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Research Article

Woody Species Diversity and Farmers' Preference of Parkland Agroforestry System in Benishangul Gumuz, Western Ethiopia

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Abstract

Although there is a wealth of indigenous knowledge on managing parkland woody species, understanding farmers' strategies on woody species diversity, preference, and purpose of keeping scattered trees with annual crops were insufficiently documented yet. This study was conducted to investigate woody species diversity, farmers' preferences, and the purpose of keeping scattered trees on farmlands in the Assosa district, Western Ethiopia. Three administrative kebeles were selected purposively. Multi-stage sampling technique was employed to collect the primary data from the sample households. A total of 114 households were randomly selected for species preference and the purpose of keeping trees; of which 59 households were randomly selected proportionally for woody species inventory. Both qualitative and quantitative data were analyzed by using Statistical Package for Social Sciences, Version 20.0, and Microsoft Excel 2010. A total of 31 plant species belonging to 30 genera and 19 families were recorded in the parkland of the study area. Shannon diversity was higher at Selga -22 Ketena-1 than Ketena-2. Selga -20 Ketena-1 has higher species diversity than that of Ketena-2, but with a non-significant difference at ($p<0.05$). On the contrary, species evenness at Selga -20 Ketena-1 was significantly higher than that of Selga -21 Ketena-2 at ($p<0.05$). The study revealed that parkland agroforestry practice plays an important role in conserving native woody species and by providing food, income, and a wide range of other products such as fuel wood, construction, fodder, food, and medicinal plants.

ABBREVIATIONS

ADANRMO: Assosa District Agriculture and Natural Resource Management Office; DAs: Development Agents; FGD: Focus Group Discussion; HHs: House Holds; KAs: Kebele Administrations; KI: Key Informants;

INTRODUCTION

Agroforestry is a land use that has been practiced for a long time in many parts of the world [1]. However, the type, composition, and extent vary from place to place because of varied topography, biophysical attributes, and socioeconomic settings [2]. There are many types of traditional agroforestry practices found in different parts of Ethiopia [3]. Based on this, Parkland agroforestry, hedgerow intercropping, multi-strata home gardens, and riparian vegetation are the most noticeable traditional practices across most agroecosystems of the country [4].Woody species in parkland agroforestry practices favor the survival of native woody plants. Consequently, overall woody species diversity in parkland agroforestry is strongly linked to the quality of parkland tree structure [5].

In parkland agroforestry practice, specific characteristics of tree species are very important for the selection of species to be planted on the farmland following certain criteria ranging between the utility, drought resistance nature of the species, compatibility with crop elements, and potential for improvement of soil fertility[6]. Moreover, understanding the roles of trees on farms and diversification of the farm in terms of species richness, as well as evenness through increasing the number of trees of rare species, or through replacement of more indigenous species, are the best options for preventing the degradation of agroforest ecosystems on farms [7].

Some studies have been carried out in different parts of the country about parkland woody species diversity [8]. Framers in the Assosa district of Western Ethiopia have a wealth of indigenous knowledge on the management of parkland agroforestry systems particularly woody and non-woody plant diversity. Despite this, understanding farmers' strategies in the woody species diversity and farmers' preference for parkland agroforestry systems are insufficiently documented. Therefore, this study investigated woody species diversity and farmers' preference in parkland agroforestry practice in the Assosa district, Western Ethiopia.

MATERIALS AND METHODS

The study was carried out in Assosa District, Benishangul Gumuz Regional State, Western Ethiopia. The district is geographically located from 9º 42' 0'' to 10º 12' 0'' N latitude and 34º 12' 0'' to 34º 42' 0'' E longitude (Figure 1) and at a distance of 687km from the capital Addis Ababa. Assosa district has 74 kebeles; 66.22 % (49 kebeles) of the kebele practice parkland agroforestry while, the other 33.78% (25 kebeles) depend on daily labors, shifting cultivation, monoculture, trade, traditional mining, etc [9].

The total population of Benishangul Gumuz Region is 460,459 with a population density of 9 persons/Km^2. Assosa zone, one of the three zones and two special districts in the region, has a total area of 1,519 Km^2 and a population of 28, 970 (population density of 19.1 persons/Km^2) [10]. The topography of the area is characterized by undulating elevation, which decreases gradually towards the western part to an average altitude of 500m along Ethiopia -Sudanese border [11]. Assosa district is characterized by an elevation range of 1300 to 1470 m above sea level [12]. The climate of the area is sub-humid with mean minimum and maximum temperatures of 14.4 and 28.5^{o}C, respectively. Assosa has a mono-modal rainfall pattern from the end of April to October with an average annual rainfall of approximately 1291.2 mm [12].

Soils of the study area are characterized by very low organic carbon and nitrogen Content, an indicator of low soil fertility status. The low nutrient status of the soils is constrained by the limited use of both organic and inorganic fertilizers and the loss of nutrients through leaching [12].Subsistence agriculture is the major economic activity, engaging approximately 80% of the population. Major crops are millet, sorghum, maize, sesame, cotton, soybean, coffee, and mango. These crops are produced by rain-fed and, to some extent in irrigated agriculture [11].

Sampling Techniques and Sample Size Determination

Multi-stage sampling technique was employed to collect the primary data from the sample households. In the first stage, to select sample kebeles out of all kebeles within the district, prior information (biophysical attributes and agroforestry practice) was collected from possible sources at the district level. In the next stage, out of 49 kebeles within the district, three kebeles were selected purposively based on the existence of parkland agroforestry practice [9], namely, Selga-20, Selga-21, and Selga-22. Finally, two villages were randomly selected from each kebele administration. In this study, the stratification of kebeles/villages was done for different reasons such as to increase the precision of population assessments, to avoid bias, to accommodate different sampling procedures, and to take accurate and reliable data from the field.

The number of sample households was determined by using proportionate random sampling to assess woody species diversity, and farmers' preference of the local community following simplified formula provided by [13] at a 92 percent of Confident interval.

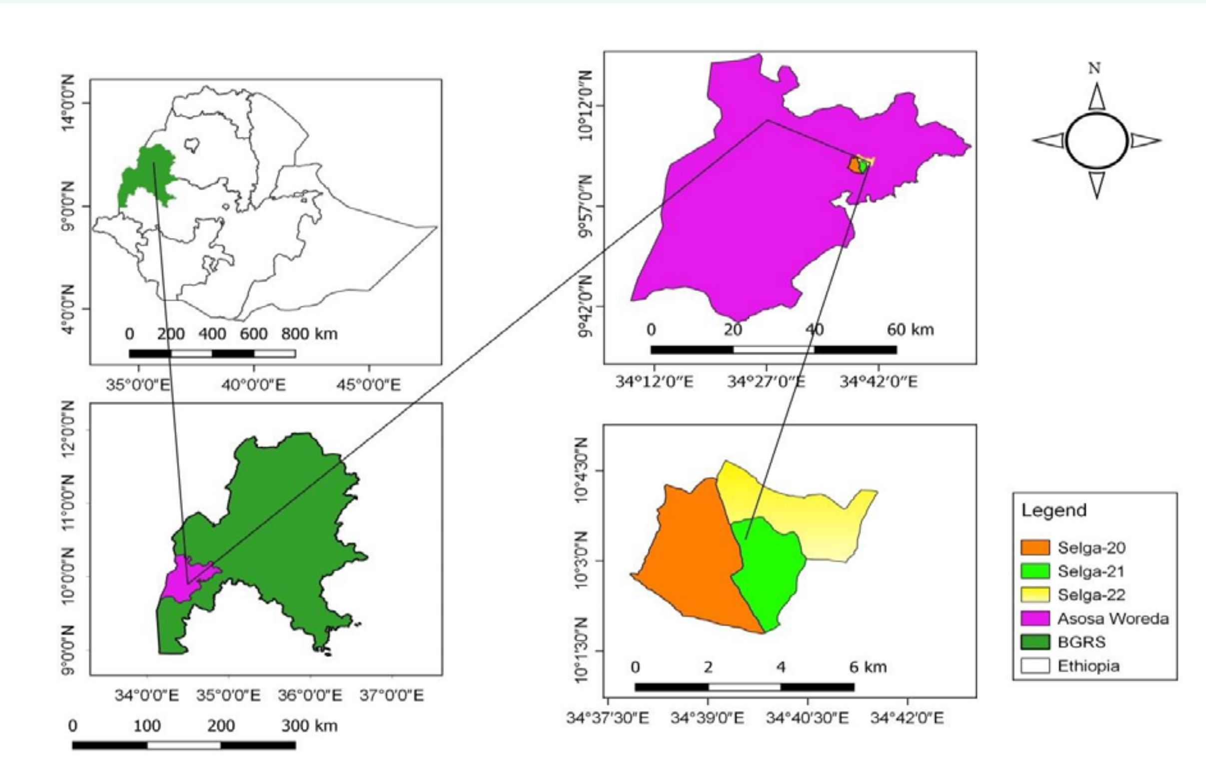

Figure 1 Map of the study area.

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

where, n=the sample size, N=the population size, e= allowed errors which are 8%.

Accordingly, from a total number of kebele households (N=422) Obtained from the Kebele agricultural development office and kebele administration, 114 HHs were randomly selected using a simple random sampling technique and a total number of households from which sample size determined in each KAs (villages) were from Selga-20 kebele 221 HHs (Ketena 1 = 112, Ketena 2= 109), Selga-21kebele 98HHs (Ketena 2= 48, Ketena 3=50) and Selga-22 kebele 103HHs (Ketena 1 =47, Ketena 2= 56). In this study, Ketena/Village is defined as the smallest sub-unit of kebele, which has many sub-units called ''Gots''. 422 (N) households in sampled Kebeles were the target households of the study.

To determine the sample household size in each Kebele, the proportional sampling formula was used.

$$n1 = \frac{N1}{N} \times n$$

where, n1= sample household size in Kebele Administration (KA)1, N1= is the total household in KAs 1, n= is a total sampled household from the three KAs and N= is the total households in the three kebele. Hence, from Selga-20 kebele 59 (Ketena 1=30, Ketena 2 =29) HHs, from Selga- 21 kebele 27 (Ketena 2 = 13, Ketena 3 = 14) HHs, and from Selga-22 kebele 28 (Ketena 1=13, Ketena 2=15) HHs were randomly selected proportionally based on the number of households heads residing in each Kebeles.

Data Collection Methods

For this study, both primary and secondary data were used to achieve the desired objectives. Primary data were collected using household surveys, Key informant interviews, Focus group discussions, and field inventory of woody plants. Secondary data were collected from thesis inputs, books, journal articles, census records, literature reviews, and annual activity reports from relevant offices to supplement the information obtained from the primary sources.

In this study key informants (KIs) are defined as persons who are knowledgeable about woody species and changes in local conditions, and village households and who have continuously lived for a long period in the villages. The selection of the key informants was done following the snowball method [14]. To select individual household heads that could identify KIs, a village tour was made with development agents (DAs). During the village tour, knowledgeable five household heads were purposively requested to give the names of seven KIs at each KA, out of 35 KIs suggested, five top rankings were selected from each KAs. The purpose of selecting KIs was to classify households into those practicing parkland agroforestry or not.

Besides, they were also provided information based on a checklist prepared about the historical background of households, species use, and farmers' preference for parkland trees and on local names of woody species in smallholder parkland agroforestry systems in the study area. This information was later used for developing a questionnaire for verification, to conduct a household questionnaire survey, the total number of households in each selected kebeles was obtained from the kebele administration office and crosschecked with KIs at each kebele for its inclusiveness. Then households were classified into those practicing parkland agroforestry by using KIs and individual household heads from each kebele were selected by using a proportionally random sampling technique on sample size determined by [13].

A questionnaire on woody species preferences and uses of parkland agroforestry was developed and pre-tested on 12 randomly selected farmers from each KA. To verify the information that was collected during the discussion with KIs and to verify the quality of the questionnaire. The data collection was done by employing six enumerators before the survey work. The enumerators were trained to provide them with skills on how to approach individual households during the interview and handle information based on the questionnaires. Finally, the survey questionnaire sheets from the households and the data from the field inventory were checked and collected from each study kebele and made ready for analysis.

Focus group discussion was held to supplement and confirm information generated in the household questionnaire and in-depth interviews were conducted with knowledgeable people about the ground situation. During information gathering, focus group discussion was carried out with 8-10 members per study area.

Woody species inventory was performed in May 2021; data were recorded on the farmers' preferences, plant use, and number and abundance of woody species from the parklands of sampled households. Inventory of woody species was conducted by using quadrats with 50m*100m sample plot sizes on selected households' parklands as being more suitable for minimum density of woody species in those areas following [15]. The sample plots were established on 59 randomly selected households practicing parklands in the study area. All tree/shrub species found in sample plots were counted for species abundance. Plant identification was carried out and the nomenclature of species was according to [16].

Data Analysis

Both qualitative and quantitative data were analyzed. The quantitative data were first summarized, tallied and coded, and processed, and were analyzed using Statistical Package for Social Sciences, Version 20.0 and Microsoft Excel 2010. The data obtained from the diversity indices were compared using one-way ANOVA. When the ANOVA showed significant differences, Tukey's test was used to compare whether there was a significant mean difference in tree species diversity among villages. Descriptive statistics were also used to present the results.

The Shannon-diversity index (H') was calculated, to analyze the diversity of tree/shrub species per parkland and it was calculated as follows:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

where, H'=Shannon-Wiener diversity index, S=number of species, i=1, 2, 3...s, pi=Proportion of individuals or the abundance of the i^{th} species expressed as a proportion of the total cover and ln is the natural logarithm (log to the base of e). Values of the index (H') usually lie between 1.5 and 3.5, although in exceptional cases, the value can exceed 4.5 [17].

The evenness index (E) is calculated to estimate the homogeneous distribution of woody species on parklands. The evenness (Shannon equitability) index (E) was calculated as follows:

$$E = \frac{H'}{H\max} = \frac{H'}{\ln s} = -\frac{\sum_{i=1}^{s} pi \ln pi}{\ln(s)}$$

with $H\max = \ln S$ (species diversity under maximum equitability conditions).

Where, S=the number of species, pi=proportion of individuals of the i^{th} species or the abundance of the i^{th} species expressed as a proportion of the total abundance. Thus, the measure of evenness (E) is the ratio of observed diversity to the maximum possible diversity. Evenness has values between 0 and 1, where 1 represents a situation in which all species are equally abundant [18].Simpson's diversity index (D) is the probability of picking two organisms at random which are of different species [19].

Simpson's diversity (D) was calculated as follows:

$$D = 1 - \left(\frac{\sum n(n-1)}{N(N-1)}\right)$$

where D = Simpson's index, n = the total number of organisms of a particular species

N = the total number of organisms of all species

In the end, the diversity index was converted to true diversity (effective number of species in the parklands) were calculated as follows:

$$T_{D=e^{H}}$$

where, T_D = true diversity, e = base of natural logarithm (e =2.718), H= Shannon diversity index.

RESULTS

Floristic Composition of Plant Species

A total of 31 plant species belonging to 30 genera and 19 families were recorded in the parkland of the study area.

Where, Local names: Amharic; Establishment methods: P-planted, NR-Naturally Regenerated; Life form/habit: T- Tree, S- Shrub; Origin: Ind- Indigenous, Ex - Exotic; Uses: BH=bee hive, Ch=charcoal, Cm=construction material, Fo=fodder, F=food, Fr=fruit, Fw=fuel wood, Is=income source, M=medicine, Lf=live fence, Sf=soil fertility, Sc= Soil conservation, Sh=shade; Source: For life forms and Origin [16].

Woody Species Abundance, Richness, and Diversity

Note: Small letters following vertical mean values indicate a significant difference (P<0.05) between villages

Woody Species Preference and Purpose of keeping

Concerning tree species preference, farmers in the study area grow trees for different purposes and no particular tree species can be regarded as being best for all requirements of the household. The choice of tree species depends on the benefits that can be drawn from keeping the trees on farmlands [20, 21].

Note:-Relative score was calculated by multiplying the number of respondents in each rank by its proportion e.g. (3*(3/114)).

DISCUSSION

Floristic Composition of Plant Species

Among the 31 plant species recorded, trees constituted 70.97% while 29.03% were shrubs. Of the recorded plant species, 74.19% were native species and the remaining 25.81% were exotic species (Table 1). This result indicates the effectiveness of parkland agroforestry practices for conserving native flora. HH respondents stated that about 48.39% of the woody species were naturally regenerated or retained while 38.7% were artificially planted and 12.9% were both planted and naturally regenerated/ retained on the parklands (Table 1).

This finding is higher than that of [22] who reported 16 tree species in the parklands of Hawassa Zuria, Ethiopia; [23] who reported 15 tree species in croplands of Tigray Region, Ethiopia. In contrast, this result is lower than the finding of [24] who recorded 39 tree species on croplands of North Western Ethiopia. Among 19 plant families, Fabaceae (5) was the most dominant followed by Combretaceae (3), Myrtaceae (3), Euphorbiaceae (2), and Rhamnaceae (2), while the remaining were represented by a single species. This finding is in line with the finding of [25] who reported a similar result in the West Shoa Zone, Oromia Regional State, Ethiopia. Farmers in the study area planted or retained different plant species in their land holdings to fulfill the demands of various products and services such as construction material, food, shade, bee forage, soil fertility improvement, fuel wood, medicine, and income source (Table 1).

Woody Species Abundance, Richness, and Diversity

A comparison of mean values showed that the highest and the lowest species abundance were found at Selga-22 ketena-2 and Selga-20 ketena-1 respectively, but with a non-significant difference at (p<0.05) (Table 2). The mean value of species richness of parkland agroforestry woody species showed a slight difference among villages (Table 2). However, the highest and the lowest species richness were recorded in parklands of Selga -22 ketena-2 and Selga -20 ketena-1respectively, but With non-significant difference at (p<0.05) (Table 2).

Woody species diversity also varies from village to village, for instance at Selga -22 Shannon diversity was higher at Ketena-1 than Ketena-2 and also in Selga -20 Ketena-1 has higher species diversity than that of Ketena-2, but it was non-significant (p<0.05) (Table 2). The highest and the lowest Simpson diversity index were recorded at Selga -22 ketena-1 and Selga -21 ketena-2 respectively but did not exhibit significant difference (p>0.05) (Table 2).

On contrary, species evenness at Selga -20 Ketena-1 was

Table 1. List of the recorded species and uses in the Assosa district.

Scientific Name	Local Name (Amharic)	Family	Source	Habit	Origin	Uses
Acacia abyssinica Hochst.	Gerar	Fabaceae	NR	T	Ind	Fw, Sh, Ch
Albizia gummifera (J. F. Gmel.) C. A. Sm.	Sesa	Fabaceae	NR	T	Ind	Bh, Cm, Sh, Is
Casimiroa edulis La Llave	Kazmier	Rutaceae	P	T	Ex	Fr, Fw, Is
Catha edulis (Vahl) Forssk. ex Endl.	Chat	Celastraceae	P	S	Ind	Is, M
Citrus aurantifolia (Christm.) Swingle	Lomi	Rutaceae	P	S	Ex	Fr,Is, M
Coffea arabica L.	Buna	Rubiaceae	P	S	Ind	Is, Fw,M
Combretum aculeatum Vent.	Zenfok	Combretaceae	NR/R	T	Ind	Fw, Sh, Ch
Combretum molle R. Br. ex G. Don	Baguri/Abalo	Combretaceae	NR	T	Ind	Ch, Is, Fw, Sh, Fo
Cordia africana Lam.	Wanza	Boraginaceae	P &NR	T	Ind	Bh,Cm,Fw, Sh,Sc,Sf,Is
Croton macrostachyus Del.	Besana	Euphorbiaceae	R	T	Ind	Bh, Cm, Ch, Fw, Sh
Discopodium penninervium Hochst.	Ameraro	Solanaceae	P&NR	T	Ind	Fw,Ch,Cm,Is,Sc
Dombeya torrida (J.F.Gmel.) Bamps	Wulkeffa	Sterculiaceae	NR	T	Ind	Cm,Fw,Sf, Sh
Eucalyptus camaldulensis Dehnh.	Key-baher zaf	Myrtaceae	P	T	Ex	Fw,Cm,Is
Ficus sycomorus L.	Shola	Moraceae	NR	T	Ind	Sh, Bh, Sf,Sc,Fr
Gardenia volkensii *K.Schum.*	Gambelo	Rubiaceae	NR	T	Ind	Fw
Grevillea robusta R. Br.	Geravila	Proteaceae	P	T	Ex	Cm,Fw,Is,Sc,Sh
Grewia ferruginea Hochst. Ex. A. Rich.	Lenquwata	Tiliaceae	NR	S	Ind	Fw,Sf,Sc
Jatropha curcas L.	Ye-ferenji Gulo	Euphorbiaceae	P	S	Ex	Lf,Sf,Sc
Mangifera indica L.	Mango	Anacardiaceae	P	T	Ex	Fr, Fw, Is, Sh,Sf,Sc
Melia azedarach L.	Mimi	Meliaceae	P	T	Ex	Fw,Cm,M,Fo,Sh, Bh
Oxytenanthera abyssinica (A.Rich.)	Kerkha	Poaceae	P	T	Ind	Cm,F,Fw, Is
Piliostigma thonningii (Schumach.) Milne-Redh. Redh.	Y-kola Wanza	Fabaceae	NR	T	Ind	Fw, Sh,Sf,Sc
Psidium guajava L.	Zeituna	Myrtaceae	P	T	Ex	Fr, Fw, Is
Rhamnus prinoides L'Herit.	Gesho	Rhamnaceae	P	S	Ind	Is, Fw,M
Senna didymobotrya (Fresen.) Irwin & Barneby	Digta	Fabaceae	NR	S	Ind	Fw,Sf,Sc,
Sesbania sesban (L.) Merr.	Sesbania	Fabaceae	P&NR	S	Ind	Fo,Fw,Cm,Sf,Sc
Stereospermum kunthianum Cham.	Washint/ Zana	Bignoniaceae	NR	T	Ind	Fw,Sh,Cm,Sf
Syzygium guineense (Willd.) DC.	Dokma	Myrtaceae	NR	T	Ind	Fr, Fw, Sh,Sf
Terminalia brownii Fresen.	Korasuma/Weyeba	Combretaceae	NR	T	Ind	Fo,Fw,CH,Sh,Sc
Vernonia amygdalina Del.	Gerawa	Asteraceae	P	S	Ind	Fw, Fo, Lf, M
Ziziphus mucronata Willd.	Kurkura	Rhamnaceae	NR	T	Ind	Bh,Ch,Fw,Fr,Sh

Table 2. Mean (±Std) of species abundance, richness, and diversity indices of tree species in parkland agroforestry at village level (n=59).

Study Areas	Villages	Species Abundance	Species Richness	Diversity index value			True Diversity
				Simpson's Diversity	Shannon Diversity	Species Evenness	
Selga-20	Ketena-1	15.80±12.35	5.13±1.41	0.73±0.16	1.31±0.35	0.54±0.17[a]	3.92±1.32
	Ketena-2	30.87±36.45	5.27±2.31	0.67±0.18	1.23±0.38	0.44±0.17	3.66±1.36[a]
Selga-21	Ketena-2	39.43±23.77	5.14±1.86	0.58±0.23	1.12±0.47	0.33±0.15[a]	3.36±1.43[b]
	Ketena-3	33.14±24.23	5.71±1.98	0.71±0.16	1.39±0.44	0.43±0.14	4.38±1.72
Selga-22	Ketena-1	34.86±17.36	6.43±2.15	0.82±0.06	1.67±0.44	0.50±0.04	5.65±1.74[ab]
	Ketena-2	50.63±43.59	7.12±2.53	0.63±0.16	1.29±0.28	0.38±0.15	3.76±1.10
Overall mean		31.47±29.34	5.66±2.07	0.69±0.17	1.32±0.39	0.45±0.16	4.02±1.51

significantly higher than that of Selga -21 Ketena-2 at ($p<0.05$) (Table 2). True species diversity at Selga -22 Ketena-1 was significantly higher than that of Selga -20 Ketena-2 and Selga-21 ketena-2 ($P<0.05$) (Table 2). True species diversity in Selga -20 Ketena-2 also showed significantly higher than that of Selga -21 ketena-2 ($P<0.05$) (Table 2). The finding suggested that as species diversity increases the true species diversity also increases.

Woody Species Preference and Purpose of keeping

According to Household respondents, the choice of trees for the parkland agroforestry system depends upon the purpose of the farmer whether to grow them for economical or ecological use. This finding is consistent with the finding of [21] who reported farmers to have planting or protecting trees in a specific case, they nearly always fulfill several functions simultaneously in India [20] also reported woody species preference depends on the benefit that can be drawn from keeping the tree in parklands agroforestry in Ethiopia.

The retaining of woody species in parkland agroforestry practices depends on farmers' preferences. To evaluate farmers' species preferences, respondents were asked to rank the five most important woody species among the species found in their parklands, and then the total relative score was calculated. Farmers selected indigenous and multi-purpose woody species in the order of Accordingly, *Cordia Africana Lam. Mangifera indica L., Oxytenanthera abyssinica (A.Rich.), Eucalyptus camaldulensis Dehnh., Grevillea robusta R. Br.,* **Ziziphus mucronata** *Willd, Melia azedarach L., Sesbania sesban (L.) Merr. Albizia gummifera (J. F. Gmel.) C. A. Sm., Syzygium guineense (Willd.) DC, Terminalia brownii Fresen., Combretum molle R. Br. ex G. Don, Ficus sycomorus L., Dombeya torrida (J.F.Gmel.) Bamps and Stereospermum kunthianum Cham.* were listed by the HH respondents (Table 3).

This finding is in line with the findings of [26, 27, 28] who reported reasons for retaining/planting different woody species depend on the tangible uses and services that they render to the household.

CONCLUSION

This study found a total of 31 woody species belonging to 30 genera, and 19 families were identified in the parkland agroforestry practice of the study site. Parkland agroforestry in the study area plays a major role in the conservation of woody species. The mean value of the Shannon diversity index of parkland agroforestry woody species showed a slight difference among villages. However, the highest and the lowest Shannon diversity index were recorded in parklands of Selga -22 ketena-1 and Selga -2 ketena-2 respectively. There was significant variation in species evenness and true diversity indices among villages. The variation may be attributed to the interest of farmers, land size, agro-climatic conditions, and characteristics of the woody

Table 3. Woody species preference ranking of parkland agroforestry practice in the study area (N=114).

Species Name	Respondents					Relative score					Total Score	Rank
	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th		
Ziziphus mucronata	3	-	-	-	10	0.08	-	-	-	1.61	1.69	6
Cordia africana	56	8	2	7	-	27.51	0.69	0.06	0.55	-	28.81	1
Mangifera indica	22	17	21	23	-	4.25	3.14	6.3	5.94	-	19.63	2
Ficus sycomorus	-	2	-	-	-	-	0.04	-	-	-	0.04	13
Albizia gummifera	1	5	1	3	5	0.01	0.27	0.01	0.10	0.40	0.79	9
Terminalia brownie	4	-	2	1	4	0.14	-	0.06	0.01	0.26	0.47	11
Combretum molle	-	4	-	3	1	-	0.17	-	0.10	0.02	0.29	12
Syzygium guineense	-	1	-	1	6	-	0.01	-	0.01	0.58	0.60	10
Melia azedarach	3	2	6	8	3	0.08	0.04	0.51	0.72	0.15	1.50	7
Stereospermum kunthianum	-	1	-	-	-	-	0.011	-	-	-	0.011	15
Eucalyptus camaldulensis	5	26	11	9	4	0.22	7.35	1.73	0.91	0.26	10.46	4
Grevillea robusta	4	6	7	5	9	0.14	0.39	0.7	0.28	1.31	2.82	5
Oxytenanthera abyssinica	11	20	18	22	13	1.06	4.35	4.63	5.44	2.73	18.20	3
Sesbania sesban	5	-	2	7	6	0.22	-	0.06	0.55	0.58	1.41	8
Dombeya torrida	-	-	-	-	1	-	-	-	-	0.02	0.02	14
Total	114	92	70	89	62							

species. In the study area, woody species preference depends on the contribution to household livelihoods and compatibility with food crops. It is concluded that the parkland agroforestry system of the study area provides goods and services for local livelihoods, is essential for the conservation of woody species diversity which complements the natural forests; and helps to counteract the loss of woody species from the natural forest. Further studies should be examined in the study area concerning the role of parkland wood species in climate change adaptation and mitigation and interested donor agencies should be promoted in terms of carbon trading.

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REFERENCES

1. Regmi BN, Garforth C. Trees outside forests and rural livelihoods: a study of Chitwan District, Nepal. Agroforestry systems. 2010; 79: 393-407.

2. Singh RP, Singh AK, Kumar V, Kumar P. Quantification and distribution of Agroforestry systems and practices at the Global Level. 2014; 3: 1-6

3. Kassa H, Gebrehiwet K, Yamoah C. Balanites aegyptiaca, a potential tree for parkland agroforestry systems with sorghum in Northern Ethiopia. Journal of Soil Science and Environmental Management. 2010; 1: 107-114.

4. Badege B, Abdu A. Agroforestry and community forestry for rehabilitation of degraded watersheds on the Ethiopian highlands. International Symposium on Contemporary Development Issues in Ethiopia, Addis Ababa, Ethiopia. 2003; 23.

5. Tews J, Brose U, Grimm V, Tielbörger K, Wichmann MC, Schwager M, et al. Animal species diversity is driven by habitat heterogeneity/ diversity: the importance of Keystone structure. Journal of Biogeography. 2004; 31: 79-92.

6. Bannister M E, Nair PKR. Agroforestry adoption in Haiti: the importance of household and farm characteristics. Agroforestry systems. 2003; 57: 149-157.

7. Kindt R, Noordin Q, Njui A, Ruigu S. Biodiversity conservation through agroforestry: managing tree species diversity within a network of community-based, nongovernmental, governmental, and research organizations in western Kenya. In the 15th annual conference of the Eastern Africa environmental network on networking for biodiversity. 2005; 27-28.

8. Melese W. Woody Species Diversity of Parkland Agroforestry in Ethiopia. Global J Technol. 2017; 8:2.

9. Assosa District Agricultural and Natural Resource Office (ADANRMO). Annual unpublished Report. 2013; 8-12.

10. Teferi F, Teferi G, Kaleab A, Tsige G. Ethno medical survey of Berta ethnic group Assosa Zone, Benishangul-Gumuz regional state, mid-west Ethiopia. Journal of Ethnobiology and Ethnomedicine. 2009; 5:14.

11. Mosissa D, Wakjira D. Large scale agricultural investment and a fragile soil paradox in Benishangul Gumuz regional state: Organic carbon stock of broadleaf and deciduous forests of Combretum–Terminalia woodlands of Benishangul Gumuz Regional State, Western and northwestern Ethiopia. J Agric Sci Bot. 2020; 4 : 1-13.

12. Tadesse E, Asfaw Z. Woody Species Richness, Use Diversity, and Management in Agroforestry Practices: The Case of Assosa District Benishangul Gumuz Region, Ethiopia. Journal of Biodiversity Management and Forestry.2016; 5:4.

13. Yamane T. Statistics: An introductory analysis . 1967; 919.

14. Bernard HR. Research methods in anthropology: Qualitative and quantitative approaches. Rowman and Littlefield publishers, 5th Ed. 2017; 666.

15. Nikiema A. Agroforestry parkland species diversity: uses and management in semi-arid West Africa. Ph.D. Dissertation Wageningen University, Wageningen. 2005; 168-6: 9-17.

16. Bekele A, Tengnäs B. Useful trees and shrubs of Ethiopia: identification, propagation, and management for 17 agroclimatic zones Nairobi, Kenya: RELMA in ICRAF Project, World Agroforestry Centre, Eastern Africa Region. 2007; 552.

17. Kent M, Coker P. Vegetation description and analysis, a practical approach–John Wiley and Sons. New York. 1992; 319.

18. Krebs C J. Ecological Methodology. 2nd edn. Addison-Wesley Longman: Menlo Park, CA. 1999; 620.

19. Magurran AE. Ecological diversity and its measurement. Princeton university press. 1988; 63-191.

20. Gindaba J, Rozanov A, Negash L. Trees on farms and their contribution to soil fertility parameters in Badessa, eastern Ethiopia. Biology and fertility of soils. 2005; 42: 66-71.

21. Chauhan SK, Sharma R, Dhillon WS. Status of intercropping in poplar-based agroforestry in India. For. Bull. 2012; 49-67.

22. Zeleke G, Abebe T, Haile W. Ficus vasta L. in parkland agroforestry practices of Hawassa Zuria District, Southern Ethiopia. Ethiopian Journal of Natural Resources. 2015; 15: 1-14.

23. Guyassa E, Raj AJ. Assessment of biodiversity in cropland agroforestry and its role in livelihood development in dryland areas: A case study from Tigray region, Ethiopia. Journal of Agricultural Technology. 2013; 9: 829-844.

24. Giday K, Debebe F, Raj A J, Gebremeskel D. Studies on farmland woody species diversity and their socioeconomic importance in Northwestern Ethiopia. Tropical Plant Research. 2019:6: 241-249.

25. Misgana D, Shibru S, Chauhan R. Woody species diversity, structure, and biomass carbon of parkland agroforestry practices in Gindeberet District, West Shoa Zone, and Oromia Regional State, Ethiopia. International Journal of Biodiversity and Conservation. 2020; 12: 1-12.

26. Yakob G, Asfaw Z, Zewdie S. Wood production and management of woody species in home gardens agroforestry: the case of smallholder farmers in Gimbo District, South West Ethiopia. International Journal of Natural Sciences Research. 2014;2: 165-175.

27. Lemage B, Legesse A. Management and socioeconomic determinants of woody species diversity in parkland agroforestry in Tembaro District, Southern Ethiopia. Biodivers. 2018; 2: 456-462.

28. Legesse A, Negash M. Species diversity, composition, structure and management in agroforestry systems: the case of Kachabira District, Southern Ethiopia. 2021; 7: 1-10.