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WOOD PRODUCTION AND MANAGEMENT OF WOODY SPECIES IN HOMEGARDENS AGROFORESTRY: THE CASE OF SMALLHOLDER FARMERS IN GIMBO DISTRICT, SOUTH WEST ETHIOPIA

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ABSTRACT

Homegardens are defined as a system of production of diverse plant species, which can be adjacent to household or slightly further away and is easily accessible. Wood production and management systems of Kaffa homegardens are poorly known. The study was conducted to assess the wood production and farmers' strategy of managing woody species in Gimbo district, South West Ethiopia. A complete homegarden woody species inventory was carried out to collect vegetation data, while simple random sampling was used to select sample households within wealth categories. From two purposely selected sites, a total of 120 households were selected for interview and vegetation data collection. Semi-structured interviews, direct observation and focus group discussions were employed to gather information on farmers' strategy of managing woody species. The DBH of all trees and shrubs ≥ 5cm was measured. The mean number of stems per garden was 34, ranging between 6 to 99. Wealth status of the household influenced the wood production of homegardens. At all studied villages, the largest number of stems per garden was recorded on gardens of wealthy households. Various trees and shrubs are managed on the same piece of land. About 92% of the respondents have retained different woody species in their homegardens while converting the original forest to settlement areas. Some woody species like Millettia ferruginea, Vernonia amygdalina, Ficus sur, Croton macrostachyus and Sapium ellipticum were more frequently retained than others. In general, the reasons for planting woody species were income generation, shade and fruit, in increasing importance order. About 96 % of the respondents did practice different types of management activities for the woody species they owned. The common management practices carried out in the homegardens were thinning, pruning, fertilizing, watering, protection, coppicing and lopping. However, only 2% of the respondents did practice compost preparation. Diseases of coffee and fruit trees were the major problem faced by the farmers in woody species management. Therefore, it is recommended that appropriate intervention either through research or extension has to take place in order to reduce the impacts.

Keywords: Wood production, Stems, Compost, Wealth status, Use, Light interception.

Contribution/ Originality

Moreover, this study is one of very few studies which have investigated relevant information in order to ensure the conservation, management and sustainable utilization of woody resources in particular and the biodiversity as a whole.

1. INTRODUCTION

Homegardens are traditional agroforestry practices characterized by the complexity of their species diversity, structure and multiple functions. Homegarden agroforestry can be defined as 'land use system involving deliberate management of multipurpose trees and/or shrubs in intimate association with annual and/or perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop animal unit being intensively managed by family labour' [1]. Woody species are very important part of homegardens that contributes to the livelihoods diversification [2]. They are managed to: i) provide shade for coffee and variety of commercially valuable spices as well as for livestock; ii) supply rural communities with fuel wood and timber; iii) provide other products such as fodder, human and livestock medicine, food and they serve as bee forage; iv) play important ecological roles which could contribute to sustainability of agricultural systems.

Homegardens have attracted significant research attention [3], mainly due to: (i) provision of diverse and stable supply of socio-economic products and benefits to the families that maintain them [4], (ii) attributes which make them an interesting model for research and the design of sustainable agro-ecosystems, including efficient nutrient cycling, high biodiversity, low use of external inputs and soil conservation potential [5, 6].

The environmental services that homegarden agroforestry practices provide include their potential contribution to the *circa situm* conservation of biodiversity, which have only recently attracted wider attention among agroforestry and conservation scientists. This new view is consistent with the ecosystem approach to natural resource management advocated by the Convention on Biological Diversity (CBD) [7]. The presence of woody species from homegardens to agricultural landscapes favors the survival of native woody species [8] and play an important role in conserving biodiversity.

The density of woody species varies from place to place. For instance, in Ethiopia, Yitebitu [9] has reported 78 trees per hectare in the homegarden agroforestry of Dilla. Reports from other countries also support the existence of diverse woody species in homegardens. For example, Fernandes, et al. [10] reported the presence of 53 species in Chagga homegardens, in Tanzania. In West Java, Indonesia Soemarwoto [11] has reported 179 species. The variation in density of trees in the different homegarden agroforestry could be related to ecological, cultural and socioeconomic conditions.

The best designers and managers of traditional agroforestry practices have been the farmers themselves. For years, farmers have developed a collection of complex indigenous agroforestry systems that are adapted to local conditions and designed to meet local needs [12-14]. These indigenous agroforestry systems are rich sources of knowledge about the cultivation of perennial species in different time and space arrangements with annual crops [15]. Many farmers understand

the habitat and growth requirements of many species, seasonal yields, compatibility with other species, and relate site characteristics of the land they farm [16]. For instance, in Gedio, the reduction of excessive shading to coffee plants has been carried out for adequate fruiting and yielding [17]. Farmers in Arsi Negele practice pruning of indigenous woody species for reducing the effect on crops, getting fodder for animals, and collecting wood to be used for fencing, constructing houses, firewood and also for sales [18].

Homegardens are the most prominent cropping system in the south and southwestern highlands of Ethiopia [2]. In Gimbo district (hereafter woreda) of Kaffa zone, it is obvious that farmers practice homegardens for economic, social and environmental benefits. However, management of woody species and their contribution is not well known by scientific communities. Hence, understanding on why and how farmers manage the homegardens: available knowledge on preference, arrangement, uses of woody species and other components is limited only to farmers. In Ethiopia, information on homegardens and on farm trees is generated from limited studies (e.g. Zemede and Ayele [19], Zemede and Zerihun [20], Zebene [21], Tesfaye [2], Motuma [18]) and are more specific in terms of site, culture and socioeconomic. These studies would not provide adequate information for better understanding of agroforestry homegardens in South West Ethiopia. Thus, the present study aimed at providing information on available knowledge for managing homegarden agroforestry practices in South West Ethiopia. The objectives of this study were to estimate wood production in homegardens and to assess farmers' strategy for managing woody species in homegarden agroforestry.

2. MATERIALS AND METHODS

The study was conducted in Gimbo district, Kaffa zone. The area lies within 07° 00'- 7° 25' N Latitude and 35° 55'-36° 37' E Longitude. The altitude of the study sites ranges from 1600 to 1900 m above sea level. The topography is characterized by slopping and rugged areas with very little plain land. The mean annual rainfall ranges from 1710 mm to 1892 mm. The mean temperature ranges from 18.1 ^{o}C to 19.4 ^{o}C [22]. The soils of the area are deep, clay red soils with an agric B- horizon dystric nitosols [23]. Gimbo is one of the woredas, in which various agroforestry practices are managed. From the woreda, two kebele administrations (KA) were selected based on the existence and extensive practice of homegardens. Four villages (two from each kebele) namely Adilagicha and Shera from Keja Araba KA, and Tena and Shuba from Tula KA (site) were selected. Key informants, KI, were used to stratify the wealth classes in the study site. They were also used for identification of local names of woody species in homegardens. The selection of key informants at each village was done by adapting snowball method. The KI is defined as individuals who are knowledgeable about woody species type, management and village households (HHs), and are elderly persons who lived in the area for more than 35 years. To select individual farmers who could identify key informants, village tour was made with kebele council members and development agents. During the village tour, five individual farmers were randomly asked to give the names of seven key informants. At each village, out of 35 key informants suggested, five top ranking were selected to categorize HHs into wealth classes. According to

Grandin [24], if the level of agreement within a community on the ranking criteria is high, three or four informants are sufficient. The name of all HHs living in the villages was obtained from the kebele's office and cross-checked with key informants at each village for its inclusiveness. Wealth-ranking of individual HHs was carried out by adapting wealth-ranking technique of Crowley [25]. Primarily, the criteria for differentiating HHs into different wealth classes were set by key informants. Then, HHs living in the villages were categorized into three wealth classes of rich, medium and poor according to the set criteria (Table 1). A total of twenty key informants, five for each village, were involved in the classification of HHs.

To carry out inventory and collect information on farmers' strategy of woody species management, a total of 120 HHs (30 HHs from each villages) were randomly selected from the total of 243 HHs. For the assessment of wood production in each homegarden, all woody species from the whole garden were identified and diameter at breast height (DBH, measured 1.3m above the ground) for all woody species ≥ 5cm were measured using a caliper or diameter tape. Key informants and sampled HHs were used to provide local names of the encountered woody species. After vernacular names were known, scientific names were identified with the help of publications of Flora of Ethiopia and Eritrea [26-30].Questionnaires on woody species preference, management practices and problems encountered in management of woody species were developed and pre-tested with some randomly selected HHs to suite the questionnaires with the practical conditions in the study site. Assistant interviewers were employed and were trained.

The homegarden level wood resource was estimated in terms of the number of stems and basal area (m^2) per ha for each homegarden. BA= $\prod d^2/4$, where d = diameter at breast-height. The number of stems and basal area per ha were used as an estimate of the relative standing yield of wood resources. Aanalysis of variance (ANOVA) were carried out using the values on the number of stems per garden if there is significant difference among different wealth classes in homegardens. Least significant difference (LSD) was used for mean separation. The data collected through the questionnaire interviews was analyzed using SPSS 20 for Windows.

3. RESULTS

3.1. Wood Production

The overall number of stem in the homegarden of the study area ranged from 6 to 99 per garden (632 to 16 per hectare) with over all mean value of 34 (113 per hectare). The basal area in the homegarden of the study area ranged from0.028 m^2 (0.23m^2 per hectare) to 14.86 m^2 per garden (49.96 m^2 per hectare) with average value 1.71 m^2 per garden (5.128 m^2 per hectare). At village level, higher overall mean number of stems per garden and per ha was recorded at Shera than Adilagicha village. Similarly, the value was higher at Shuba village than Tena (Table 2). When comparing mean number of stems on garden of different wealth categories at Shera, Tena and Shuba villages, significantly higher number of stems per garden was observed from rich and medium households than poor. However, higher number of stems per ha was observed on gardens of poorer farmers (Table 2).

3.2. Woody Species Preference

In the study area, there is a tradition of retaining woody species during conversion of forestland to agricultural land. About 92% of the respondents have retained different woody species in their homegardens while converting the original forest to settlement areas. The number and type of species retained by respondents differed and some species (e.g. *Millettia ferruginea, Vernonia amygdalina, Ficus sur, Croton macrostachyus and Sapium ellipticum*) were more frequently retained than others. The reasons for retaining different woody 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 in the order of their importance as; fuel wood > shade > construction > beehive stand > fence and boundary > agricultural implements > soil fertility > beehive making > source of income.

To evaluate farmers' species preferences, respondents were asked to rank the five most important woody species and then total relative score was calculated. Accordingly, *Coffea arabica*, *Persea americana*, *Millettia ferru*ginea, *Cordia africana* and *Mangifera indica* were the five most preferred woody species for retaining and planting in homegardens (Table 3).

3.3. Planting Practice of Woody Species

In addition to retention of woody species, planting of different woody species is widely practiced in the study area. About 96% of the sample households had experienced planting woody species. The frequency of planting of these species is quite different among households and some species are more commonly planted than others.

Farmers mentioned several different sources of planting material. Most of the respondents (80%) acquired their planting material from different nurseries (private, government and development projects), garden and natural forest. The common planting materials in the study area were seedlings, seed and cuttings. Most respondents (93%) in the study area preferred seedling as a source of planting material for coffee due to its availability and better survival. A few (8%) of the respondents did practice stumping for regeneration of *Coffea arabica*. About 60% respondents acquired seedlings of exotic woody species from private and government nursery. They use

naturally regenerated seedlings and cutting as a source of planting material for indigenous woody species which can be acquired from both garden and natural forest. Self-establishment of woody species seemed to play a larger role in the study area.

The major reasons for planting woody species in the study area are in the order of its use includes: as source of income > shade > fruit > construction wood > household consumption > fuel wood > beehive stand. Most of the respondents (52%) were interested to improve the component of their homegarden through introduction of some fruit trees and the remaining 48% were unable to plant any more, mainly because of shortage of land.

3.4. Management of Woody Species

Woody species which are either planted or retained in the homegarden demand different types of management. About 96 % of the respondents did practice different types of management activities for the woody species they owned. The common management practices were thinning, pruning, fertilizing, watering, protection, coppicing and lopping (Table 4). According to the respondents, protection was done through fencing to protect from damage by animals. The pruning of shade tree species retained in the homegarden was done for reduction of the shade for coffee production and collecting wood to be used for fencing, constructing houses, firewood and also for sales. According to the majority of farmers (75%), organic waste material from the household and animal manure were the only form of fertilizer added to the homegardens. Only 2% of the respondents prepare compost to use as a form of fertilizer in their garden. Watering was done for early survival of planted seedlings. According to some respondents (19%), coppicing was done only for harvesting of Eucalyptus tree species.

The result of this study revealed that disease was the major problem that encountered homegardens productivity. According to most of the farmers (60%), disease on *Coffea arabica*, *Persea americana* and *Mangifera indica* was one of the major problems in the homegarden. Lack of technical knowledge in managing exotic woody species is also another aggravating problem in the homegarden. Most of the respondents (70%) pointed out no remarkable problem for seedling production in the study area, whereas some (19%) reported disease and shortage of water as impediments of seedling production. Removing diseased coffee plant through burning was possible strategy by farmers in the study area for reducing the extent of damage by the disease.

3.5. Homegarden Design

Homegardens in the study area showed no clear planting pattern. However, most of woody species like *Euphorbia candelabrum, Erythrina spp, Eucalyptus spp, Olea welwitschii* and *Vernonia amygdalina* occupied the garden borders, primarily for property demarcation and live fence. The garden owners also preferred scattered planting for shade and fruit trees. About 63% farmers reported that the criteria for designing their homegarden were light interception, plant and commercial requirements and space constraints. Some farmers (15%) also reported that no particular reason as major criteria for designing of their homegarden.

4. DISCUSSION

4.1. Wood Production

The present mean woody species density 113 ha^{-1} was higher than those reported for Dilla (78 trees ha^{-1}) [9], but lower than reported for Arbegona (705 tree ha^{-1}) [31]. The present study revealed that lower number of stems per garden and per ha was recorded at villages that are more accessible to market and road network infrastructure. The result of this finding was in line with Tesfaye [2] who reported lower stock of wood at site with more access to market. It was evident that marketing led to intensive exploitation of woody species, which can result in lower mean number of stem per farm [2]. Regarding wealth categories more number of stems per ha was found on gardens of poor farmers indicating the ability of poor farmers to intensively utilize their smaller garden. The presence of more number of stems per ha on smaller farms was also reported by Zebene [21] for Sidama, Muktar [31] from Arbegona and Den Biggelaar [32] from Rwanda.

4.2. Management of Woody Species

Farmers in the study area recruit important woody species like *Millettia ferruginea* and *Coffea arabica* through different methods which allow them to obtain planting material for free from locally available sources. They assist naturally regenerated seedlings to grow in their gardens. Moreover, they plant naturally regenerated wildings in their garden which was obtained from adjacent natural forest. This is consistent with the report by Aerts, et al. [33] in semi-forest coffee systems in which farmers usually transplant semi-wild coffee plants that naturally regenerate spontaneously inside the forest to fill open spaces. Farmers in the study sites did try to manage woody species on their garden to obtain different benefits. The most frequently mentioned purposes for planting and retaining woody species in the homegardens were consistent with the findings of Kahurananga, et al. [34], Zebene [21] and Tesfaye [2] where they asserted that tree species were deliberately retained and/or planted on farmlands for the provision of fuel wood and wood supply, income generation and environmental services. However, farmers' effort to maintain the soil fertility of their garden was not satisfactory. For example, the practice of compost preparation in the study sites was very low. Interviews on importance and management of woody species indicated that most of woody species preferred were indigenous and multipurpose woody species. This shows that the abundance of woody species is influenced by preference of farmers. Most of preferred woody species were native and they also have the ability to fix N_2 and produce large quantities of organic material [9, 35]. This is similar with a study of Zebene [21], which shows farmers' woody species preference was mainly indigenous multipurpose trees species which were incorporated into the homegardens. The result of the present study revealed that soil management in the homegarden was entirely depended on addition of organic matter from the woody component and manure. Only 2% of the respondents did practice compost preparation. In spite of this fact, compost preparation is very important for sustainable management of homegarden [17]. According to the respondents, disease was one of the most seriously threaten constraints in the study sites, which could affect the diversity of woody species in the homegardens. Gilbert [36] revealed that plant disease cause mortality and reduces fecundity of individual plants, diverse host population dynamics, and affects the structure and composition of natural plant communities.

5. CONCLUSIONS AND RECOMMENDATIONS

Woody species have various socio-economic and ecological roles. Many existing native species, such as *Cordia africana, Milletia ferruginea, Albizzia gummifera*, etc., are planted and retained dominantly as a basic components of their homegardens structure because of their roles in providing shade and soil fertility, wood and other products. Homegardens are an important element of rural landscape of the study area and they play a vital role in the predominantly biodiversity conservation. Wealth status and accessibility of homesteads to market and road network infrastructure influenced the wood production of homegardens. Sampled households indicated that disease of coffee and fruit trees are the major problems that hinders the productivity of homegardens in the study area. Therefore, it is recommended that appropriate intervention either through research or extension has to take place in order to reduce the impacts. Widespread of organic matter and manure application were the major management practices in the homegarden to improve the soil fertility status of the homegardens. However, farmers' knowledge on compost preparation was very limited. Therefore, provision of awareness creation and training is very crucial for improvement of soil fertility in the homegardens.

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Table-1. Main criteria used by the key informants classifying households in to three main wealth categories

	Study villages and rank*			
Criteria	**Adilagicha**	**Shera**	**Tena**	**Shuba**
Total land size	1	1	1	1
Size of coffee field	2	2	2	2
Honey production	5	3	5	5
Size of cattle	6	4	6	3
Standard of housing	4	5	4	4
Off-farm revenue	3	-	3	-

*Within-village the ranking criteria range from 1, being the most important, to 6 being the least important

Table-2. Mean number of stem per garden and ha for different wealth categories at study villages

	Mean stem per garden and ha at Village Level							
Wealth	**Adilagicha**		**Shera**		**Tena**		**Shuba**	
	Stem/garden	Stem/ha	Stem/garden	Stem/ha	Stem/garden	Stem/ha	Stem/garden	Stem/ha
Rich	50± 6a	85	55±6a	86	40±4a	82	50.5±8a	89
Medium	39±3 a	135	51±5a	115	36±2a	125	40±4a	109
Poor	30±5 a	139	33±5b	121	22±3b	128	23±7b	168
Overall mean	39	119	46	107	32	111	37	122

Wealth classes having the same letter are not significantly different from each other.

Table-3. Ranking of preference for woody species in homegarden and total relative score by the questionnaire respondents at Gimbo

Species	Respondent's Total relative score
Coffea arabica L.	94.9
Persea americana Mill	69.6
Millettia ferruginea(Hochst.) Bak.	35.2
Cordia africana Lam.	33.6
Mangifera indica L.	11.7
Eucalyptus camaldulensis Dehnh.	10.4
Albizia gummifera (J.F.Gmel.) C.A.Sm.	0.34
Olea welwitschii (Knobl.) Gilg & Schellenb.	0.25
Psidium guajava L.	0.16
Croton macrostachyus Del.	0.09
Erythrina abysinica Lam.Ex.Dc.	0.06
Euphorbia candelabrum Kotschy	0.01

Table-4. Species type and management practices employed by sample households for different woody species in Gimbo

Species	Number of households employing various management activities					
	Thinning	Prunning	Fertilizing	Watering	Protection	Lopping
Persea americana	0	13	77	27	51	0
Mangifera indica	0	6	31	8	14	0
Coffea arabica	23	5	59	27	61	0
Cordia africana	0	4	0	1	5	0
Vernonia amygdalina	0	0	0	0	0	1
Croton macrostachyus	1	1	0	0	0	0
Millettia ferruginea	2	4	0	0	1	0
Dracaena steudneri	0	0	0	0	0	4
Eucalyptus camaldulensis	11*		2	11	27	0
	38	33	169	74	159	5

*Refers singling of coppice