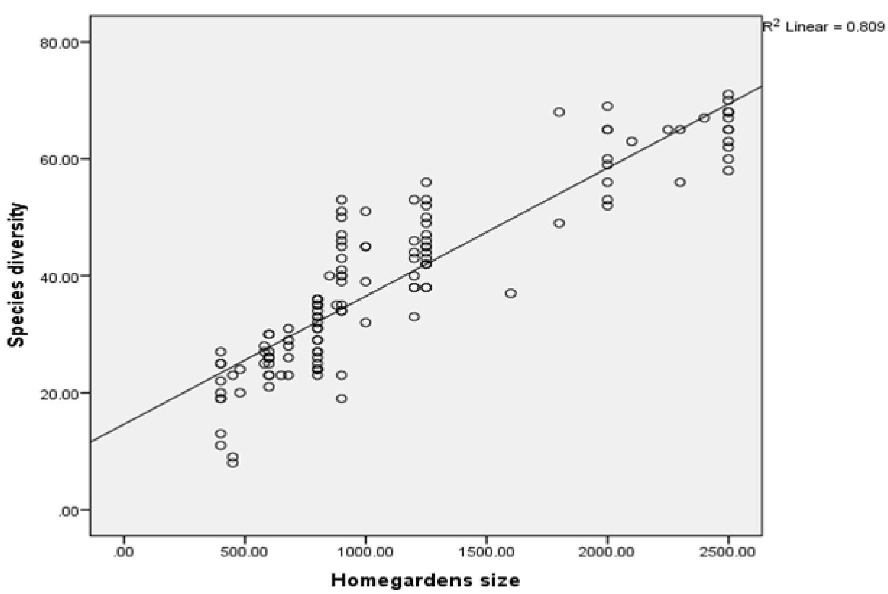

Figure 2. The relationship between HG size and plant species diversity.

3.4. Homegarden Management Practice and Traditional Knowledge among the Residents

HG plants were handled by HH members. Plants were established, irrigated, manured, gathered, and flogged by women and children. Ploughing, gaining eminence seeds/seedlings, implanting trees, fencing and guardianship at night were performed by men. Children overwhelm in irrigating, guarding the plants from animals and transport the products to the marketplace. To reserve HG plants, people had their own traditional management system. Thus, damaged, or infested HG plants were detached, harvested products were dried and stored safely until they are consumed. Most of the respondents replied, that production of their HGs increased from year to year while others, indicated during the last 10 years production decreased due to environmental hazard. On the other hand, (23%) of them indicated that their HGs production was unchanged over the last 10 years and (27%) revealed that their HGs plants and their production were not constant.

Many of the respondents (69.3%) showed that they used rainwater for their HG. The others, 14.6% responded they used river water, and 16.17% indicated they used both rainfall and river water for their homegardening. To acquire a worthy yield of HG, it desires to be managed well. Some of the management activities by the local people include tidying, digging for soil preparation, fencing and regular watering.

3.5. Diversity of Plant Species

HGs of the study sites harbor a wide variety of plants, varying from small herbs to tall trees. There were 72 plant species under 63 genera and 38 families recorded (see Appendix 1). Fabaceae ranked top of the list (10 species) followed by Solanaceae (6 species). The diversity index (H') ranged from 3.33 to 2.53 and evenness (E) from 0.82 to 0.73 (Table 7).

Table 7. Species richness, Shannon diversity index and evenness of the study kebeles.

Kebele	***Species richness***	***Shannon's index (H')***	***Evenness (H'/H'max)***
Kogo ashebeka	56	3.33	0.82
Mankula Gobale	49	3.11	0.80
Ashebeka walkite	47	2.91	0.76
Burkitu alkesa	40	2.53	0.73

Respondents stated that the reason for variation in HGs plant composition can be related to HG size, difference, in indigenous knowledge towards management practices and distribution of multipurpose plants. In all the four sites, most HGs were covered with herbs, followed by trees and shrubs (Fig 3).

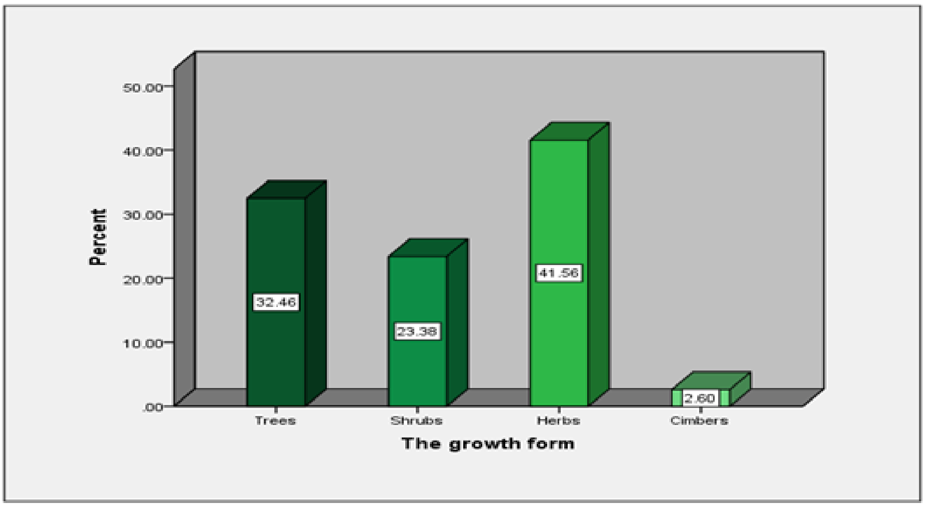

Figure 3. The growth form of plants in the studied home gardens.

3.6. Similarity of the HGs in the Study Sites

The HGs of Burkitu alkesa and Mankula Gobale had a higher similarity than other combinations (Table 8).

Table 8. Sørensen's similarity index of the HGs.

Sites	***Kogo ashebeka***	***Mankula Gobale***	***Ashebeka walkite***	***Burkitu alkesa***
Kogo ashebeka	1			
Mankula Gobale	0.64	1		
Ashebeka walkite	0.44	0.64	1	
Burkitu alkesa	0.57	0.66	0.44	1

3.7. Direct Matrix Ranking of Multipurpose Trees

To assess the relative importance of multipurpose trees five common such tree species were selected and ranked against seven functional categories through direct matrix ranking (Table 9). *Juniperus procera* and *Eucalyptus globulus* are the most common multipurpose trees planted in the HGs for various uses.

3.8. Ecological Values of HG Plant Species

The HG plant resources provide different forms of ecological and environmental values in addition to affording social use values according to results obtained from semi-structured interviews and focus group discussions (Table 10). These include habitat provision to many organisms, enhancing water quality, maintenance of soil fertility, prevention of soil erosion, carbon sequestration, improving soil moisture by providing shade and living fences by trees.

Table 9. Result of direct matrix ranking by eight key informants for five multipurpose trees (5 is best; 1 is least; 0 is not used).

Scientific name	***Functional categories***							***Total***	***Rank***
	Edible	***Constru-ction***	***Shade***	***Fence***	***Firewood***	***Ornamental***	***Medicine***		
Juniperus procera	0	40	30	40	39	24	38	211	1
Eucalyptus globulus	0	39	32	39	39	28	0	177	2
Olea europaea	0	38	28	35	28	40	0	169	3
Cupressus lusitanica	0	31	25	30	18	28	0	132	4
Cytisus scoparius	40	10	12	29	8	30	0	129	5

Table 10. Valuation of ecosystem services provided by HG owners (n = 130 informants) (Criteria adapted from Calvet-Mir et al. (2012).

Ecosystem Services	***Av. valuation (from 0 to 5)***
Regulating services	
Pollination	1.85
Maintenance of soils fertility	4.47
Local climate regulation	2.62
Enhanced water quality	2.26
Purification of air	2.10
Total average score of regulating services (range 0 to 25)	11.04
Habitat provision	
Living space for wild plants and animals	4.64
Maintenance of landraces	3.65
Total average score of habitat services (range 0 to 10)	8.29
Production services	
Provision of quality food	4.91
Provision of fodder and green manure	4.30
Crop improvement and material for medicinal purposes.	3.92
Provision of medicinal plants	4.26
Provision of resources for worship and decoration	2.97
Total average score of production services (range 0 to 25)	20.36
Cultural services	
Enjoyment of home garden aesthetic features	3.97
Hobby	3.52
Use in folklore, art, and design	2.70
Connection with spiritual feelings	2.25
Place to carry out environmental education and scientific research	4.50
Heritage value of home gardens & associated traditional ecological knowledge	3.51
Place for creating and enhancing social networks	4.64
Total average score of cultural services (range 0 to 35)	24.39
Total average score of all services (range 0 to 95)	64.08

3.9. Use categories of the HG plants

We found eight major social use categories of the HG plants, as listed in figure 4. Food and medicine were the most important. In addition, a single plant can play two or more functional roles. For instance, *Allium sativum* and *Beta vulgaris* serve as medicinal and edible while the former is also used as a spice. Most spice plants are also medicinal plants. Thus, a species can be included in two or more use categories.

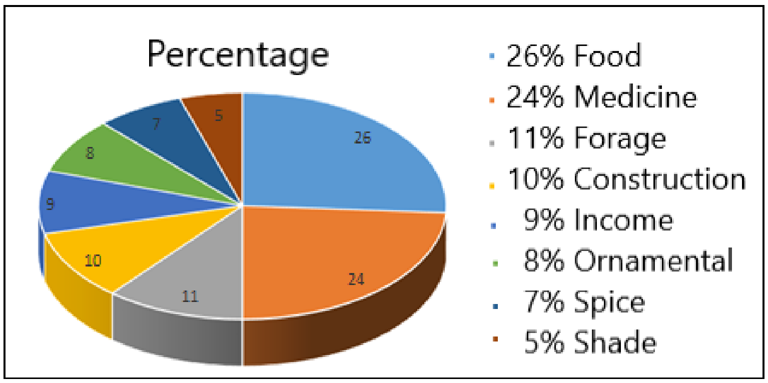

Figure 4. Social use categories of the HG plants in the study area.

3.10. Edible Plants

Out of the recorded 72 HG plant species, 20 species of 12 plant families (Appendix 1) are noted as edible. These are used as food on a regular basis. Among these, 55% are vegetables and tuber/bulbs, 41% are fruits and the rest are seeds. Of the six preferentially ranked food plants, *Brassica integrifolia* was the most preferred and used followed by *Solanum tuberosum* (Table 11).

Table 11. Preference ranking by sixteen key informants for the five most important HG edible plants.

Plant Species	***Key informants (1 – 16)***																***Total***	***Rank***
	1	***2***	***3***	***4***	***5***	***6***	***7***	***8***	***9***	***10***	***11***	***12***	***13***	***14***	***15***	***16***		
Brassica integrifolia	4	5	5	5	4	5	4	5	5	5	5	5	4	5	4	5	75	1
Solanum tuberosum	5	4	4	4	5	5	4	5	5	4	4	4	5	5	5	5	73	2
Capsicum annum	4	5	5	5	2	5	4	5	3	5	4	5	2	5	4	5	68	3
Beta vulgaris	3	3	5	4	4	5	4	4	4	3	5	4	5	5	4	4	66	4
Allium sativum	4	5	3	2	2	4	3	5	4	5	3	2	2	4	3	5	56	5

3.11. Medicinal Plants

We found 15 species (Table 12) of medicinal plants useful for treatment for humans, livestock, or both. Of these, 57% were herbs, 22% shrubs, 15% trees and 6% were climbers. Among the medicinal species, 61% were used to treat human aliments, 17% for treating livestock and 22% for both humans and livestock. The plant parts most frequently used as medicine were leaves (58%), followed by roots (26%) and seeds (16%) (Table 12).

Table 12. List of medicinal plants used to treat human and livestock ailments.

Medicinal plant	***Disease to be treated***	***Part of plant used***	***Way of preparation***	***Application***
Allium sativum	Malaria protection, Headache, abdominal crump and flu	Bulb	The bulb is eaten alone/ with injera	Eating with injera
Artemisia absinthium	For treating measles	Leaf	Squeezing	Rubbing on body
Beta vulgaris	Constipation	Root	Cooking	Eating with injera
Clematis hirsuta	To kill ticks from animals	Whole part	Squeezing & mixing with water	Washing the body
Coffea arabica	For headache, amoebic dysentery and giardiasis	Seed	Cooking, grinding, and mixing with two spoons of honey	Drinking
Cucurbita pepo	Tapeworm treatment	Seed	Grinding, mixing with food	Eating
Echinops kebericho	Evil eye	Rhizome	Smoking	Smelling
Eucalyptus globulus	Typhoid	Leaf	Boiling the leaf	Smelling
Foeniculum vulgare	Urine problem	Leaf	Squeezing, mixing with water	Drinking
Hagenia abyssinica	For tape worm	Flower	Grinding & mixing with	Drinking
Lactuca sativa	Respiratory problem	Leaf	Boiling with water	Drinking with coffee
Ocimum lamiifolium	For headache	Leaf	Squeezing	Drinking with coffee
Rhamnus prinoides	Tonsils	Leaf	Chewing and swallowing	Eating
Ruta chalepensis	For abdominal pain	Leaf	Chewing and swallowing	Eating
Thymus schimperi	Common cold	Leaf	Boiling	Drinking

3.12. Forage Plants for Livestock

Nine plant species used as forage plants for domestic animals were collected from the HGs (Table 13). Six species are trees, and three species are herbs.

3.13. Spice Plants

Six plant species (*Allium sativum, Lippia adoensis, Ocimum basilicum, Rosmarinus officinalis, Ruta chalepensis* and *Thymus schimperi*) were recorded as spice plants, used for increasing the flavor of foods (wot and butter, local language), coffee and other drinks.

3.14. Aesthetic and Ornamental Plants

The owners of HGs practice planting various species for their aesthetic and ornamental values around their houses. Four such plant species (*Canna indica, Dovyalis caffra, Justicia schimperiana* and *Rosa richard*) were identified.

Table 13. Forage plants for livestock.

Scientific Name	***Family***	***Habit***	***Parts Used***
Acacia senegal	Fabaceae	Tree	Lf, St, Fl
Acacia seyal	Fabaceae	Tree	Lf, St, Fl
Celtis africana	Ulmaceae	Tree	St, Lf
Chamaecytisus prolifer	Fabaceae	Tree	Lf
Beta vulgaris	Solanaceae	Herb	Lf, Rt
Medicago sativa	Fabaceae	Herb	Lf, Fl
Pennisetum	Poaceae	Herb	Lf
Sesbania aculeata	Fabaceae	Tree	Lf, St, Fl
Sesbania sesban	Fabaceae	Tree	St, Lf

Note: Lf = leaf, St = stem, Fl = flower, Rt = root.

3.15. Markets and availability of HG Products

There are main and petty market days in the area; the main (Gabayaa guddaa, local language) is the known market in the area and locally named as Sagure Hamuse Gebeya. The resident people and other people from the nearby district joined on Thursday in Sagure town for exchange of their products. The petty market is a type of local market where resident people in the surrounding area continuously join on Monday, Tuesday, and Saturday. In these local markets, fruits, medicinal plants, vegetables, and cereals were observed in the market.

Different products of HGs are being bought and traded in these local markets. The sale of these products generates income to the families. Women and children play an important role in the marketing of HG products such as *Allium sativum, Beta vulgaris, Brassica integrifolia, Daucus carota, Solanum tuberosum, Rhamnus prinoides,* etc.

3.15. Challenges to Homegarden Plant Species Diversity and Their Composition

Most of the respondents indicated that, the species richness, diversity, composition, and social and ecological values of HG in the area are affected by factors like, lack of water, lack of quality seeds or seedlings, insufficient technical support by Agricultural experts, disease and pests, low educational level and lack of transportation. They recommend these obstacles should be addressed by responsible administrative and agricultural experts of the area for sustainable use of the resources in the future.

4. DISCUSSION

HGs in the study sites deliver several amenities to the resident societies. The main purpose is swift and easy access to foodstuff and medicine used to treat everyday ailments. Similarly, homegardening systems are essential to ensure required nutrition and food security, especially in the lower income countries of Africa and Asia (Maroyi, 2009; Galhena et al., 2012; Mellisse et al., 2018; Whitney et al., 2018). The vernacular name comparable for the term HG, in Afan Oromo is "eddo", which means land at a backyard of the house (Tesemma, 2017; Amberber et al., 2014). The resident HG owners develop a HG structure with a significant variety and flexibility which enables production of the main livelihood supplies, such as medicinal plants, fruits, vegetables, fodder for animals and plants with a cultural value. They have accomplished to select plants that are co-adapted and that give manifold values.

Gardeners in the locality have a strong tradition of HG arrangement, intercropping, manure preparation, species collection and erosion control. Use of live fence with shrubs and trees is one of the management practices to protect HG species from raiders. Soil fertility is maintained by using biological fertilizers, such as manure and ashes, as also reported by (Tesemma, 2017; Wolde and Desalgn, 2020).

HGs in the study area have various design and local positions (front-yard, back-yard, side-yard or mixed), as also found by Seta (2007); and Asfaw (2002). In the study area, more than half of the HGs are placed in the backyard with edible plants and some multipurpose plant species. As majority of the respondents indicated, most of the time people make their cattle to yearn to front yards. Therefore, when HGs are placed in the front yard, animals eat the plants and may damage them. It seems that people prefer the backyards to prevent this. A similar result was reported by Amberber et al. (2014). Most of the household owners fence their HGs to protect against destruction by domestic animals and for fear of theft, which is similarly reported by several authors about HGs in Ethiopia (Wolde and Desalgn, 2020; Asfaw, 2002; Wassihun et al., 2003; Abebe, 2005; Sahle et al., 2022, Woldeamanual et al., 2018). In addition, safeguarding and handling of all HG activities are managed through a division of labor among family members.

As mentioned, all family members take part in the work with traditional division of labor which is the base for the modern culture. Such customs were also observed in other parts of the country and elsewhere (Amberber et al., 2014; Seta, 2007; Christanty, 1990). Thus, HGs allow all family members to be involved in some form or another. It allows for greater participation by female members, thereby perhaps increasing their feeling of self-worth. Thus, in HGs dominated by subsistence crops, women did most of the work, but in fruit tree and cash crop dominated HGs, women contributed only little work. Such a clear gender division in HG responsibilities is frequently recorded in the literature (Galluzzi et al., 2010; Trinh et al., 2002; Ninez, 1987).

People have their own indigenous management system to conserve HG plants. This includes isolating infected plants, drying and storing the matured plant products and preservation of crop plants by smoking and hanging them around their house framework. Seeds of different HG plant species that are with unique features during different phases in planting, harvesting and storage time are selected by local people to enable them to get a better yield, resistant to pest and drought and market preference. Exchange of selected seed varieties and knowledge to manage the diversity of plant species in HG give important social linkages (Hu et al., 2023). To spread knowledge amid families, friends, and neighbors by conversant leaders are important to preserve the traditional ties, serving to uphold indigenous cultural understanding and practices (Martin, 1995).

According to the informants, the HGs also provide ecological services. These include habitat provision to many soil organisms, enhancing water quality, maintenance of soil fertility, prevention of soil erosion**,** carbon sequestration and improved soil moisture by providing shade. This outcome agrees with the research done by Calvet-Mir et al. (2012), who identified and characterized ecosystem services provided by HG in northern Spain.

Apart from 'maintenance of soil fertility', this study provides relatively little explanation about the production of regulating services. Maintenance of soil fertility as an important ecosystem service value (Table 10). On the other hand, 'local climate regulation', understood as urban cooling (Gómez-Baggethun and Barton, 2013), was given a lower value, and 'pollination' even lower. The 'maintenance of soil fertility' was strongly related to practices of composting and the introduction of compost and manure into the soil. Less recognition was given to ecological soil processes. 'Pollination' was mainly related to flowering ornamental plants. However, the scientifically undisputed importance of 'pollination' as supporting service for 'food supply' and 'biodiversity' (Andersson et al., 2007) stayed widely unrecognized by the gardeners. On the other hand, studies by Linger (2014) in North-Western Ethiopia, reported that homegarden agroforestry has a great role in adapting climate change through soil fertility maintenance out of the garden/other farm field and saves soil moisture through composting.

HGs typically included a wide variety of plants, from small herbs to tall trees. The family Fabaceae ranked top among the species followed by Solanaceae, which agrees to other Ethiopian studies (Mekonen, 2010; Yirefu et al., 2019; Tamrat, 2011; Seid and Kebebew, 2022; Kidane et al., 2023). The Shannon-Wiener index agrees with other studies (Tamrat, 2011; Mengistu and Fitamo, 2016) and is within the normal range for agroecosystems (Kent and Coker, 1992). As confirmed by the respondents, the reason for the variation of number of HG plants composition in different parts of the study area is related with different factors as indicated above.

We grouped the species into eight major use categories. Most plants of the HGs were of edible and medicinal value, confirming statements by Tesemma (2017), Wolde and Desalgn (2020), Hu et al. (2023) and Yirefu et al. (2019). From the documented 72 plant species, 20 species were recorded as food value plants directly used for household family food and nutrition sources on regular basis. This result agrees with the suggestion made by other scientists (Galhena et al., 2012; Whitney et al., 2018; Seid and Kebebew, 2022; Lossau and Qingsong, 2011; Kidane and Kejela, 2021) that agrobiodiversity in the HG can improve both continuous access to foods and the nutritional quality for HHs.

Availability of a diversity of edible plants helps the household families to overcome "hidden hunger", meaning disorder because of the lack of essential vitamins and minerals in the diet (Uchendu and Atinmo, 2010). The fruits that were grown by the farmers are Peach (*Prunus persica*), Apple (*Malus sylvestris*), Avocado (*Persea americana*), these were the recent and rare fruit crops in the study area that were used mainly for home consumption. These semi-wild fruits are found in and alongside the bush/shrubs in the wild too. According to Kidane and Kejela (2021); and Asfaw and Tadesse (2001), semi-wild edible plants are reserve foods that fill the food deficit gap. The food plants diversity in the study area has the important role to increase nutritional and income status of the local people.

According to Wolde and Desalgn (2020), more than half of the plant species in Ethiopian HG agroforestry are edible, contributing up to 30-40% of the household income. It has been identified as a means of providing all year-round access to food for rural HHs (Kumar and Nair, 2006; Kebebew et al., 2011). In comparison with other countries like Tanzania, contribution of homegardens is higher than in Ethiopia. In Tanzania homegardens agroforestry contribute up to 98% for food security (Nzilano, 2013). On the other hand, as it is indicated by Asfaw and Nigatu

(1995) in Ethiopia, about 78% of the plant species from HGs were food crops.

Cash crops and fruit trees play substantial roles in income generation in addition to household consumption. There is variation among households in the amount of income gained from these plants. The important role of HGs in generating revenue to HHs in Ethiopia has also been stated by different researchers (Amberber et al., 2014; Yirefu et al., 2019; Wondimu, et al., 2007; Abdi and Asfaw, 2005). Study in Mbeya district Tanzania described that HGs have 25% income contribution (Nzilano, 2013). Similar studies in Ethiopia revealed, that HGs afford financial strength to farmers and offer a substantial amount (30-50%) of household revenue (Mattsson et al., 2013). Emphasis to cultivate few cash crops by overlooking other valuable crops could reduce the diversity of species produced in HGs same to other researchers. On the other hand, Wiehle et al., (2014) from Sudan indicated that species richness was numerically even higher for market oriented HGs compared to subsistence ones.

The custom of planting medicinal plants in HGs has a vital role for conservation of agrobiodiversity. From the total 72 plant species identified in the study, 24% were used as medicinal plants (Table 12). The result acquired were comparable to that of Wassihun et al. (2003) who reported presence of 18 medicinal plant species grown in the HGs of Gamo, south Ethiopia. The size of considered HGs was in a range of 0.04 to 0.30 ha. Which is comparable to other findings by Seid and Kebebew (2022). A study from different agro ecology of 10 selected HG systems in sub-Saharan Africa also shows that the average sizes of tropical HGs are less than 0.5 ha (Fernandes and Nair, 1986). Other results from 80 HG of upper Assam, India presented a size range from 0.05 to 0.3 ha (Yinebeb et al., 2022a; Saikia et al., 2012) which is in the range of our results.

The positive correlation between HG size and species richness has been found also elsewhere (Abdoellah et al., 2002; Das and Das, 2005; Woldemichael et al., 2018). As confirmed by the respondents, the reason for variation of plant composition in different sites of the study area can be related with HG size, difference in indigenous knowledge towards management practices and distribution of multipurpose plants.

In the study area, HHs with small HG grow the most useful plant species but give less attention to plants of less use. On the other hand, HHs with large HG size also grow fodder plants and flowering plants which increases species richness. The plant diversity and HG productivity is largely a function of the patch size and large HGs offer adequate products for the personal consumption as well as necessary financial achievements through sale of extra produces (Fernandes and Nair, 1986; Das and Das, 2005).

Challenges for HG productivity was described during interviewees and most respondents indicated lack of water and availability of quality seed/seedlings supply as the main hindering factors for the productivity of their HGs. Primarily they were using rain fed systems and their HG diversity and productivity decreased in the dry season due to lack of water, but some of the HHs who could draw water through irrigation and ground water were able to produce and harvest HG products throughout the year.

Farmers also complain that they were not receiving any technical support from the Agricultural experts such as use and preparation of compost from fallen and dead leaves and animal wastes. Low educational level was also mentioned as a hindrance factor for better outcome from the HGs. It reveals that the level of education attained by the household is related to the human capital as well as the ability to cope with the modern farm decision making process (Tesemma, 2017; Muchara, 2010). Abebe (2005) found that access to major roads, access to markets, altitude, slope of the farm and livestock holding were among the most important factors that influenced species richness and evenness of crops. Similarly, Yakob et al. (2014) stated that wealth status and accessibility of homesteads to market and roads were among the important factors to produce HGs.

5. CONCLUSION AND RECOMMENDATIONS

Farmers in the study locality have a rich tradition of HG cultivation and handling of diverse plant species determinant for their survival. The study revealed presence of a rich HG plant diversity contributing as source of food, medicine, and income generation. HGs could improve by efficient ways of vertical layering in planting the species to optimize space. Safeguarding and management of all HG activities are accomplished through a traditional division of labor among family members which is the base for the present agricultural practice. The greater participation of female members possibly increases their feeling of self-worth. Even though the HGs in the study area provide many uses for the residents and several ecological goods and services, they are threatened by different factors. Therefore, for improved and integrated agrobiodiversity maintenance of these rich resources, collaborative efforts by all concerned stakeholders is required. Building cognizance within the community about the role of species diversity in environmental wellbeing needs highlighting. Generally, the community, government and non-government organizations should work together to maximize benefits obtained from the HG system. If these challenges receive attention, the system will be able to preserve its current agrobiodiversity and the indigenous management systems on a sustainable basis in the future.

6. CONFLICT OF INTERESTS

The authors declare that they have no competing interests.

7. ACKNOWLEDGEMENTS

The authors are very grateful to Digelu Tijo District farmers, agricultural experts and development agents who really play a leading role being willing to participate in the study during the time of data collection. We thank department of Biology, College of Natural and Computational Sciences, Mekelle University for material and financial support to undertake the study. The authors also would like to thank Mr. Abdella Edo for providing field materials and assistance given at the time of data collection. Besides, we are indebted to Professor Ingvar Backeus, Researcher at Department of Plant Ecology and Evolution, Upsala University, Sweden, for his assistance to develop and revise the paper critically and upgrade grammatical and scientific concepts of the manuscript.

8. ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical approvals were obtained prior to data collection from Mekelle University, Digelu Tijo District Administrative office and Digelu Tijo Agriculture and Rural Development Office. In addition, in order to develop a confident mindset among informants and the researcher, the purpose and significance of the study were introduced to the local officials and to the community. After they understood the objectives and value of the research, all data were collected through their agreements. Accordingly, ethnobotanical data were collected based on inclusive participation, friendly interactions, and the willingness of informants.

9. REFERENCE

Abdi, A. & Asfaw, Z. 2005. In-Situ (On-Farm) Conservation Dynamics and the Patterns of Uses of Sorghum (Sorghum bicolor (L.) Moench) Landraces in North Shewa and

South Welo, Central High Lands of Ethiopia. Ethiop. *SINET: Ethiopian Journal of Science*, **26**: 123-136.

Abdoellah, O., Gunawan, B. & Hadikusumah, H.Y. 2002. Homegardens in the upper citarum watershed, West Java: a challenge for in situ conservation of plant genetic resources. In: Watson, J. W and Eyzaguirre P. B (eds.). Homegardens and in situ conservation of plant genetic resources in farming systems. 17-19 July 2001, Witzenhausen, Germany/IPGRI, Rome, 140-147.

Abdoellah, O.S., Schneider, M., Nugraha, L.M., Suparman, Y., Voletta, C.T., Withaningsih, S., Heptiyanggit, A. & Hakim, L. 2020. Homegarden commercialization: extent, household characteristics, and effect on food security and food sovereignty in Rural Indonesia. *Sustain. Science*, **15(3):** 797–815.

Abebe, T. 2005. Diversity in Homegarden Agroforestry Systems of Southern Ethiopia. *Ph.D dissertation*, Wageningen University, Netherlands.

Amberber, M., Argaw, M. & Asfaw, Z. 2014. The role of homegardens for in situ conservation of plant biodiversity in Holeta Town, Oromia National Regional State, Ethiopia. *International Journal of Biodivers Conservation*, **6(1):** 8-16.

Andersson, E., Barthel, S. & Ahrné, K. 2007. Measuring social-ecological dynamics behind the generation of ecosystem services. *Ecological applications*, **17(5):** 1267-1278.

Asfaw, Z. 2002. Home gardens in Ethiopia: some observations and generalizations. Home gardens and in situ conservation of plant genetic resources in farming systems, 125–128.

Asfaw, Z. & Nigatu, A. 1995. Home–gardens in Ethiopia: Characteristics and plant diversity. *Ethiopian Journal of Science*, **18(2):** 235-266.

Asfaw, Z & Tadesse, M. 2001. Prospects for sustainable use and development of Wild food plants in Ethiopia. *Economic Botany*, **55:** 47-62.

Berhanu, A. & Asfaw, Z. 2014. The Role of homegardens for conservation and sustainable utilization of plant biodiversity of Ethiopia. In: *Proceedings* of the Workshop Biological Society of Ethiopia, Addis Ababa, Ethiopia.

Birhane, E., Ahmed, S., Hailemariam, M., Negash, M., Rannestad, M.M & Norgrove, L. 2020. Carbon stock and woody species diversity in homegarden agroforestry along an elevation gradient in southern Ethiopia. *Agroforestry Systems*, 94: 1099–1110. doi: 10.1007/s10457-019-00475-4

Calvet-Mir, L., Gomez-Baggethun, E & Reyes-Garcia, V. 2012. Beyond food production: Ecosystem services provided by home gardens. A case study in Vall Faosca, Catalan Pyrenees. *Ecological Economics*, **74:** 153-160, DOI: 10.1016/j.ecolecon.2011.12.011.

CSA (Central Statistical Agency). 2010. CSA, Ethiopia: *Statistical Abstract*, Addis Ababa, Ethiopia.

Christanty, L. 1990. Home-gardens in Tropical Asia, with special reference to Indonesia. In: K. Landauer and M. Brazil (eds.). Tropical Homegardens, pp. 9-20. United Nations University Press, Tokyo.

Cotton, C.M. 1996. *Ethnobotany: principle and applications.* West Sussex: Wiley.

Das, T & Das, A.K. 2005. Inventorying plant biodiversity in homegardens: A case study in Barak Valley, Assam, Northeast India. *Current science*, **89(1):** 155.

Digelu Tijo District Agricultural Office Annual Report, East Arsi Zone, Oromia, Ethiopia, *Annual Report*, 2015.

Edwards, S., Tadesse, M & Hedberg, I (eds). 1995. Flora of Ethiopia and Eritrea. Canellaceae to Euphorbiaceae *volume 2 part 2*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and The National Herbarium, Addis Ababa University, Addis Ababa.

Edwards, S., Demissew, S & Hedberg, I (eds.). 1997. Flora of Ethiopia and Eritrea. Hydrocharitaceae to Arecaceae *volume 6*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and The National Herbarium, Addis Ababa University, Addis Ababa.

Edwards, S., Tadesse, M., Demissew, S & Hedberg, I (eds). 2000. Flora of Ethiopia and Eritrea. Magnoliaceae to Flacourtiaceae *volume 2 part 1*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and The National Herbarium, Addis Ababa University, Addis Ababa.

Eyasu, G., Tolera, M & Negash, M. 2020. Woody species composition, structure, and diversity of homegarden agroforestry systems in southern Tigray, Northern Ethiopia. *Heliyon*, **6(12):** e05500, https://doi.org/10.1016/j.heliyon.2020.e05500.

Fernandes, E. C & Nair, P. K. 1986. An evaluation of the structure and Function of tropical Homegardens. *Agroforestry Systems*, **21**: 279-310.

Galhena, D.H., Mikunthan, G & Maredia, K.M. 2012. Homegarden for enhancing food security in Sri Lanka Farming. *Matter*, **28(2)**: 1-12.

Galluzzi, G.P., Eyzaguirre, V & Negri. 2010. Home gardens: Neglected hotspots of agro biodiversity and cultural diversity. *Biodiversity and Conservation*, **19(13):** 3635-3654, doi: 10.1007/ s10531-010-9919-5.

Getachew, E., Lemessa, D & Leulekal, E. 2022. Socio-ecological determinants of species composition of crops in homegardens of southern Ethiopia. *Agroforestry Systems*, **96(1):** 11–21.

Gómez-Baggethun, E & Barton, D.N. 2013. Classifying and valuing ecosystem services for urban planning. *Ecological Economics*, **86:** 235–245, doi:10.1016/j.ecolecon.2012.08.019.

Hedberg, I & Edwards, S (eds). 1989. Flora of Ethiopia and Eritrea. Pittosporaceae to Araliaceae *volume 3*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and The National Herbarium, Addis Ababa University, Addis Ababa.

Hedberg, I & Edwards, S (eds). 1995. Flora of Ethiopia and Eritrea. Poaceae (Gramineae) *volume 7*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and The National Herbarium, Addis Ababa University, Addis Ababa.

Hedberg, I., Edwards, S & Nemomissa, S (eds.). 2003. Flora of Ethiopia and Eritrea. Apiaceae to Dipsacaceae *volume 4 part 1*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and the National Herbarium, Addis Ababa University, Addis Ababa.

Hedberg, I., Friis, I & Edwards, S (eds.). 2004. Flora of Ethiopia and Eritrea. Asteraceae volume *4 part 2*. Ethiopia: Department of Systematic Botany, Uppsala University, Uppsala and the National Herbarium, Addis Ababa University, Addis Ababa.

Hedberg, I., Kelbessa, E., Edwards, S., Demissew, S & Persson, E (eds.). 2006. Flora of Ethiopia and Eritrea. Plantaginaceae *volume 5*. Ethiopia: Department of Systematic

Botany, Uppsala University, Uppsala and The National Herbarium, Addis Ababa University, Addis Ababa.

Hu, R., Xu, C., Nong, Y & Luo, B. 2023. Changes in homegardens in relocation villages, a case study in the Baiku Yao area in Southern China. *Journal of Ethnobiology and Ethnomedicine*, **19:** 1-7, https://doi.org/10.1186/s13002-023-00578-4.

Kebebew, Z., Garedew, W & Debela, A. 2011. Understanding Homegarden in Household Food Security Strategy: Case Study Around Jimma, Southwestern Ethiopia. Research. *Journal of Applied Sciences*, **6(1):** 38-43.

Kent, M & Coker, P. 1992. *Vegetation description and analysis*: a practical approach. New York: Wiley.

Kidane, L & Kejela, A. 2021. Food security and environment conservation through sustainable use of wild and semi-wild edible plants: a case study in Berek Natural Forest, Oromia special zone, Ethiopia. *Agriculture Food Security*, **10:** 1-29. https://doi.org/10.1186/s40066-021-00308-7.

Kidane, L., Balke, B & Ingvar Backéus. 2023. Contribution of Participatory Forest Management Program in Non-Timber Forest Products to balance Livelihood Improvement and Conservation: a case of Sera Forest, Amigna District, Southern Ethiopia. *Momona Ethiopian Journal of Science*, **15(2)**: 235-271.

Kothari, C.R. 2004. *Quantitative Techniques*, 2^{nd} edition, Vikas Publishing House Pvt. Ltd, New Delhi.

Krupnick, G. A & Kress, W. J. 2005. Plant Conservation: A Natural History Approach. Foreword by Daniel H. Janzen.

Kumar, B. M & Nair, P. 2006. *Tropical Homegardens*. Springer, Dordrecht, 377p.

Lamont, S. R & Eshabugh, W.H. 1999. Species composition diversity and use of home gardens among three Amazonian village. *Economic Botany*, **54:** 312.

Linger, E. 2014. Agro-ecosystem and socio-economic role of homegarden agroforestry in Jabithenan District, North-Western Ethiopia: implication for climate change adaptation. *Springer Plus*, **3(1):** 154.

Lossau, A.V & Qingsong, L (Eds.). 2011. *Sourcebook* on Sustainable Agrobioidiversity Management, Social Sciences Academic Press, P.R. China.

Maroyi, A. 2009. Traditional homegardens and rural livelihoods in Nhema, Zimbabwe: a sustainable agroforestry system. *International Journal of Sustainable Development & World Ecology*, **16(1):** 1-8.

Martin, G.J. 1995. *Ethnobotany*: *a method Manual*. A 'people and plants' conservation manual. London: Chapman and Hall.

Mattsson, E., Ostwald, M., Nissanka, S.P & Marambe, B. 2013. Homegardens as a multi-functional land-use strategy in Sri Lanka with focus on carbon sequestration. *Ambio*, **42(7):** 892-902.

Mcneely, A. J & Schroth, G. 2006. Agroforestry and biodiversity conservation traditional practices, present dynamics, and lessons for the future. *Biodivers Conserv*, **15:** 549-554, doi:10.1007/s10531-005-2087-3.

Mekonen, T. 2010. Homegardens Agrobiodiversity Conservation in Sebeta-Hawas Wereda, Southwestern Shewa Zone of Oromia Region, Ethiopia. MSc Thesis, Addis Ababa University, Ethiopia.

Mellisse, B.T., Descheemaeker, K., Giller, K.E., Abebe, T & Van de Ven, G.W. 2018. Are traditional home gardens in southern Ethiopia heading for extinction? Implications for productivity, plant species richness, and food security. *Agric Ecosyst Environ*, **252:** 1-13.

Mengistu, M & Fitamo, D. 2016. Plant Species Diversity and Composition of the Homegardens in Dilla Zuriya District, Gedeo Zone, SNNPRS, Ethiopia. *Plant*, **3(6):** 80-8.

Meragiaw, M., Woldu, Z & Singh, B. R. 2022. Land use and land cover dynamics and traditional agroforestry practices in Wonchi District, Ethiopia. *PeerJ*, **10**: e12898, https://doi.org/10.7717/peerj.12898.

Muchara, J. 2010. Understanding family literacy. In: Foundations in Family Literacy Alberta, CA: Centre for Family Literacy.

Ninez, V. 1987. Household Gardens: Theoretical and Policy Considerations. In*:* *Agricultural Systems*, **23:** 167-186.

Nzilano, B.L. 2013. Contribution of agroforestry homegardens to household food security and income generation among communities in Mbeya rural district, Tanzania (*Doctoral dissertation*, Sokoine University of Agriculture).

Pandey, C. B., Kanak, L., Venkatesh, A & Medhi, R. P. 2006. Diversity and species structure of home gardens in South Andaman. *Tropical Ecology*, **47(2):** 251-258.

Sahle, M., Saito, O & Demissew, S. 2022. Characterization and mapping of enset-based home-garden agroforestry for sustainable landscape management of the Gurage socioecological landscape in Ethiopia. *Environtal Science and Pollution Research,* **29(17)**: 24894-24910, https://doi.org/10.1007/s11356-021-17605-0.

Saikia, P., Choudhury, B & Khan, M. 2012. Floristic composition and plant utilization pattern in homegarden of upper Assam, India. *Journal of tropical ecology,* **53:** 105-118.

Seid, G & Kebebew, Z. 2022. Homegarden and coffee agroforestry systems plant species diversity and composition in Yayu Biosphere Reserve, southwest Ethiopia. *Heliyon*, **8**: e09281, https://doi.org/10.1016/j.heliyon.2022.e09281.

Seta, T. 2007. Diversity in Ensete-Based Homegardens and Its Significance to Household Supply in Welayita (Southern Ethiopia): An Ethnobotanic Approach. *M.Sc. Thesis*, Addis Ababa University, 105p.

Shanka, T.S. 2022. Characterizing to sustain the agrobiodiversity in the Gedeo Zone. Southern Ethiopia. In: Manoj Kumar Jhariya, Ram Swaroop Meena, Arnab Banerjee, Surya Nandan Meena (eds.), Natural Resources Conservation and Advances for Sustainability. *Elsevier*, 581- 612. https://doi.org/10.1016/B978-0-12-822976-7.00021-1

Shannon, C. E & Wiener, W. 1949. *The Mathematical Theory of Communication* University of Illinois, Chicago, USA.

Shumi, G., Dorresteijn, I., Schultner, J., Hylander, K., Senbeta, F., Hanspach, J., Ango, T. G & Fischer, J. 2019. Woody plant use and management in relation to property rights: a social-ecological case study from southwestern Ethiopia. *Ecosystems and People*, **15(1):** 303–316.

Sutrisno, I. H., Akob, B., Navia, Z. I., Nuraini, N & Suwardi, A. B. 2020. Documentation of ritual plants used among the Aceh tribe in Peureulak, East Aceh District, Indonesia. Biodiversitas *biodiversitas*, **21(11):** 4990-4998, DOI: 10.13057/biodiv/d211102.

Tamrat, S. 2011. Study of useful plants in and around Gette Ouduma (Traditional Gedeo homegardens) in kochere wereda, South Ethiopia; an ethnobotanical approach. *M.Sc. Thesis*, Addis Ababa University, Ethiopia.

Tesemma A. 2017. Homegarden plant diversity and associated use-values in Digeluna-tijo woreda, East arsi zone, Oromia, Ethiopia. MSc Thesis, Hawassa University, Ethiopia.

Thangjam, U., Thong, P., Sahoo, U. K., Ahirwal, J., Malsawmkima, B & Hrahsel, L. 2022. Tree species diversity in relation to site quality and homegarden types of North-East India. *Agroforestry Systems*, **96:** 187-204. https://doi.org/10.1007/s10457-021-00715-6.

Trinh, L. N., Hue, N. T., De, N. N., Minh, N. V & Chu, P. T. 2002. Role of homegardens in the conservation of plant genetic resources in Vietnam. In: Homegardens and in-situ conservation of Plant Genetic Resources in Farming Systems, 97-104.

Uchendu, F. N & Atinmo, T. 2010. The silent and neglected crisis of malnutrition: scientific evidence for taking decisive action. *Global Journal of Health Science*, **3(1):** 193-202.

Wassihun, B., Asfaw, Z & Demissiew, S. 2003. Ethnobotanical Study on Useful Plants in Daniio Gade (Homegardens) In Southern Ethiopia. *Ethiopean Journal of Biological Sciencei*, **2(2):** 119-141.

Whitney, C. W., Luedeling, E., Hensel, O., Tabuti, J. R. S., Krawinkel, M., Gebauer, J & Kehlenbeck, K. 2018. The role of homegardens for food and nutrition security in Uganda. *Human Ecology*, **46:** 497–514. doi: 10.1007/s10745-018-0008-9.

Wiehle, M., Goenster, S., Gebauer, J., Ali Mohamed, S., Buerkert, A & Kehlenbeck, K. 2014. Effects of transformation processes on plant species richness and diversity in homegardens of the Nuba Mountains, Sudan. *Agroforest Systems*, **88:** 539–562, DOI 10.1007/s10457-014-9717-2.

Wolde, A & Desalgn, S. 2020. Review on Contribution of Homegarden Agroforestry Practices on Well- Being of Ethiopia. *International Journal of Current Research and Academic Review*, **8(3):** 6-14.

Woldeamanual, W., Asfaw, Z & Lemessa, D. 2018. The effect of the surrounding landscape and socioeconomic characteristics on woody species diversity in homegardens of Shewarobit District, Northeast Ethiopia. *Small Scale Forestry*, **17(56):** 471-483, DOI:10.1007/s11842-018-9398-1.

Woldemichael, G., Chimdessa, M & Abebe, A. 2018. Species Diversity and Use of Homegardens in Misha Woreda, Hadiya Zone of the Southern Nations, Nationalities and Peoples Regional State, Ethiopia. *International Journal of Food Science and Agriculture*. **2(7):** 118-129, DOI: 10.26855/ijfsa.2018.12.001.

Wondimu, T., Asfaw, Z & Kelbessa, E. 2007. Ethnobotanical study of medicinal plants around 'Dheeraa'town, Arsi Zone, Ethiopia. *Journal of Ethnopharmacology*, **112(1)**: 152-161.

Yakob, G., Asfaw, Z & Zewdie, S. 2014. Wood Production and Management of Woody Species in Homegardens Agroforestry: The Case of Smallholder Farmers in Gimbo District, Southwest Ethiopia. *International Journal of Natural Sciences Research*, **2(10)**: 165-175.

Yinebeb, M., Lulekal, E & Bekele, T. 2022a. Composition of homegarden plants and cultural use in an indigenous community in Northwest Ethiopia. *Journal of Ethnobiology and Ethnomedicine*, **18:** 47, https://doi.org/10.1186/s13002-022-00545-5.

Yinebeb, M., Lulekal, E., Bekele, T., & Lemessa, D. 2022b. Homegardens plant species richness and their use types have positive associations across agricultural landscapes of Northwest Ethiopia. *Global Ecology and Conservation*, **40**: e02342. https://doi.org/10.1016/j.gecco.2022.e02342.

Yirefu, T., Adugna, B & Behailu, B. 2019. Homegarden Plant use and their Traditional anagement Practice in Bule Hora District, West Guji 00151 Zone, Southern Ethiopia. Agri Research *& Technology: Open Access Journal*, **21(4)**: 138-151, DOI: 10.19080/ARTOAJ.2019.21.556168.

Appendix 1. List of plants collected from the study area.

No	***Scientific Name***	***Local Name***	***Family Name***	***Habit***
1	*Acacia senegal* (L) Willd.	Sapessa (Or)	Fabaceae	Tree
2	*Acacia seyal* Del.	Wasiya (Or)	Fabaceae	Tree
3	*Ajuga integrifolia* Buch-Ham. ex D.Don.	Harmaagusaa (Or)	Lamiaceae	Herb
4	*Allium cepa* L.	Shunkurtii diimaa (Or)	Alliaceae	Herb
5	*Allium porrum* L.	Shunkurtaa baaroo	Alliaceae	Herb
6	*Allium sativum* L.	Qulluubbii adii (Or)	Alliaceae	Herb
7	*Allophylus abyssinicus* (Hochst.) Radlk	Embuse (A)	Sapindaceae	Tree
8	*Artemisia absinthium* L.	Arritaa (Or)	Asteraceae	Herb
9	*Arundo donax* L.	Shenbeko (A)	Poaceae	Herb
10	*Beta vulgaris* L.	Hundee diimaa (Or)	Chenopodiacea	Herb
11	*Brassica integrifolia* L.	Raafuu maramaa	Brassicaceae	Herb
12	*Brassica rapa* L.	Kosxaa (A)	Brassicaceae	Herb
13	*Brassica oleracea* L.var.capitata	Raafuu simbiraa (Or)	Fabaceae	Herb
14	*Buddleja davidii* Franch.	Amfar (A)	Loganiaceae	Shrub
15	*Canna indica* L.	Setakuri (A)	Cannaceae	Herb
16	*Capsicum annum* L.	Qaaraa (A, Or)	Solanaceae	Herb
17	*Capsicum frutescens* L.	Yabisha karia (A)	Solanaceae	Herb
189	*Casimiroa edulis* La Llave	Casimer (A)	Rutaceae	Tree
19	*Casuarina equisetifolia* L.	Shawushawwee (Or	Casuarinaceae	Tree
20	*Celtis africana* Burm.f.	Tuyyee (Or)	Ulmaceae	Tree
21	*Clematis hirsuta* Perr. & Guill.	Yeazo hareg (A)	Ranunculaceae	Climber
22	*Coffea arabica* L.	Buna (Or)	Rubiaceae	Shrub
23	*Cucurbita pepo* L.	Dabaaqula (Or)	Cucurbitaceae	Herb
24	*Cupressus lusitanica* Mill.	Gaattiraa faranjii (Or)	Cupressaceae	Tree
25	*Cymbopogon citratus* (DC) Stapf	Tej-sar (A)	Poaceae	Herb
26	*Cytisus scoparius* L.	Tree Lucerne (E)	Fabaceae	Tree
27	*Daucus carota* L.	Kaarotii (Or)	Apiaceae	Herb
28	*Dovyalis caffra* (Hook.f.Harv.) Hook.f.	Koshoommii (Or)	Flacourtiaceae	Shrub
29	*Echinops kebericho* Mesfin	Qabarichoo (Or)	Asteraceae	Herb
30	*Ensete ventricosum* Welw.	Warqee (Or)	Musaceae	Herb
31	*Erythrina brucei* Schweinf.	Korich (A)	Fabaceae	Tree
32	*Eucalyptus globulus* Labill	Baargamoo adii (Or)	Myrtaceae	Tree
33	*Fodder beet* L.	Dinnicha loonii (Or)	Solanaceae	Herb
33	*Foeniculum vulgare* Mill	Ensilal (A)	Apiaceae	Herb
35	*Grevillea robusta* A.Cunn. Ex.R.Br	Gravilia (E)	Proteaceae	Tree
36	*Hagenia abyssinica* (Bruce) J.F. Gmel.	Heexoo (Or)	Rosaceae	Tree
37	*Juniperus procera* Hochst. ex.Endl	Gaattiraa (Or)	Cupressaceae	Tree
38	*Justicia schimperiana* L.	Sensel (A)	Acanthaceae	Shrub
39	*Lacctuca sativa* L.	Selata (A)	Asteraceae	Herb
40	*Lippia adoensis* Hochst	Sukaayii (Or)	Verbenaceae	Shrub
41	*Lycopersicon esculentum* Mill	Timaatima (Or)	Solanaceae	Herb
42	*Maesa lanceolata* Forssk.	Abbayyii (Or)	Myrsinaceae	Shrub

43	*Malus sylvestris* Miller	Apple (A)	Rosaceae	Tree
44	*Mangifera indica* L	Mango (E, A, Or)	Anacardiaceae	Tree
45	*Maytenus arbutifolia* (A.Rich.) Wilczek	Kombolcha (Or)	Celasteraceae	Tree
46	*Medicago sativa* L.	Alfalfa (E, Am, Or)	Fabaceae	Herb
47	*Millettia ferruginea* (Hochst.) Bak.	Birbirraa (Or)	Fabaceae	Tree
48	*Ocimum basilicum* L.	Besobila (A)	Lamiaceae	Herb
49	*Ocimum lamiifolium* Hotest	Damakese (A, Or)	Laminaceae	Shrub
50	*Olea europaea ssp cuspidata* (Wall. ex G. Don) Cif.	Ejersa (Or)	Oleaceae	Tree
51	*Osyris quadripartita* Decne.	Keret (A)	Santalaceae	Shrub
52	*Pennisetum violaceum* (Lam.) L. Rich	Marga araba (Or)	Poaceae	Herb
53	*Persea americana* Mill.	Abocado (A, Or)	Lauraceae	Tree
54	*Phoenix reclinata* Jacq.	Meexxii (Or)	Arecaceae	Tree
55	*Phytolacca dodecandra* L'Herit.	Handoodee (Or)	Phytolaccaceae	Shrub
56	*Prunus africana* (Hook.f.) Kalkm.	Muka gurraacha (Or)	Rosaceae	Tree
57	*Prunus persica* (L.) Batsch	Kookii (Or)	Rosaceae	Tree
58	*Psidium guajava* L.	Zayituunaa (Or)	Myrtaceae	Tree
59	*Rhamnus prinoides* L'Herit.	Geeshoo (Or)	Rhamnaceae	Shrub
60	*Ricinus communis* L.	Qobboo (Or)	Euphorbiaceae	Shrub
61	*Rosa hybrida* Hort.	Tigerda (A)	Rosaceae	Shrub
62	*Rosmarinus officinalis* L.	Sigametibesha (A)	Lamiaceae	Shrub
63	*Ruta chalepensis* L.	Tenadam (A)	Rutaceae	Shrub
64	*Saccharum officinarum* L.	Shankoora (Or	Poaceae	Herb
65	*Schinus molle* L.	Turmanturi (E)	Anacardiaceae	Tree
66	*Sesbania aculeata* (Willd) Pers	Sesbania (A)	Fabaceae	Tree
67	*Solanecio gigas* (Vatke) C. Jeffrey	Yeshikoko gomen (A)	Fabaceae	Shrub
68	*Solanum tuberosum* L.	Moosee (Or)	Solanaceae	Herb
69	*Thymus schimperi* Ronniger	Xosiinee (Or)	Lamiaceae	Herb
70	*Vernonia amygdalina* Del.	Grawa (A)	Asteraceae	Tree
71	*Vicia faba* L.	Bakela (A)	Fabaceae	Herb
72	*Zea mays* L.	Boqqoollaa (Or)	Poaceae	Herb

Note: A= Amharic, E= English, Or= Oromigna.