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Research Article

Woody Species Diversity and Management in Homegarden Agroforestry: The Case of Shashemene District, Ethiopia

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The study was conducted in Shashemene district, Ethiopia. Management-related data were collected using informal and formal surveys. Woody species diversity and related parameters were collected from 60 households. Woody species with ≥5 cm diameter at breast height (DBH) were measured and recorded and below 5 cm were counted and recorded in 10 m ∗ 10 m and 1 m ∗ 1 m plot, respectively. A total of 36 woody species were recorded, of which 58% were indigenous to the area. The overall mean number of woody species per plot was 3.13. Four woody species, namely, *Cordia africana*, *Croton macrostachyus*, *Persea americana*, and *Catha edulis*, showed highest importance value index. Farmers' preference ranks for selected woody species were recorded in order of *Cordia africana*, *Eucalyptus camaldulensis*, *Croton macrostachyus*, and *Cupressus lusitanica*, respectively. The similarity in woody species composition between the study villages ranged from 0.46 to 0.60. To sustain the management of woody species, farmers implemented pruning, thinning, composting, weeding, digging, and watering activities in the area. Garden availability and market and road accessibility are the major determinants of woody species in homegarden agroforestry. The study revealed woody species diversity, management practices implemented, and factors affecting woody species diversity management in homegarden agroforestry. Therefore, government should be worked on infrastructure, resource reallocation, and awareness creation in communities for the better improvement of species diversity and its sustainable management in homegarden agroforestry.

1. Introduction

Homegarden is a traditional land-use system which extensively practiced throughout the world [1]. It is found in most ecological regions of the tropics and subtropics, but a majority of them are in the lowland humid tropics [2, 3]. Homegardens usually exhibit high species diversity [4–8]. Many studies have been conducted on the diversity, structure, composition, and management practices of Ethiopian homegarden plant species [4, 9, 10]. The practice of homegarden is influenced through cultural barriers, lack of land, available labor, capital, agricultural extension advice, appropriate plants, and livestock [11]. Several socioeconomic and physical factors related to household and external environments of farmers such as altitude, slope of farms, and access to market and road affect species richness and evenness. For instance, farm size, economic status, and farm labor force influence the area share of major crop species in homegarden [10]. Effective development and management of homegarden species diversity are essential for sustainable growth and poverty reduction [12]. Homegardening culture has developed a general structure with considerable diversity and flexibility that allows owners to produce species of their choice [13]. Therefore, identifying factors influencing the management of homegarden agroforestry is important to understand how farmers manage diverse species in homegarden under different circumstances. Traditionally, local communities' carryout homegarden agroforestry practice in both developing and developed countries. In Ethiopia, homegarden agroforestry is widely practiced as a major source of daily food and income generation [4, 10]. The study was conducted on woody species diversity identifications, management techniques, and factors

affecting homegarden agroforestry in Shashemene district which is located in East Arsi Zone of Oromia region.

2. Materials and Methods

2.1. Description of the Study Area. The study was conducted in Shashemene district, Ethiopia, which is located at a distance of 250 km south of Addis Ababa, the capital city of Ethiopia, and 25 km north of Awassa, SNNPRS. It is bordered to the south by SNNPR, west by Seraro, north by Arsi Negele, and east by East Arsi Zone (Figure 1).

The altitude of the district ranges from 1500 to 2300 meters above sea level. The agroecology of the district is categorized as Kolla (50%), Woina Dega (29%), and Dega (21%). Shashemene district receives an annual rainfall of 700–950 mm and the minimum and maximum annual temperature of 12°C and 27°C, respectively. The total population of the district is 350,084, of whom 175,832 are males and 174,252 are females with an estimated population density of 455.32 people per square kilometers [14]. The total land coverage of the area is 76,888 ha, of which 48,975 ha is used for cropland and 7440 ha for forest land [15].

2.2. Sampling Strategy. In this research, stratified random sampling was used. Two kebele administrative, namely, Ilala Korke and Wotara Shagule were selected based on the presence of homegarden agroforestry practices and proximity to the market area and main road from Kuyera area, Shashemene district. Four villages (Shasha 01 and Shasha 02 from Ilala Korke and Bake and Wotara from Wotara Shagule) were selected by random sampling techniques. Key informants (KIs) and households were involved to assess the technical knowledge. KIs are defined as persons who are knowledgeable about woody species diversity, management, and factors influencing the practice and who lived there at least for continuous 25 years. KIs were selected by the snowball method. During the selection processes, a guide tour was carried out with field assistance and 5 KIs at each village and a total of 20 KIs were selected for the study. These KIs were used to classify farmers into three wealth categories (poor, medium, and rich). Finally, from each wealth class, 5 households were selected randomly, making 15 households per village and 60 households for this study.

2.3. Data Collection. Structured questionnaires, focus group discussion, and field observation were carried out to gather data on the overall information about the woody species diversity, management practices, and factors influencing woody species diversity in homegarden.

2.4. Woody Species Inventory. In order to determine the diversity of woody species existing in homegarden agroforestry practices, woody species inventory was made on 10 m ∗ 10 m main plot and 1 m ∗1 m subplot size established in the homegardens of randomly selected households. At each sample plot, all woody species with ≥5 cm diameter at breast height (1.3 m from the ground) were measured using a caliper and recorded in 10 m ∗ 10 m and those below 5 cm DBH were counted and recorded in 1 m ∗ 1 m plot. Woody species identification and data collection were carried out using knowledgeable persons from the local community and the researcher. Woody species nomenclature was done by using useful trees and shrubs of Ethiopia [16] and Flora of Ethiopia and Eritrea [17, 18].

2.5. Data Analysis. Data were analyzed using Statistical Package for Social Sciences (SPSS) software version 16. Woody species analysis was made using Shannon diversity index (H^1), Equitability (E), and Simpson diversity index (D) to compare the diversity indices of woody species in homegarden agroforestry at village level and wealth categories. Importance value index (IVI) was calculated at site and village levels to estimate the importance of each woody species in the surveyed homegarden. Sørensen similarity index was calculated to compare the similarity of woody species between the study villages. Basal area per plot and per hectare was calculated at kebele administration and village level. Shannon diversity index (H^1) as a measure of species abundance and richness was used to quantify how well species are represented within a community [19]. Importance value index (IVI) indicates the importance of species in the system and it is calculated as the sum of the three components (relative density, dominance, and frequency) [20].

3. Results and Discussion

3.1. Woody Species Diversity. A total of 36 woody species categorized under 25 families were recorded in surveyed homegarden agroforestry (Table 1).

A total of 19, 21, 16, and 16 woody species were recorded at Shasha 01, Shasha 02, Bake, and Wotara villages, respectively. There was a significant difference ($P < 0.05$) in woody species richness at village level (Table 2).

The woody species (36) recorded is smaller than the woody species (64) reported from Beseku, Ethiopia [7]. *Cordia africana* was the most frequent tree species occurring in 45% followed by *Croton macrostachyus*, *Persea americana*, and *Casimiroa edulis*. The results are in agreement with the study from Sidama homegarden in which six tree species with high frequent occurrence were reported [10]. The total woody species abundance per ha (1020) recorded was about two-thirds of the woody species abundance (1535 per ha) reported from Barak Valley, North East Indian homegardens [5]. The higher mean values in woody species abundance at Shasha 01 and Shasha 02 could be associated with the presence of cash-generating species like *Catha edulis* and other fruit tree species. Proximity to the market place and main road also plays a vital role in the results observed. The highest value of Shannon and Simpson diversity index was registered in Shasha 02, while the Evenness value was highest in Bake village (Table 3).

This could happen as high Shannon diversity index does not depend on density or total abundance [21] but can be associated with increase in species richness [10]. Highest species Evenness was recorded in Bake with lower species richness and abundance which indicated better

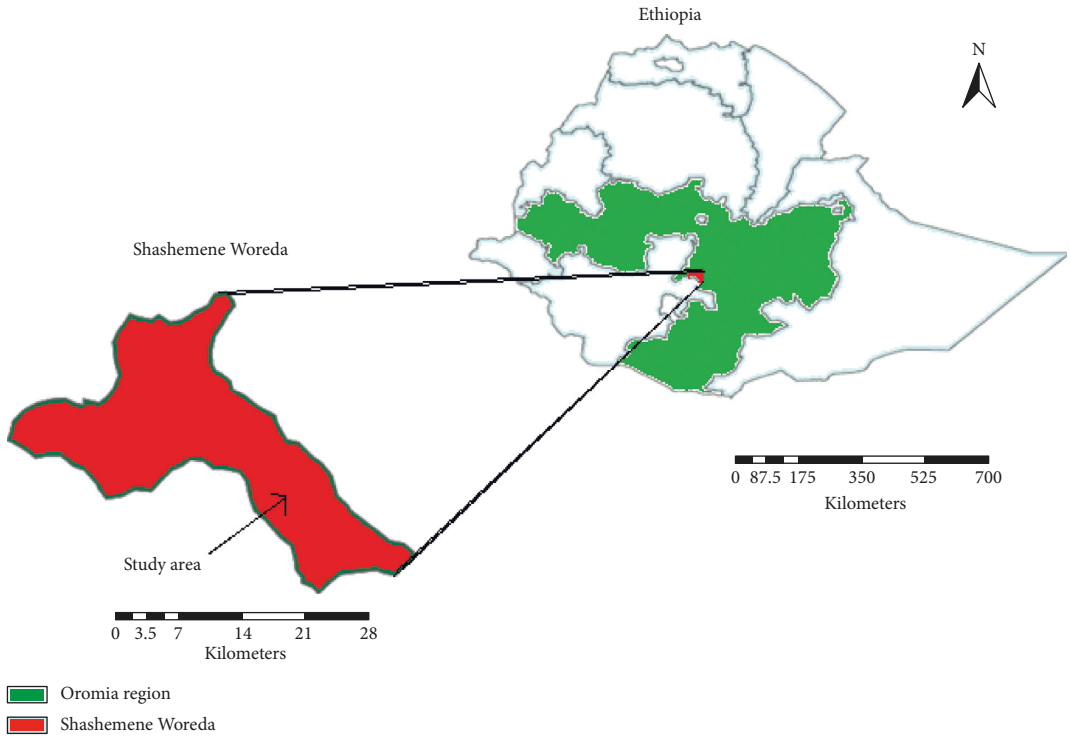

Figure 1: Location map of Shashemene Woreda.

representation of woody species in Bake than other villages. Simpson diversity index was highest in Shasha 02 with 21 different woody species while lowest in Shasha 01 with 19 different woody species. Therefore, the result indicated that the Simpson index does not increase with increasing the abundance of woody plants. Shannon diversity index, Evenness, and Simpson diversity index calculated between the three wealth categories at the four study villages showed a slight variation between and/or among wealth classes for all villages. However, the variation was not significantly different ($P < 0.05$) and it is in line with the result reported from Beseku, Ethiopia, by Tolera et al. [7]. To determine the importance of each woody species, their importance value index (IVI) was calculated. *Cordia africana*, a tree most preferred and conserved by the farmers, had the highest importance value index (69) followed by *Croton macrostachyus*, *Persea americana*, *and Catha edulis* with the importance value index of 31, 30, and 29, respectively. The results are in line with the study by Tesfaye [10], who reported four tree species with highest importance value indices. The similarity in woody species among the study villages ranged from 0.46 to 0.60, indicating that there was a more or less similar type of woody species in surveyed homegardens. Village level average basal area was 0.24, 0.23, 0.18, and 0.09 m^2 per plot and 23.54, 22.57, 18.28, and 9.5 m^2 per ha for Shasha 01, Shasha 02, Bake, and Wotara villages, respectively.

3.2. Woody Species Management. In many parts of the country, farmers need to manage woody species in homegarden agroforestry for multiple purposes including household consumption and improving their household economy. Farmers' preference for tree species is a basic criterion to select a tree and devise appropriate management in homegarden agroforestry. The interviewed respondent indicated that farmers of the study area managed species such as *Cordia africana*, *Croton macrostachyus*, *Cupressus lusitanica*, and *Eucalyptus camaldulensis* to provide multiple contributions for households. Such type of homegarden agroforestry woody species and their benefits was also reported by Savard et al. [22]. In the present study, farmers apply different management techniques while establishing and growing woody species in homegarden agroforestry. The common management practices are pruning, thinning, composting, weeding, digging, watering, and application of insecticides (Figure 2).

3.3. Factors Affecting Woody Species Composition. There are a lot of hindering factors to effectively and efficiently manage and sustainably utilize woody species in the homegarden agroforestry practices. The result obtained from the interviewed respondent indicated that farmers were encountered with many different problems in establishing, conserving, and using homegarden woody species in the study area. Lack of market access, enough garden size, and access to road are some commonly known factors affecting woody species richness and abundance. Location of market place negatively or positively affected the farmers in growing woody species in homegarden [8–10]. Accordingly, villages nearest to the local market and main road showed a significant difference ($P < 0.05$) in woody species richness and abundance compared to villages far from the market place and main road.

Table 1: Local, botanical, family names, and origin of woody species of the study site.

No.	Botanical name	Local name	Family name	Or.
1	*Acacia abyssinica Hochst. ex Benth.*	Garbi	Mimosoideae	I
2	*Albizia gummifera* (J. F. Gmel.) CA. Smith	Karchofe	Mimosaceae	I
3	*Azadirachta indica* A. Juss.	Nimi	Meliaceae	E
4	*Bersama abyssinica* Fres.	Horoqqa	Melianthaceae	I
5	*Calpurnia aurea* (Lam.) Benth.	Chekata	Papilionaceae	I
6	*Carica papaya L.*	Papaya	Caricaceae	E
7	*Casimiroa edulis* La Llave & Lex.	Kasmir	Rutaceae	E
8	*Catha edulis* (Vahl.) Forssk. ex Endl.	Chat	Celastraceae	I
9	*Celtis africana* Burm. F.	Amalaqqa	Ulmaceae	I
10	*Coffea arabica* L.	Buna	Rubiaceae	I
11	*Cordia africana* Lam.	Woddessa	Boraginaceae	I
12	*Croton macrostachyus* Hochst. ex Del.	Bakkannisa	Euphorbiaceae	I
13	*Cupressus lusitanica* Mill.	Yeferenji-tid	Cupressaceae	E
14	*Erythrina abyssinica* Lam. ex DC.	Walensu	Papilionaceae	I
15	*Eucalyptus camaldulensis* Dehn.	Baarzaafii dimaa	Myrtaceae	E
16	*Eucalyptus globulus* Labill.	Baarzaafii adi	Myrtaceae	E
17	*Eucalyptus citriodora* Hook.	Shito bar zaf	Myrtaceae	E
18	*Ficus sur* Forssk.	Harbu	Moraceae	I
19	*Ficus vasta* Forssk.	Kiltu	Moraceae	I
20	*Grevillea robusta* A. Cunn. Ex. R. Br.	Grevillea	Proteaceae	E
21	*Lantana trifolia* L.	Kusaye	Verbenaceae	I
22	*Malus sylvestris* (L.) Mill.	Apple	Rosaceae	E
23	*Mangifera indica* L	Mango	Anacardiaceae	E
24	*Olea europaea* L. ssp.	Ejersa	Oleaceae	I
25	*Persea americana* Mill.	Avokado	Lauraceae	E
26	*Podocarpus falcatus* (Thunb) Mirb.	Birbirsa	Podocarpaceae	I
27	*Prunus africana* (Hook.f.) Kalkm	Suke/Homi	Rosaceae	I
28	*Psidium guajava* L.	Zeyitunaa	Myrtaceae	E
29	*Rhamnus prinoides* L Herit	Gesho	Rhamnaceae	I
30	*Ricinus communis* L.	Qobboo	Euphorbiaceae	I
31	*Morus alba* L.	Yeferenji injori	Rosaceae	E
32	*Schinus molle* L.	Qunda barbare	Anacardiaceae	E
33	*Sesbania sesban* (L.) Merr.	Sasbaniya	Papilionoideae	E
34	*Syzygium guineense* (Willd) DC.	Baddeessaa	Myrtaceae	I
35	*Vernonia amygdalina* Del.	Eebicha	Asteraceae	I
36	*Vernonia auriculifera* Hiern.	Reji	Asteraceae	I

Or.: origin; I: indigenous; E: exotic.

Table 2: Mean woody species richness and abundance per plot at the study villages.

Villages	Abundance		Richness	
	Total	Mean	Total	Mean
Shasha 01	19	$3.33^{ab} \pm 0.40$	254	$16.9^{a} \pm 4.61$
Shasha 02	21	$3.93^{a} \pm 0.49$	144	$9.6^{ab} \pm 1.76$
Bake	16	$2.87^{ab} \pm 0.43$	118	$7.9^{ab} \pm 1.60$
Wotara	16	$2.40^{b} \pm 0.24$	96	$6.4^{b} \pm 0.83$
Overall mean	**18**	**3.13 ± 0.21**	**153**	**10.2 ± 1.39**

Note: single different letters on mean values indicate significant difference at $P < 0.05$ between the study villages.

Table 3: Shannon index, Evenness, and Simpson diversity index of woody species.

Villages	Shannon index	Evenness	Simpson index
Shasha 01	1.75	0.59	0.70
Shasha 02	2.49	0.82	0.89
Bake	2.35	0.85	0.88
Wotara	2.29	0.83	0.87

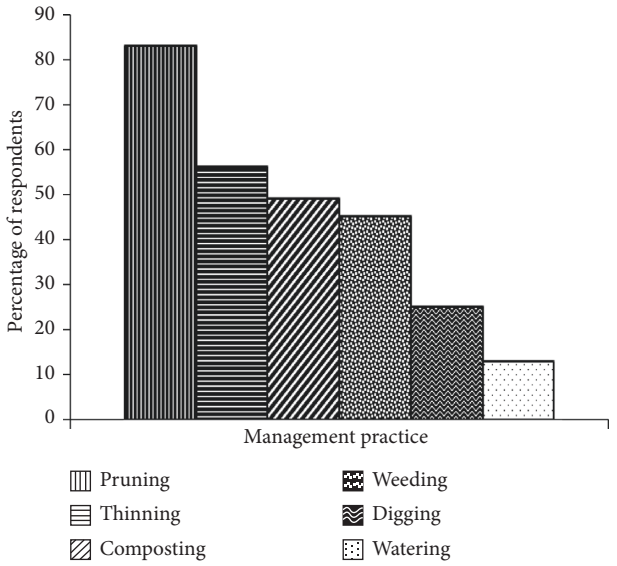

Figure 2: Woody species management practices and percentage of respondents.

On the other hand, damage from animals, insect pest, and diseases were mentioned as additional factors affecting homegarden woody species composition. Similarly, the study conducted in Bangladesh also revealed the problems of animals, storms, and insect pests in tree establishment and management in homegarden [23, 24].

4. Conclusion

Homegarden agroforestry is a diverse land-use system in which multipurpose trees and shrubs are deliberately grown in intimate association with annual and perennial agricultural crops and/or livestock. The study was conducted in homegarden agroforestry of Shashemene district, Ethiopia, which encompasses a variety of indigenous and exotic woody species. The Shannon diversity index, Evenness, and Simpson diversity index calculated at village level and wealth categories showed variation in both cases, but there was no significant difference at $P < 0.05$. Farmers' woody species preference rank was recorded in the order of *Cordia africana* > *Eucalyptus camaldulensis* > *Croton macrostachyus* > *Cupressus lusitanica*. Farmers use management practices such as pruning, thinning, composting, weeding, digging, and watering to upgrade the diversity of woody species in homegarden. However, problems related to access to extension service, road, and market and garden size negatively affect the practices. Therefore, focus should be given to infrastructure, resource reallocation, and extension services to diversify, manage, and sustainably use woody species in homegarden agroforestry.

Data Availability

No data were used to support this study.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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