Management of Traditional Agroforestry Homegarden and its Contribution to Household Livelihood Diversification in Tembaro District, Southern Ethiopia

Desta Hamore[1] and Belayneh Lemage[2*]

[1]Arba Minch Agricultural Research Center, Arba Minch, Ethiopia
[2]Jinka Agricultural Research Center, Jinka, Ethiopia
***Correspondent author**: belaynehlemage@gmail.com

Received: June 3, 2019 **Accepted: August 28, 2019**

Abstract: *Homegarden is more diverse and provides multiple products for farm households. The objective of this study was to record and describe management practices, identifying the contribution of homegarden to household livelihood, assess the structural arrangement as well as factors affecting species diversity of the practice at Tembaro district, Southern Ethiopia. For this study, socio-economic data were collected from 120 households by using semi-structured questionnaires. Structural arrangement data were collected during the field survey. A total of 29 woody species categorized under 22 families were recorded in the homegarden agroforestry of the study area. Woody species richness and abundance were significantly higher ($P < 0.05$) in richer household than medium and poor once in both study kebeles. Coffee arabica, Cordial africana, Persea americana and Mangifera indica are the most frequently recorded woody species in both sites. The highest diversity indices were recorded at Debub Ambukuna than Sigezo, due to environmental and socioeconomic factors. Species composition depends on the farmer's preference and attribute of preferred species. This study has identified three different vertical arrangements and 4-6 horizontal compartments in both study sites. The farm households have benefited with different outputs from this practice. To sustain production, farmers carried out different management practices. Each household's members have been participating in homegarden management. However, women have been involved in more responsibilities than other members in each study sites. Managing species diversity associated with different factors, socioeconomic once are the most determinants. Institutional intervention is important on infrastructural issues in growing and diversifying economically valuable plant species in homegarden agroforestry and to improve the rural community in facility service to encourage the exchange products effectively and efficiently. Further study is needed in management practices of each component in homegarden agroforestry and improvement of production and productivity obtained from the homegarden agroforestry.*

Keywords: Arrangement of homegarden, vegetable and spice crops, woody species diversity

1. Introduction

Homegarden is a traditional land-use system which is extensively practiced throughout the world (Wajtkowski, 1998). Homegarden agroforestry can be defined as land use system involving deliberate management of multipurpose trees and/shrubs in intimate association with agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop-animal unit being intensively managed by family labor (Fernandes and Nair, 1986). It is found in most ecological regions of the tropics and subtropics, but a majority of them are in the lowland humid tropics (Fernandes and Nair, 1986; Nair, 1993). In homegarden agroforestry trees and crops provide numerous benefits to households, such as the production of building materials, food and firewood; generate family income and protect against soil erosion (Salam *et al*., 2000). Because of the high plant species diversity existing in homegardens, a wide spectrum of multiple-use products can be produced with relatively low labour, cash, or other external inputs (Soemarwoto,

1987; Christanty, 1990; Hochegger, 1998;; Das and Das, 2005). Woody species are very important components of homegarden that contribute to the livelihoods diversification (Tesfaye, 2005).

Homegarden agroforestry is characterized by high species diversity and have different vertical and horizontal arrangements. It usually encompasses 3-4 vertical canopy strata which results in intimate plant associations (Fernandes and Nair, 1986; Nair, 1993; Zemede and Ayele, 1995). Various studies have shown that broad-leaved trees dominated the upper story of homegardens in southern and other parts of Ethiopia (Zebene, 2003; Muktar, 2006; Yitebitu, 2009; Tesfaye *et al.,* 2010). It is also known that the middle story of these kind systems contains annual and perennial crop types (Jama *et al.,* 2006), while vegetables, spices, and herbs cover the ground layers.

Farmers employ indigenous knowledge in managing homegardens where management activities are mostly responsibility of women. For instance, study conducted by Fentahun (2008) in Amhara Region, shown that farmers carry out pruning, pollarding, lopping, weeding, fencing and etc. to manage tree species diversity in homegarden. In Ethiopia, homegarden agroforestry is widely practiced as a major source of daily food and income generation (Zemede, 2002; Tesfaye, 2005). Southern Nation's Nationalities and Peoples' Regional State is the most commonly known example of perennial-crop based homegarden in Ethiopian highland (Tesfaye, 2005). Tembaro district is among of the districts which widely practice homegarden agroforestry in Southern Nations, Nationalities and People's Regional State. Within districts where homegarden agroforestry is practiced, information on management practices, their contribution to sustainable livelihood to the local community of the area and factors influencing the management of homegarden is very limited or not available. Therefore, this study is an attempt in this direction for the district to illuminate information on the management practices, contributions to household livelihood as well as factors affecting the management of homegarden in order to create an effective way of household contributions and appropriate management techniques for diverse species of homegarden agroforestry.

2. Materials and Methods

2.1. Description of the study area

The study was conducted in Tembaro district in Kembata Tembaro Zone, Southern Ethiopia. Geographically, it is located between 37º36'32'' to 37º21'5'' E and 7º11'8'' to 7º21'51'' N. The altitude of the study area ranges from 800 to 2600 meter above sea level (Figure 1).

Figure 1. Map of the study area

2.2. Study site selection

Tembaro district encompasses three agro-ecological zones, from which Kola and Woyena dega cover the largest proportion. Two kebeles were selected purposively from the above agro ecological zones, namely Sigazo kebele from midland and Debub Ambukuna from lowland based on the presence of extensive homegarden agroforestry practice. Before the field data collection, a preliminary reconnaissance survey and direct field observations were conducted to obtain similar data prior to a detailed survey.

2.3. Data collection

Formal survey data collection was conducted on the sample households with the structured questionnaires in each selected village. Both primary and secondary data sources were used as an information tool. At the household level, the necessary data related to the homegarden management and its contribution to household livelihood was collected using a structured questionnaire through interviewing the household heads. To assess farmers' management practices and socioeconomic factors affecting the practice within the study area, then all farmers who practiced homegarden were stratified based on wealth status using the record of total households living in the study area using livelihood standard by the help of key informants. Following stratification of households into wealth category, from each wealth class respondents were randomly selected for the household survey. Then six percent sample households were employed in the interview at each wealth class. About 120 respondents were used for household interview.

Data on plant inventory, plant use, species abundance and the total count of individuals of each species were collected from entire gardens of 120 randomly selected households to estimate its richness, abundance and frequencies in garden level. The local name of the plant species found in the sample plots was identified and recorded with the help of key informants and scientific nomenclature was carried out using plant identification manuals and books namely useful trees and shrubs of Ethiopia (Azene, 2007) and Flora of Ethiopia and Eritrea (Edwards, *et al*. 1995). Homegarden structure characterization carried out accordingly to collect structural arrangement data of homegarden. The number of vertical strata and the plant species occupying each stratum in each site was recorded following the classification of Millate (1998). Accordingly, six different vertical strata; <1 m, 1-3 m, 3-5 m, 5-7 m, 7-9 m, and >9 m were considered.

2.4. Data analysis

Non-quantifiable elements such as events, behaviors, activities, meanings from the informal survey were interpreted, analyzed, and synthesized using descriptive statistical analyses. Quantitative data obtained from household questionnaire survey was entered to the computer, analyzed and synthesized using SAS software. One-way ANOVA was used to test whether there is a significant difference in income generated from homegarden agroforestry, woody species diversity and richness among as well as between the different wealth groups. Microsoft-Excel was also used to generate tables and graphs. These data were organized and results were presented in frequency and tables.

2.4.1. Shannon diversity index (H')

It relates the proportional weight of the number of individuals per species to the total number of individuals for all species. Shannon diversity index was calculated as:

$$H' = -\sum_{i=1}^{s} Pi \ln Pi \qquad [1]$$

Where

H′ = Shannon-Wiener Diversity Indexes; s = number of species; Pi = Proportion of individuals or abundance of the i^{th} species expressed as a proportion of the total cover; Ln = log base (natural logarithm).

2.4.2. Equitability (evenness) index

Evenness (equitability) index (J) was calculated following the formula indicated below.

$$\text{Equitability } (J) = H'/Hmax \quad [2]$$

Where

J = Evenness; H' = Shannon-Wiener Diversity Index; Hmax = lnS; S = total number of species in the sample.

3. Results and Discussions

3.1. Socio-economic and demographic characteristics

From a total of 120 households interviewed for this study, male respondents accounted for 90.8% and the rest were females of the sampled population, 38% were illiterate, 26% elementary school (grade1-4) complete, 23% second cycle (grade 5-8 complete) and the rest 13% were high school and above. All respondents were categorized into three age categories. The lower age category (28-45) year accounted for 54% and the rest medium (46-64) and old (above 64) accounted for 39% and 7%, respectively. The mean, maximum, and minimum land holding of the respondents was 0.82, 6 and 0.25 hectares, respectively. The occupation of people in the study area was mixed agriculture/crop cultivation and animal husbandry/ which are common farming practices.

3.2. Woody species diversity

3.2.1. Component arrangement

Homegarden agroforestry in the study area is an assemblage of different life forms with the compartments of different vertical and horizontal arrangements. The upper story was dominated by *Cordia africana*, *Albizia gummifera*, *Millettia ferruginea*, *Persea americana* and *Mangifera indica*; the middle story occupied with ensete, coffee, maize and banana while vegetables, spices, and herbs cover the ground layers. This study identified three different vertical arrangements or strata in both study sites. Similar multilayer vertical structures with 3-6 vertical strata have been reported in different tropical homegardens (Gajaseni and Gajaseni, 1999; De Clerck and Negreros-Castillo, 2000; Albuquerque *et al*., 2005; Fentahun, 2008). Various studies have shown that broad-leaved trees and fruit tree crops are among woody species that dominated the upper story of the coffee-based agroforestry practice and homegarden in southern and other parts of Ethiopia (Badege and Abdu, 2003; Zebene, 2003; Muktar, 2006; Yitebitu, 2009; Tesfaye *et al.,* 2010). It is also known that the middle story and of these practice comprise Enset, coffee and maize (Jama *et al.,* 2006) while vegetables, spices, and herbs cover the ground layers (Zebene and Ågreen, 2007).

Besides the vertical strata, homegarden in the study area is characterized by horizontal compartment where different crops receive different management practices. In the present study, 4-6 horizontal arrangement was identified in most homegarden. Most prominent of these management zones common in the majority of homegarden include distinct compartments for enset, coffee, root and tubers and vegetables. Spices and medicinal plants often planted in plots close to the house next to beehives. Enset suckers are also raised next to spices and medicinal plants for special protection such as composting and watering in the dry season. Distance from home position, size, crop composition, and planting pattern of the garden are the principal determinants (Kumar and Nair, 2004). The arrangement of components in this homegarden is not haphazard but a designed one. Such an arrangement of the various management units indicates farmers' indigenous knowledge of planting pattern. Many authors have reported that distinct horizontal zones occur in the homegarden, and that their location, size and plant species composition reflect deliberate management strategies (Abdoellah, 1990; Zemede and Ayele, 1995; Mendez *et al*., 2001).

3.2.2. Woody species diversity indices

Analysis of species diversity was carried out for both locations; its value varies in both sites depending on different socioeconomic factors.

Table 1: Richness and abundance of woody species in homegardens of two kebeles in Tembaro District of Ethiopia

Sites	Altitude	Richness		Abundance	
		Total	Mean (±std)	Total	Mean (±std)
Sigezo	1820-2000	25	8.3b±2.1	9138	152.3b ±73.6
Debub Ambukuna	1506-1650	29	9.6a ±1.8	12558	209.3a ±84.9
Overall mean		27	8.95±1.95	10848	180.8±79.25

Means in column followed by the same letter/s are not significantly different at P<0.05

Woody species recorded in homegarden of the study sites were 29, which categorized under 22 families. Fabaceae family had the highest number of species (4) followed by Rutaceae and Euphorbiaceae both with 3 species. The rest families had only one species for each. Generally, woody species richness was significantly higher (P < 0.05) in Debub Ambukuna than Sigezo. The abundance of woody species in the present study varied between two sites.

Species richness and abundance were also calculated for the three wealth classes in both sites. Woody species richness was significantly (P<0.05) higher in gardens of rich than medium and poor wealth categories at both sites. Similarly, it was significantly higher for the medium wealth category than the poor. From all wealth categories, the highest species richness and abundance were recorded in Debub Ambukuna for rich and the lowest in Sigezo for poor class. However, there was no significant difference (P > 0.05) among rich and medium wealth categories at both kebeles for species abundance (Table 2).

In order to get a better picture on the extent of woody species diversity, diversity indices were calculated in both study sites respecting to agro-ecological base and wealth classes. The highest Shannon and Simpson diversity indices were recorded at Debub Ambukuna. Species evenness also showed similar trend like Shannon and Simpson indices in terms of species diversity. Generally, woody species diversity was higher in homegarden at lowland site than midland (Table 3). Woody species diversity was significantly higher in rich than medium and poor wealth categories. Similarly, the three diversity indices were significantly higher for the medium wealth category than the poor. However, there was no significant difference (P > 0.05) among rich and medium wealth categories at Sigezo kebele for Simpson diversity index (Table 4). Farmers grow diverse woody species in their homegarden for different services. Wide variations in species assemblages of different geographic/eco-climatic regions are apparent (Kumar and Nair, 2004). The number of species in homegarden from different parts of the world ranged from 60 (Zemede and Zerihun, 1997, in southern Ethiopia) to 324 (Mendez *et al*., 2001, in Nicaragua).

In the present study, the mean woody species richness and woody species diversity per homegarden varies within and between sites. The difference in species richness and diversity between sites could be the result of differences in agro-ecology of the sites whereas within site variation related to garden size (land), management skill and household species preference for various purposes. It is in line with the result reported from Beseku, Ethiopia by Motuma *et al.* (2008). The mean number of woody species per homegarden in this study (8.95) is lower than that (11.0) reported by Zemede and Ayele (1995) from 111 sample homegarden from different agro-ecological zones in Ethiopia and (16.0) reported for Sidama homegarden (Tesfaye, 2005).

Table 2: Richness and abundance of woody species in garden`s of different wealth categories in different kebeles in Tembaro District of Ethiopia

Wealth category	Sigezo Kebele		Debub Ambukuna Kebele	
	Richness	Abundance	Richness	Abundance
Rich	9.6a ±2	213a ±262	10.7a ±1.2	285a ±130
Medium	8.3b ±2.2	155a ±132	9.6b ±1.5	236.4a±105
Poor	7.1c ±1.4	88.5b ±35	8.5c ±1.4	107b ±21
Overall mean	8.3±2.1	152.3±175.6	9.6±1.5	209±85

Means in column followed by the same letter/s are not significantly different at P<0.05

Table 3: Shannon, Simpson and Evenness diversity indices of two kebeles in Tembaro district of Ethiopia

Kebeles	Altitude	Shannon index	Simpson index	Evenness
Sigezo	1820-2000	0.81b +0.28	0.40b +0.14	0.43b +0.17
Ambukuna	1506-1650	1.09a +0.27	0.54a+0.12	0.46a +0.12

Means in column followed by the same letter/s are not significantly differences at P<0.05

Table 4: Shannon, Simpson and Evenness diversity indices of different wealth categories in two kebeles in Tembaro district of Ethiopia

Kebeles	Wealth	Shannon	Simpson	Evenness
Sigezo	Rich	0.81c±0.24	0.40b±0.12	0.46b±0.12
	Medium	0.70c ±0.23	0.39b±0.13	0.33d±0.09
	Poor	0.67c ±0.22	0.35b ±0.14	0.32d ±0.12
Debub Ambukuna	Rich	1.32a±0.20	0.62a±0.08	0.58a ±0.09
	Medium	1.098b ±0.14	0.57a ±0.05	0.45bc±0.07
	Poor	0.84 c±0.19	0.42b±0.12	0.36cd ±0.09

Means in the same column followed by different letters are significantly different (P<0.05)

3.3. Management of homegarden agroforestry

Woody species in the study area receive different management practices by household members. Activities like pruning, thinning, coppicing, pollarding, composting, weeding, digging or hoeing and planting material production taking place for woody species management. This is in line with the result of Tefera (2010); Fentahun (2008) who reported in most part the rural people uses different management practices. In the study area, farm households have well-founded indigenous knowledge to manage each component of homegarden. Farmers manage woody species mainly to reduce resource competition, enhance growth, and to achieve the aim of targeted production. These productions continued through the integration of multipurpose woody species, which are economically feasible and socially acceptable. A similar finding was reported by Negussie and Mesele, (2006) Wonago district, Southern Ethiopia. Zemede (2002) also reported that homegarden management depends on the indigenous knowledge of the community and the household's partners.

However, there are several factors that hinder the rising of germplasm and management of the practice in the study area. In order to solve such problems, local farmers traditionally use practices such as fencing, guarding, cultural practices (sanitation) and the application of insecticides to reduce the impact of damages. Farmers of the study site have different sources of germplasm. According to the present study, self-regeneration, own nursery, Ministry of Agriculture and others

(sharing between homegarden owners) were the main sources. The finding of the study is comparable to earlier studies done elsewhere. For instance, Sunwar (2003) reported the majority of sources for planting materials for homegarden are self- established by farmers themselves. Few fruit, coffee and *Gravilia robusta* seedling received from government nurseries in both study sites. Similarly, Sunwar (2003); Fentahun (2008) reported farmers obtained homegarden species from government organization nursery site.

Farm households preferred some woody species to integrate deliberately to homegarden based on their desirable functions. Accordingly, *Coffee arabica*, *Cordia africana*, *Persea americana*, *Mangifera indica*, *Albizia gummifera* and *Grevillea robusta* are highly preferred tree species by the farm households. The species preferences in the homegarden depends on their economic advantages, ability to fertilize the soil, fast decomposition rate, sparse crown, and absence of severe competitive effects with the other homegarden components. Similar research has been conducted in Nigeria, which suggests that for their best trees, farmers had a wide range of preferences and often gave more than one character (Lovett and Haq, 2000).

Farmers were encountered with a number of problems while establishing and growing woody species in homegarden agroforestry. Such damage and control measures are not restricted to current study area. For example, in Bangladesh major problem that farmers faced in tree establishment and management were the damage caused by animals, storms, and insect pests (Alam *et al*., 2005; Zaman *et al*., 2010). However, depending on the local experience there could be a number of approaches applied to protect farm trees in homegarden. For instance, farmers in the study area solve the problems of insect pest and disease using insecticides. On the other hand, fences are constructed to protect woody species from animal damage while guarding was a recommendable solution to reduce damage from thieves and wild animals.

3.4. Contribution of homegarden agroforestry to household livelihood

Homegarden of the study sites is an assemblage of annual and perennial crops, which are major sources for diverse products to human use. Farmers in the study area manage homegarden for various purposes; it has a wider contribution to livelihood diversification. It plays a vital role in contributing to the livelihood of respondent households. In both study sites, farmers are growing different species in their homegarden primarily for household consumption and to a lesser extent income generation. The plant species diversity in homegarden plays a fundamental role in the provision of diversified products for household utilization. In a similar manner, diversified outputs in homegarden have been reported across Ethiopian gardens (Zemede and Ayele, 1995). Studies made elsewhere also support the view of sampled farmers on the benefits of homegarden cotribution. The number of functional units in the homegarden of the study area is also comparable to Sidama homegarden (10 functional units per homegarden) (Tesfaye, 2005). Similar benefits have been reported from elsewhere (e.g. Gebauer, 2005).

As observed in field survey, homegarden size varied depending on different socioeconomic characteristics. For instance, rich and medium households' homegarden with better management and species composition than a poor farmer, thus the former two categories have got high income from diverse plant species than the later. The mean annual income (2009-2011) from homegarden was showed that there is significantly different between wealth categories within a study site (Table 5). Rich farmers got higher mean annual income (12942.9 Birr), than medium (7915.2 Birr) and poor (5185.9 birr) across study sites.

Table 5: Annual income (2001-2003 EC) obtained from homegarden in Tembaro District of Ethiopia

Sites	Wealth category	Mean(± std) income
Sigezo	Rich	11279.3b ±4419.7
	Medium	7170.4cd±2361.2
	Poor	4991.5d±1301.7
Debub Ambukuna	Rich	14606.5a ±3405.7
	Medium	8660c ±2549.2
	Poor	5380.3d ±957.7

Means in the same column followed by different letters are significantly different (P<0.05)

Cash crops and fruit trees play a vital role in cash income generation in the study area in addition to household consumption. Coffee, ginger, avocado and mango are major sources of income while satisfying household consumption. The income difference between households was may be wealth status difference, knowledge of desirable species integration and composition of economically important species and the size of homegarden and households preference for specific crops. Similarly, in Indonesia, total annual income generated from 6.6% to 55.7% depending on the size of the homegardens, family needs and species composition (Soemarwoto, 1987).

3.5. Factors Influencing Plant Species Richness and Diversity in Homegarden

Land availability is an important factor that determines the development of each component of homegardens. The average size of homegarden obtaiend from the study site was 0.41 ha per household (Table 6). As Homegarden size increased plant species richness and diversity were increases, where it offers the space to integrate compatible plant species. A positive relationship between garden size and species richness has been documented by many workers, e.g. Tesfaye, (2005) in Southern Ethiopia, Abdoellah *et al*., (2002) in Indonesia, Das and Das, (2005) in India, and Sunwar *et al*., (2006) in Nepal. Wealth status was another factor that influenced plant species richness in homegarden. Rich households cultivate significantly higher (P< 0.05) number of plant species than medium and poor households (Table 6). Several studies have reported the influence of wealth on the tree density and tree species richness on farmlands (*e.g*. Den Biggelaar, 1996; Zebene, 2003; Tesfaye, 2005). However, Warner (1993) noted that a lack of capital may hinder a farmer from obtaining a preferred species or a large number of seedlings, although it does not prevent him from planting trees.

Table 6: Homegarden size and plant species in different wealth categories in Tembaro district of Ethiopia

Wealth Categories	Sigezo (higher altitudinal site)		Debub Ambukuna (lower altitudinal site)	
	Average size of homegarden (ha)	Average plant species	Average size of homegarden /ha	Average plant species
Rich	0.55a ± 0.17	12a ± 0.95	0.50a ± 0.11	14.5a ± 0.75
Medium	0.42b ± 0.14	9.6b ± 0.25	0.38b ± 0.15	11.0b ± 0.70
Poor	0.34b ± 0.11	7.3b± 0.40	0.31b ± 0.10	8.8b ± 0.40

Means in column followed by the same letter/s are not significantly differences at P<0.05

Age of the respondents was another socio-economic factor which influenced plant species richness in homegarden in the study area. As it was observed from the survey result, older respondents

have significantly higher (P<0.05) species richness than the younger ones (Table 7).

Table 7: Plant species in homegardens of different age category of households Tembaro District of Ethiopia

Age category (years)	Sigezo Kebele	Debub Ambukuna Kebele
	Plant species	plant species
Lower (28-45)	8.3c ± 0.40	9.8c ± 0.40
Medium (46-64)	9.9b ± 0.25	11.6b ± 0.70
Old (>64)	11.2a ± 0.95	13.5a ± 0.75

Means in column followed by the same letter/s are not significantly differences at P<0.05

In the study area different socioeconomic factors were stated by interviewed respondents, that influnce the abundance and richeness of the species. Villages of the lower site have a higher abundance of coffee and fruit tree species than the upper altitudinal site (Table 1 and 3). Location of market place negatively or positively affected the farmers in growing woody species in homegarden (Zebene, 2003; Tesfaye 2005; Sandya Kumari, 2009). Altitude is an important ecological factor that influences plant species richness in homegarden in the study area. Debub Ambukuna in lower altitudinal has higher plant species richness than Sigezo in the higher altitudinal site. Species richness is generally said to decrease with increasing elevation due to decreasing mean temperature. This is in line with the work of Karyono, 1990; Hodel *et al*., 1999 and Krebs, 1985.

4. Conclusion and Recommendations

4.1. Conclusion

Traditionally, farm households manage homegarden by employing different options to achieve sustainable production. Activities like pruning, thinning, coppicing, pollarding, composting, weeding, digging or hoeing and planting material production were taking place in garden management. The growing of woody species in homegarden depends on farmers' preference. Accordingly, farmers selected woody species in the order of *Coffee arabica*, *Cordia africana* and *Persea americana* followed by *Mangifera indica* based on the benefits they provide. Seedlings of the woody species planted were obtained from self-raised (own nursery), self-regeneration (under mother tree around the home), MoA and others. Livestock damage, disease, theft, insect pests and wild animals' damage were the main problems encountered during homegarden management. However, local farmers traditionally use practices such as fencing, guarding and application of organic pesticides to solve the problems. On the other hand, farm size, wealth, agro-ecology, age of household, and market and road access were the major factors determining species composition in homegarden agroforestry.

Homegarden agroforestry has a variety of contributions in improving the household livelihood. For instance, food crops, cash crops, fuelwood, animal feed, timber, household tools, medical plants, spices, farm implements, honey and uncounted ecological services such as soil fertility improvement, providing shade for living organisms, etc. are the contributions households obtained from homegarden agroforestry.

4.2. Recommendations

Based on the results of the present study the following recommendations are forwarded.

- Framers in the study area should be encouraged to use their indigenous knowledge in managing homegarden and assisted through extension services, to make them well equipped and used as a source of information center.
- Empowering experts to find a solution for the described constraints to promote and implementation of homegarden agroforestry in areas where it is advanced.

- Accessibility of infrastructure is a critical issue in growing and diversifying economically important plant species in homegarden agroforestry. Therefore, the intervention of institutions is needed to improve the rural community in facility service to encourage the exchange products effectively and efficiently.

- Further detailed study is required in management practices of each component in homegarden agroforestry and further improvement of production and productivity obtained from the homegarden agroforestry.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgements

We would like to extend our great appreciation to farmers and experts for devoting their precious time in providing information and sharing their knowledge for this study. We also would like to thank Dr. Zebene Asfaw for his assistance during research work.

References

Abdoellah, O.S. (1990). Homegardens in West Java and their future development. pp. 69–79. In: Landauer K. and Brazil M. (eds), Tropical Homegardens, United Nations University Press, Tokyo.

Abdoellah, O.S., Parikesit; Gunawan, B., and Hadikusumah, H.Y. (2002). Home gardens in the upper Citarum watershed, West Java: A challenge for in situ conservation of plant genetic resources. Proceedings of the Second International Home Gardens Workshop, 17-19 July 2001, Witzenhausen, Germany. IPGRI, Rome, Italy, p. 140-147.

Abebe, T. (2005). Diversity in homegarden agroforestry systems in Southern Ethiopia. PhD. Thesis. Wageningen University, Wageningen. P. 153

Abebe, T., Wiersum K.F., and Bongers, F. (2010). Spatial and temporal variation in crop diversity in agroforestry homegardens of southern Ethiopia. Agroforest Syst 78:309-322

Achalu, N., and Negash, M. (2006). Indigenous Agroforestry Practices and their Implications on Sustainable Land Use and Natural Resources Management: The Case of Wonago Woreda. Research Report No 1. Sustainable Land Use Forum (SLUF). Addis Ababa, Ethiopia

Alam, M.S., Masum, K.M., and Mamum-Or-Rashid (2005). Tree Species Diversity and Management Practices of Woodlot in Homegarden of the Offshore Island of Bangladesh. Pakistan Journal of Biological Sciences 8 (4): 561-566

Albuquerquea, U.P., Andrade, L.H.C., and Caballero, J. (2005). Structure and Floristic composition of Homegardens in Northeastern Brazil. Journal of Arid Environments, 62: 491–506.

Asfaw, Z. (2002). Home gardens in Ethiopia: some observations and generalizations. In: Waston and Eyzaguirre (eds). Proceeding of the second international homegardens workshop: contribution of homegarden to in situ conservation of plant genetic resources in farming systems, Witzenhausen. Federal Republic of Germany. International Plant Genetic Resources Institute, Rome. PP. 125-139

Asfaw, Z. (2003). Tree Species Diversity, Top Soil Conditions and Arbuscular Mycorrhizal Association in the Sidama Traditional Agroforestry Land-Use, Southern Ethiopia. PhD. Thesis. Swedish University of Agriculture, Uppsala, Sweden

Asfaw, Z., and Ågren, G. (2007). Farmers' local knowledge and topsoil properties of agroforestry practices in Sidama, Southern Ethiopia. Agroforestry Systems 71:35–48

Asfaw, Z., and Nigatu, A. (1995). Home-gardens in Ethiopia: Characteristics and plant diversity. SINET: Ethiop. J. Sci., 18 (2): 235-266.

Asfaw, Z., and Woldu, Z. (1997). Crop association of home-gardens in Welayta and Gurage in

southern Ethiopia. SINET: Ethiop. Journal of science, 20(1):73-90.

Bekele, A. (2007). Useful Trees of Ethiopia: Identification, Propagation and Management in 17 Agro- ecological Zones. Nairobi: RELMA in ICRAF Project 552pp.

Bishaw, B., and Abdelkadir, A. (2003). Agroforestry and Community Forestry for Rehabilitation of Degraded Watersheds on the Ethiopian Highlands. International Symposium on Contemporary Development Issues in Ethiopia, July 11-12, Addis Ababa, Ethiopia. 22 pp.

Christanty, L. (1990). Home-gardens in Tropical Asia, with special reference to Indonesia. In: Tropical Home-Gardens, pp. 9-20 (Landauer, K. and Brazil, M., eds.). United Nations University Press, Tokyo.

Das, T., and Das, A. K. (2005). Inventorying Plant Biodiversity in Homegardens: A Case Study in Barak Valley, Assam, North East India. Current Science 89(1): 155-163

De Clerck F.A.J., and Negreros-Castillo P. (2000). Plant species of traditional Mayan homegardens of Mexico as analogs for multistrata agroforests. Agroforest Syst 48: 303–317

Den Biggelaar, C. (1996). Farmer experimentation and innovation: a case study of knowledge generation process in agroforestry systems in Rwanda. In: Nancy, H. (ed) Community forestry Case Study Series 12, FAO, Rome. 123pp

Edwards, S., Mesfin T., and Hedberg I. (1995). Flora of Ethiopia and Eritrea, Vol. 2, Part 2. The National Herbarium. Addis Abeba University/Department of Systematic Botany, Uppsala University, Addis Ababa/Uppsala. 456 pp.

Fernandes, E.C.M., and Nair, P.K.R. (1986). An evolution of the structure and function of tropical homegardens. ICRAF. Working Paper No. 38. Nairobi, Kenya.

Gajaseni, J., and Gajaseni, N. (1999). Ecological rationalities of the traditional homegarden system in the Chao Phraya Basin, Thailand. Agroforest Syst 46: 3–23.

Gebauer, J. (2005). Plant Species Diversity of Home Gardens in El Obeid, Central Sudan. Journal of Agriculture and Rural Development in the Tropics and Subtropics 106 (2): 97–103

Hochegger, K. (1998). Farming Like the Forest - Traditional Home Garden Systems in Sri Lanka. Margraf Verlag, Weikersheim, Germany, 203 pp.

Hodel, U., Gessler, M., Cai H.H., Thoan, V.V., Ha, N.V., Thu, N.X., and Ba, T., (1999). In situ conservation of plant genetic resources in homegardens of Southern Vietnam. IPGRI, Rome, Italy, 106 pp.

Jama, B., Elias, E., and Mogotsi K. (2006). Role of agroforestry in improving food. Journal of the Drylands 1(2): 206-211

Karyono (1990). Home Gardens in Java. Their Structure and Function. In: Landauer, K.; Brazil, M. (eds.). Tropical Home Gardens. The United Nations University, Tokyo, Japan, p. 138-146.

Krebs, C.J. (1985). Ecology: The experimental analysis of distribution and abundance. Harper & Row Publishers, New York. 800 pp.

Kumar, BM., and Nair P.K.R. (2004). The enigma of tropical homegardens. Agroforestry Systems, 61: 135–152.

Lovett, P.N., and Haq, N. (2000). Evidence for anthropic selection of the sheanut tree (Vitellaria paradoxa). Agroforestry systems 48:273-288. Kluwer Academic Publishers, The Netherlands.

Mekonen, T. (2010). Homegardens Agro biodiversity Conservation in Sebeta-Hawas Wereda, Southwestern Shewa Zone of Oromia Region, Ethiopia. MSc thesis. Addis Ababa University, Ethiopia.78 pp.

Mendez, V.E., Lok, R., and Somarriba, E. (2001). Interdisciplinary analysis of homegardens in Nicaragua: micro-zonation, plant use and socioeconomic importance. Agroforest Syst 51: 85–96.

Mengistu, F. (2008). Fruit tree species in the wild and in homegarden agroforestry: species composition, diversity and utilization in western Amhara region, Ethiopia. PhD. Thesis. Vienna University, Vienna. 207 pp.

Millat-e-Mustafa, M. (1998). Overview of Research in Home-garden Systems. In: Applied Ethnobotany in Natural Resource Management Traditional Home-gardens, pp.

13-19 (Rastogi, A., Godbole, A. and Shengji, P., eds.). International Center for Integrated Mountain Development, Kathmandu, Nepal.

Moges, Y. (2009). The impact of overstorey trees on sustainable coffee (Coffea arabica L.) Production in southern Ethiopia. PhD Dissertation, Horizonte Bd. 25, Der Andere Verlag, Tönning, Lübeck and Marburg

Nair, P.K.R. (1993). An Introduction to Agroforestry. Kluwer Academic Publishers-ICRAF. P. 489

Reshad, M. (2006). Farm characteristics and tree species diversity in Arbegona district, highlands of southern Ethiopia. M.Sc. Thesis, Hawassa University, Wondo Genet College of Forestry and Natural Resource, Ethiopia

Salam, M.A., Noguchi, T., and Koike, M. (2000). Understanding why farmers plant trees in the homestead Agroforestry in Bangladesh. Agroforestry systems 50(1): 77-93

Sandya Kumari, M.A. (2009). Plant diversity in home gardens and its contribution to household economy in Suburban areas in Sri Lanka. MSc. Thesis. Mahidol University, Thailand

Soemarwoto, O. (1987). Homegardens: A traditional agroforestery system with promising future. In: Agroforestery a decade of development, Pp. 157-172. (Steppler, H.A and Nair, P.K.R., eds.). ICRAF, Nairobi, Kenya.

Sunwar, S. (2003). Home gardens in western Nepal: Opportunities and challenges for on farm management of agro biodiversity. MSc thesis. Swedish Biodiversity Centre. No. 29.

Sunwar, S., Thornstrom, C., Subedi, A., and Bystrom, M. (2006). Homegardens in Western Nepal: Opportunities and challenges for on-farm management of agro-biodiversity. Biodiversity and Conservation, 15: 4211-4238.

Tolera, M. (2006). Woody species diversity of agricultural landscapes in Arsi Negelle District, Ethiopia: Implications for biodiversity conservation. MSc thesis, University of Hawassa, Wondo Genet College of Forestry, Wondo Genet, Ethiopia.

Tolera, M., Asfaw, Z., Lemenih, M., and Karltun, E. (2008). Woody species diversity in a changing landscape in the south-central highlands of Ethiopia. Agriculture, Ecosystems and Environment 128: 52–58

Wajtkowski, A. (1998). The Theory and Practice of Agroforestry Design. A comprehensive study of the theories, concepts and conventions that underline the successful use of agroforestry. Science publishers, Inc. U. S. A. 282 pp.

Warner, K. (1993). Patterns of farmer tree growing in Eastern Africa.: A socio-economic analysis. Tropical Forestry Paper no.27. Oxford Forestry Institute and Nairobi: ICRAF. 27pp.

Zaman, S., Siddiquee, S. U., and Katoh, M. (2010). Structure and Diversity of Homegarden Agroforestry in Thakurgaon District, Bangladesh. The Open Forest Science Journal 3: 38-44