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Woody Plant Species Diversity and Management Practices in Homegardens of Heban Arsi Woreda, South Central, Ethiopia

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Abstract

In Ethiopia forest resources are decreasing at alarming rate. Agroforestry practice such as homegarden play an important role for the conservation of woody species and also improving human wellbeing. Although homegardens are known to substantially contribute various benefits to households, there is lack of quantitative information on the benefits of homegardens in the study area. Therefore the aim of the study was to assess woody species diversity, management practices of woody species of the study area. The study was conducted in Heban Arsi wereda, Oromia, Ethiopia. A total of 99 households were randomly selected for questionnaire survey to gather information on farmers' strategy of managing woody species diversity in homegarden. Vegetation data was collected from homegarden of 54 randomly selected households. Systematic sampling technique was used to collect vegetation data from nested thirty 20m X 20m sample in the adjacent natural forest. Sampling plots were placed at every 100 m interval along the transect lines at 150m apart. Woody species > 5 cm diameter at breast height were measured and recorded. All woody species with dbh < 5cm were counted and recorded. The vegetation data from the homegarden was collected from 20m x 20m plot size. A total of 73, 58 homegarden and 48 in natural forest woody plant species belonging to 35 families were recorded from homegardens and the adjacent natural forest in the study area. The dominant families which contributed to the overall species richness in both land uses were Fabaceae and Rutaceae. The total number of woody species in the homegardens and the natural forest was 58 and 48 respectively. Natural forest showed higher diversity (H' = 2.28) than homegarden (H' = 1.98). The similarity in woody species composition between homegardens and adjacent natural forest was 62.5%. Afrocarpus falcatus and Croton macrostachyus are the most important woody species among the woody species common to both homegarden and adjacent natural forest. To sustain the management of all woody species, farmers carry out management practices such as pruning, thinning, composting, weeding, hoeing and watering. Finally, this study indicated that homegarden agroforestry play a vital role in conservation of biodiversity. Community of the study area should be strongly encouraged and capacity building to further conserves woody species should be done.

Keywords: *Biodiversity; Household; Species Richness*

Introduction

Biodiversity is the variety of all living things; the different plants, animals and microorganisms, the genetic information they contain and the ecosystems they form that can be usually explored at three levels genetic diversity, species diversity and ecosystem diversity [6]. Biodiversity is essential for survival, health and well-being of humans. It gives greater resilience to ecosystem and organisms [30]. Biodiversity conservation is receiving increased attention of world scientists and leaders because of the growing recognition of its importance and the adverse impacts of climate change particularly on genetic diversity [37].

Ethiopian people have developed local knowledge that has supported them to use and conserve a diversity of plants for different purposes [4,24]. One of the best aspects of local knowledge is diversion of labor in managing homegarden based on sex and women are mostly responsible for homegardens [20]. Farmers use different management techniques to manage diverse species in homegarden. For instance, study conducted by Fentehun Mengistu [11] in western Amhara region, Ethiopia indicated that farmers carry out pruning, pollarding, and lopping, weeding, fencing to manage tree species diversity in homegarden. Many components of plant agrobiodiversity would not survive without human interference as local knowledge and culture are integral parts of plant agrobiodiversity management [9,24].

Studies conducted on homegardens in different parts of the world indicate a significantly high number of woody plant species incorporated into the system. For example, Maroyi A [19] reported the presence of 69 species in Nhema, Zimbabwe. In West Java, Indonesia, Soemarwoto O [31] reported that there were 179 woody plant species. Some reports from Ethiopia also indicated existences of diverse plant species in homegardens are maintained from place to place. Over 198 woody species of cultivated crops (98) and trees (120) were recorded from 144 homegardens in four woreda's of Sidama zone, SNNPR [35]. On the other hand, a total of 75 plant species with ten use categories have been recorded in studied homegarden of Dilla wareda, Gedeo Zone, SNNPRS Ethiopia [21]. According to Euwuketu Linger Mekonnen., *et al*. [8] in Jabithenan district, Northwestern Ethiopia, a total of 69 plant species (44 woody and 25 herbaceous), belonging to 44 families and different functional groups were recorded. Survey of the homegardens of Basketo and Kafa yielded a total of 224 species of which 149 species belonged to Basketo gardens while 192 were recorded from Kafa gardens [10]. Yitebitu Moges [39] has reported 78 trees per hectare in the homegarden agroforestry of Dilla. On the other hand, 64 woody species were recorded in Beseku homegarden [25].

In the study area (Heban Arsi woreda), farmers have been practicing homegarden agroforestry practice by integrating different woody perennials and livestock components in their lands. But, the agroforestry species diversity and local management have not been subjected to study.

Aim of the Study

The aim of the present study was to assess the diversity of woody plant species in the homegardens in relation to adjacent natural forest along with their local management practices.

Materials and Methods

Description of the study area

Heban Arsi woreda is located in west Arsi zone of Oromia Regional State. The woreda is found at about 226 kms distance from the Addis Ababa on the south east. The woreda encompasses 9 rural and 3 urban kebeles[1] which are located in three different agro-ecological zones. The total area of the study site is 35,613.6 hectares. Its geographical position is between $07^0$09'N- $07^0$42'N latitude and $38^0$25' E - $38^0$54'E longitude. The altitude ranges between 1500 - 3000 masl [15].

The topographic feature of Heban Arsi woreda is mostly flat and undulating landscape. It is characterized mostly by *badda daree* (midland), *baddaa* (highland) and few places of *gammoojjii* (lowland) agro-climatic zones. These agro-ecological zones differ in altitude and in rainfall distribution. The rainfall distribution is bimodal type, with short rainy seasons that starts from March to May and long rainy season from July to October. The annual average rainfall of the study area is 825 mm (ranges 500 - 1150 mm) and the mean annual temperature is 19°C (ranges 10^0C - 27^0C) [15]. The dominant soil type of the Heban Arsi District is largely derived from volcanic activities in the rift valley. The soils of the study area are classified as Mollic Andosols [27].

[1]*Kebele* refers to the lowest administrative unit of the woreda.

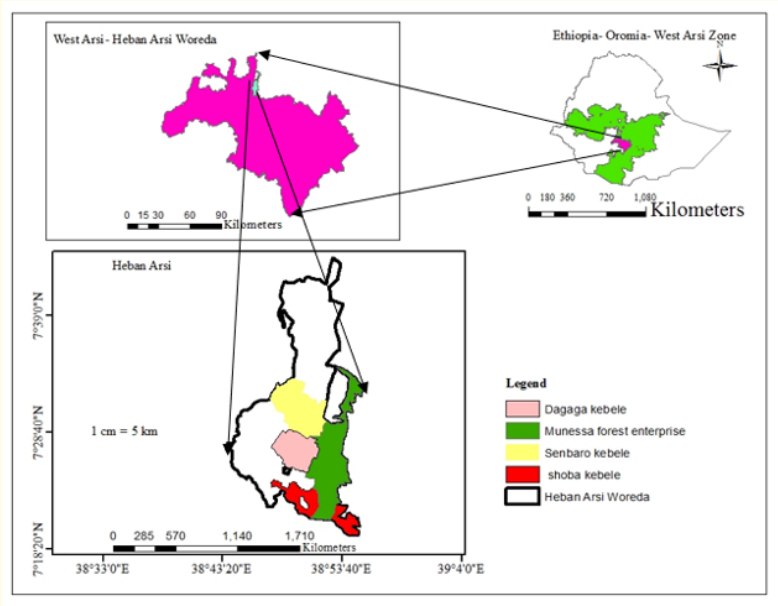

Figure 1: *Map of the study area.*

Before 20 years ago, the woreda was appreciably covered with natural forests [15]. But today, that is only history and much of the area, including farmlands and homegardens are covered by planted forests and woodlots. The study site is covered by 19.19% forest area out of the total land area including natural forest, community forest and private forest. Important species of trees and shrubs in the area include *Cordia africana, Ficus sur, Croton macrstachyus, Cupressus lustanica, Casimiroa edulis*, *Coffea arabica*, *Afrocarpus falcatus*, *Juniperus procera*, *Haginia abyssinica*, *Eucalyptus* spp [15].

The major agricultural activities in the woreda are crop production and livestock rearing in the form of mixed farming system. Maize, wheat and barley are the most widely grown cereal crops in the study area [15].

The agroforestry practices done in the study area are alley cropping (raw intercropping), boundary planting of tree, trees and shrubs as shelterbelt and windbreak, homegarden and wood lots on agricultural land.

Reconnaissance survey

A reconnaissance survey was done in the study area to select the Kebeles for the study. The survey gives a good understanding to choose the specific study Kebeles. During that period, overall information on the study area was obtained and representative sampling sites were identified by consulting the head of rural agriculture office of the study area.

Sampling design

The study sites were identified and selected purposively. It was based on the presence of traditional homegarden practices and proximity to natural forest for comparison of woody species between the two land use systems and their location in the same altitudinal range.

Accordingly, from 12 kebeles administration under Heban Arsi woreda three Kebele administrations (KAs) namely Dagaga, Senbaro and Shoba Bultum Kebeles which are in the same agroecology and adjacent to natural forest were selected.

Key informants (KIs) were selected by snowball method [13]. During the reconnaissance survey, five individual local people were in turn selected through snowball method and individual local people were asked to give the name of six (6) KIs as defined by Getahun Yakob., *et al* [13]. Out of the mentioned thirty (30) KIs, the most frequently appeared, five KIs were selected at each Kebeles. Accordingly, a total of 15 KIs were selected for the study.

To select the representative respondent HHs, the name of all HHs (3297) living in the respected kebeles was obtained from three KAs and cross checked with key informants at each selected kebele. The criteria for local wealth status determination were set with the help of key informants: total land holding size, number of livestock, standard of housing and size of plantation trees as well as size of fruit tree fields were the major indicator of wealth in the study area. Then, all HHs were stratified into three strata as descried based on the set wealthy criteria. According to Storck., *et al*. (1991), the size of the sample depends on the available funding, time, manpower and not necessarily on the total population. Accordingly, 33 HHs were randomly selected from each KA, 11 from each stratum of farmers (rich, medium and poor). In total 99 HHs were selected for the present study.

Data collection

Data were collected at three levels: Woreda, Kebele administration and household levels. At woreda level, general information was collected on the management and factors affecting woody plant species diversity in homegarden agroforestry practice through secondary sources and interviews held with experts from Woreda Agriculture and Rural Development Office. At Kebele administrations, data were collected from KIs, DAs and observations were made during reconnaissance survey of the kebele administrations. At household level, data were collected from the interview held with KIs and field observations. The interview at this level focused on the general information about homegarden practice and its' management systems in homegarden at the study area.

Structured questionnaire was designed and data on the overall information about the woody plant species diversity, management practices and factors influencing woody plant species diversity in homegarden were collected. Generally, data were collected by an investigator and enumerators who have experience in data collection and capacity of speaking Afan Oromo (a local language of the area).

Woody plant species inventory

Homegarden woody plant species diversity Inventory

Inventory of woody plant species was made on the sampled household's homegarden and adjacent natural forest in the close vicinity of the practice. To assess the woody plant species diversity in homegarden, 18 households from each Kebele, and 6 from each wealth category of households making 54 households from the three study kebeles were randomly selected. The positions of homegarden are varying in size, type and vegetation structure. They are backyard, sideyard and frontyard, but the predominant were backyard type homegardens that were used for this study. Additionally, the size of homegardens in the respective study site was averagically range between 0.08 to 0.5 hectares.

To assess the diversity and composition of woody plant species 20m x 20m sample plot was designed in randomly selected homegardens of each kebele [1]. This was carried out through partitioning of each homegarden of the selected HHs into 20m x 20m plot size for all wealth classes [22]. After doing so, one sample plot was randomly picked up from each partitioned homegarden of HHs with different wealth classes. In each plot, all woody plant species were identified and diameter at breast height (dbh) for all woody plant species ≥ 5

cm [13] was measured using calliper. Similarly, woody plant species < 5 cm diameter at breast height (dbh) were counted. Local names and habits of each woody plant species occurring in the plots were recorded. Woody plant species identification and nomenclature were made during survey with the help of KIs and owners of the sample homegardens. Furthermore, book of useful trees and shrubs of Ethiopia [3] were used to identify scientific names of woody plant species. Specimens of unknown woody plant species found in the sampled homegardens were collected, numbered, pressed and dried. Then, the collected specimens were brought to Ethiopian biodiversity institute (EBI) Herbarium found at AA for identification. With technical support obtained from the technical personnel and taxonomic experts of the institution Herbarium, further confirmation of the botanical names were established including by comparing specimens with the true specimens found at the National Herbarium.

Natural forest

On the other hand, woody plant species diversity in natural forest adjacent to the homegarden landscapes was assessed and used as a reference for comparison with data collected from the homegarden landscapes. The natural forest is currently found under the concession area of oromia forest and wildlife enterprise Arsi branch.

In the natural forest, data were collected from the forest closer to homegarden to avoid differences in species composition that may be created due to differences in altitude. To assess woody plant species diversity in the natural forest, a systematic sampling technique was used. The first transect lines was laid at a distance of 50 meters from the edges in order to control the border effect of disturbances. Following this, a total of six transect lines (2 from each of KA) were laid 150m apart from each other. A total of thirty (10 from each of Kebele) 20m X 20m sample plots for woody species were laid at every 100m along the transect lines in natural forest. In addition, five 2mX2m subplots were established to count and record saplings and seedlings for those woody plants with dbh < 5 cm [1]. Then, identification of woody species and nomenclature followed the same procedure as discussed above in case of homegarden.

Vegetative data analysis

Measurement of woody species diversity

Species richness: Is defined as the number of species per sample plot area or community. It is a measure of the total number of different species present per quadrant or community [17].

Shannon diversity index (H'): Diversity indices take into account both species richness and the relative abundance of each species to quantify how well species were represented within a community. The Shannon diversity index (H^1) was used to quantify the diversity of the plant species as a measure of species abundance and richness [18]. The Shannon's diversity index (H^1) was calculated using the following formula:

$$H' = -\sum_{i=1}^{s} \text{pilnpi} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots..(1)$$

Where, S = total number of species, Pi = is the proportion of each species in the sample.

ln=log base n

Equitability index/Evenness (E) is an index that makes the H^1 values comparable between communities by controlling for the number of species found within the communities. The value of E is between 0 and 1 with 1 being complete evenness.

Shannon's equitability (EH) or Evenness was calculated as follows:

$$EH = \frac{H}{Hmax} = \frac{H}{\ln s} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

Simpson's diversity index (D): it is the most widely used method of estimating the richness diversity of community and to compare different communities or habitats [18]. Simpson diversity is less sensitive to richness and more sensitive to evenness is derived from probability theory and it is the probability of picking two organisms at random which are of different species. Simpson's diversity index (D) was calculated using the following formula:

$$D = 1 - \sum p_i^2 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

Where: D = Simpson's diversity index and Pi = the proportion of individuals of the i^{th} species or the abundance of the i^{th} species expressed as proportion of total cover.

Measurements of similarity

Similarity indices measure the degree to which the species composition of quadrats or samples is alike, whereas dissimilarity coefficient assesses which two quadrats or samples differ in composition. Accordingly, the similarity of species composition between the natural forest and HGA was calculated with the Sørensen coefficient of similarity with the formula:

Sorensen's similarity coefficient will be expressed as: $Ss = \frac{2a}{2a+b+c}$ [16]

Where a = Number of species common both homegarden and natural forest.

b = Number of species unique to homegarden.

c = Number of species unique natural forest.

Often, the coefficient is multiplied by 100 to give a percentage similarity index.

Importance value index

The importance value index (IVI) indicates the importance of woody species in the system based on their relative density, relative dominance and relative frequency. IVI was analyzed by summing up relative frequency, relative dominancy and relative density for homegardens and natural forests. This equation was calculated with three components adopted for [16,38] as follows:

Importance Value Index (IVI) = RA. + RDO. + RF

Relative abundance: Is the study of numerical strength of a woody species in relation to the total number of individuals of all the species and can be calculated as:

Relative Abundance (RA) = $\frac{\text{Number of individuals ofa species}}{\text{number of individuals of all species}} * 100 \dots\dots\dots\dots\dots (4)$

Relative dominance: Dominance of a species was determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

Relative dominance (RDO) = $\frac{\text{The basal area of the species}}{\text{Total basal area of all species}} * 100 \dots\dots\dots\dots\dots (5)$

Basal area of a tree is calculated; BA = $\frac{\pi * dbh^2}{4}$ ……. (6)

Where, Π = 3.14 and dbh = diameter at breast height (cm)

Relative frequency: It is the degree of dispersion of individual species in an area in relation to the number of all the species occurred.

Relative frequency (RF) = $\frac{\text{Frequency of a species}}{\text{Sum of frequency of all species}} * 100$ …… (7)

Results and Discussion

Woody plant species diversity

Plot number-species accumulation curve

The plot number-species accumulation curve of woody plant species of the two studied land uses flattened before the total number of samples considered were exhausted (Figure 2a and 2b) showing that sufficient number of samples were considered to determine woody plant species diversity of each system. The curve for the natural forests starts to flatten from the 16th sample natural forests (Figure 2a), while the curve of the homegardens flattened after the 37th plot (Figure 2b).

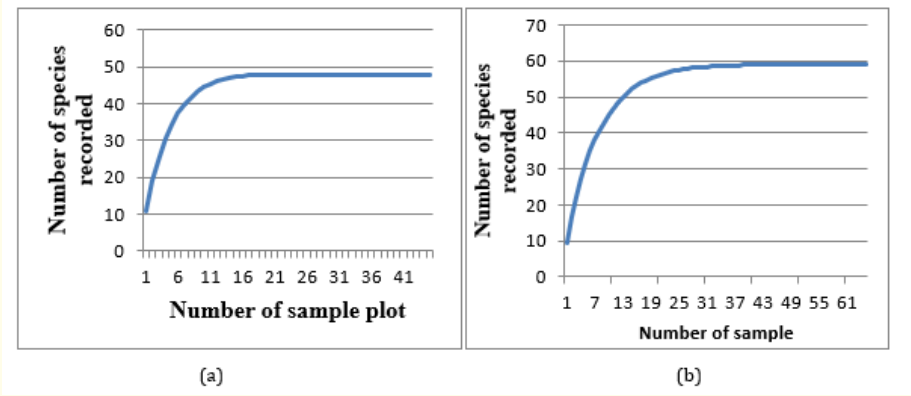

Figure 2: *Plot number-species accumulation curve of woody plant species in (a) the natural forest and (b) the homegardens in Heban Arsi, Ethiopia.*

Species diversity and frequency

The current study identified total of 73 woody plant species in natural forest and homegardens at the study area. Among these (i.e. species richness) were 58 and 48 for homegardens and the natural forest respectively. The highest number of woody plant species was recorded in homegardens as compared to the natural forest. The planting of various exotic and native woody species in the homegardens lead to higher species richness. The introduced woody species include exotic species, different fruit trees, cash crops and some species which were brought from other localities (e.g. *Cordia africana*). Yet, the higher degree of overlap between woody species in the homegardens and natural forest also shows that a large number of woody species of the natural forest still are preserved in the homegardens. The deliberate introduction of woody species into homegardens might be related to the right of ownership which, according to farmers feeling, is more secured in the homegardens as compared to the others. Hence, homegardens were a vital part of the land uses systems,

providing high diversity of woody plant species with different uses. Other studies also reported similar findings showing the role of agroforestry homegardens in other parts of Ethiopia [12,23,29,32,40]. To these connection 59 (80.8%) of these species were indigenous and the remaining with 14 (19.2%) species were exotic to the area. 80.8% native woody plant species in the homegardens of present study is also higher than similar studies reported elsewhere. For example, [2] in agroforestry homegarden in São Luis city, Maranhão, Brazil who indicated 60% of woody species being indigenous. The introduced woody plant species include exotic species, different fruit trees, and cash crops. Moreover, the higher degree of overlap between woody species in the homegardens and natural forest also shows that a large number of woody plant species of the natural forest still are preserved in the homegardens. This imply that homegarden have high potential for conservation of woody plant species diversity in the study area. The entire recorded species were belonging to 35 families in both homegardens and natural forest. Fabaceae and Rutaceae family have the highest number of species seven (7) each followed by Amoraceae, Asteraceae and Myrtaceae four (4) each (Appendix 1). The frequency occurrence of these woody plant families showed variation regarding to agroecological gradient. This is, probably, related to differences in species preferences of farmers, site characteristics, garden sizes and climatic differences. This is consistent with earlier studies which describes and classifies Ethiopian vegetation [36] in western of Ethiopia.

The Shannon diversity index is high in the natural forest and low in the homegardens, which is associated with the high evenness in the abundance of species in the natural forest as compared to homegardens. Simpson diversity index exhibited similar trend as that of Shannon diversity index (Table 1). This result is dissimilar to findings of Zenebu Mahderu [40] and Tefera Mekonnen., *et al*. [33] who reported that higher diversity and number of woody plant species in homegardens than natural forest. On the other hand, the result is similar to the study by Motuma Tolera., *et al*. [25] and Getahun Yakob [14] who reported a higher diversity in the adjacent natural forest. This variation may be related to low deforestation rate and good management.

Land use	Species richness	Shannon diversity index	Simpson diversity index	Species Evenness
Natural forest	48	2.28	0.88	0.90
Homegardens	58	1.98	0.74	0.79

Table 1: *Diversity indices of woody plant species in natural forest and homegardens in Heban Arsi, Ethiopia.*

Frequency of woody plant species in natural forest and homegarden

The result of the current study indicated that *Croton macrostachyus* (56%), *Afrocarpus falcatus* (53%), *Maytenus arbutifolia* (40%), and *Milletia ferrugenea* (37%) were the most frequently observed woody species in the natural forest. In contrast to this, species like *Ficus vasta*, *Solanecio manni* and *Olea capensis* were less frequently encountered than other woody plant species (Table 2). The finding of this study further revealed that in the homegardens *Coffea arabica* was the most frequently observed woody plant species with (65%), followed by *Rhamnus prinoides* with (37%) and *Malus sylvestris* with (30%), while the least abundant woody plant species was *Bytterneria catalpitiolata* (Table 3).

No	Botanical name	Frequency (%)
1	*Croton mycrostachyus*	56
2	*Afrocarpus falcatus*	53
3	*Maytenus arbutifolia*	40
4	*Milletia ferrugenea*	37
5	*Maytenus gracilipes*	33
6	*Celtis africana*	30
7	*Psydrax schimperiana*	30
8	*Bersama abyssinica*	27
9	*Cordia africana*	27
10	*Dovyalis abyssinica*	26

Table 2: *The top ten frequencies of woody plant species in the natural forest of Heban Arsi Woreda, Ethiopia.*

No	Botanical name	Frequency (%)
1	*Coffea arabica*	65
2	*Rhamnus prinoides*	37
3	*Malus sylvestris*	30
4	*Eucalyptus camaldulensis*	26
5	*Eucalyptus globulus*	26
6	*Persea americana*	26
7	*Croton macrostachyus*	24
8	*Milletia ferrugenea*	22
9	*Cupressus lusitanica*	20
10	*Carica papaya*	20

Table 3: *The top ten frequencies of woody plant species in the homegardens of Heban Arsi Woreda, Ethiopia.*

Woody plant species similarity

The finding with regard to the similarities in woody plant species composition of homegarden and adjacent natural forest showed that, 62% similarity in woody plant species composition was recorded. To this connection, from a total woody plant species recorded (73), 33 woody plant species were found commonly in both land uses. The Sorensen coefficient of similarity indicated that there is higher similarity observed between homegarden and natural forest (Figure 3 and appendix 1). This implies that the degree of species similarity within the two land use system is high and woody plant species diversity within each land use system was similar. In addition, the two land uses have high overlapping species with each other. The similarity of woody species composition among the HG and NF was higher than 50% because of the fact that they are found within in the same agroecology and domestication of wild woody species by farmers in HG. This could be due to the result of site characteristics similarity and might be related the deliberate introduction of woody plant species into homegardens according to farmers feeling which is consistent with the findings of Motuma Tolera [26]. Furthermore, in the study area homegardens can serve as gene pools for the eroding indigenous woody species. Many indigenous woody plant species like *Prunus africana, Hagenea abysisinica, Olea capensis, Erythrina brucei, Cordia africana* and *Ekebergia capensis* that are very rare in natural forests are conserved in homegarden of the study area because of their multiple benefits.

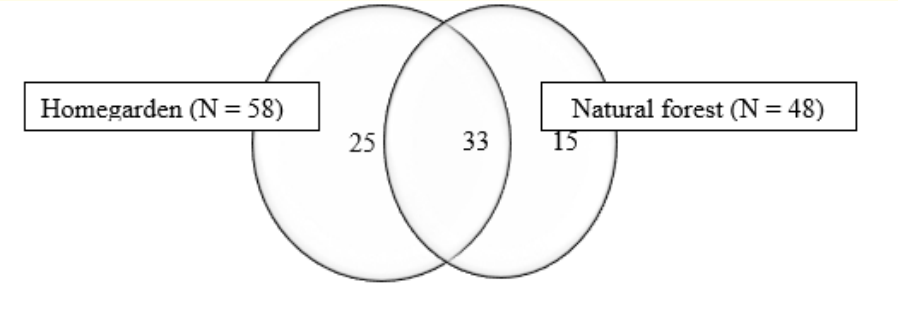

Figure 3: *Linear Venn diagram of the woody plant species richness pattern in the homegardens and the natural forest in Heban Arsi, Ethiopia.*

Importance value index of woody plant species

In terms of IVI, species with higher IVI are varied and depend on the systems. In the case of agroforestry practice the species importance depend on the product value of the species. For example, in shade grown coffee agroforestry practices woody plant species with the highest IVI are *Coffea arabica* and few other shade tree species. In homegarden woody plant species with highest IVI are fruit tree species and other high market value species [5]. According to this study species with high IVI is associated with the land uses and based on the local people's preference. In this manner *Coffea arabica* scores the first and *Eucalyptus camaldulensis* follows in HG (Appendix 2). This finding is in line with [8] which show that species with multiple uses showed higher IVI value. In the case of natural forests, species with high IVI is associated with those species which are dominant and well adapted in that agro ecology. Similarly, *Croton macrostchyus* and *Afrocarpus falcutus* showed higher IVI value in NF (Appendix 3). On the other hand, the result of the analysis of importance value index indicates that *Afrocarpus falcatus* is the most important woody plant species both in the natural forest and in the homegarden (Table 4). It is also the second most important woody plant species in the homegardens. *Afrocarpus falcatus* is one of the multipurpose tree species that provides multiple benefits. It provides shade and mulch in coffee and it increases the soil fertility. The wood produces durable quality timber that is used for the manufacture of furniture, doors, beehives and farm tools. This result confirms the report by Motuma Tolera [26] which stated that *Afrocarpus falcatus* is the most dominant woody plant species of the forest in the same study area.

	Important value index		
Species	**Homegarden**	**Natural forest**	**Average**
Afrocarpus falcatus	12.19	21.72	23.06
Croton mycrostachyus	8.18	28.72	22.55
Cordia africana	7.41	17.76	16.30
Acacia abyssinica	6.68	5.23	9.30
Teclea nobilis	6.28	6.62	9.59
Albizia gummifera	6.15	9.43	10.86
Vernonia auriculifera	5.47	3.25	7.10
Ficus vasta	5.44	3.16	7.03
Millettia ferruginea	5.33	28.09	19.38
Prunus africana	5.15	3.35	6.83
Vepris dainelli	4.90	3.36	6.59
Syzgium guneense	4.87	4.58	7.17
Ligia endonesis	4.40	2.36	5.58
Juniperus procera	4.24	5.14	6.81
Celtis africana	4.23	11.76	10.12
Bersama abyssinica	4.10	7.27	7.74
Acacia albida	4.05	4.02	6.07
Dovyalis abyssinica	3.97	5.94	6.94
Psydrax schimperiana	3.85	7.71	7.70
Olea europea	3.40	2.79	4.80
Flacourtia indica	2.77	3.48	4.52
Schefflera abyssinica	2.77	4.25	4.90
Ekebergia capensis	2.59	4.92	5.05
Clausena anisata	2.58	3.68	4.42
Ficus sur	2.58	3.39	4.27
Cassipourea malosana	2.46	3.24	4.08
Polyscias fulva	2.20	3.37	3.89
Acokanthera schimperi	2.16	5.60	4.96
Dombeya torrida	1.61	3.41	3.32
Carrissa edulis	1.54	3.85	3.47
Calpurnia aurea	1.13	3.97	3.12
Maesa lanceolata	1.43	5.11	3.27
Syzgium guneense	4.88	4.58	4.73
Hagenia abyssinica	2.65	3.12	2.88

Table 4: *Woody plant species common to homegardens and adjacent natural forest and their corresponding IVI in Heban Arsi, Ethiopia.*

Management practices of woody plant species in homegarden

Woody plant species preference

In this study, farmers' species preferences in relation to the most important woody plant species revealed that, *Coffea arabica*, *Rhamnus prinoides* and *Eucalyptus camaldulensis* were the three most preferred of the various woody plant species retained in homegarden (Table 5). The reasons for retaining different woody plant species depend on the tangible uses and services that they render to the household. In the study area, the respondents' major reasons for retaining woody species were ranked based on their importance as; construction > food > income > timber production > fuel wood > shade > soil fertility > others (fodder, beehive stand, beehive making) (Figure 4).

		Respondent's total
Woody plant species	**Importance**	**Relative score**
Coffea arabica	Cash	54.05
Rhamnus prinoides	Cash	21.37
Eucalyptus camaldulensis	Cash	7.40
Cupressus lusitanica	Cash	3.19
Persea americana	Cash	0.66
Carica papaya	Cash	0.45
Croton macrostachyus	Shade	0.13
Malus sylvestris	Cash	0.13
Mangifera indica	Cash/fruit	0.17
Cordia africana	Timber	0.18
Milletia ferrugenea	Timber	0.10

Table 5: *Ranking of preference for woody plant species in homegarden by the questionnaire respondents (N = 99) at Heban Arsi, Ethiopia.*

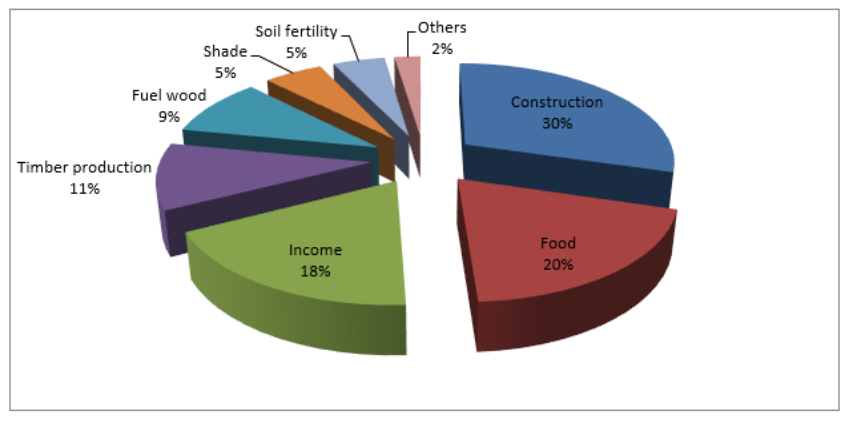

Figure 4: *Purpose of planting woody plant species and percentage of respondents planting different woody plant species for the stated purposes in Heban Arsi district, Ethiopia.*

Management practices

Farmers in the study area traditionally managed woody plant species in homegarden to get multiple benefits. Interviewed respondents indicated that pruning, thinning, composting, weeding, digging and watering are most commonly used woody plant species management practices in the site (Table 6). In most case, application of compost was carried out for fruit species like *Persea americana* and *Casmarea edulis,* and also *Cordia africana* (Table 6). On the other hand, weeding, digging and watering were also carried out for fruit species such as *Malus sylvestris*, *Casmorea edulis*, *and Persea americana* and *Mangifera indica* especially at seedling stages (Table 6). The purposes of these management practices were to increase the growth of active growing trees, to minimize competition by reducing shade effect, to use the intermediate products for fuelwood and fencing demands, as claimed by the respondents. This is in line with the result of [11,34] who reported in most part of the rural people uses different management practices. Similar finding was reported by [28] Wonago district, SNNPRS, Ethiopia.

No	Woody Plant Species	% of respondent for selected species in each management (n = 99)					
		Thinning	Prunning	Composting	Weeding	Hoing	Watering
1	*Cupressus lusitanica*	47	37	-	5	-	12
2	*Persea americana*	-	-	33	33	33	33
3	*Rhamnus prinoides*			19	49	49	32
4	*Afrocarpus falcatus*	22	-	-	-	-	-
5	*Casimorea edulis*	-	-	8	8	8	8
6	*Catha edulis*	-	-	16	16	16	16
7	*Celtis Africana*	20		-	-	-	-
8	*Coffea arabica*	-	-	38	83	83	30
9	*Cordia Africana*	32	-	-	-	-	-
10	*Croton macrostachyus*	16	-	-	-	-	-
11	*Eucalyptus camaldulensis*	53	-	-	-	-	-
12	*Eucalyptus globulus*	21	-	-	-	-	-
13	*Grevillea robusta*	-	22	-	22	22	-
14	*Mangifera indica*			25	25	25	25
15	*Prunus africana*	-	14	-	-	-	-
16	*Milletia ferrugenea*	-	31	-	-	-	-

Table 6: *Management practices employed by sample households for different woody plant species in Heban Arsi, Ethiopia.*

Conclusion

A total of 73 woody plant species belonging to 35 families were recorded indicating that the homegarden had a higher number of woody plant species, with variation in species composition, diversity indices, IVI and frequency of woody species occurrences as compared to the adjacent natural forest. However, Homegarden agroforestry practices encompass relatively lower woody plant species diversity as compared to adjacent natural forests in terms of Shannon diversity index.

Coffea arabica, *Rhamnus prinoides* and *Eucalyptus* spp. are the most preference woody plant species in the study area based on multiple uses and services they gave. Hence, to conserve and sustainably use the diverse woody plant species in homegarden agroforestry, farmers

apply different types of management practices. Pruning, thinning, composting, weeding, digging and watering were the most common management practice in homegarden agroforestry.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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