International Journal of Research in Agriculture, Biology & Environment (IJAGRI)

E-ISSN : 2582-6107

DOI: 10.47504/IJAGRI.2023.4.1.1

Volume 4(1) 2023
Jan - March -2023

Assessment on Farmers Tree Growing Practices and Tree Species Diversity in the Home Garden, Farmlands, and nearby Forest of Abaychomen District, Oromia Region, Ethiopia

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ABSTRACT

This study was conducted to investigate the farmers' tree growing practices and diversity of tree species in the home garden, farmlands, and nearby forest areas of Abaychomen District, Eastern Wollega, Oromia region, Ethiopia. Data were collected from sampled Households (HHs) using purposive random sampling methods for the socio-economic survey and a systematic sampling technique for vegetation assessment. For the interview, 152 HHs were selected from the two Peasant Associations of Gutene and Dinoberema. Focus group discussions and site observations were used. The result showed 51 tree species in Dinoberema and 41 in Gutene were identified and recorded. The Shannon diversity index is high in the natural forest of both sites and low in the crop fields of Gutene and home garden area of Denoberema. Simpson diversity index exhibited a similar trend as the Shannon diversity index in both sites. Croton macrostachyus and Podocarpus falcatus are the 1st and the 2nd most important tree species in both sites. Higher Sorensen coefficient similarity observed between crop field and home gardens. The result also revealed, HHs within the rich wealth class have a large area of home garden related to medium and poor. According to respondents viewed, (80 % observed labour availability) in Gutene and (60% observed land availability) in Dinoberema were opportunities to grow trees. However, shortage of cash and land were the main constraints for tree growing practices. Therefore, this study is important for effective tree biodiversity. Hence, identifying and documenting the tree species diversity and practices of local peoples on tree management are necessary to build the gaps in knowledge.

Key words: Crop field, Diversity index, Ethiopia, Home garden, Important tree species, Natural forest, Sorensen coefficient.

1.INTRODUCTION

Trees play various functions in rural livelihoods, contribute significantly to the economy (via sales of wood, timber, and wood products), and have ecological advantages. For instance, Eucalyptus trees grow faster and are productive (Arnold *et al*., 2022; Lusambo *et al*., 2021). They are a part of biodiversity (e.g., decrease soil degradation). Almond *et al*. (2020) assert that the absence of conservation efforts and widespread and intensive exploitation reduces the biological variety. Furthermore, some conventional agricultural methods are common to a diversity of plant species while there is low species diversity. The diversity of tree species acted as a buffer against disturbances like drought or pest outbreaks, according to Berthelot *et al*. (2021) and Loreau *et al*. (2021). By enhancing and stabilizing the social, economic, and environmental benefits, even it provides additional income by supporting smaller-holder production (Octavia *et al*., 2022). The main traits and purposes of tree diversity were for sustainable agricultural production and land management (Tsufac *et al*., 2021; Salamath *et al*., 2022); additionally, the presence of numerous diverse herbs, shrubs, and tree species in agricultural landscapes favors the survival and maintenance of native species (Montagnini, 2020). Understanding the resource's complexity, diversity, and management is necessary for managing the tree species. This study aimed to record the extensive body of indigenous knowledge in the district and the farmers' justifications for implementing it because there was no recording of the farmers' knowledge and practices in managing tree species in the area (Luvoni, 2021). Effective decisions in land use and management of landscapes in agricultural and conservation techniques developed by farmer communities are important to preserve the biodiversity of plant species outside the protected areas. According to research by Abayneh Legesse and Mesele Negash (2021), for instance, Ethiopia's landscapes in agriculture have a variety of plant species; however, concentrated on home garden systems and traditional agroforestry land use based on ensete coffee (Mesfin Sahle *et al*., 2021). Consequently, farmers' biodiversity protection is crucial, but little research is accessible (Abayneh Derero *et al*., 2021).

2. MATERIALS AND METHODS

2.1. The Study Area's Description

Abaychomen District is found in the Horoguduru Zone of Eastern Wollega of Oromia Regional State, in the western region of Ethiopia. The District is located at 9°31'N longitude and 37°30'E latitude (Figure 1).

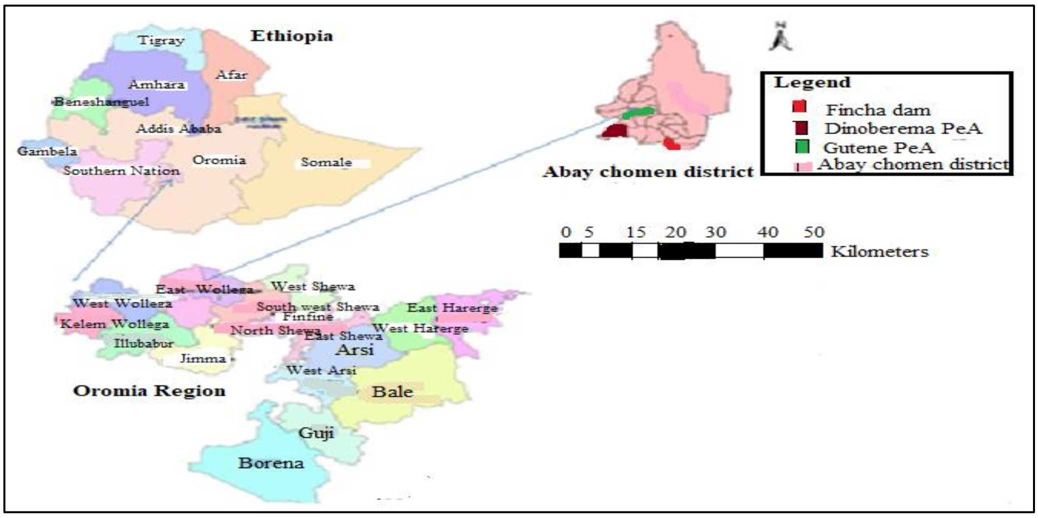

Figure 1. Map of Ethiopia Showing Oromia Regional States and Location of the Study Area

2.2. Selection of the Study Area

Reconnaissance surveys were conducted between October 15, 2022, and December 10, 2022. Discussions with interested parties and local experts, field observations, a socioeconomic survey using a questionnaire, and in-person interviews were all done as part of the reconnaissance surveys. Afaan Oromo, the local language, was used to translate the English-language questionnaires before being disseminated to the primary resource people—the locals and farmers. The survey included participant observations, interviews, and the utilization of historical data (i.e., secondary data sources). Based on observations, consultations with local experts, and secondary data sources, only two Peasant Associations (PeAs) among twelve were chosen by considering the two agroecological divisions (i.e., Highland and Middle altitude). Besides, criteria such as- market accessibility, traditional tree planting, managing practices, and representation of the main agro-climate were considered for this study. There are similarities and contrasts between the two PeAs. They differ in that the Gutene PeA has high land coverage (80%) agro climate with temperatures between 20°C and 25 °C and rainfall between 1300mm and 1800 mm, while the Denoberema PeA has a low land coverage (60%) agro climate with temperatures between 20 °C and 30 °C and rainfall between 20mm and 1500 mm. They have similar farming system, soil coverage, and land use scheme shared characteristics (mixed; crops and livestock). But, the Denoberema PeA area has covered with more riparian areas and forest cover than Gutene PeA.

2.3. Methods

2.3.1. Data collection

Both primary and secondary data-gathering techniques were used. For instance, interviews and a questionnaire were applied to generate the original data. To represent farmers' indigenous knowledge on the contribution of livelihood and conservation perception regarding the diversity of tree species on agricultural landscape and their implications for each HH was considered during data collection in the sampled HHs. The questionnaires were prepared in English, then translated into the Afaan Oromo dialect before being distributed to the respondents. For this research, household and vegetation surveys were used. HHs were chosen based on their financial standing, the presence of on-farm tree species, their significance to livelihood, and their value to biodiversity conservation. To determine whether the questionnaires were appropriate for the real-world circumstances at the study sites, some randomly chosen HHs participated in the pre-testing of the questionnaires. Three key informants from each of the two PeAs were carefully chosen and questioned. They are familiar with the conditions of the inhabitants of their respective sites because they worked in their "kebeles" leadership during various seasons. Sixteen people from two groups—eight experienced farmers in each "kebele"—participated in the FGD, including seniors, traditional leaders, and students. The FGD's goal was to gather more data on farmers' views and knowledge on the variety of tree species, planting techniques, and management of trees on agricultural land. In general, gathered information through interviews with 22 farmers who were significant informants in FGD.

2.3.2. Households selection and Sampling size determination

Knowing the socio-economic status and wealth ranking criteria (Taye Lemma & Girma Mengesha, 2021; Maheswarappa *et al.*, 2022) is used for selecting HH farmers (sampled HHs). The key informants (KIs) helped classify farmers into socio-economic status; through wealth categories (poor, medium, and rich), mainly based on the number of cattle, amount of annual crop

DOI: 10.47504/IJAGRI.2023.4.1.1

production, and type/standard of housing. A random selection procedure was used to obtain samples of individual HHs from each wealth category to have a systematic approach. In this study, the population number of each PeA was taken from the members' register in 2020. The total HHs of both PeAs was 457, of which 295HHs were in Gutene and 162 HHs in Denoberema. The sample frame of the HHs in both study areas holds persons who own at least a plot of farmland (N=336), of which 174 and 162 HHs were respectively, for Gutene and Denoberema PeAs. The sampled HHs determined following the formula of Kothari (2004). The formula to determine the sample size for finite population is indicated below.

$$n = \frac{Z^2 * p * q * N}{e^2 (N-1) + Z^2 * p * q};$$

Where, n= sample size,

Z = 95% confidence limit (interval) under the normal curve, i.e. 1.96.

p = 0.1(proportion of the population to be included in the sample, i.e.10%)

q = non-occurrence of event which is equal to (1- 0.1), i.e. 0.9.

N = Total number of population or Households

e = margin of error or degree of occurrence (acceptable error term) 0.05.

Based on the above formula, the calculated sample size of the HH members that were subject for both study areas was 152 HHs; of which 77and75 HHs were respectively for Gutene and Denoberema PeAs. The HHs from each of the three stratified wealth categories in the "kebeles'' were interviewed. Based on wealth ranking, about 81.6% of the sampled HH farmers were medium and poor farmers, indicating a subsistence type of farming and livestock production to earn their livelihood. In general, from the total sampled HHs (152 HHs), 18.42% were rich, 51.31% were medium and 30.27% were poor (Table 1).

Table 1. The number of selected HHs for the study

Name-of PeAs/Kebeles	Total Pop.no.	Total no.of HHs	Distribution of HHs based on wealth status						
			Total no. of HHs			Selected sampled HHs			
			Rich	Medium	Poor	Rich	Medium	Poor	Total
Gutene	1,947	295	44	140	111	12	36	29	77
Dinoberema	1,098	162	34	90	38	16	42	17	75
	3,045	457	78	230	149	28	78	46	152

2.3.3. Vegetation Sampling Method and Sampling Size Determination

A systematic sampling method was used to locate the sample plots in order to investigate species composition, diversity, abundance, dominance, similarity, and population structure (Kent and Coker, 1992). Sampling plots for both sites were taken considering the spatial distribution of the tree. The researcher made transect walking especially in the forest nearest to agricultural lands (250 m by 200 m) or 5 ha of the total plots. The transect lines were spaced 50 m between and within the parallel lines following (Gaya *et al*., 2022; Mandl *et al*., 2022). Transect lines were laid on the edge and inside of the natural forest, home garden, and agricultural lands using GPs, tape meters, and sample plots with 20 m x 20 m intervals of spacing (Berhe Mengistu *et al*., 2021) established for tree species. The sample plots were arranged systematically in blocks; at the edge and inside of the forest. Ten sample plots were taken from 5 ha area coverage in each study site; of which tree species in Jimmo and Laga Ciraa forests nearest to agricultural land of Gutene and Denoberema PeAs were respectively sampled. The sampling size on crop fields, natural forests, and home gardens was taken for this study. In crop fields, the researcher had taken 10 plots from 10 ha of which, each plot had a 1 ha size in each study site. The crop fields are fragmented and one farmer most probably owns 0.25 ha of a crop field. Tree species diversity in the natural forest adjacent to the crop field was used as a reference for comparison with other crop/home garden fields and its data was collected randomly from 5 ha of 10 plots each 20 m by 20 m sample plots that were systematically laid out along transect. In-home gardens, 60HHs (40% of the sampled HHs or 13% of total HHs in the study sites) were selected among 152 sampled HHs that were selected for the questionnaire survey. When identification of the trees was difficult in the field, local/vernacular names were recorded, and the sample specimens of the trees were collected, pressed, and identified at the National Herbarium (ETH) with the help of the volumes of the Flora of Ethiopia and Eritrea and by comparing them to the authenticated plant specimens housed at ETH, and their botanical names were listed along with their respective local names and collection numbers (Sue Edwards *et al*., 1997; SueEdwards *et al*., 2000).

2.4. Data Analysis

2.4.1. Socio-economic

The data were analyzed by using simple descriptive (qualitative) and quantitative (numerical methods). The in-depth information obtained based on people's perceptions and attitudes was summarized and interpreted through descriptive statistics (such as percentage and frequency) to understand different trends. Besides, the Chi-square test ($\chi 2$) was conducted on the frequency of occurrence while assessing the knowledge and attitudes of farmers toward tree planting practices, constraints, and management on agricultural landscapes. Finally, the results were interpreted or represented using tables, graphs, and charts

2.4.2. Vegetation

The tree species diversity on crop fields, home gardens, and adjacent to the natural forest was estimated using indices of species diversity and evenness of species distribution analyzed through the Shannon-Wiener indices of diversity and evenness (Kent and Coker, 1992). By using the following measurement of diversity indices formula (1), Shannon diversity index:-H' = - $\sum p_i \ln p_i$; Where, H' = Shannon diversity; P_i = proportion of individuals found in the i^{th} species. Values of the index (H') usually lie between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5 (Kent and Coker, 1992). (2), Simpson's diversity index: The Simpson's diversity (D) is given by the formula: $D = 1 - \sum p_i^{\,2}$; Where, D = Simpson's diversity index, P_i = as described above. Simpson's diversity index gives relatively little weight to the rare species and more weight to the most abundant species. It ranges in value from 0 (low diversity) to a maximum of (1-1/S), where S is the number of species (Krebs, 1985) and (3), Measure of the Species Evenness (Equitability):- $J = \frac{H'}{H'_{\max}} = \frac{\sum_{i=1}^{s} p_i \ln p_i}{\ln s}$ Where, s = the number of species, H', and P_i = as above. The higher the value of J, the more even the species is in their distribution within the sample (Kent and Coker, 1992). Similarity indices measure the degree to which the species compositions of different systems are alike. The Sorensen similarity coefficient was applied to qualitative data and widely used; it gave more weight to the species that were common to the samples rather than to those that only occur in either sample (Kent and Coker, 1992). The Sorensen coefficient of similarity (S_s) is given by the formula: $Ss = \frac{2a}{2a+b+c}$; Where, S_s = Sorensen similarity coefficient, a = number of species common to both samples, b = the number of species in sample 1, c = the number of species in sample 2 and, the coefficient is multiplied by 100 to give a percentage.

The importance of each tree species was also determined by Important Value Index (IVI), to estimate the home gardens, adjacent to natural forests and crop fields. According to Curtis and McIntosh (1951), IVI should be analyzed by adding the relative abundance, relative frequency, and relative dominance of each species, as indicated below:

$$\text{Relative density} = \frac{\text{Number of individuals of the species}}{\text{Total number of individuals}} * 100$$

$$\text{Relative dominance} = \frac{\text{Dominance of a species}}{\text{Total number of all species}} * 100$$

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

3. RESULT AND DISCUSSION

3.1. Tree Species Diversity

3.1.1. Tree diversity in the forest

From two study sites, a total of 72 tree species were recorded. 51 tree species in Denoberema and 41 in Gutene. Among these: 33 tree species were common for both study sites (Appendix table 1). The numbers of tree species (i.e., species richness) recorded in the Denoberema site were 22, 23, and 29 for home gardens, crop fields, and the natural forest, respectively. The Gutene site also had 21, 11, and 27 for home gardens, crop fields, and the forest, respectively (Appendix table 1). The Shannon diversity index is high in the forest and lowest in the crop fields, and there was a high Simpson diversity index in the crop fields followed by the natural forest (Table 2). In Dinoberema, more diversity of tree species was observed relatively than in Gutene. But, the evenness of the species was relatively high in Gutene PeAs (Table 2). Based on the Sorensen similarity percentage, higher Sorensen coefficient similarity was observed between crop fields and home gardens (Table 2). The presence of tree species existing today on crop fields/home gardens in the study sites might be the remnants of the vegetation in the natural forest that had been covered in the past. Due to this reason, similarities in tree species composition are expected between the nearby natural forest, crop fields, and home gardens.

The two PeAs were situated 35 km apart, but within each PeA the forest, farmland, and home gardens were within a 5 km distance. In the study sites, about 11.11% of natural forests in Guntene and 31.03% in Dinoberema were observed in their crop fields. About 25.92% of natural forest in Gutene and 27.58% in Dinoberema were also observed in the home gardens while 81.82% of crop fields in Gutene and 47.83% in Denoberema were observed in the home gardens (Appendix table 1). *Croton macrostachyus* in Gutene and *Podocarpus falcatus* tree species were the most important and widespread in both sites (Table 3). However, *Albizia schimperiana* is the most important tree in the natural forest of Gutene PeAs (Table 3). For comparison, the IVI of the nearest natural forest of the Denoberema study site (Table 3), showed that *Podocarpus falcatus* is the most important and frequent tree followed by *Carissa spinarum, Olea capensis, Clausena anisata,* and *Syzygium guineense.* While the estimated value

DOI: 10.47504/IJAGRI.2023.4.1.1

of IVI in the Gutene site showed that *Albizia schimperiana* is the most important and frequent tree followed by *Croton macrostachyus*, *Dodonaea Angustifolia*, and *Calpurnia area* (Table 3). More tree species occurred in the natural forests that were still preserved in the home gardens like *Croton macrostachus* and *Podocarpus falcatus*. More tree species were recorded in the Denoberema study site than in Gutene due to less disturbed by human interference and cutting of trees. The Shannon and Simpson diversity indices showed a high value in the natural forest as compared to the agricultural landscapes (Table 2). The similarity in tree composition between the natural forest and crop fields might show that there are native and remnants of tree species from the clearance of natural forest as a result of the expansion of agricultural land. The Sorensen coefficient similarity for crop fields and home gardens was greater than that of home gardens and natural forests or natural forest and crop fields (Table 2). This shows the high number of tree species in the natural forest which were not in the home gardens or crop fields. The tree species recorded in the natural forests were (27) in Gutene and (29) in Denoberema, respectively. It was slightly less or equal to the number reported by Motuma Tolera (2006; 31 tree species) and slightly greater than that of Mulugeta Lemenih *et al.* (2004; 25 native tree species), Feyera Senbeta (1998; 27 tree species), and Melaku Alebel (2021; 23 native tree species); and less than the number reported by Mulugeta Lemenih and Demel Teketay (2005; 33tree species) and in this study, very less number of trees were observed when compared with the number reported by Atomsa Dereje & Dibbisa, Duguma (2019; 48 native tree species), and the trees were found nearby forest areas of agricultural landscapes in different district areas of Ethiopia.

Table 2. Diversity of indices and Sorenson similarity percentage of tree species in natural forest, crop field and home garden in the two study sites

Land use	**Gutene PeAs (41Species)**			**Denoberema PeAs (51 Species)**		
	Shannon diversity index	Simpson diversity index	Species evenness	Shannon diversity index	Simpson diversity index	Species evenness
Natural forest	3.22	0.95	0.97	3.26	0.97	0.95
Crop fields	2.38	0.91	0.99	2.96	0.96	0.94
Homegardens	3.15	0.95	1.00	3.00	0.95	1.00
Sorensen similarity percentage in Tree species composition among the CF,HG and NF						
Land use	**Gutene PeAs**			**Dinoberema PeAs**		
	Natural forest (NF)	Crop fields (CF)	Homegardens (HG)	Natural forest (NF)	Crop fields (CF)	Homegardens (HG)
Natural forest	-	13.04	22.22	-	25.0	19.05
Crop fields	13.04	-	32.00	25.0	-	33.85
Homegardens	22.22	32.00	-	19.05	33.85	-

Table 3. Top Tree species found in crop field, home gardens and adjacent natural forest and their corresponding IVI in Gutene and Dinoberema PeAs.

Name of PeAs	**Scientific names**	**Important Value Index**			
		Crop field	Home garden	N/forest	Average
Gutene	*Albizia schimperiana*	0.00	8.13	25	11.22
,, ‘‘	*Croton macrostachyus*	56.47	22.02	19.75	32.75
,, ‘‘	*Dodonaea angustifolia*	0.00	10.56	15.78	8.78
,, ‘‘	*Calpurnea aurea*	0.00	7.34	15.56	7.63
,, ‘‘	*Clausena anisata*	0.00	0.00	15.06	5.02
,, ‘‘	*Syzygium guineense*	4.02	12.16	7.4	7.86
,, ‘‘	*Cordial africana*	7	3.5	14	2.06
,, ‘‘	*Sideroxylon oxyocanthum*	0.00	0.00	10.77	3.59
Dinoberema	*Clausena anisata*	6.89	0.00	15.76	7.55
,, ‘‘	*Podocarpus falcatus*	27.94	11.35	26.27	21.85
,, ‘‘	*Carissa spinarum*	0.00	0.00	16.89	5.63
,, ‘‘	*Syzygium guineense*	6.95	0.00	14.19	7.05
,, ‘‘	*Oleo caponises*	6.95	0.00	16.05	7.67
,, ‘‘	*Sideroxylon oxyocanthum*	4.92	0.00	15.72	6.88

3.1.2. Tree diversity in the crop fields

In both study sites, *Eucalyptus camaldulensis* was the most important tree species in crop fields/ in farm boundaries. The *Croton macrostachyus*, *Podocarpus falcatus*, and *Eucalyptus camaldulensis* were frequent in the crop fields of Gutene (Table 4). But,

DOI: 10.47504/IJAGRI.2023.4.1.1

Croton macrostachyus and *Podocarpus falcatus* were the next frequent tree species in the crop fields followed by *Eucalyptus camaldulensis* in Denoberema (Table 4). For instance, a photo of *Podocarpus falcatus* tree species with maize (in Denoberema) and out of maize crop (in Gutene) study sites observed while data collection as indicated in (Figure 2).

Table 4. List of major Tree species and its relative frequency, abundance and dominance (%) and IVI in Homegarden and Crop fields in Gutene and Dinoberema PeAs, in Abaychoman District

PeAs /Kebeles/	Land used	Species names	Freq.	Rel. freq. (%)	Abund.	Rel.Abund. (%)	Domin.	Rel. dom. (%)	IVI
Gutene	H/garden	*Eucalyptus camaldulensis*	10	5	143	20.69	18	16.51	42.2
	C/field	*Eucalyptus camaldulensis*	5	16.67	150	43.1	45	67.16	126.9
	C/ field	*Eucalyptus globulus*	1	3.45	121	34.77	0	0	38.22
Dinoberema	H/garden	*Eucalyptus camaldulensis*	6	5.34	146	28.51	42	32.06	65.91
	C/field	*Eucalyptus camaldulensis*	5	16.67	150	43.1	45	67.16	126.9
	C/field	*Eucalyptus globulus*	1	3.45	121	34.77	0	0	38.22
Gutene	H/garden	*Cupressus lusitanica*	16	8	81	11.72	9	8.26	27.98
Dinoberema	H/garden	*Cupressus lusitanica*	15	13.27	156	30.47	30	22.9	66.64
Gutene	H/garden	*Vernonia amygdalina*	7	3.5	54	7.81	15	13.76	25.07
	H/garden	*Croton macrostachyus*	18	9	52	7.52	6	5.50	22.02
Dinoberema	H/garden	*Croton macrostachyus*	15	13.27	56	10.94	6	4.58	28.81
	C/ field	*Croton macrostachyus*	7	23.33	45	12.93	13	19.4	55.66
Gutene	H/garden	*Podocarpus falcatus*	20	10	48	6.95	4	3.67	20.62
	C/field	*Podocarpus falcatus*	6	20	15	4.3	5	7.46	31.76
Dinoberema	H/garden	*Podocarpus falcatus*	8	7.08	14	2.73	2	1.53	11.35
	C/field	*Podocarpus falcatus*	6	20	15	4.3	5	7.46	31.76
Gutene	H/garden	*Rhamnus prinoides*	11	5.5	46	6.66	6	5.50	17.66
Dinoberema	H/garden	*Rhamnus prinoides*	4	3.56	16	3.12	5	3.82	10.48
Gutene	H/garden	*Nuxia congesta*	14	7	33	4.77	3	2.75	14.52
Dinoberema	H/garden	*Grevillea robusta*	6	5.34	21	4.10	7	5.34	14.78
	H/garden	*Cordia africana*	8	7.08	11	2.15	2	1.53	10.77
Gutene	C/field	*Croton macrostachyus*	7	23.33	45	12.93	13	19.4	55.66
	C/field	*Ficus sur*	3	10	6	1.72	3	4.48	16.2
Dinoberema	C/field	*Ficus sur*	3	10	6	1.72	3	4.48	16.2

Tree diversity and density exist in crop fields and can vary over time. Many wood lots with exotic trees may be converted into cropland, leaving a high number of remnant trees. Also, the value of a species may change in the market value. Similar results reported by Aklilu Bajigo *et al*. (2019) found a non-significant relationship between tree species richness and distance to market. The cause for the decline of forest resources was the ever-increasing population pressure and expansion of agricultural land. The threatened tree species were: *Hagine abyssinia*, *Cordia africana*, *Olea europaea*, *Vepris danielle*, *Albizia schimperiana*, and the species *Juniperus procera* has become nearly extinct from the study sites, and even in the sampled HHs there was no *Juniperus procera* available during data collection. Before 5 to 10 years ago, this species was available in the PeAs, but now extinct. As farmers recognized, the extinction of the species was due to clearing for agricultural land, cutting for fire, construction of wood, agricultural implements, wildfire (illegal fire, and others like for lumber and rope purposes. However, most farmers reported that farm-level tree cover increased by using their indigenous knowledge concerning tree species on their farmlands and homestead. This result confirms the report of (Kreitzman *et al*., 2022); the integration of plants, especially tree species in the crop fields, has been proposed as one way of diversifying agro-ecosystems in a way that is beneficial to the environment and can maintain and enhance biodiversity.

Figure 2. Photo of *Podocarpus falcatus*: In farmland without crop (Gutene-A) and with maize crop (Denoberema-B)

3.1.3. Tree diversity in the homestead

In the home garden area of Gutene, *Eucalyptus camaldulensis* is the most important tree species. Besides, *Cupressus lusitanica*, *Vernonia amygdalina*, *Croton macrostachyus*, and *Podocarpus falcatus* are important trees (Table 4). *Podocarpus falcatus* was the most frequent tree species, and *Eucalyptus camaldulensis* was the most abundant tree species, which alone comprised about 20.69% of the total abundance of all 21 tree species recorded in home gardens of Gutene (Table 4) (Appendix table1). In the home garden area of Denoberema study site, *Cupressus lusitanica* is the most important tree species. Next to it, *Eucalyptus camaldulensis*, *Croton macrostachyus*, *Grevillea robusta*, and *Podocarpus falcatus* (Table 4).

Table 5. Area of Home garden in Relation to Species Richness and Wealth Status of both Study Sites

Items	Gutene PeAs			Denoberema PeAs		
	Poor	Medium	Rich	Poor	Medium	Rich
Total area of home garden (ha)	0.91	2.4	4.02	1.17	2.78	4.17
Average area of homegarden	0.09	0.24	0.40	0.12	0.28	0.42
Total number of trees	166	208	244	233	279	296
Average Number of tree	17	21	24	23	28	30

The diversity of tree species in home gardens was affected by the wealth status of the household, area, and age of the home gardens (Table 5). In both study sites, the HHs within the rich wealth class has a larger average coverage area, and the tree species in the home garden were higher than the medium and poor HHs (Table 5). The direct relationship between the tree richness, area, and age of the home garden indicates that tree richness increases with the increasing size and age of the home gardens. The result also showed that HHs within the rich wealth class has a larger average area of the home garden as compared to the HHs in the medium and poor wealth classes (Table 5). Giday Kidane *et al.*(2019) and Mebrate Abiyot *et al.* (2021) reported a positive relationship between farm size and tree species richness per farm and a similar relationship between wealth status and farm size in southern Ethiopia.

3.2. Tree growing and management practices

Tree planting patterns in the two PeAs described (Table 6) reveal some of the farms that had most trees maintained or planted by farmers. All farmers (100%) planted trees inside/around their homes (Table 6). Trees along the roadside in both PeAs accounted for the largest share of the total trees (i.e., Gutene 37.73% and Dinoberema 38.3%). There was a significant difference in practicing planting trees among the study areas along the gully and rivers (DF=1, $P<0.05$, $\chi2 =2.15$) and woodlots (DF=1, $P>0.05$, $\chi2 =3.9$) (Table 6). In both study areas, both practices of planting trees along the gulley and rivers, woodlots used for soil and water conservation, and firewood and construction wood.

Table 6. Number and (%) of participant farmers on trees growing and Proportion of trees

Type of land unit	Proportion of farmers practicing tree growing		Proportion of trees in each habitats and PeAs	
	Gutene	Dinoberema	Gutene	Dinoberema
Homestead	77(100%)	75(100%)	835(8.44%)	1791(19.74%)
Tree along roads	43(55.84%)	61(81.33%)	3,734(37.73%)	3,466(38.20%)
Tree along gully & rivers	21(27.27%)	4(5.33%)	1,231(12.44%)	926(10.21%)
Tree in farm land	77(100%)	75(100%)	864(8.73%)	1484 (16.36%)
Woodlots	25(32.46%)	10(13.33%)	3,233(32.67%)	1404 (15.48%)

DOI: 10.47504/IJAGRI.2023.4.1.1

Total	77HHs	75HHs	9,897(100%)	9,071(100%)

[The numbers before the parentheses indicate frequencies (number of farmers), those inside parentheses show the percentages]

Fencing and thinning practices are applied by farmers as the most common management practices (Figure 3). All 77(100%) respondents viewed that fencing tree management practice was common in Gutene. While 64 (85.33%) of respondents agreed, thinning was more practiced in Dinoberema (Figure 3). There was an insignificant difference in managing trees through pruning (DF=3, $P<0.05$, $\chi 2 = 2.64$) and weeding and hoeing (DF=3, $P<0.05$, $\chi 2 = 1.16$) among the sites.

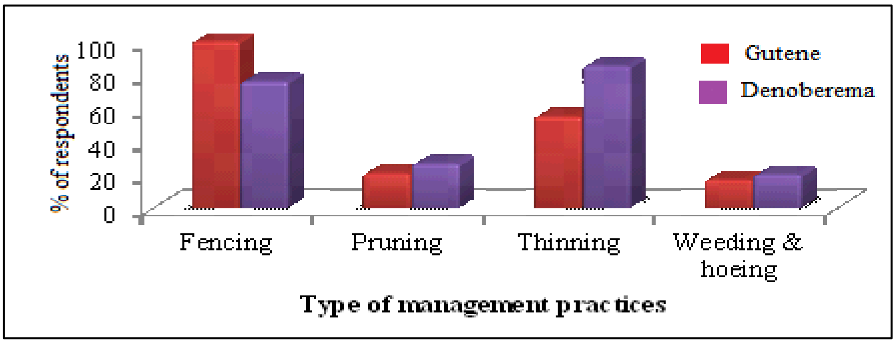

Figure 3. Farmers Tree management practices in Gutene and Dinoberema Peasant Associations

The study in Sidama by Shanka Talemos (2022) showed that most farmers in all surveyed villages practiced cultivation, thinning, and coppice wood removal for Eucalyptus woodlots. In this study area, farmers have considerable knowledge of seedling production and tree growing; they propagate *Eucalyptus globulus, E. camaldulensis*, and *Rhamnus prinoides*. This finding agrees with a study conducted in Northwestern Ethiopia by Ruelle Morgan & Asfaw Zemede (2022), who reported that the knowledge concerning tree planting and maintenance is not mentioned as a constraint, except when new tree species are introduced farmers are unfamiliar. Most of the farmers in the study area have used seedlings from wild regenerations to replace old indigenous trees in their farm, including trees such as *Acacia abyssinica* and *Croton macrostachyus*. Many agree that to protect young natural existed than to plant nursery stock. The practice of managing the existing natural regeneration, rather than raising seedlings in nurseries and then replanting has many advantages of labor and cost reduction (Haase *et al*., 2021)

3.3. Opportunity and constraints on tree growing practices

About 62(80%) and 65(84%) of respondents in Gutene and 49(65%) and 53(70%) in Dinoberema PeAs viewed respectively that shortage of cash and land were the main constraints to the growing tree (Figure 4). Comparatively, labor shortage and tools/equipment scarcity were high in Denoberema than in Gutene (Figure 4). Access to marketing, credit (an organization that gives money to purchase fertilizer, domestic animals, and others for farmers), infrastructure, land, and labor availability were also identified (Table 7). Respondents viewed a higher number of the fair households' perceptions to access market (i.e., 62%) (in Gutene) and poor households' perceptions to access credit (i.e., 90%) (in Denoberema) for tree-growing practices. Labour (80%) and land availability (60%) showed excellent access to Gutene and Dinoberema study sites, respectively (Table 7). There was a significant difference observed in tree-growing constraints with the shortage of cash (DF=3, $P>0.05$, $\chi 2 = 220$) and land (DF=3, $P>0.05$, $\chi 2 = 318$).

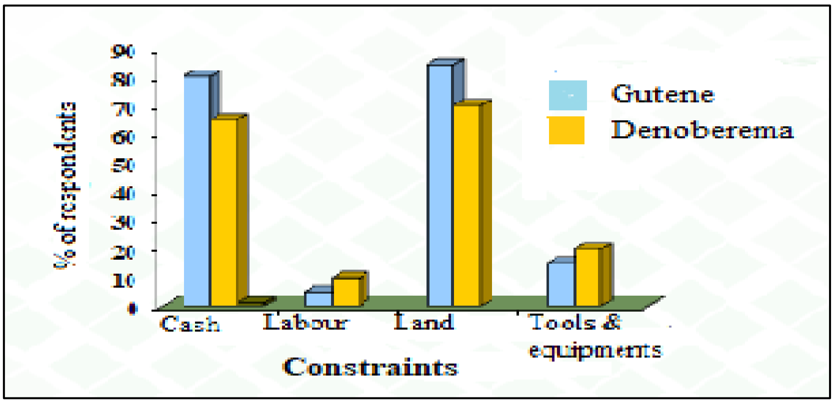

Figure 4. Major Constraints Identified on Tree Growing Practices in both Study Sites

Table 7. Farmers' Opinion to Access Facilities and Resources on both PeAs

Access to:	Households respondent perception%							
	Gutene PeAs (N=77)				Denoberema PeAs (N=75)			
	Excellent	Good	Fair	Poor	Excellent	Good	Fair	Poor
Credit	0	7	13	80	0	4	6	90
Infrastructure	0	50	42	8	0	20	50	30
Labour availability	80	10	5	5	25	25	50	0
Land availability	0	48	36	16	60	5	5	30
Marketing	0	35	62	3	0	20	50	30

In this study, land shortage, tools, equipment, and labor are other constraints to managing tree growth (Figure 4). Labor availability was mentioned as a constraint in agroforestry practice in Kenya by Luvoni (2021), and another study by Tesfay Asgele *et al.* (2021) showed that shortage of water and land were the most constraints in eastern Tigray, in Ethiopia. The capital was not an obstacle for the farmers not to plant trees, regardless of their wealth status in the community. Market accessibility, credit, infrastructure, land, and labor availability were factors for tree growing and management practices (Figure 4). Farmers in the study sites obtain credit from Ormia Credit and Saving Association and other local organizations. Similarly, farmers in Tigray explained that they take credit from the Relief Society of Tigray Reda Kelemaworke & Gidey Desta (2021). Other factors that affect the development of trees justified by the extension staff workers were: the absence of land, unstable organizational structures, inadequate extension approach, lack of capital, time factor to get the return, securing of land, adequate budget, and materials, etc., were factors which affect farmers not to plant more trees even though, they had a traditional way of managing trees, similar to findings of Van Khuc *et al*. (2020).

4. CONCLUSION

In tree-growing practices, there were both opportunities and constraints. Management-related factors encourage/discourage tree growth. Farmers know what type of trees they want to grow in their land use system. The number and species types that the farmers grow mainly in the home gardens were easy to look after because of the distance factor that the trees located around dwellings. The species richness in home gardens may lead to the assumption that ownership is right in preserving tree species diversity. Farmers are still utilizing the tree resources that exist in their crop fields. There is no current legal right not to use the trees. The properties in the home gardens are under farmer control for protection and utilization. Agricultural land policies must encourage the inclusion of diverse tree species that are of high value, both ecologically and economically, without hampering production, simultaneously ensuring the sustainability of production and food security. So, monoculture trends have to reverse because of the low levels of diversity, susceptibility to disease and pests, and lower levels of resilience.

ACKNOWLEDGMENTS

Firstly, I would like to express my gratitude to the Abay Chomen District, Rural and Development Office, and Kebeles offices of Gutene and Dinoberema PeAs for their valuable assistance. Besides, I thank the key informants, FGDs, and the individuals who assisted me during the data collection. My special thanks also go to the staff and Development Agents of both PeAs who helped me while collecting data. Finally, I thank Ambo University for its financial support.

DECLARATION

Abbreviations: FGDs- Focus Group Discussants, HHs-Households, PeAs-Peasant Associations
Ethical consent for publication: Not applicable
Conflict of interest: The Author declares that there is no competing interest
Author contribution: All contribution was carried out by the author, starting from data collection, writing the draft, editing, and approval.

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Appendix table 1. List of all tree species recorded and similarity in composition of tree species among Crop fields, Homegardens and Natural forest at Gutene and Dinoberema PeAs.

Scientific names	Name of Peasant Associations		Similarity in composition of tree species among Home garden, Crop field and Natural forest						
	Gutene	Dinoberema	H	C	N	C x H	C x N	H x N	C x H x N
Acacia abyssinica	✓		0	0	1	0	0	0	0
		✓	0	1	1	0	1	0	0
Acacia etbaica		✓	0	1	0	0	0	0	0
Podocarpus falcatus	✓		1	1	0	1	0	0	0
		✓	1	1	1	1	1	1	1
Albizia gummifera	✓		1	0	1	0	0	1	0
		✓	1	1	1	0	0	0	0
Apodytes dimidiata	✓	✓	0	0	1	0	0	0	0
Bersama abyssinica	✓		0	0	1	0	0	0	0
Buddleja polystachya		✓	0	1	0	0	0	0	0
Carissa spinarum	✓	✓	0	0	1	0	0	0	0
Catha edulis	✓	✓	1	0	0	0	0	0	0
Cayii *		✓	0	0	1	0	0	0	0
Celtis africana	✓		1	1	0	1	0	0	0
		✓	1	0	1	0	0	0	0
Coffea arabica	✓		1	0	1	0	0	0	0
Clausena anisata	✓		0	0	1	0	0	0	0
		✓	0	0	1	0	0	0	0
Cordia africana	✓		1	0	0	0	0	0	0
		✓	1	1	0	1	0	0	0
Croton macrostachyus	✓	✓	1	1	1	1	1	1	1
Cupressus lusitanica	✓		1	0	0	0	0	0	0
		✓	1	1	0	1	0	0	0
Dodonaea agustifolia	✓		1	0	1	0	0	1	0
		✓	0	0	1	0	0	0	0
Dovetails abyssinica		✓	0	1	0	0	0	0	0
Ekebergia capensis	✓		0	1	0	0	0	0	0
		✓	1	1	1	1	1	1	1
Ensete ventricosum	✓		1	0	1	0	0	1	0
		✓	1	0	0	0	0	0	0
Eucalyptus	✓		1	1	0	1	0	0	0
camaldulensis		✓	1	1	0	1	1	1	0
Eucalyptus globulus		✓	1	1	0	0	0	0	0
Ficus ovata	✓		1	1	0	1	0	0	0
		✓	1	1	1	1	1	1	1
Ficus sur		✓	0	0	1	0	0	0	0
Ficus sycomorus		✓	0	0	1	0	0	0	0
Ficus vasta	✓	✓	0	0	1	0	0	0	0
*Gagura**	✓		0	0	1	0	0	0	0
Gaarii *		✓	0	0	1	0	0	0	0
Grevillea robusta	✓		1	0	0	0	0	0	0
		✓	1	0	0	0	0	0	0
Grewia mollis		✓	0	0	1	0	0	0	0
Hagenia abyssinica	✓		0	0	1	0	0	0	0
Hypericum revolutum	✓		0	0	1	0	0	0	0
Justicia schimperiana		✓	1	0	0	0	0	0	0
Leucaena leucocephala	✓		0	0	1	0	0	0	0
Malus sylvestris	✓		1	0	1	0	0	1	0
Maytenus arbutifolia	✓		0	0	1	0	0	0	0
		✓	0	1	1	0	0	0	0
Maytenus undata	✓		0	0	1	0	0	0	0
		✓	0	1	1	0	1	0	0
Mimusops kummel	✓	✓	0	0	1	0	0	0	0
Myrica salicifolia		✓	0	0	1	0	0	0	0
Olea capensis		✓	0	0	1	0	0	0	0
Olea europaea		✓	0	1	0	0	0	0	0
Olinia rochetiana	✓		0	0	1	0	0	0	0
		✓	0	0	1	0	0	0	0

DOI: 10.47504/IJAGRI.2023.4.1.1

Osyris quadripartita		✓	0	0	1	0	0	0	0
Phoenix reclinata	✓		0	0	1	0	0	0	0
		✓	0	1	0	0	0	0	0
Pinus patula	✓		0	1	0	0	0	0	0
Prunus africana	✓		1	1	1	1	1	1	1
		✓	1	1	1	1	1	1	1
Qilinxoo *		✓	0	0	1	0	0	0	0
Qomonyo *		✓	0	1	0	0	0	0	0
Rejii * (*Vernonia spp.*)	✓		0	0	1	0	0	0	0
		✓	1	1	0	1	0	0	0
Rhamnus prinoides	✓		1	0	1	0	0	0	0
		✓	1	0	0	0	0	0	0
Rhus glutinosa	✓		0	0	1	0	0	0	0
		✓	0	0	1	0	0	0	0
Rosa abyssinica		✓	0	1	1	0	1	0	0
Schinus molle	✓		1	0	1	0	0	0	0
		✓	1	0	0	0	0	0	0
Schrebera alata		✓	0	0	1	0	0	0	0
		✓							
Spathodea campanulata	✓		0	0	1	0	0	0	0
		✓	1	0	0	0	0	0	0
Syzygium guineense	✓		1	1	1	1	1	1	1
		✓	0	1	0	0	0	0	0
Teclea nobilis	✓		0	1	0	0	0	0	0
		✓	0	0	1	0	0	0	0
Olea welwitschii	✓		1	1	0	1	0	0	0
		✓	1	1	0	1	0	0	0
Vernonia amygdalina	✓		1	0	0	1	0	0	0
		✓	1	1	0	1	0	0	0
Total	**41**	**51**	**21G/22D**	**11G/23D**	**27G/29D**	**9G/11D**	**3G/9D**	**7G/8G**	**3G/5D**

`

Note: tree species recorded in Homegarden were (21 in Gutene/22 in Dinoberema); in Crop fields (11 in Gutene/23 in Dinoberema) : in Natural forest (27 in Gutene/29 in Dinoberema). Species recorded in both Crop field and Homegarden (9 in Gutene/11 in Dinoberema), in both Crop field and Natural forest (3 in Gutene/ 9 in Denoberema), in both Homegarden and Natural forest (7 in Gutene and 8 in Dinoberema); and in both Homegarden, Crop field and Natural forest (3 in Gutene/ 5 in Dinoberema). In general, 33 species were recorded in both study sites.*Local names; absent=0, present=1, C = crop fields; H = Homegardens; N = natural forest, G= Gutene, D= Dinoberema

DOI: 10.47504/IJAGRI.2023.4.1.1