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The impact of land uses on the diversity and farmers' preferences for woody species in the selected highlands of Ethiopia

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Abstract Various woody species are growing in diverse landscapes and form a prominent component of farmland in Ethiopia. Farmers' preferences for woody species also vary in different parts of the country. The diversity and farmers' preferences for woody species have been described earlier. However, a simultaneous analysis of land use diversity and farmers' preferences for woody species is scarcely available. Therefore, to fill the gap, this study was conducted in three selected highlands of Ethiopia to assess the land use diversity and farmers' preferences for woody species. A total of 320 households were randomly selected, and out of these, 105 households were purposely selected for species inventory. Overall, 525 plots were made using a 30 m × 30 m plot size for different land uses. Focus group discussion and key informant interviews were used for farmers' preferences. The results imply that 32 woody species belonging to 16 families were recognized. Fabaceae was the leading family with 25% of species, followed by Rosaceae with 12.5% of species. In terms of species diversity, home garden (2.39) was more diverse than grazing land (1.94), crop land (1.50), boundary (0.92), and woodlot (0.54) in all areas. Among the preferred species, *Eucalyptus globulus*, *Cuppressus lusitanica*, *Malus domestica*, *Cytisus proliferus*, and *Acacia decurrens* were the most preferred and planted woody species by farmers. Generally, farmland maintains various tree and shrub species according to landscape practices. Farmers preferred and planted different woody species based on their benefits. Woody species must be maintained on farmland to overcome socio-economic and environmental problems.

Keywords Farmers' preference · Farmland · Land use · Species diversity · Woody species

Introduction

Background of the study

Woody species are an essential feature of most human-dominated agricultural landscapes around the world. The integration of perennial woody species into land use landscapes via agroforestry systems may boost nutrient availability, soil enrichment, and water infiltration (Barrios et al. 2018; Sanou et al. 2010). Woody species can also be used to provide fruit, fodder, fuel, fiber, and timber, which can boost the community's revenue directly or indirectly (Nyaga et al. 2015). Increasing tree cover in land use systems can also boost carbon storage above and below ground (Zomer et al. 2016), which is associated with the

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development of a climate-resilient green economy (Sinclair et al. 2019). Thus, the use of multipurpose woody species in agricultural systems can improve food and nutrition security for impoverished rural people, providing ecosystem services and contributing to the development of a climate-resilient farming landscape (Kuyah et al. 2016; Barrios et al. 2018).

In many parts of Ethiopia, farmers are managing natural regeneration and planting different woody species on their land uses. Trees on farmland provide a wide range of important products and ecological services (Abebe et al. 2010; Mekonnen et al. 2019). The diversification of vegetation with different tree-based agricultural systems contributes to ecological diversity and product stability in the event of diseases and pest outbreaks (Abebe et al. 2010). Consequently, the mixture of woody species contributes to the productivity, services, and sustainability of ecosystems in farming landscapes (Kibet 2011).

Many useful indigenous tree and shrub species are conserved in land use and make up an important section of agricultural landscapes. Such a landscape is often referred to as an agroforestry system. It is a name given to these "land use practices and technologies in which woody perennials are firmly mixed on the same land with crops and livestock in the form of spatial or sequential arrangements" (Dagar and Tewari 2017). Agroforestry systems can be practiced at various scales on agricultural lands. It is characterized by well-developed trees spanning arable land and other land uses. Smallholder farmers mostly plant Eucalyptus woodlots and boundary planting for firewood production and house construction (Lemenih and Kassa 2014), although these practices have a negative impact on biodiversity and the environment. Thus, increasing woody species in land uses as part of an agroforestry system is an important natural resource management method that increases tree diversity, particularly in Ethiopia's heavily deforested and degraded highlands (Derero et al. 2021).

Multipurpose woody species in agricultural landscapes are combinations of trees and shrubs that farmers choose for certain purposes and grow with essential food crops (Faye et al. 2010). Trees and shrubs found on land have both conservation and productive functions (Kibet 2011). Therefore, the integration of important native as well as some exotic woody species into agricultural landscapes has been mentioned as an example of traditional land-use systems that contribute to conserving biodiversity (Kidane and Kejela 2021). However, due to commercialization, farmers in some regions develop crops of high economic value that often cause damage to agro-biodiversity. The reduction of farm size and improving access to roads decreased multipurpose tree species in agroforestry in southern Ethiopia (Abebe et al. 2010; Jemal et al. 2018). Furthermore, the crucial socioeconomic and environmental roles of woody species across land uses have been endangered by overgrazing and deforestation (Duguma et al. 2019), resulting in the depletion of natural resources in Ethiopia.

In different parts of Ethiopia, farmers' preferences for woody species are not the same due to variances in socioeconomic activities. For example, men may prefer timber far from home, while women may choose fruit and forage trees near the homestead. Women realize which species are excellent for firewood, food, and fodder for their livelihood (Sanon et al. 2007). In most cases, farmers can focus on producing a few major food crops, depending on their individual economic value, with limited access to resources. Similarly, farm size affects woody species selection, layout, density, and the overall management of agroforestry practices (Abide and Asfaw 2022). The production and distribution of some seedlings to farmers do not help preserve and expand the diversity of trees in land use. Thus, farmers' preferences for woody species, as well as community participation in tree planting, improve tree cover in agricultural landscapes (Derero et al. 2021).

The problems of managing tree species and the lack of land-use systems have led to a quick decline in woody species diversity (Zhao et al. 2023). The investigation was undertaken in a few highlands in Ethiopia: Yem Special *Woreda*, Welmera *Woreda,* and Sinan *Woreda*. Currently, trees in the farmland of Ethiopia's highlands are facing the challenge of degradation due to tree cutting. Farmers prefer annual crops that generate short-term income to meet their basic needs (Tefera et al. 2014; Tsegaye 2019). These activities affect the diversity of tree species and pose a great challenge to environmental conservation in the study area. So the study aim is to understand the existing diversity of tree species and farmers' preferences for woody species to fill the gap that helps us manage our environments. Therefore, this study was applied in selected highlands to determine the diversity of woody species present in various land uses

and learn more about farmers' preferences for tree species.

Objective

General objective

- To assess land use diversity and farmers' preferences for woody species in the three selected highlands of Ethiopia.

Specific objectives

- To assess the composition and diversity of woody species that exists in the land uses of the study site
- To identify farmers' preferences for woody species associated with their purposes or uses in the study area

Materials and methods

Description of the study area

The investigation was conducted in three particular *woredas* located within the highlands of Ethiopia. These *woredas* are Yem special *woreda*, Welmera *woreda,* and Sinan *woreda* (Fig. 1). Yem special *woreda* is found in the Central Ethiopia Region and is situated 243 km west of Addis Ababa. The *woreda* is sited at 7°57′N to 8°02′N latitude and 37°40′E to 37°61′E longitude. Welmera is located in the West Shewa Zone of the Oromia Region. It is found in the central highlands of Ethiopia and is about 40 km away from Addis Ababa along the Ambo road. The area is located at 8°50′ to 9°15′N latitude and 38°25′

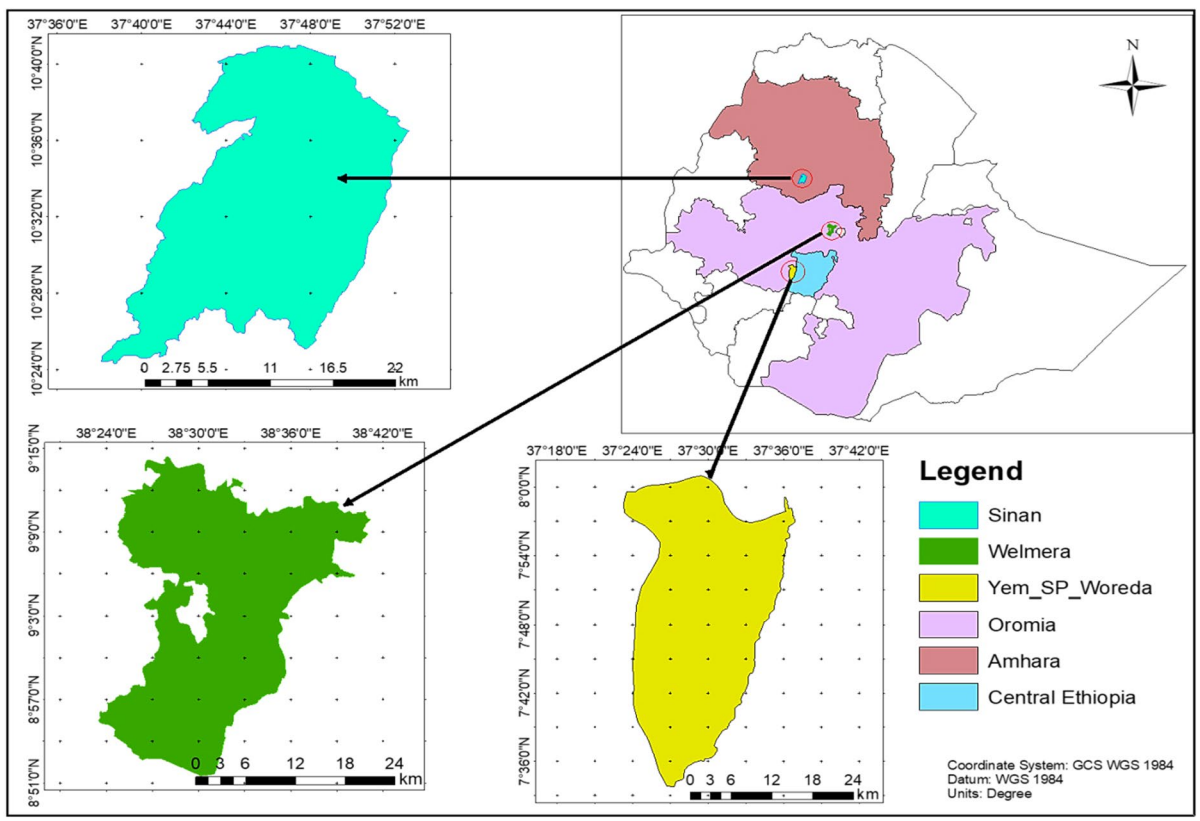

Fig. 1 Map of the study woredas and their locations in Ethiopia

to 38°45′E longitude. Sinan is found in the eastern Gojam zone of the Amhara Region. It is situated about 327 km north-west of Addis Ababa. The area is located at 10°10′ to 11°05′N and 37°30′ to 38°02′ E latitude and longitude, respectively.

Both Yem special *woreda* and Welmera *woreda* have a bimodal rainfall pattern, which receives a mean annual rainfall of 900–2200 mm and 1000–1100 mm, respectively. Yem and Welmera *woreda* have a mean annual temperature of 12–30 °C and 18–24 °C, respectively. Sinan *woreda* has a unimodal rainy season and a mean annual rainfall of 900–1500 mm. The yearly temperature of the *woreda* is 1–20 °C.

The landscape of the Yem *woreda* is categorized by continuing mountains extended beautiful land, sloppy areas, and level plateaus. The area has an elevation of 1967 to 2859 m.a.s.l. (Legesse and Negash 2021). The major soil types in the *woreda* are nitosols, luvisols, and vertisols. Welmera *woreda* is mainly plain and has an elevation of 2000 to 3000 m.a.s.l. The soil types of the area are clay, vertisols, and sandy soil. The landscape of Sinan *woreda* is known for its plain and undulating slopes with an altitude of 2300 to 4100 m.a.s.l. According to the Sinan *woreda* Agricultural Office, the common types of soil found in the area are luvisols, cambisols, nitosols, and vertisols. The vegetation types of Welmera, Sinan, and Yem *woreda* are classified under dry evergreen Afromontane forest and Afromontane rain forest, respectively.

Methods

Sample design and sampling technique

Site selection The three *woredas* were selected purposefully from three regional states to understand woody species diversity and farmers' tree preferences in the highland system with the aim of promoting sound tree-based livelihood systems. Though the environmental conditions are representative of the highlands, the *woredas* were selected to represent different socio-political and socioeconomic conditions. There are also variations in the conditions of the farmed landscapes, including smallholder plantation development and agroforestry practices, and in the extent of land degradation and tree clearance in the areas. Yem *woreda* is dominated by more agroforestry practices, while the Welmera and Sinan are changing to extensive woodlot systems over time.

One highland kebele (the smallest administrative unit in Ethiopia) was selected purposely from each woreda (Table 1) that represents the Dega (cool highlands) part of the study area. The following criteria were used to select highland kebele: These criteria were the perceived willingness and experiences of communities to embrace tree-based livelihoods and land availability for the promotion of smallholder plantations either privately or communally. In addition, factors such as water availability and past experiences were considered in selecting the kebeles. This baseline data and the findings of the study were expected to inform future interventions on promoting tree-based livelihoods in the areas.

Household sample size determination The sample size has been designed using the formula developed by Yamane (1967), with a 95% confidential level. Accordingly, a total of 320 household heads were selected from all kebeles and interviewed (Table 1).

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

where n = the desired sample size, N = Population size of the household head, e = level of precision.

Table 1 List of selected sites and some biophysical features and sampling targets

Highland (Dega) Kebeles	Region	Woreda	Agro ecology	Average altitude	Total HHs	No. of HHs interviewed
Tach Chabi	Amhara	Sinan	*Dega*	2800	787	158
Welmera Choke	Oromia	Welmera	*Dega*	2480	456	92
Shewsher Almama	CE	Yem	*Dega*	2800	347	70
Total					1590	320

HHs Households, *CE* Central Ethiopia

$$n = \frac{1590}{1+1590(0.05)^2} = \frac{1590}{1+1590(0.0025)} = \frac{1590}{4.975} = 319.59 \approx 320.$$

Data collection method

Woody species assessment in land uses Out of the 320 surveyed HHs as presented in Table 1, a subset of 105 of the HHs were purposely selected (HHS that have five land uses) to carry out an inventory of woody species. Then, 35 HHs were selected randomly by generating random numbers from each kebele out of 105 HHs. In this, the lists of the selected household heads (105 HHs) were taken as a base line. The subset sampling was done following the study by Endale et al. (2017). Five land use categories were identified and surveyed for species diversity analysis. These land use categories include: homegarden (homestead land use system contains multipurpose trees, annual crops, and perennial crops); woodlot (area committed to small-scale production of wood); boundary planting (planting of trees along all types of boundaries); cropland (area containing annual crops or perennial crops); and grazing land (area assigned for grazing).

An inventory of all existing trees and shrubs was carried out in all land use categories owned by each of the 35 selected HHs in each kebele. The sample plots (homegarden, cropland, grazing land, and woodlot) were inventoried by taking one sample with a size of 30×30 m at the center of each land use, with some adjustments in the study field. The sample size was determined based on the studies by Tolera et al. (2008) and Fifanou et al. (2011). Five sample plots were inventoried for each household, and a total of 175 sample plots were carried out for each site.

All encountered woody perennial species were counted and their diameter at breast height (≥ 2 cm DBH) and height (≥ 2 m height) measured (Kebede et al. 2013). In the field, vernacular names were recorded, and identification was carried out with the help of woredas Environmental Protection, Forest, and Climate Change experts and using some guidebooks that describe trees and shrubs well (Bekele and Tengnas 2007). In addition, my advisor (forestry professional) assisted me in species identification. When identification was difficult in the field, tree and shrub species were documented by their local names, and samples were collected and deposited in the Addis Abeba National Herbarium for further identification.

When the inventory was conducted, the number of tree and shrub species, DBH, and height were recorded. The diameter was measured using a tree caliper at 1.3 m above the ground, and the height was measured using a hypsometer. The tree height was measured with a hypsometer by standing at a fixed distance from the tree. Then it was calculated by subtracting the base measurement from the top measurement for level ground (if both measurements were positive) and adding them together for sloping ground (if the base measurement was negative).

Household survey procedures The household sample was calculated depending on the total households obtained from each selected site, as presented above in sample size determination. In each kebele, proportional households were calculated by using the total households of three kebeles, the total household head of each kebele, and sampled households (Table 1). Once households were selected, every household had an equal chance of being included in the survey. Therefore, lists of total household heads were obtained from each selected kebele office as a sample frame, and simple random sampling was used for face-to-face interviews. In simple random sampling, all households were numbered, and then a number between one and the total number of households (N) was selected through a random number generator (it is available in Microsoft Excel). Then the households were selected by using random numbers until the desired sample size was reached.

A household interview was conducted to assess farmer preferences for woody species within their benefits using a structured questionnaire. A focus group discussions (FGDs) and key informant interview were also used to identify woody species found in the area. The questionnaire was prepared in English and interpreted into the native language of the study area. The questionnaire had two parts: independent variable and woody species preference items. A face-to-face interview was conducted with 320 household heads at the three selected study sites. If a household head was not present at the time of the interview, the interview was delayed to another day. If the household head had not existed in the area for more than a week, the next closest household was interviewed. A face-to-face interview was conducted by skilled data collectors from the Ethiopian Environment and Forest Research Institute.

The household survey questionnaires were arranged by asking open and closed questions about farmland woody species and the existence of specific native as well as exotic woody species among those registered at the site based on their land uses (Amare et al. 2019). The survey examined whether farmland trees are commonly managed woody species in terms of ecological, management, and utility factors influencing intercropping perennial trees in farms (Dumont et al. 2019).

Respondents were asked to list the five most significant woody species in order of their importance and the number of individual tree species they want to plant under each utility (Iiyama et al. 2017). The utilities include:

- Primarily for commercial use: timber, fruit, fodder, and medicine
- Subsistence: construction, tools for local purposes, and fuel (firewood, charcoal).
- Environmental services: shade, windbreaks, soil fertility, erosion control
- Fencing: either as live fences or poles and other utilities

Data analysis

Woody species diversity analysis in land uses The measurement of species diversity was required to quantify and describe farmland woody species, allowing for the degree of their diversity in the area. The collected data on species richness and diversity were first summarized, matched, coded, processed, and analyzed with Microsoft Excel. Tree species diversity and equitability were calculated by means of the Shannon diversity (H) and Evenness (J) indices, respectively (Kent 2011). Comparisons of diversity among land use categories were analyzed using a one-way ANOVA. In addition, a rank abundance curve, or Whittaker plot, was used to visualize species abundance distributions. In the plot, the number of individuals of each species was arranged in descending order, and the relative number of individuals for each species is shown beside the tree species rank. The importance value indexes and the basal area of woody species were also carried out.

Shannon diversity index

Shannon diversity measures the uncertainty and makes it challenging to properly estimate the species of the following individuals collected in the sample. Species evenness states the relative abundance of species, whereas species richness indicates the number of species per farm (Bock et al. 2007). Shannon diversity index (H') was designed to analyze the diversity of tree and shrub species per farm, and it was calculated as follows:

$$H' = -\sum pi \ln pi \tag{2}$$

H' = Shannon diversity index, Pi = the percentage of individuals found in the ith species or the numbers of individual.

Evenness (equitability) index

Evenness (equitability index) was considered to assess the uniform distribution of tree species on farming lands. The evenness of woody species was calculated by Bock et al. (2007).

$$E = \frac{H'}{H\max} = \frac{H'}{\ln S} \tag{3}$$

With H max = ln(s), E = Evenness, H′ = Calculated Shannon diversity, H max = ln(s) [species diversity under maximum equitability], S = Number of species.

Similarity analysis

Sorensen similarity was carried out to compare the similarity in the species composition across land uses and between study areas because it gives more weight to the species that are common in the samples rather than to those that only occur in either sample (Kent 2011). Sorensen similarity (S s) is given by the following procedure:

$$Ss = \frac{2a}{2a + b + c} * 100 \tag{4}$$

where Ss = Sorensen similarity, a = Number of species common to both samples, b = Number of species in sample 1, c = Number of species in sample 2.

Importance Value Index (IVI)

IVI is a relative measure of species frequency, density, and abundance (Kent 2011). Density was calculated by adding up all stems across all areas and converting to hectares. The importance value index displays the significance of species and is calculated by summing three components.

$$\text{Density} = \frac{\text{Total number of individual species}}{\text{Sample area (ha)}}$$

$$\text{Relative density} = \frac{\text{Density of individual of species}}{\text{Total density of all species}} * 100$$

$$\text{Relative abundance} = \frac{\text{Total number of individual species}}{\text{Total number of species population}} * 100$$

$$\text{Frequency} = \frac{\text{Area of the plot that species occurs}}{\text{Total number of sample plot}}$$

$$\text{Relative frequency} = \frac{\text{Frequency of a species}}{\text{Frequency of all species}} * 100$$

$$\text{IVI} = \text{Relative(density} + \text{frequency} + \text{abundance)}$$

The basal area of tree species in the overall study sites and in different land use types was calculated as follows: $BA = \pi\ r^2 = \frac{\pi}{4}(DBH)^2$ where BA is the basal area (m^2).

Household survey data analysis

The collected data through household interviews was coded, cleaned, and examined by means of Statistical Package for Social Sciences (SPSS) version 24 and Microsoft Excel 2010. The household survey data was used to characterize farmers' preferences for tree species on their farms in different utilities using a multivariate analytical method. Farmers' preferences for tree and shrub species were calculated following the study by Roothaert and Franzel (2001). It was done with the following steps: First, the household head lists tree species and the number they want to plant under each benefit. Then a rank is given to the species depending on the number of individuals. Add together the frequency of the rank given to the tree species under the ranks (1st, 2nd, 3rd, and 4th). Then, multiply the numbers under 1st by 4, under 2nd by 3, under 3rd by 2, and under 4th by 1 for each species. Finally, add together the values, and this result shows the rank of tree species.

Results and discussions

Socio-economic characteristics of the respondents

To emphasize these points, this subtitle covers the socioeconomic backgrounds of the survey respondents. The investigation of respondents' socioeconomic backgrounds is critical in social science studies because it promotes comprehension of their social and economic situations and aids in the study of their personality patterns. Most of the respondents' age was between 30 and 60. Table 2 describes others socioeconomic characteristics of respondents.

Land use woody species compositions and diversity

Woody species compositions in land uses

The investigation results revealed that a total of 32 woody species belonging to 16 families were identified in the overall study site (Fig. 2, Appendix 1). Out of these plant families, *Fabaceae* and *Rosaceae* were the most dominant. They have 25% and 12.5% of the species numbers for *Fabaceae* and *Rosaceae,* respectively. This outcome is in line with the results of Molla et al. (2023), Wari et al. (2019), and Misgana et al. (2020). They reported that *Fabaceae* was a dominant family in the Gununo Watershed in Wolayita, Jimma, South West Ethiopia, and Gindeberet, West Shewa, respectively.

Overall, 26 woody species were documented in the homegarden, 16 in the boundary plantation, 6 in the woodlots, 14 in crop fields, and 13 in grazing land. Of the recorded woody species, 62.5% were indigenous, and the other 37.5% were exotic. The relatively higher number of native species in the areas may be

Table 2 Distribution of respondents based on socio-economic characteristics (N = 320)

Variables	Frequency	Percentage
Age of the respondents		
≤ 34	16	5
35–43	74	23
44–52	72	22
53–61	80	25
62–70	60	19
≥ 71	18	6
Gender		
Male	267	83
Female	53	17
Family size in number		
≤ 4	103	32
5–8	185	58
≥ 9	32	10
Marital status		
Married	277	87
Divorced	43	13
Land holding size in hectare		
≤ 1	92	29
1.25–2.25	154	48
2.26–3.26	54	17
≥ 3.27	20	6
Educational status		
No education	107	33.4
Primary (1–8)	73	23
High school	7	2
Higher education	2	0.6
Others	131	41

the result of maintaining natural regeneration as well as planting on the farmland, owing to their multiple benefits. Regarding plant growth habits, 75% of recognized woody species were trees, 21.9% were shrubs, and 3.1% were woody grasses**.** The result is the same as in the reports of Amberber et al. (2014), Mekonen et al. (2015), Molla and Kewessa (2015), and Wari et al. (2019), who conveyed that most of the documented woody species were trees.

The identified woody species in homegardens were categorized as more complex than other land categories. It is similar to the conclusion of Tefera et al. (2014), Molla and Kewessa (2015), and Wari et al. (2019), who conveyed that homegardens had a higher number of woody species than other land categories. Overall, 14 woody species were recorded on the cropland. Trees were scattered in the field and had low tree density when related to home gardens and boundary planting. However, it was higher than woodlots and grazing land in species richness. The tree density is relatively identical with the finding of Guyassa and Raj (2013) in Tigray Region (15 species), but less than the finding of Wari et al. (2019) in Jimma (25 species) and Tolera et al. (2008) in Central Ethiopia (32 species). This variation may be due to differences in the original species richness, other environmental factors such as climatic conditions, and some socio-economic factors.

The woody species documented in the woodlot were six (6). Woody species known in the woodlot were lesser than those reported by Alem and Pavlis (2012), Wari et al. (2019) (37 species) and (13 species), respectively, in South Western Ethiopia, and Tyynela (2001) (39 species) in North Eastern Zimbabwe. However, it was characterized by a higher tree

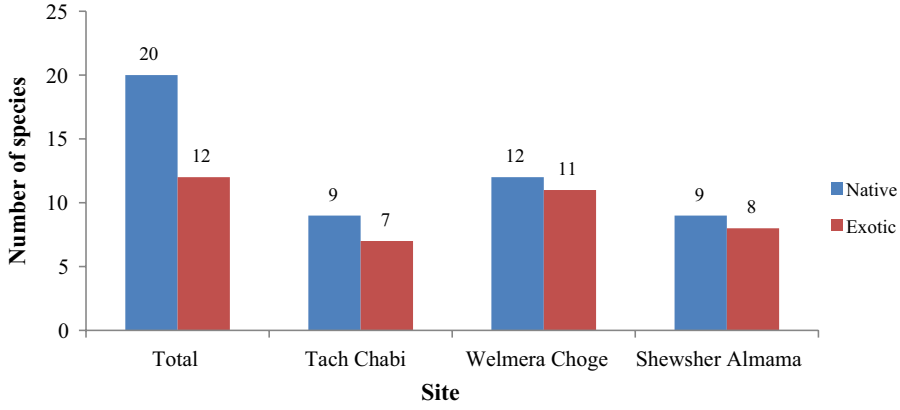

Fig. 2 The number of woody species at the three study sites

density than other land use categories at the study sites. Woodlots were mainly characterized by single-species dominance. This is due to the great relative density of *Eucalyptus globulus* and *Cuppressus lusitanica* woodlots.

In the boundary plantation, a total of 16 woody species were documented**.** It was planted near cropland and along the road, and its species number was relatively higher than that of woodlot, crop field, and grazing land. The result of this study is much lower than the conclusion of Endale et al. (2017) in the semi-arid East Shewa of Ethiopia (48 species). This difference is due to the variation in socioeconomic activities at the study site. On the grazing land, only 13 woody species were documented. The number of woody species recorded in the grazing land was less than the outcome of Wari et al. (2019) (33 species) in the Jimma but greater than that of Tefera et al. (2014) (11 species) in Northern Ethiopia.

Regarding the distribution of species identified across the sites, about 8 (25%) of them were common to all sites. Shewsher Almama and Welmera Choge shared 4 (12.5%) woody species; 2 (6.25%) species were found in Welmera Choge and Tach Chabi; and 2 (6.25%) species were common to Tach Chabi and Shewsher Almama sites (Table 3).

Woody species diversity index in land uses

The species diversity of homegardens, boundary planting, woodlots, crop fields, and grazing land was 2.39, 0.92, 0.54, 1.50, and 1.94, respectively (Table 4). The maximum species diversity was recorded in the home garden land use categories, compared to others. Similarly, home garden species diversity at each site was higher than in other land use categories. This outcome is relatively similar to the study of Tekle and Maryo (2022) and Wari et al. (2019), who conveyed that woody species of diverse land uses have various species diversity due to several functions.

The species diversity of the Welmera Choge site (H = 2.21) was higher than that of Tach Chabi (H = 1.77) and the Shewsher Almama site (H' = 1.88),

Table 4 Richness, Shannon diversity and evenness of trees and shrubs in the study areas

Land use category/site	Species richness	Shannon diversity	Species evenness
Homegarden	26	2.39	0.42
Shewsher Almama	13	1.88	0.50
Welmera Choge	17	2.21	0.53
Tach Chabi	13	1.77	0.45
Boundary planting	16	0.92	0.16
Shewsher Almama	8	1.21	0.42
Welmera Choge	8	0.17	0.15
Tach Chabi	8	0.79	0.27
Woodlots	6	0.54	0.28
Shewsher Almama	4	1.10	0.74
Welmera Choge	2	0.04	0.52
Tach Chabi	3	0.05	0.35
Cropland	14	1.50	0.31
Shewsher Almama	6	1.40	0.67
Welmera Choge	8	1.45	0.53
Tach Chabi	3	0.59	0.60
Grazing land	13	1.94	0.53
Shewsher Almama	6	0.97	0.44
Welmera Choge	8	1.43	0.52
Tach Chabi	4	0.80	0.56

Table 3 Unique woody species and species overlap among the three study sites

Unique species for different sites		Common species for different sites	
Welmera Choge	**Shewsher Almama**	**ShA and WCh**	**ShA, WCh and TCh**
Acacia abyssinica	*Cordia africana*	*Eucalyptus camaldulensis*	*Acacia decurrens*
Acacia melanoxylon	*Podocarpus falcatus*	*Grevillea robusta*	*Cuppressus lusitanica*
Azadirachta indica	*Ricinus communis*	*Hagenia abyssinica*	*Eucalyptus globulus*
Croton macrostachyus	**Tach Chabi**	*Persea americana*	*Ficus sur*
Ekebergia capensis	*Cytisus proliferous*	**ShA and TCh**	*Juniperus procera*
Erythrina abyssinica	*Dombeya torrida*	*Yushania alpina*	*Malus domestica*
Millettia ferruginea	*Rhus natalensis*	*Erythrina brucei*	*Prunus domestica*
Rhus glutinosa	*Rosa abyssinica*	**WCh and TCh**	*Vernonia amygdalina*
Sesbania sesban		*Morus alba*	
		Olea europaea	

ShA Shewsher Almama, *WCh* Welmera Choge, *TCh* Tach Chabi

in the homegardens of the study areas. The evenness of woody species was 0.53, 0.45, and 0.50 for Welmera Choge, Tach Chabi, and Shewsher Almama sites, respectively. This result is lower in Shannon diversity than home gardens in the semi-arid East Shewa (Endale et al. 2017) (H = 3.05) and homegarden agroforestry in Jimma, South Western Ethiopia (Wari et al. 2019) (H' = 2.87).

The maximum species diversity was documented in the crop field of the Welmera Choge site (H = 1.45), followed by Shewsher Almama (H = 1.40) and the Tach Chabi site (H = 0.59), and the species evenness was 0.53, 0.67, and 0.60, respectively. This variation might occur due to different socioeconomic activities within the croplands of different sites. This conclusion is similar to that of Amberber et al. (2014) and Wari et al. (2019), who revealed that the existence of species among crop fields in different study areas was irregular. The result was almost the same with the investigations of Guyassa and Raj (2013) (H = 1.12, E = 0.41 in the Tigray region), Tefera et al. (2014) (H = 0.58, E = 0.21 in Northern Ethiopia), and Tolera et al. (2008) (H = 2.22, E = 0.64 in Central Ethiopia) in Shannon diversity and species uniformity.

In the grazing land, the maximum species diversity was documented in Welmera Choge, than Shewsher Almama, and Tach Chabi sites, and species uniformity extended between 0.44 and 0.56 (Table 4). This result was lower in both species diversity and species uniformity than the findings of Guyassa and Raj (2013) in the Tigray region (H = 2.04, E = 0.71), and Endale et al. (2017) in semi-arid East Shewa, Ethiopia (H = 1.9, E = 0.67). Similarly, the result was much smaller in both species diversity and species uniformity than the investigation of Wari et al. (2019) Jimma (H = 3.10, E = 0.88).

Comparatively, higher species diversity was recorded in Shewsher Almama (1.10) than in Tach Chabi (0.05) and the Welmera Choge site (0.04) in the woodlot land use type. Similarly, species uniformity extended between 0.35 and 0.74 for this land use type. This outcome is almost the same in species diversity and higher in species evenness than the investigation of Wari et al. (2019) in the Jimma (H = 0.66, E = 0.26). Likewise, the result is lower in species diversity and higher in species uniformity than the report of Endale et al. (2017) in semi-arid East Shewa, Ethiopia (H = 1.8, E = 0.21). The documented species diversity in Shewsher Almama (1.21) was higher than that in Tach Chabi (0.79) and the Welmera Choge site (0.17), and species evenness extended between 0.15 and 0.42 in the boundary planting. This report is much lower than the investigation of Endale et al. (2017) in the semi-arid zone of Ethiopia (H = 3.1, E = 0.46) in both species diversity and species uniformity.

The observed result of survey work was similar to the responses of key informants and FGDs who stated that various woody species were cultivated in different land uses. Similarly, woodlots of *Eucalyptus globulus* increase more than native species in the study areas because of their requirements for construction, fuel wood, income generation, and the fast-growing nature of the tree. Farmers were changing some grazing land and crop fields to *Eucalyptus* woodlots, especially at the Tach Chabi site. The findings of Ango et al. (2014) and Wari et al. (2019) that stated the expansion of woodlots was the result of rising demand for several tree products are similar to this justification. The individuals' number of exotic woody species was higher than that of native species. However, native woody species had higher Shannon diversity than exotic trees (Table 5).

A comparison of species richness, Shannon diversity, and species uniformity revealed that there was variation between different land use categories (Table 6). The analysis of variance indicated that the average richness and Shannon diversity index of woody species in the homegarden were greater than those of other land use types.

A rank abundance curve, or Whittaker plot, was used to visualize species abundance distributions (Fig. 3). The result of the species rank abundance curve showed that Tach Chabi and Welmera Choge had lower evenness and higher species abundance than Shewsher Almama.

Table 5 Shannon diversity and evenness of woody species in the three study site

Site/species diversity	Shannon diversity		Species evenness	
	Native	Exotic	Native	Exotic
Shewsher Almama	0.95	1.22	0.29	0.42
Welmera Choge	1.90	0.34	0.56	0.13
Tach Chabi	1.28	0.60	0.40	0.26

Table 6 Richness, Shannon diversity and evenness of different land use types (n = 105)

Land use types	Species richness	Shannon diversity	Evenness
Homegardens	$2.99^{b}(\pm 1.25)$	$.88^{c}(\pm .42)$	$.87^{a}(\pm .18)$
Woodlots	$.90^{a}(\pm .50)$	$.04^{a}(\pm .13)$	$.56^{b}(\pm .36)$
Boundary planting	$1.51^{c}(\pm .87)$	$.33^{b}(\pm .35)$	$.73^{c}(\pm .25)$
Croplands	$1.05^{a}(\pm .79)$	$.27^{b}(\pm .33)$	$.88^{a}(\pm .22)$
Grazing lands	$.61^{d}(\pm .67)$	$.13^{a}(\pm .25)$	$.87^{a}(\pm .11)$
P Value	0.000	0.000	0.000

Mean values in columns followed by the same letter(s) are not significantly different ($p > 0.05$) according to Post Hoc and LSD multiple comparison of means test

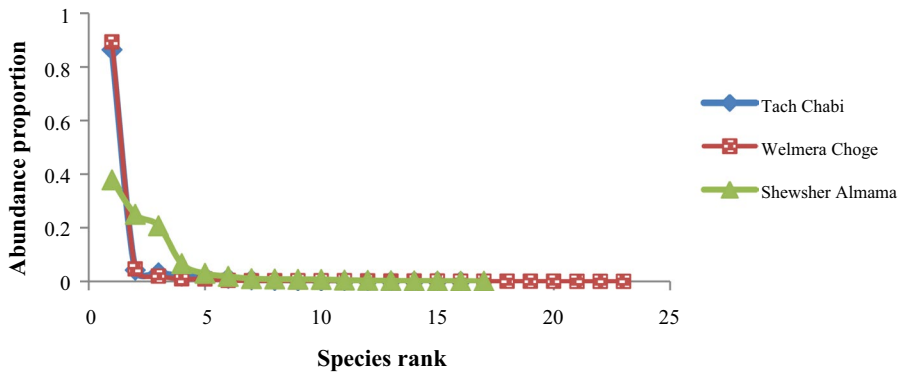

Fig. 3 Species rank abundance curve or Whittaker plot of the three study sites

Table 7 Sorensen similarity indexes of woody species (%) among three sites

Site	Shewsher Almama	Welmera Choge	Tach Chabi
Shewsher Almama	–	–	–
Welmera Choge	67	–	–
Tach Chabi	74	61	–

Similarity index among sites and land use categories

The species similarity index indicated in the Shewsher Almama and Tach Chabi sites had the highest similarity (74%), followed by the Shewsher Almama and Welmera Choge sites at 67% (Table 7). The Welmera Choge and Tach Chabi study areas had the lowest species similarity index (61%), compared with other study sites.

The Sorensen similarity index of species indicated that grazing land and woodlots were 100% similar (Table 8). The home garden and woodlot had the lowest species similarity index (50%) as compared with other land use types.

Table 8 Sorensen similarity indexes of species (%) among land use types of three sites

Land use types	Homegarden	Boundary	Woodlots	Crop field	Grazing land
Homegarden	–	–	–	–	–
Boundary	66	–	–	–	–
Woodlots	50	85	–	–	–
Cropland	64	82	86	–	–
Grazing land	66	90	100	95	–

Woody species structural diversity in land uses

Density

A total of 30,247 individuals' woody species were documented from 47.25 ha and 525 plots in three selected highlands, with a density of 640.1 individuals per hectare. A total of 7564 trees and shrubs in Shewsher Almama, 11,247 in Welmera Choge, and 11,436 in Tach Chabi were recorded and have a total density of 480.3, 714.1, and 726.1 individuals per hectare, respectively. Regarding land use types, the total density of woodlots was greater than other land use categories, followed by boundary planting and homegardens in all study areas except the Shewsher Almama site (Table 9).

In the homegardens of the three study areas, species like *Eucalyptus globulus, Cuppressus lusitanica, Yushania alpina, Rhus glutinosa,* and *Sesbania sesban* were the top five species with the highest density (96.3 to 323.9 individuals per hectare). Other species were very low, with 11.1 individuals per hectare. In the cropland, *Cytisus proliferous, Acacia decurrens*, *Vernonia amygdalina,* and *Malus domestica* had the highest density (153.2, 77.8, 52.8, and 33.3 individuals/ha, respectively), whereas other species were much sparser, with densities of up to 11.1 individuals per hectare. Species like *Eucalyptus globulus*, *Cuppressus lusitanica, Yushania alpina, Eucalyptus camaldulensis,* and *Juniperus procera* were highly populated species (974.1, 691.3, 511.1, 303.7, and 265.4 individuals per hectare, respectively) in boundary planting.

In the grazing land, *Juniperus procera, Acacia decurrens,* and *Cytisus proliferous* species were highly populated (193.3, 69.1, and 61.9 individuals/ha, respectively), while others ranged from 11.1 to 55.6 individuals per hectare. *Eucalyptus globulus*, *Yushania alpina,* and *Cuppressus lusitanica* were the most populated species in woodlots (2205.3, 1762.2, and 1490.7 individuals/ha, respectively), whereas others had densities of 116.7 up to 344.4 individuals per hectare.

The study results showed that there was variation in species density among different land use types. The density of woody species is much lower than the investigation of Wari et al. (2019) in Jimma in all land use categories. This result is due to the monocropping agricultural practices and continuous cultivation of farmland with no fallow practices in the study areas. The parallel study result of Misgana et al. (2020) in the farmland agroforestry of Gindeberet, West Shewa, agrees with this explanation. In the woodlot land use categories, the documented woody species density was related to the result of Dibaba et al. (2014) (1845 stems/ha) in Gololcha District.

Frequency

The rate parameter of woody species recorded was calculated. The most repeatedly documented woody species in the homegarden were *Cuppressus lusitanica, Prunus domestica, and Malus domestica* (44.8%, 41.9%, and 39.1%, respectively) from the entire study area. *Persea americana* (65.7%), *Prunus domestica* (51.4%), and *Malus domestica* (31.4%) were the most frequently encountered tree species in the homegarden of Shewsher Almama. In the homegarden of Welmera Choge, *Grevillea robusta* (60%), *Cuppressus lusitanica* (57.1%), *Eucalyptus globulus* (51.4%), *Acacia decurrens* (48.6%), and *Prunus domestica* (34.3%) were the most frequently recorded woody species. Similarly, *Malus domestica* (65.7%), *Cuppressus lusitanica* (60%), *Prunus domestica* (40%), and *Acacia decurrens* (34.3%) in Tach Chabi were the most frequently encountered tree species in homegardens.

Cytisus proliferous (26.7%), *Erythrina brucei* (23.8%), and *Acacia decurrens* (19.1%) were more frequently recorded woody species than others in the

Table 9 Total densities of woody species in three sites within land use categories

Variable	Density per hectare				
	Homegarden	Boundary	Woodlots	Cropland	Grazing land
Site	289.7	1035.3	1778.2	68.5	29.0
Shewsher Almama	198.1	1159.4	962.2	42.2	39.4
Welmera Choge	365.4	1123.2	2038.1	14.3	29.5
Tach Chabi	305.7	823.5	2334.3	148.9	18.1

cropland of all study sites. In terms of site, *Erythrina brucei* (71.4%) and *Ficus sur* (31.4%) in Shewsher Almama; *Acacia abyssinica* (8.6%) in Welmera Choge; and *Cytisus proliferous* (80%) and *Acacia decurrens* (48.6%) in Tach Chabi site were the most frequently encountered tree species.

The result implies that, *Eucalyptus globulus* was repeatedly encountered in the woodlot. It had a frequency of 68.6% in the overall study areas, 25.7% in Shewsher Almama, 88.6% in Welmera Choge, and 91.4% in Tach Chabi. Similar study reports by Tyynela (2001) and Wari et al. (2019) revealed that woodlot land use was dominated by single species. Similarly, the recurrently encountered tree species in the boundary planting were *Eucalyptus globulus* (75.2%) and *Cuppressus lusitanica* (30.5%) in the overall study sites.

In the grazing land, *Ficus sur* (11.4%), *Acacia abyssinica* (10.5%), and *Erythrina brucei* (9.5%) were more frequently observed species than other woody species in the overall study sites. *Erythrina brucei* and *Ficus sur* (28.6%) each in Shewsher Almama, *Acacia abyssinica* (31.4%) and *Acacia decurrens* (11.4%) in Welmera Choge, and *Cytisus proliferous* (20%) and *Acacia decurrens* (14.3%) in Tach Chabi were the most repeatedly observed woody species in the grazing land of the study sites.

Importance value index (IVI)

The importance value index estimates the structural importance of each woody species for each land use category (Appendix 2). The species *Eucalyptus globulus* and *Cuppressus lusitanica had the* highest values of relative dominance (72.1% and 12.4%, respectively), and this resulted in the maximum IVI in all study areas. Having a higher relative density and a greater rate of recurrence also contributed to increasing the importance value index (Agidie et al. 2014; Wari et al. 2019).

Woody species such as *Cuppressus lusitanica, Eucalyptus globulus, Malus domestica, Prunus domestica,* and *Acacia decurrens* were the top five significant species in the homegardens of the study areas. This conclusion is in agreement with the findings of Mekonnen et al. (2014) in Jabithenan district, Northwest Ethiopia, and Wari et al. (2019) in Southwest Ethiopia. On cropland, *Cytisus proliferous, Acacia decurrens, Erythrina brucei, Vernonia amygdalina,* and *Ficus sur* were the top five important woody species recorded. Similarly, *Juniperus procera, Acacia decurrens, Cytisus proliferous, Acacia abyssinica,* and *Erythrina brucei* were the top five significant species on the grazing land.

The most important woody species recorded in the woodlot were *Eucalyptus globulus, Yushania alpina, and Cuppressus lusitanica.* Woody species recorded in this land use type were lower than in other land use categories. Eucalyptus species dominated the woodland land use type (Wari et al. 2019). This variation is related to the higher density of the recorded species, which makes the species dominant and accounts for more of the woodlots at study sites. In the boundary planting, *Eucalyptus globulus, Cuppressus lusitanica, Juniperus procera, Yushania alpina,* and *Eucalyptus camaldulensis* were the top five significant species from the recorded species.

In general, woody species with high IVI depend on farmers' preferences for woody species. The investigation by Mengistu and Asfaw (2016) is comparable with this justification. The attention of farmers to species selection depends on the product and service value received from woody species. Some exotic tree species, like *Eucalyptus,* become dominant and are also extremely supportive of the livelihoods of farmers, particularly in the Tach Chabi and Welmera Choge sites. However, as different studies applied in different countries and areas indicated the expansion of *Eucalyptus species* has harmful effects on environments.

Diameter at breast height (DBH)

The diameters of woody species were evaluated and categorized into six classes (Fig. 4). Accordingly: (1) 2–8 cm, (2) 8.1–14 cm, (3) 14.1–20 cm, (4) 20.1–26 cm, (5) 26.1–32 cm, and (6) > 32 cm. The diameter of all individuals' species in several classes indicated a reversed J shape in all study sites. Most tree species had the greatest number of individuals in the lowest DBH classes, which gradually decreased as DBH increased. Similarly, the DBH class distribution of individuals' species in categorized classes displayed an inverted J shape in the homegarden, woodlot, grazing land, and crop field land use categories. This outcome is the same as the study conclusions of Dibaba et al. (2014), Mekonen et al. (2015), Worku et al. (2015), and Wari et al. (2019). Whereas

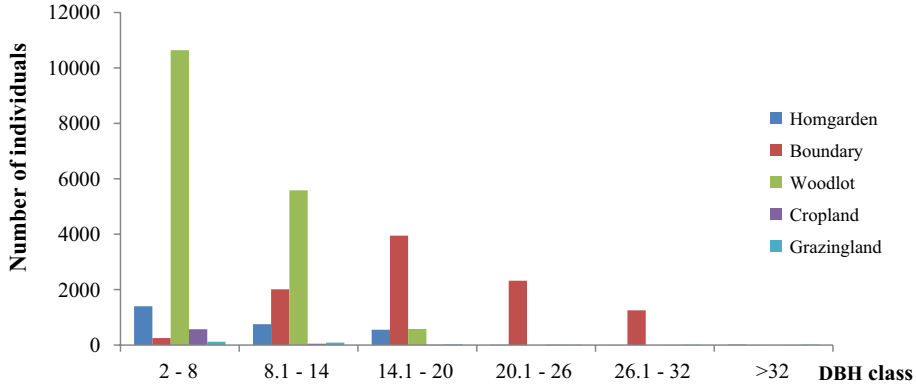

Fig. 4 DBH class distribution of woody species in land use types of study sites

the diameter classes of individual species in different classes were made into a bell shape in the boundary planting.

Basal area

The basal area of woody species recorded in each land use type was calculated. (Appendix 3). Accordingly, the calculated basal area of woody species was 15.95 m^2/ha in the homegarden, 76.56 m^2/ha in boundary planting, 40.57 m^2/ha in the woodlot, 3.74 m^2/ha in cropland, and 9.99 m^2/ha in grazing land. *Eucalyptus globulus* (51.91 m^2/ha), *Cuppressus lusitanica* (25.81 m^2/ha), *Eucalyptus camaldulensis* (16.54 m^2/ha), *Ficus sur* (9.17 m^2/ha), and *Yushania alpina* (7.88 m^2/ha) were the top species with the maximum basal area in the farm landscapes studied.

Although *Eucalyptus globulus* 4.17 m^2/ha and *Croton macrostachyus* 2.15 m^2/ha were in the homegarden, *Eucalyptus globulus* 33.72 m^2/ha and *Eucalyptus camaldulensis* 12.61 m^2/ha were in the boundary planting, and *Cuppressus lusitanica* 16.29 m^2/ha and *Eucalyptus globulus* 14.02 m^2/ha were in the woodlot, they had a higher basal area than other species. Similarly, *Cordia africana* (0.83 m^2/ha) and *Ficus sur* (0.67 m^2/ha) in cropland and *Juniperus procera* (2.33 m^2/ha) and *Ficus sur* (1.49 m^2/ha) in grazing land had a higher basal area than other woody species. *Eucalyptus globulus* had the highest basal area of all woody species in all study sites due to its productivity, easy establishment, and fast growth. This suggestion is similar to the investigations of Endale et al. (2017) and Wari et al. (2019), who reported that *Eucalyptus* species had the highest basal area as well as density.

Height class distribution

All woody species greater than or equal to 2 m in height were recorded from the field and categorized into five height classes for various land use types (Fig. 5). These height classes were (1) 2–7 m, (2) 7.1–12 m, (3) 12.1–17 m, (4) 17.1–22 m, and (5) > 22 m. A greater number of individual species

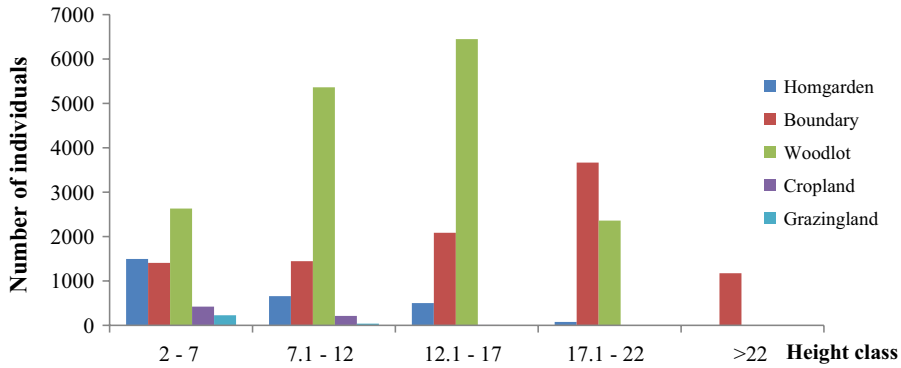

Fig. 5 Height (m) class distribution of woody species for each land use types

was recorded at inferior height classes in homegardens, croplands, and grazing land. This result is the same as the finding of Mengistu and Asfaw (2016), who stated that frequently, encountered management of multipurpose trees in homegardens and farmland affects height growth. The tree height in the homegarden and crop field was frequently managed in order to minimize the competition and uses of their products (Wari et al. 2019), and this affected the height of woody species. Boundary planting was more or less dominant in the higher height class distribution in comparison to other land use types. Whereas, woodlots were dominated by the middle class due to farmers using their products as soon as they reached for them.

Farmers preference and purpose of planting woody species

The purpose of planting woody species

Farmers have planted various trees and shrub species on their farmland for livelihood purposes (Fig. 6). During FGDs, it was recognized that most of the farmers were planting trees for construction, timber, fruit, environmental services, fuel wood, and fences in order of their importance. The study reports of Chakraborty et al. (2015) and Mulukh et al. (2018) exposed that farmers prefer and plant woody species on their own farmland for various benefits, and generally they select multipurpose species.

From the FGDs and key informants, the most commonly planted woody species in the study sites were *Eucalyptus globulus, Cuppressus lusitanica, Malus domestica, Prunus domestica, Acacia decurrens,* and *Cytisus proliferous.* Local farmers have traditional knowledge, experience, and a habit of planting and

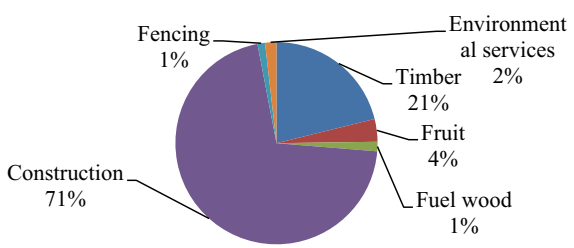

Fig. 6 The purpose of planting trees and shrubs species on farmlands

managing indigenous trees. Fast-growing multipurpose exotic woody species were also preferred and planted by farmers. A similar study report by Mandila et al. (2015) revealed that agroforestry practices might deliver more trees obtainable on farmland for local consumption and sale. In addition, planting trees as an agroforestry practice has the capacity to determine conflicts between different land users as a multiple land use system since most farmers are willing to plant tree species. Aladi and John (2014) also reported that most farmlands contain a mixture of various woody species. The same condition is observed in the farmland of the present study areas.

Woody species preference ranking with their relative benefit

Woody species preference depends on the purpose or benefits (Table 10). The result showed that species like *Eucalyptus globulus* were ranked first for timber, construction, fuels, tools, and fencing; *Malus domestica* for fruit; *Cytisus proliferous* for fodder, shade, and improving soil fertility; and *Juniperus procera* for medicine. The outcome of the importance value index also specified which species were the most important and were planted more in the study area. So, this implied that the importance value index and farmers tree species preferences were associated with each other.

Farmers have planted and preferred important woody species for their livelihood. However, no specific woody species can be observed as actually meeting all the necessities of the household. Singh and Kumar (2014) conveyed that the choices of woody species growing in farmland are based on the benefits of the species, whether to grow them for consumption or for market. Therefore, the selection of woody species is based on the benefits that can be gained from preserving trees on farmland. The roles of trees in achieving the requirements of households have been well understood by farmers over centuries and have been clearly established in traditional tree-based mixed agriculture (Mulugeta and Admassu 2014).

Most of the farmers preferred and planted high numbers of *Eucalyptus globulus* in their farmland due to its fast growth, quick returns, and low management when compared with the other species. The species was also used for different functions like timber, fuel wood, construction, different tools, and income

Table 10 Farmers' preferences of top four woody species within their benefits

Benefit	Trees/shrubs species	Ranks				Score				Total
		1st	2nd	3rd	4th	1st	2nd	3rd	4th	
Timber	*Eucalyptus globulus*	260	4	–	–	1040	12	–	–	1052
	Cuppresus lusitanica	32	172	6	1	128	516	12	1	657
	Grevillea robusta	4	34	22	1	16	102	44	1	163
	Juniperus procera	13	19	18	6	52	57	36	6	151
Fruit	*Malus domestica*	159	10	–	–	636	30	–	–	666
	Prunus domestica	43	80	2	–	172	240	4	–	416
	Persea americana	65	3	–	–	260	9	–	–	269
	Morus alba	–	1	–	–	–	3	–	–	3
Fodder	*Cytisus proliferous*	125	–	–	–	500	–	–	–	500
	Vernonia amygdalina	50	13	–	–	200	39	–	–	239
	Sesbania sesban	18	–	–	–	72	–	–	–	72
	Yushania alpina	15	–	–	–	60	–	–	–	60
Medicine	*Juniperus procera*	58	–	–	–	232	–	–	–	232
	Vernonia amygdalina	55	–	–	–	220	–	–	—	220
	Olea africana	12	1	–	–	48	3	–	–	51
	Hagenia abyssinica	–	4	–	–	–	12	–	–	12
Construction	*Eucalyptus globulus*	292	1	1	–	1168	3	2	–	1173
	Acacia decurrens	24	35	–	–	96	105	–	–	201
	Juniperus procera	1	35	12	–	4	105	24	–	133
	Eucalyptus camaldulensis	–	17	2	–	–	51	4	–	55
Fuels	*Eucalyptus globulus*	273	–	–	–	1092	–	–	–	1092
	Acacia decurrens	33	91	2	–	132	273	4	–	409
	Acacia abyssinica	9	14	2	–	36	42	4	–	82
	Eucalyptus camaldulensis	1	15	–	–	4	45	–	–	49
Tools	*Eucalyptus globulus*	125	–	–	–	500	–	–	–	500
	Ficus sur	24	38	–	–	96	114	–	–	210
	Yushania alpina	31	2	–	–	124	6	–	–	130
	Cordia africana	15	9	–	–	60	27	–	–	87
Shade	*Cytisus proliferous*	69	1	–	–	276	3	–	–	279
	Erythrina brucei	53	11	1	–	212	33	2	–	247
	Ficus sur	16	43	4	–	64	129	8	–	201
	Acacia decurrens	39	13	–	–	156	39	–	–	195
Fence	*Eucalyptus globulus*	90	7	–	–	360	21	–	–	381
	Erythrina brucei	41	1	–	–	164	3	–	–	167
	Erythrina abyssinica	32	–	–	–	128	–	–	–	128
	Cuppresus lusitanica	18	16	–	–	72	48	–	–	120

NB: Score (1st *4, 2nd*3, 3rd*2, and 4th*1) for 1st, 2nd, 3rd, and 4th score respectively

generation. This conclusion is consistent with the suggestions of Mulugeta and Admassu (2014) and Zerga and Berta (2016), who revealed that *Eucalyptus* species have various peculiar characteristics compared to other tree species that were preferred and planted by farmers in Ethiopia. They also stated that most farmers grow *Eucalyptus* trees for fuel wood and as housebuilding materials.

Because of the high population pressure in the study area, such fast-growing and multi-purpose tree species are very important for income generation. Mostly *Eucalyptus* trees were planted as woodlots around the homestead, along the roadside, and in boundary plantations. However, some farmers planted near the crop land or on land that is accessible for crop production. This activity influences the yield of

the crop, soil fertility, and the overall resulting crop land degradation. Fruit trees like *Malus domestica* and *Prunus domestica*, shade trees like *Erythrina brucei* and *Ficus sur,* and fodder trees and shrubs like *Cytisus proliferous* and *Vernonia amygdalina* were the most observed woody species in the study areas.

In general, most farmers prefer woody species based on their utility. The result showed that there were no traditional or governmental bodies that forced the planting of woody species in the study areas. Therefore, most farmers have just preserved and planted the available multipurpose woody species on their farmland in the landscape studied. The species similarity between preferred species and recorded species was almost 96%.

Conclusions and recommendations

Conclusions

Farmers' were mostly planting woody species on the farmland in different niches (homegarden, cropland, boundary planting, grazing land, and woodlot) purposefully. The land use types determine the composition and diversity of woody species. Relatively, homegardens had the maximum diversity, followed by grazing land in the whole study area. Minor species richness and diversity were documented in the woodlot land use type. Homegardens had various woody species, whereas woodlots were dominated by almost a single species. The woody species grown on cropland and grazing land were scattered as related to another landscape studied. The maximum density of tree species was recorded in the woodlot land use category. *Eucalyptus globulus* was the most closely inhabited and important tree species, having the highest importance value index and basal area. Currently, it is expanding and fulfilling the interests of the local people with its fast growth, easy establishment, and productivity. Farmers' choose woody species for their farmland based on their benefits. The result of importance value index and farmers' woody species preferences was related to each other. Species rank analysis showed that *Eucalyptus globulus* was selected for timber, construction, fuel, tools, and fencing; *Cytisus proliferus* for fodder and improving soil fertility; *Malus domestica* for fruit; and *Juniperus procera* for medicine.

Recommendations

Woody species should be maintained and introduced on land for different socioeconomic and environmental benefits by allowing the preferences of farmers and suitable management. The expansion of Eucalyptus globulus in the study sites may affect the native species as well as the environment. So, conservation of multipurpose indigenous woody species is needed for the rehabilitation of ecosystems and the provision of livelihood support in the study areas. Managing woody species on land for ecosystem services requires considering which tree species to embrace and how to manage them in different socio-economic and environmental contexts. This awareness needs to be shared and transformed into sustainable choices with local farmers.

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Author contribution The authors have responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Availability of data This manuscript is the original work. So all data are available in the hand of the author and all materials are cited carefully in the reference.

Declarations

Conflict of interest The authors declare that they have no conflict of interests.

Ethics statement This is our original manuscript that has not published before, and is not currently under consideration by another journal and also all sources in the manuscript were cited carefully. We have taken a responsible for the submission of this research article and we accept the conditions of submission agreement.

Appendix

Appendix 1: List of trees and shrubs species found in the study areas

No	Scientific name	Family name	Origin	Type
1	*Acacia abyssinica*	*Fabaceae*	Indigenous	Tree
2	*Acacia decurrens*	*Fabaceae*	Exotic	Tree
3	*Acacia melanoxylon*	*Fabaceae*	Exotic	Tree
4	*Azadirachta indica*	*Meliaceae*	Exotic	Tree
5	*Cytisus proliferous*	*Fabaceae*	Exotic	Shrub
6	*Cordia africana*	*Boraginaceae*	Indigenous	Tree
7	*Croton macrostachyus*	*Euphorbiaceae*	Indigenous	Tree
8	*Cuppressus lusitanica*	*Cupressaceae*	Exotic	Tree
9	*Dombeya torrida*	*Sterculiaceae*	Indigenous	Tree
10	*Ekebergia capensis*	*Meliaceae*	Indigenous	Tree
11	*Erythrina abyssinica*	*Fabaceae*	Indigenous	Tree
12	*Erythrina brucei*	*Fabaceae*	Indigenous	Tree
13	*Eucalyptus globulus*	*Myrtaceae*	Exotic	Tree
14	*Eucalyptus camaldulensis*	*Myrtaceae*	Exotic	Tree
15	*Ficus sur*	*Moraceae*	Indigenous	Tree
16	*Grevillea robusta*	*Proteaceae*	Exotic	Tree
17	*Hagenia abyssinica*	*Rosaceae*	Indigenous	Tree
18	*Juniperus procera*	*Cupressaceae*	Indigenous	Tree
19	*Malus domestica*	*Rosaceae*	Exotic	Tree
20	*Millettia ferruginea*	*Fabaceae*	Indigenous	Tree
21	*Morus alba*	*Moraceae*	Exotic	Tree
22	*Olea europaea*	*Olacaceae*	Indigenous	Tree
23	*Persea americana*	*Lauraceae*	Exotic	Tree
24	*Podocarpus falcatus*	*Podocarpaceae*	Indigenous	Tree
25	*Prunus domestica*	*Rosaceae*	Exotic	Tree
26	*Rhus glutinosa*	*Anacardiaceae*	Indigenous	Shrub
27	*Rhus natalensis*	*Anacardiaceae*	Indigenous	Shrub
28	*Ricinus communis*	*Euphorbiaceae*	Indigenous	Shrub
29	*Rosa abyssinica*	*Rosaceae*	Indigenous	Shrub
30	*Sesbania sesban*	*Fabaceae*	Indigenous	Shrub
31	*Vernonia amygdalina*	*Asteraceae*	Indigenous	Shrub
32	*Yushania alpina*	*Poaceae*	Indigenous	Woody grass

Appendix 2: Importance value index of woody species in five land use types

Important value index of species							
No	Species name	Land use categories					Average IVI
		HG	BD	WL	CL	GL	
1	*Eucalyptus globulus*	47.03	146.7	197.5	–	–	78.26
2	*Cytisus proliferous*	–	6.86	4.15	118.0	35.94	32.99
3	*Cuppressus lusitanica*	63.50	59.11	35.45	4.52	–	32.51
4	*Acacia decurrens*	20.41	8.47	5.98	56.54	46.52	27.59
5	*Juniperus procera*	8.07	21.99	–	3.46	73.18	21.34
6	*Yushania alpina*	13.64	15.97	48.77	–	–	15.68
7	*Erythrina brucei*	4.30	3.98	–	33.48	27.35	13.82
8	*Vernonia amygdalina*	12.55	4.31	–	24.51	18.81	12.04
9	*Ficus sur*	2.78	2.18	–	14.84	26.64	9.29
10	*Acacia abyssinica*	–	2.18	–	9.39	32.32	8.78
11	*Malus domestica*	28.51	–	–	8.55	–	7.41
12	*Eucalyptus camaldulensis*	1.02	13.63	8.11	–	–	4.55
13	*Prunus domestica*	22.12	–	–	–	–	4.42
14	*Persea americana*	18.69	–	–	–	–	3.74
15	*Erythrina abyssinica*	1.02	3.73	–	–	13.05	3.56
16	*Grevillea robusta*	15.16	2.18	–	–	–	3.47
17	*Cordia africana*	1.72	–	–	10.43	3.86	3.20
18	*Ekebergia capensis*	–	–	–	5.87	8.45	2.86
19	*Croton macrostachyus*	3.97	–	–	3.46	3.86	2.26
20	*Hagenia abyssinica*	1.02	2.88	–	–	6.16	2.01
21	*Olea europaea*	2.11	–	–	3.46	3.86	1.89
22	*Sesbania sesban*	7.66	–	–	–	–	1.53
23	*Rhus glutinosa*	7.33	–	–	–	–	1.47
24	*Acacia melanoxylon*	6.51	–	–	–	–	1.30
25	*Millettia ferruginea*	–	–	–	3.46	–	0.69
26	*Dombeya torrida*	–	3.34	–	–	–	0.67
27	*Podocarpus falcatus*	3.29	–	–	–	–	0.66
28	*Azadirachta indica*	–	2.49	–	–	–	0.50
29	*Ricinus communis*	2.48	–	–	–	–	0.50
30	*Rhus natalensis*	2.11	–	–	–	–	0.42
31	*Morus alba*	1.99	–	–	–	–	0.40
32	*Rosa abyssinica*	1.02	–	–	–	–	0.20
	Total	300	300	300	300	300	300

HG-Homegarden BD-Boundary planting WL-Woodlot CL-Crop land GL-Grazing land.

Appendix 3: The lists of recorded species in decreasing order of basal area

Basal area of species in (m^2/ha)							
No	Species name	Land use categories					Total BA
		HG	BD	WL	CL	GL	
1	*Eucalyptus globulus*	4.17	33.72	14.02	–	–	51.91
2	*Cuppressus lusitanica*	1.25	8.21	16.29	0.05	–	25.81
3	*Eucalyptus camaldulensis*	0.03	12.61	3.89	–	–	16.54
4	*Ficus sur*	1.67	5.34	–	0.67	1.49	9.17
5	*Yushania alpina*	0.60	1.97	5.32	–	–	7.88
6	*Juniperus procera*	0.39	3.68	–	0.06	2.33	6.46
7	*Acacia decurrens*	0.28	2.31	0.85	0.32	0.61	4.37
8	*Croton macrostachyus*	2.15	–	–	0.31	1.07	3.53
9	*Erythrina abyssinica*	0.15	1.71	–	–	1.26	3.12
10	*Cordia africana*	1.09	–	–	0.83	1.07	2.99
11	*Acacia abyssinica*	–	0.98	–	0.50	0.91	2.40
12	*Dombeya torrida*	–	2.05	–	–	–	2.05
13	*Grevillea robusta*	0.39	1.41	–	–	–	1.80
14	*Erythrina brucei*	0.36	0.89	–	0.14	0.31	1.70
15	*Vernonia amygdalina*	0.28	0.41	–	0.27	0.33	1.29
16	*Acacia melanoxylon*	0.80	–	–	–	–	0.80
17	*Cytisus proliferous* -		0.31	0.19	0.17	0.09	0.75
18	*Olea europaea*	0.47	–	–	0.11	0.09	0.67
19	*Azadirachta indica*	–	0.63	–	–	–	0.63
20	*Persea americana*	0.63	–	–	–	–	0.63
21	*Hagenia abyssinica*	0.06	0.32	–	–	0.17	0.55
22	*Malus domestica*	0.27	–	–	0.13	–	0.40
23	*Ekebergia capensis*	–	–	–	0.13	0.25	0.38
24	*Podocarpus falcatus*	0.37	–	–	–	–	0.37
25	*Sesbania sesban*	0.14	–	–	–	–	0.14
26	*Rhus glutinosa*	0.14	–	–	–	–	0.14
27	*Prunus domestica*	0.08	–	–	–	–	0.08
28	*Ricinus communis*	0.07	–	–	–	–	0.07
29	*Millettia ferruginea*	–	–	–	0.06	–	0.06
30	*Rosa abyssinica*	0.04	–	–	–	–	0.04
31	*Rhus natalensis*	0.04	–	–	–	–	0.04
32	*Morus alba*	0.03	–	–	–	–	0.03
	Total	15.95	76.56	40.57	3.74	9.99	146.80

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