Research Article

Wood production potential of different agroforestry practices and underlying production constraints in Tula woreda of Sidama regional State, southern Ethiopia

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Abstract

On-farm trees have an essential role in supporting the livelihoods of the community in the study area thouth providing various wood products. The objective of the study was to characterize the attributes, constraints, and opportunities of on-farm wood production, with the view to increase farm wood production in the study area. Tula district was purposively chosen because it is among areas with a high concentration of smallholder tree growers. Both qualitative and quantitative methods were employed investigate farmers' tree-growing conditions, constraints and to undertake tree inventory using selected potential wood production sites. The results of the study showed that home gardens, boundary planting, and woodlots were the three major agroforestry practices (AFPs) contributing to the production of 1,750 ± 292 m³ (Mean ± SE, ha) wood volume per annum in the area. Indigenous trees were investigated from natural regeneration while exotic ones were established through planting from seedlings. There were 20 tree species recorded in the three AFPs. As a constraint, the lack of access to planting material in terms of quality and quantity tree species was the major problem faced by farmers in the study area. Therefore, it is recommended that multidimensional intervention mechanisms with regard to improve tree management practices, facilitate determinant factors of production desired tree species, and improve extension services towards purpose-driven tree growing practices should be put in place to change the state of wood production in the study area.

Keywords: Agroforestry practices, crown volume, mixed species woodlot, tree management, wood products

1. Introduction

The then Ethiopian Ministry of Environment, Forest and Climate Change (MEFCC, 2017) reported theat there is high demand of fuelwood and forest/ tree product consumption have exerted pressure on existing forest resources and contributed to forest and land degradation, soil erosion and loss, water pollution, landslides, and flooding. Damte et al. (2012) have also reported that wood is becoming scarce in many parts of Ethiopia. According to MEFCC (2017), the projected fuelwood gap wiil be around 80 million m³ in 2033, and hence to close this gap, plantation areas of about 4 million ha are required. Therefore, trees on farms for fuelwood supply and construction material have received due attention in Ethiopia (Duguma, 2013, Eshetu, 2014 and MEFCC, 2017). Wood production is the quantity of wood produced (Mangnussen and Reed (2004), whereas volume is the most widely used measure of wood quantity (Mangussen and Reed, 2004; Henning and Mercker, 2009). McCabe (2013) reported on-farm trees are sources of farm wood production and are spatially arranged in different agroforestry practices. These trees could be naturally regenerated and also deliberately planted through direct

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sowing tree seeds and planting tree seedlings (Rao et al. 1997). There are factors that determine the growth of trees on farms and enhance better wood production. For instance, Bekele (2011) stated the provision of financial and technical support to the local farmers; (Perdomo 2017) reported also the availability of technical assistance for the sustainability of farms and the adoption of new technologies; Kiptot and Franzel, 2011; Glover et al., 2013 and Eshetu et al. ,2018) claimed the availability of land and labor as the decisive factors for the households to choose farming practices. Land size and tenure are important factors in changing the decision of households to plant trees on their farmlands (Tsegaye, 2008, Mekonnen, 2009, Bekele, 2011).

In many parts of Ethiopia and specifically in the study area, the amount of wood that contributes to household consumption and marketing was not well documented and the overall yields and quality of the trees are lower. Tree management has a significant role in farm wood production, but little has been reported about its practices in the study area. Also to meet the wood demand gap in the study area, investment consideration and the provisioning status of necessary production material and facilitations made were not reported. Therefore, the objective of the study was to characterize the attributes, constraints, and opportunities of on-farm wood production, with the view to increase farm wood production in the study area.

2. Materials and Methods

2.1 Study area Selection

Tula is one of the districts of the Sidama Region and was purposely selected to carry out the study. Out of 12 kebelles in Tula district, Chefasine kebelle was selected due to its high concentration of smallholder tree growers planting trees in different agroforestry practices known for their Sidama Agroforestry practices (CSA, 2007). Existing value chain studies, marketing, and its proximity to the main road made its selection appropriate.

The Chefasine kebelle is located between 6°55’0’’ to 8°57’35’’ N latitude and 38°29’0’’ to 38°30’48’’ E longitude (Fig. 1). According to the Kebelle Administration Office, Chefasine kebelle has an area of 1,040 hectares (Perdomo, 2017). The most common agroforestry practices identified in Chefasine during the reconnaissance survey of the area were boundary planting, home gardens, and farm woodlots. Different woody tree species are spatially distributed in these practices at most. Based on the data from the Chefasine Kebele Administration Office (2018); Butelo, Belamo, and Argeta ‘development groups’ or sub-kebeles were selected purposively as potential wood production sites in the kebelle. They have been using the name ‘development group’ to express the hierarchy below kebele which is almost similar to the term village. According to the report of Eshetu et al. (2018), Chefasine kebele has an estimated population size of 12,366. There are 1,110 households and among these, 97% are male-headed. Since the area is in the Sidama Region, the language spoken in the area is Sidama and the Sidama culture is also well practiced by the local people regardless of where they come from originally.

2.2 Methods of Data collection

Household Survey and sampling intensity

The number of households in the three villages according to the Chefasine Kebele Administration Office (2018) was: Belamo (503), Butelo (231), and Argeta (253) households in the selected villages were randomly selected using a lottery method encompassing 62 households from Belamo, 28 households from Butelo, and 31

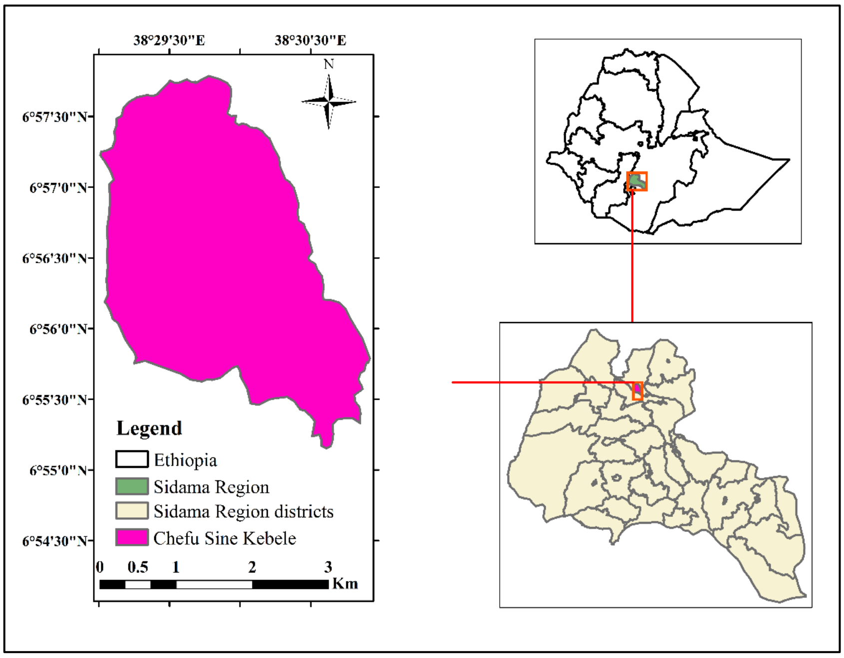

Figure 1. Location map of the Study area (Source: Ethio-GIS, Admin boundaries shape files)

households from Argeta totaling 121 sample households were selected for interview based on Cochran (1977) in Equation (1). Both structured and semi-structured questions were computed to obtain responses.

$$n_o = \frac{Z^2pq}{e^2} \quad (1)$$

This is valid where n_o is the sample size, Z^2= the value of the desired confidence level (95 %/ 1.96), e is the desired level of precision (0.05), p is the estimated proportion of an attribute that is present in the population (10 %/ 0.1), and q is 1-p (0.9).

The sample size was corrected using a finite population correction factor for proportions as follows;

$$n = \frac{n_o}{1+\frac{(n_o-1)}{N}} \quad (2)$$

Where n is the sample size and N is the population size

The number of households in each Kebeles was calculated as follows:

$$n1 = \frac{n * N1}{N} \quad (3)$$

Where n1= sample size in the first Kebele, n number of households in the first kebele, N1= total number of households -121- in the study, N= total number of households in three sub kebelles.

Focus Group Discussions and Field Observation

Three focused group discussions, thirty (30), ten (10) participants from each village composed of groups of men and women interviewed together. The focus group discussions and field observation were administered and used to triangulate household survey findings and to create a common understanding of some relevant issues based on the methos uaed by Angelsen ed. (2011).

Key Informants Interview

Key informants are knowledgeable individuals who have lived in the study area for a long time as well as of possess expertise and experience about the identified problems of the study (Angelsen ed., 2011). Thus, the interview with the selected Key informants helped to develop variables that were important during the study and minimized misunderstandings. An exponential non-discriminative of snowball sampling method was adopted for the selection of key informants to icrease the quality of key study variables before conducting the household survey. A total of fifteen (15) key informants farmers from the three villages were asked to provide their responses on the selected topics.

Several direct field observations mostly using transect walks were conducted during field visits to acquire a deeper understanding and to validate the information gathered through interviews.

Inventory

Overall 24 farms representing 20 % of sample households were selected for tree dimension measurements in the three selected villages. Then, based on the selected household sample sizes, sample farms were proportionally distributed over the study sites (selected villages) to conduct the required measurements. Accordingly, the measurements were conducted on 12 farms from Belamo, and 6 farms each from Butelo and Argeta. Caliper and Hypso meter were used to measure the diameter at breast height (dbh) and height of the trees, respectively. All trees that have a breast height diameter of more than 10 cm were measured to obtain necessary data. As measured by Asfaw and Hulten (2003), crown diameter above 2m was measured for trees in the homegarden and boundary planting. It was assumed that the trees in farm field have enough volume of wood production for utilization.

Measuring Trees in Boundary Planting. The method used by Asfaw and Hulten (2003) was adapted also to measure trees in boundary planting practices. Accordingly, the total length of the boundary tree was determined and sectioned into every 50m. Again the 50m long boundary section was sectioned at every 10 m and became five sctions. For measurement purposes, one section was selected randomly out of five and a complete count and record of trees was made. Actual length of some sections was considered for boundaries with less than 10 m. For boundary planting having more than one line of trees, the area was calculated from boundary length and width. The area of boundary planting with a single line of trees was defined based on the existing length of the boundary and the spacing between the section border. A total of sixteen (16) boundary planting sections/fields were obtained and sampled for measurements from all sites.

Measuring Trees in Homegarden Practice. The actual size of a section was sampled since trees were planted far from each other. Then the results were extrapolated to hectare. A total of twenty-four (24) sample sections within the homegarden were measured in all sample sites.

Woodlot tree measurement. A total of six (6) woodlots from all sampled sites and trees measurements were undertaken. Measurements were conducted in a plot that represents different height classes that included dominant, co-dominant, and intermediate trees. A plot size (10 x 10 m) accounting for 10 % of the size of the woodlot was used for sampling. Proportionality sampling method was selected because it is appropriate for any small woodlot field. Then, the results were extrapolated to a hectare basis.

2.3 Data Analysis

Qualitative data collected from KIIs and FGDs were summarized, transcribed, and narrated for use in the report. Data collected from the household survey were coded and entered into IBM SPSS statistical package (Version 20). The data were analyzed using frequency and descriptive and summarized using tables and graphs. Data from field measurements were analyzed using MINITAB (V.17). Descriptive statistics was used to calculate the averages.

Wood Volume Quantification

The results obtained from the sampled tree measurements were extrapolated to describe the amount of wood under production, according to the equation proposed by Magnussen and Reed (2004) as follows;

$$V = 0.42 * B * H \quad (4)$$

Where B is tree basal area at breast height and H is tree merchantable tree height.
The basal area will be calculated as;

$$BA = \pi * DBH^2/40000 \quad (5)$$

Where the basal area is in m^2 DBH is in cm and 40,000 is the converted DBH in square centimeters to square meters. In one square meter, there are 10,000 square centimeters.

The volume calculated from merchantable height does not consider the wood products that might be obtained from branches. According to Johnson et al. (2005), the wood volume obtained from merchantable height is mostly for saw logs and pulp woods. Thus, the calculation of crown volume is important. Crown volume was measured for Eucalyptuses trees of boundary plantings and mixed species woodlots since they have relatively medium to large branch sizes. So, Laar Van and Akca (1997) calculated crown volume as follows;

For conifer tree species

$$V_{cr} = 1/3 * \pi/4 * d_{cr}^2 * l_{cr} \quad (6)$$

For deciduous tree species

$$V_{cr} = 1/2 * \pi/4 * d_{cr}^2 * l_{cr} \quad (7)$$

Where $\mathbf{V_{cr}}$ is crown volume, d_{cr} is crown diameter and l_{cr} is crown length.

Finally, total tree volume was used to report the amount of wood produced per hectare basis as follows;

$$\text{Total Volume} = \text{Merchantable tree volume} + \text{Tree crown volume} \quad (8)$$

3. Results and discussion

3.1. Socio-demographic characteristics of Household respondents

The majority (54 %) of the respondents have attended elementary education (Grade 1-8) (Table 1). This showed the literacy level of the respondents was not an obstacle to comprehend lessons in extension services.

The average household size was 7 persons per household which is similar to what Eshetu et al. (2018) reported. This also shows that household size has implications for the possibility of farm wood production. The average land size of the household was 1.1 ha (Table 2). It is described as total land size because any available open space helps farmers of the area to grow trees and also any crop and tree growing are interlinked.

Table 1: Socio-demographics (categorical variables) of the study site (n = 121)

List of Attributes		Percentage (%)
Sex	Male	85
	Female	15
Marital status	Single	2
	Married	96
	Widowed	2
Education	Illiterate	30
	Read and Write	5
	Elementary (1-8)	54
	High school (9-12)	6
	College and Secondary Education	5
Occupation	Working on farm	100
	Casual farm labor	2
	Salaried or Wage labor	6
	Student	2
	Merchant	12

Table 2: Socio-demographics (continuous variables) of the study site

Attribute	Average
Age	50
Household family size	7
Household average land size (ha)	1.1

3.2 Agroforestry practices contributing to wood production in Chefasine

The Agroforestry practices contributing to wood production in the study area including their field of planting are presented in Table 3. This is in agreement with different authors that Small-scale forest plantations provide a range of benefits to rural communities tangible material products and other non-tangible environmental services (Bekele, 2011); Live fences and windbreaks or boundary planting are also some of the practices that have been practiced by farmers for wood production and other ecosystem services (Perdomo, 2017); and Woodlot practice also exists for fuel wood, construction purpose, and fencing pole and as source of income (Alemayehu, 2019; Eshetu et al., 2018).

Boundary tree planting was arranged both as irregular planting (no standard spacing) with densely planted trees (a single or mixture of trees) and also was arranged (with spacing) 2-3 rows of trees planted up to the compound limit (mostly single species). Boundary planting practice (80 %) was the second largest agroforestry practice next to homegarden (100%) contributing to wood production in the study area. Alemayehu (2019) reported 50 % boundary planting in the same area which is 30 % lower than present study. Also, the high percentage of boundary planting practice is in agreement with a report made by Duguma and Hager (2010) and Abiyu et al. (2016) that boundary plantings are the most common tree planting practices.

Homegarden practice in the area is extended farm fields around the home as categorized also by Rgalema et al. (1994). Within the practice, different woody spp. were grown together (Table 3) with other crops that provide households with different wood products for different purposes.

Woodlots were spatially arranged around homes and away from home based on the availability of the land. Farmers have been planting woodlots around homes and away from their homes. Some woodlots have a bigger land size (above 0.125 ha, which is the minimum land size of the study area), and were located far from the homestead (field observation). Eshetu et al. (2018) reported that woodlots were planted near the homestead which were easy to manage and use. In terms of species, single species woodlots mostly constitute Eucalyptus species have been planted on sloppy and erosion (water erosion) affected areas which are not appropriate for cropping perennial cash and annual crops. This practice was also in agreement with what Alemayehu (2019) has reported. Mixed species woodlots were mostly planted on available spaces around homesteads. These are large stemmed trees (with larger dbh) having characteristics of natural woodlot. Some scholars like Asfaw and Agren (2007) including Negash et al. (2005) characterized these trees as “front yard trees” under some situations. Such kind of practice has a prominent role in household income diversification, risk diversion, and environmental benefits. In this case, it was observed that all trees do not have the same maturity age for utilization as well as do not have the same wood quality and demand for consumption and marketing purposes. Moghaddam (2014) also discussed, “under subsistence and commercial level timing of production there might be more predictable advantages of mixture plantings”. Mixtures are important for economic improvement and ecological restoration.

Table 3: Major Agroforestry Tree Practices available, planting fields in the study area (n = 121, multiple responses possible)

Types of Agroforestry tree planting practices	Respondents (%)	Planted Fields
Boundary planting	80	Border of Khat field and other crop House front side/compound border along the roadside
Homegarden	100	Enset-coffee shade tree Khat with shade tree, Enset-Khat-shade tree and Khat alone
Woodlot	32	Single species woodlot mixed species woodlot

Eucalyptus spp was planted abundantly on the border of the Khat field, house front side, and along the roadside while other diverse indigenous tree spp were planted at the border of other crop fields (Table 4). Cordia africana (98 %), Croton macrostachyus (32 %), and *Millettia ferrugenia* (30 %) were among the highly grown tree species in Enset-coffee shade tree, Khat with shade tree, Enset-Khat shade tree and Khat alone. The availability of C. africana and *M. ferrugenia* as the most widely used species in this practice is in line with what Asfaw and Agren (2007) reported in their study results. The study made in the same area by Perdomo (2017) also confirmed C. africana is the most widely used shade tree in enset-coffee-based homegarden practices.

Eucalyptus camaldulensis (90 %) is grown as a single species woodlot and a Mix of indigenous and exotic tree species in mixed type woodlot.

Table 4: Tree Species abundance in AF practice's in the study site (n = 121)

Tree Species	Boundary planting %	Homegarden %	Woodlot %
Cordia africana	2	98	
Croton macrostachyus	6	32	
Grevillea robusta	30	4	6
Eucalyptus camaldulensis	51		90
Olea africana	3	4	
Ilex mitis	3	2	3
Juniperus procera	10		9
Podocarpus falcatus	8		
Celtis africana	0.8		
Eucalyptus citrodora	2		
Cupressus lusitanica	4		
Pinus patula	2		
Acacia seyal	2		
Casuarina equisetifolia	6		
Ficus sur		21	
Milletia ferrugenia		30	
Galiniera saxifraga		6	3
Albizia gummifera		4	
Acacia seyal		4	
Bersama abyssinica		3	
Pinus patula			3

3.3 Agroforestry Land Size and Number of Stem

The average size of sampled woodlots was 0.33 hectares with a maximum of 0.5 hectares and a minimum of 0.125 hectares (Table 5). The average land size of the study area is 0.36 ha which is similar to to study result obtained by Alemayehu (2019) in the same study area. The mean number of stems was 18 in homegarden which is much lower than reported by Yakob et al. (2014) which is 34 in the southwest part of Ethiopia. This shows that there is still a chance to increase the number of woody species in homegarden in the study area besides farmers' diverse perspectives of interaction among components and uses obtained from them. In boundary planting, *Eucalyptuses camaldulensis* was planted with high density resulted in less vigorous stems because of competition (Field observation). This is in agreement with the reports of Orwa et al. (2009) and Mendham et al. (2011), Forrester et al. (2013) stated that "Productivity declines because of poor forestry tree management practices"

3.4 Tree establishment and management

Tree establishment aspects

Narrow intra-row spacing of 20 cm (n=121, 72 %) and inter-row spacing of 30 cm (n=121, 19 %) were used for field tree planting in the study area. Thus, it decreases mean wood volume per tree as well as low tree production per year and unit area because of high density. Alcorn et al. (2007) and Forrester et al. (2012) reported, narrow spacing negatively resulted in a smaller average tree size because of resource competition. Figure (2) below shows the planting pit size of the study area resulting in huge misplacement of trees could lead to different physiological disorders like poor growth of the seedlings.

Table 5: Mean (± std, ha) of Agroforestry land size and number of stems in Chefasine

Practices	Land size	Min	Max	Stem number	Min	Max
Boundary planting	0.013 ± 0.002	0.001	0.025	16812 ± 4907	7200	23000
Homegarden	0.8 ± 0.4	0.3	2.0	18 ± 5	7	32
Woodlot/ Mixed Spp.	0.5 ± 0.07	0.4	0.5	3075 ± 869	2000	4000
Woodlot/ Single Spp.	0.4 ± 0.2	0.13	0.5	7500 ± 5000	2082	10000
Woodlot(Both)	0.33 ± 0.15	0.13	0.5			

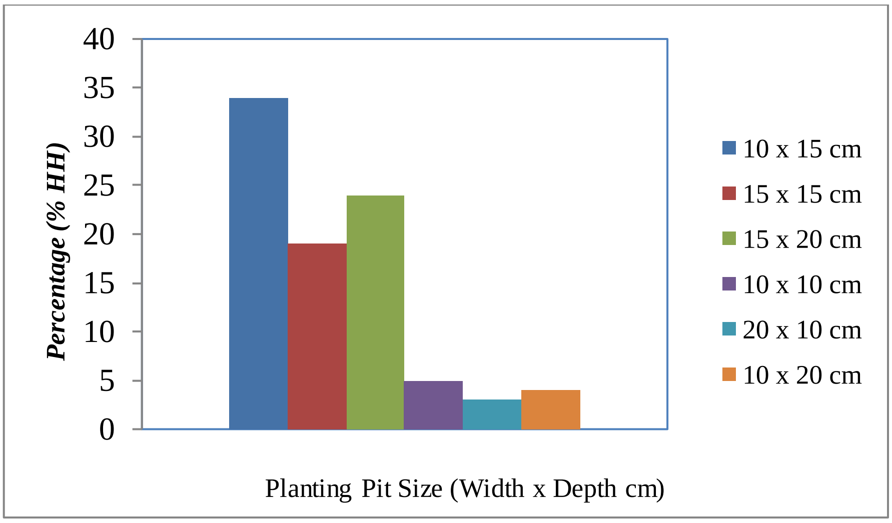

Figure 2: Planting pit sizes used by households (%) at the study site (n = 121)

The Indigenous trees were mostly from natural regeneration in the study area (Table 6). This is almost following the finding of Liyama et al. (2016) who reported that farmers in the Rift Valley use farmer-managed natural regeneration as the principal strategy of tree establishment. Eduardo Somarriba et al. (2012) also reported trees on farms are the result of selection (and protection) of valuable trees obtained from natural regeneration. Farmers in the study area transplant newly regenerated seedlings (70 %) to appropriate areas in the farm when needed. Farmers also protect trees (85 %) from damage at seedling or early growth. This shows every important management that has been given to the trees at early stages determines the quality of the tree at the later stage

Farmers responded that the source of planting material for most tree species is from own sources (Table 7). *G. robusta* as a highly planted tree in the area obtained from traders as the highest source of planting material (n=121, 44 %). This shows G. robusta has a better source of planting material than other species.

Tree Management aspects

Watering. Planted trees in the area like *Eucalyptus* spp. (mostly) and G. robusta; and the new naturally regenerated trees require watering during dry months in some cases. January (n=121, 9 %), February (n=121, 9 %) and March (n=121, 7 %) were the major dry months trees require watering. Overall, there was limitation of water is available during those months in the study area. According to Abebe et al. (2010), the rainy season also could extend from March to September. This shows the period of the dry season could be extended over the rainy season if the month March is added. The frequency of watering of those species at the time of need was two times per day (n=121, 9 %). Tending Operations (Thinning and Pruning). January, February, and March were the three most common months in which the tending operations are applied in the study area. The frequency of thinning and pruning was not more than twice a year (Table 7). Most of the indigenous trees being under use at the study area were deliberately retained with crops and passed through important management practices at different times. In a similar study area, Zeleke et.al (2015) reported that the majority of the farmers apply pruning and pollarding to the trees on

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Table 6: Tree planting material of some selected tree species at the study site (n = 121)

Species name	Regeneration (%)		
	Sowing seeds	**Seedling planting**	**Natural regenerated seedlings**
C. africana	21	6	72
F. sur	6	2	14
C. macrostachyus	2	3	29
M. ferrugenia	3		22
G. robusta	9	44	
J. procera	1	10	
E. camaldulensis	15	54	

Table 7: Responses of the households on the sources of selected tree species in the study site (n = 121)

Species name	Plantoing material sources (%)			
	Farmers	**Traders**	**Self(own)**	**Government**
C. africana	3	3	16	2
F. sur			8	
C. macrostachyus			2	3
M. ferrugenia			2	
G. robusta	4	44	11	16
J. procera	6	3	3	
E. camaldulensis	2	29	21	5

their farms. The frequency of pruning was around once every year or every year followed by twice a year rarely. This was done to reduce shade effect on underlying crops and at the same time to obtain firewood to meet household energy needs. This is in line with what Abebe (2005) reported that farmers apply pruning of branches for different reasons and at the same time use wood energy. Zeleke et al. (2015) and Abebe (2005) also reported farmers apply different tree management practices to obtain multiple products. Thinning is not applied fully and regularly on a timely basis, especially in woodlot practices in study the area. The woodlots were densely planted and branches from pruning are less demanded than thinning supposed to reduce stocking and generate some income in the area. Forrester et al. (2013) revealed that pruning effects can be smaller in un-thinned stands of Eucalyptus plantations i.e. lower crowns of fast-growing eucalypt trees shed rapidly whether they are pruned or not.

Harvesting and Coppice management. The harvesting age of E. camaldulensis and *G. robusta* was short which reflects the two spp. are frequently utilized (Table 7). Grevillea has been planted recently along boundaries of farms and woodlot which may play the same role as that of Eucalyptus species in the future. The harvesting and utilization age of indigenous trees such as C. africana, F. sur, and J. procera was the longest while C. macrostachyus and M. ferrugenia showed medium harvesting age. The coppice rotation age of Eucalyptus species was 4 years (Table 8) and lies between what Asfaw and Agren (2007) have found who stated 3 - 7 years rotation age used by poor and rich households, and de Rezende et al. (2005) reported two cycle rotations are more profitable. The number of coppiced stems (3-4) allowed to grow in the area is a good practice to be considered. Ferraz Filho et al. (2014) reported the abundant regeneration of sprouts per stump can either be managed by thinning to one, two, or three coppice stems per stump for harvesting in the later years or with no thinning but can be harvested during earlier years for biomass. A coppice stump thinning operation reduces growth competition between coppiced stems, which can result in more vigorous growth for the remaining coppice stems.

Table 7. Tending operations of some selected species in the study site (n = 121)

Tree Species	**Thinning month %**			**Thinning frequency yr^{-1}, %**	**Pruning month, %**			**Pruning frequency yr^{-1}, %**	
	Jan	**Feb.**	**Mar.**	**Once**	**Jan.**	**Feb.**	**Mar.**	**Once**	**twice**
C. africana		8		8		68	22	64	10
F. sur			2	1		3	6		
C. macrostachyus		7		2		19	12	17.8	
M. ferrugenia	2		3	4		6.5	10.8	10.8	
G. robusta		35		33		32	10	51	
J. procera		4	1	4		5	3	62	
E. camaldulensis	20	29	4	25	15	26	7	24	

Table 8. Mean harvesting and coppice rotation age (±std); and number of coppice stems per stump (±std) in the study site

Tree Species	Harvesting age	Coppice rotation age	No. of coppice stems per stump allowed to grow
C. africana	15.0 ± 5.0	4.0 ± 1.0	2.0 ± 1.0
F. sur	15.0±7.0	3.0 ± 1.0	2.0 ±1.0
C. macrostachyus	9.0 ±4.0	3.0 ±1.3	2. ± 0.0
M. ferrugenia	6.0 ±2.0	3.0 ±1.0	1.0 ±1.0
G. robusta	7.0 ±1.0	-	-
J. procera	13.0 ± 1.0	-	-
E. camaldulensis	6.0 ± 1.0	4.0 ±1.0	3.0±1.0

3.5 Wood Production and Utilization

The overall mean wood volume, 1750 m^3 was recorded for all measured trees in all practices in Table (9) below. Highest wood volume and high standard deviation were obtained for trees in boundary planting because trees planted in this practice were mostly overstocked and big-sized trees were also common (mostly *E. camaldulensis*). A low amount of wood volume was recorded for homegarden due to the density of trees per hectare basis was too low as compared to others.

Table 9. Mean wood volume (±std, m³ ha-1) production in the study site

Practices	Volume	SE
Boundary planting	3405 ± 9183	700
Homegarden	70 ± 60.5	4.25
Woodlot	2582 ± 4287	520
Total Volume	1750 ± 6155	292

The mean wood volume is less than the production objective of households energy consumption and market selling as a source of income (Table 10)

Based on the ratio of wood produced for different uses, 53.5 % (945 m^3) was desired for household consumption purposes out of the total volume while 42.5 % (752.5 m^3) for market selling. The left 3 % (52.5 m^3) is considered as the trees that do not face cutting for a long time for cultural and different ecological benefits.

Table 10. Wood products obtained from trees grown on farmers' fields and their purpose of utilization in the study site (n = 121)

Wood products	House Consumption	Market (selling)
Firewood	77	-
Fuelwood	-	34
Timber	-	41
Construction	30	45
Average	53.5 %	42.5%

Note: In this paper, firewood refers to the wood used for household energy consumption while fuel wood refers to the wood used to sell to the market.

3.6 Major constraints of tree growing

Major constraints of tree growing in the study area are lack of seeds, seedlings and proper extension services of some species among others in the order of importance (Table 11). Some of the these constraints found are similar to those reported by Alemayehu (2019). Negash et.al (2005) also stated farmers have been expanding Eucalyptus planting with little support from extension agents as poor access to extension service is one of the constraints raised by the farmers.

Table 11: Farm wood Production Constraints (%) at the study site (n = 121, multiple answers possible)

No.	Wood Production Constraints	Percent (%)	Rank
1	Lack of access to seed	100	1
2	Lack of access to seedling	93	2
3	Poor access to extension service	47	5
4	Lack of water for watering during the dry season	59	3
5	Competition between trees and crops	35	8
6	Farm size	95	2
7	Land tenure problem	38	7
8	High costs for transporting wood products to market	42	6
9	Inaccessible road	50	4

4. Conclusion

Homegarden, boundary planting, and woodlot practices are the three agroforestry practices important for wood production in the study area. The purpose of growing trees in these different agroforestry practices in the area was principally to meet household domestic wood consumption and to sell to the market. Broad-leaved species are commonly used species forconsumption and marketing purposes due to their branching habit that helped farmers to obtain enough firewood and the remaining stem or large size stem parts mostly used for saw logs. Eucalyptus spp. (mostly *E. camaldulensis*) is the most widely used species that provides farmers with enough firewood, fuelwood, and construction material through splitting and cutting into pieces or direct use in the household. Despite some environmental consequences, the sound role of Eucalyptus species for different uses in the area helps conserve other indigenous tree species that have even better wood quality. Other conifer species are also the sources of different wood product as well as mostly small wood leftovers used as firewood and fuel wood after harvesting.

There were no universal tree establishment and management practices in the study area. Indigenous trees known for their wood quality are rarely available in the open wood market. This was due to the farmers having been implementing a ban on cutting these trees. Lack of appropriate planting material and no focus made on conservation of these species from further extinction.

Tree production is in the state of traditional subsistence level that was not supported by different tree development technologies. The availability of different Agroforestry practices for tree growing is a high opportunity for future improvements. Especially, practices like mixed species woodlot encompassing a mixture of trees have multiple ecosystem services. In order to obtain enough amount of production, it is recommended that to have standard tree planting and management sytem, put inplace mixed species wood lots, avail sustaibale planting materials or seed sources other tha Eucalyptus species and improve access to credits facility associated with interest free banking service for farmers.

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